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# The Global Return on Capital, the Lucas Paradox and the 'Savings Glut'

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A thesis submitted for the degree of
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## Summary

This thesis is composed of three chapters related to the measurement, analysis and application of cross-country data on the return on physical capital. In Chapter 1, we derive a database of returns on physical capital that is fully consistent across the ten largest economies in the world (measured at 2005 US Dollar exchange rates). The database covers more than a quarter of a century of data in every case, with significantly earlier starting dates for some economies. The ten economies are the United States, Japan, Germany, China, UK, France, Italy, Canada, Spain and South Korea and, together, they account for more than 75% of global GDP. The estimates are based on data sourced directly from national statistical agencies, with adjustments made where necessary to ensure full cross-country consistency. Given a broad and consistent dataset, we can combine the individual measures of the return on capital (ROC) into an estimate of the global ROC for the first time, and conduct more comprehensive cross-sectional and time-series analysis. We discuss the existing literature in deriving estimates of the return on capital and provide a summary description of the main characteristics of our dataset. Two features stand out: First, we find significant cross-country variation in returns. Although the cross-country standard deviation of returns decreased during the 1980s and 1990s ('sigma convergence'), it increased once again during the 2000s. Second, there has been a trend increase in the global return on physical capital within the sample. Although the return on capital fell in 2008 following the onset of the 2007/08 financial crisis, it remains above its long-term average.

In Chapter 2, we use the database set out in the first chapter to explore the Lucas paradox. Neo-classical theory suggests that, in the absence of full capital market integration, rates of return should be higher in poor countries than in rich ones, and that, reflecting these differences, capital should flow from rich to poor countries. Since Lucas (1990) posed the question "Why doesn't capital flow from rich to poor countries?", a variety of explanations have been put forward. This paradox can be usefully split into two distinct questions: "Are rates of return higher in poor countries?" and "Do capital flows systematically respond to differences in rates of return?", and proposed explanations typically address one of these two questions. Using our cross-country database of ex-post rates of return on capital, we find considerable and persistent differences in rates of return that are positively correlated with GDP per capita growth and negatively correlated with the level of GDP per capita, as neo-classical theory would predict. However, we find no systematic response to these differences in overall cross-country capital flows, net FDI inflows or net equity inflows. Our findings imply a 'yes' in answer to the question of whether rates of return are higher in low-income

countries but a clear 'no' to the question of whether capital flows systematically respond to differences in the rates of return. This does not appear to represent a specific failure of capital to flow from rich countries with low returns to poor countries with high returns—it also represents a failure of capital to flow from rich countries with low returns to rich countries with high returns. Our findings provide evidence against the *fundamentals* explanation of Lucas's paradox. We discuss some alternative explanations for the Lucas paradox—including domestic market imperfections, the relation between savings and growth, and heterogeneity in financial market development—and find evidence of a strong link between growth and capital outflows.

In Chapter 3, we extend the discussion of 'uphill' capital flows and return on capital data to make a contribution to the literature analysing the formation of the 2007/08 financial crisis. There is a growing body of opinion that macro imbalances played an important part in the formation of the financial crisis. According to this account, excessive saving in the emerging world held down real interest rates and facilitated a boom in credit. However, in the years preceding the crisis, we show that the global economy was also characterised by rising returns on physical capital and increased equity risk premia—the latter illustrated by a new database of ex-ante global equity risk premia that we have also estimated. These are two features that the standard imbalances (or 'savings glut') story cannot easily account for. We argue not that the savings glut account is wrong but that, by neglecting emerging market (EM) portfolio preferences (the composition of that saving), it is incomplete. Either because EM investors have been genuinely more risk-averse or because they were institutionally constrained in that way, a higher proportion of their ex-ante saving went into fixed-income assets, as opposed to equity. We suggest that higher ex-ante saving in large emerging markets and high levels of risk aversion are related, and that this connection explains both low bond yields and high returns on risky capital.

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# Chapter 1: The Rate of Return on Physical Capital


## Abstract

We derive a database of returns on physical capital that is fully consistent across the ten largest economies in the world (measured at 2005 US Dollar exchange rates). The database covers more than a quarter of a century of data in every case, with significantly earlier starting dates for some economies. The ten economies are the United States, Japan, Germany, China, UK, France, Italy, Canada, Spain and South Korea and, together, they account for more than 75% of global GDP. The estimates are based on data sourced directly from national statistical agencies, with adjustments made where necessary to ensure full cross-country consistency. Given a broad and consistent dataset, we can combine the individual measures of the return on capital (ROC) into an estimate of the global ROC for the first time, and conduct more comprehensive cross-sectional and time-series analysis. We discuss the existing literature in deriving estimates of the return on capital and provide a summary description of the main characteristics of our dataset.

## Section 1: Introduction

We derive a database of returns on physical capital that is fully consistent across the ten largest economies in the world (measured at 2005 US Dollar exchange rates). The database covers more than a quarter of a century of data in every case, with significantly earlier starting dates for some economies. The ten economies are the United States, Japan, Germany, China, UK, France, Italy, Canada, Spain and South Korea and, together, they account for more than 75% of global GDP.

We define the rate of return on physical capital (ROC) as being equal to the yield on capital (the ratio of profits, gross of interest payments and tax but net of depreciation, to capital at replacement cost) plus the capital gain/loss from real changes in the replacement cost of capital. Previous studies have typically ignored the capital gain element of the return on capital calculation, reporting instead the yield on capital as being the 'return on capital'.[1] One important innovation of this database is that we have combined the yield and the capital gain/loss to report correctly the return on capital. We also calculate a return on capital measure that is net of corporate taxation.

The inputs into our ROC estimates are based on data sourced directly from national statistical agencies. Where official capital stock measures are not available, we have constructed our own estimates using data on investment flows, real investment prices and depreciation. We have taken a number of steps to ensure comparability of the ROC measures across countries. For instance, we focus on the non-financial corporate sector, where the measurement of profits and capital stocks is most accurate, and we have adjusted for differences in the treatment of imputed labour income of the self-employed across countries.

This is the first broad-based, cross-country, fully consistent return on capital database of its type. Previous studies in which the return on capital was the principal variable of interest have typically used one of three different approaches: using rates of return on financial capital (ROFC)—usually bond or equity returns—as a proxy for whole-economy rates of return;[2] calculating 'top-down' estimates of the gross marginal product of capital under the assumption that a number of the inputs are fixed and equal across countries, and which

[1] See, for instance, Citron and Walton (2002), Broadbent, Schumacher and Schels (2004), European Central Bank (2004), Liang (2006) and Bai, Hsieh and Qian (2006). Caselli and Feyrer (2007) and Mello (2009) provide cross-country estimates of the marginal product of capital, abstracting from both deprecation and the capital gain/loss.
[2] Hall (1988).

abstract from cross-country variation in depreciation rates and capital gains/losses;[3] or calculating the yield on capital using a methodology that is similar to ours but only doing so for individual economies or a small group of economies.[4]

The database set out in the chapter has clear advantages over all three of these approaches:

- The use of returns to equities or bonds as a proxy for the ROC is unsatisfactory because, as Mulligan (2002) has argued, there are significant differences between rates of return on physical and financial capital within individual economies (and, indeed, across returns to different asset classes).

- Relative to the 'top-down' MPK estimates of Caselli and Feyrer (2007) and Mello (2009), there are a number of advantages. First, we measure the actual return on capital rather than the gross marginal product of capital, taking account of capital gains/losses and of cross-country variation that results from differences in depreciation rates. Second, while we impose a common methodology in calculating each of the inputs into our return on capital estimates, we also allow for genuine cross-country and time-series variation in these inputs. Third, in focusing on the returns to privately-held capital, we abstract from differences in whole-economy returns that arise from variations in the size, type and structure of government. Fourth, if property rights are ill-defined and profits are at risk of appropriation, then a return on capital measure based on reported profits is more likely to reflect the true return available to investors than one based on 'top-down' estimates of $\alpha$, $Y$ and $K$. Fifth, the potential for measurement error is limited by focusing on returns to the private non-financial sector, where profitability and capital stocks are most accurately measured, and using data that are sourced directly from national accounts.

- Relative to studies that have calculated the yield on capital for individual economies or small sub-sets of economies using national accounts data and applying an approach that is similar to our own, the principal advantages are: First, that we take account of the real capital gain/loss. Second, given a broad and consistent dataset covering 28 years of returns data, we can combine the individual measures of the return on capital (ROC) into an estimate of the global ROC for the first time and the database facilitates a more comprehensive cross-sectional and time-series analysis.

[3] Caselli and Feyrer (2007) and Mello (2009).
[4] See, for instance, Mulligan (2002), Citron and Walton (2002), Broadbent, Schumacher and Schels (2004), European Central Bank (2004), Liang (2006), and Bai, Hsieh and Qian (2006).

Prior to the conclusion of this chapter, we provide a summary description of the main cross-country characteristics of our estimates of return on physical capital. Two features stand out: First, we find significant cross-country variation in returns (Figures 1 and 2). Although the cross-country standard deviation of returns decreased during the 1980s and 1990s ('sigma convergence'), it increased once again during the 2000s. Second, there has been a trend increase in the global return on physical capital within the sample (Figures 3 and 4). Although the return on capital fell in 2008 following the onset of the 2007/08 financial crisis, it remains above its long-term average.

The principal value of the database set out in this chapter lies in its application to a number of important macroeconomic questions:

1. What determines the behaviour of the whole-economy returns on capital, both within and across economies? With perfectly open capital markets, economic theory provides strong guidance in this regard. Quite simply, there should be *no* differences in (risk-adjusted) expected returns. If there were, then rational investors would smooth out such differences by investing where expected rates of return were relatively high. Economic theory also provides guidance as to what determines the rate of return in a fully-closed economy, absent of cross-border trade in goods or capital. In a standard Ramsey growth model, for instance, with optimising agents and a constant relative risk aversion utility function, the equilibrium rate of return is given by solving the Euler equation. In the steady state, $r = \rho + \theta g$ (where $r$ is the rate of return, $\rho$ the discount rate, $\theta$ the rate of time preference and $g$ the rate of change in available technologies).[5] However, few countries approximate to the fully-open or fully-closed theoretical ideals.[6] So what determines differences in rates of return in this middle, or semi-open, state? To what extent doe the ROC fluctuate with economic growth? Does it lag or lead growth? Is the return on capital influenced by population growth?

2. Why doesn't capital flow from rich to poor countries? (The Lucas paradox). Neo-classical theory suggests that, in the absence of full capital market integration, rates of return should be higher in poor countries with low levels of capital per worker than in rich countries with high

[5] The technology term is sometimes interchanged with GDP per capita depending on the initial model formulation.

[6] All countries now engage, at least to some limited extent, in international goods and capital trade. It is perhaps more contentious to suggest that no country is fully open, given the well-documented rise in goods and capital market integration in the past quarter-century. But, while a number of developed economies have removed all legal obstacles to full capital-market integration and the cost of cross-country capital trade has declined significantly, there remain institutional and behavioural obstacles to fully-open capital markets.

levels of capital per worker, and that, reflecting these differences, resources should flow from rich to poor countries. Since Lucas (1990) posed the question "Why doesn't capital flow from rich to poor countries?", various explanations have been put forward for why this does not appear to be the case. The paradox can be usefully split into two distinct questions: "Are rates of return higher in poor countries?" and "Do capital flows systematically respond to differences in the rates of return?", and proposed explanations typically address one of these two questions. Obstfeld (1995) argues that the clearest answer to the Lucas paradox would be provided by a direct comparison of rates of return on capital. The database we set out here enables such a comparison.

In Chapter 2 of this thesis, we use the database to investigate questions 1 (the determinants of the return on capital) and 2 (the Lucas paradox).

3. Gauging the extent of capital market integration. Obstfeld and Taylor (2004) accumulate a large body of evidence to argue that the integration of capital markets since the early 20th century has been essentially U-shaped, with a high degree of capital market integration in the first Gold Standard (1880-1914); a low degree of capital market integration in the inter-war and Bretton Woods era (1945-1971); and a steady rise in capital market integration since the 1970s, recently surpassing the previous "integration high". Obstfeld and Taylor base their findings on quantity evidence (to which the Lane and Milesi-Feretti (2001, 2007) database on the international investment positions of countries is an important new contribution), and also on price evidence (for instance, looking at differences between on-shore and off-shore interest rates). However, Obstfeld and Taylor, and other studies of this kind, base their price evidence on the rates of return on financial capital (ROFC) rather than on returns to physical capital (ROC). Documenting the behaviour of rates of return on physical capital across countries and across time would provide additional price evidence to this body of literature.

4. Do the intertemporal elasticity of substitution and interest rates move together as implied by classical theories, such as Fisher (1930) and Ramsey (1928), and also by modern theories of consumer behaviour, such as Modigliani & Brumberg's (1954) Life-Cycle Hypothesis and Friedman's (1957) Permanent Income Hypothesis? Hall (1988) argued that the relation between the real return (on US Treasury Bills) and the rate of change of consumption does not support the idea of strong intertemporal substitution at a macroeconomic level. However, Mulligan (2002) argues that the failure to find a good relation between the intertemporal marginal rate of substitution and interest rates is only because the latter has not been measured correctly. 'The' interest rate in consumption/investment theory is neither the yield on government bonds nor that on any other single market instrument. The rate available to

households/firms—on average—when they are deciding whether to consume today or save until tomorrow is the post-tax expected marginal return on a representative piece of capital (which, under the assumptions of a constant-return production function and perfectly competitive domestic capital markets, is equal to the average return on capital).[7] The distinction is an important one because, as Mulligan shows, the return on US Treasury bonds behaves very differently from his estimates of the US whole-economy return on capital. He goes on to argue that the intertemporal marginal rate of substitution does co-move with his ROC measure of 'the' interest rate. Our cross-country dataset is similar in construction to Mulligan's and can be used to explore the same empirical question across a number of countries.[8]

The outline of this chapter is as follows: In Section 2 we review the existing empirical literature in deriving measures of the return on physical capital across countries. In Section 3 we set out a version of Jorgenson's (1963) derivation of the user cost of capital based on the neo-classical theory of optimal capital accumulation and its relationship with the return on capital. We also set out the framework and issues relating to the measurement of the return on capital. In Section 4 we provide a summary description of our results. Finally, in Section 5, we draw some conclusions.

[7] This also approximates most closely to 'the' interest rate in many other theoretical models. But not all: in the money demand function, 'the' interest rate is a short-term nominal money-market rate. In the 'IS curve', it is the gap between the rate of return on physical capital and the long-term real interest rate.

[8] There is one important difference between our datasets and those of Mulligan. As we discuss later, our rate of return measure is based on the private non-financial corporate sector. Mulligan's is a wider measure including the household and financial sector, but excluding the government sector.

## Section 2: Literature Review

The return on capital is fundamental to a number of core macroeconomic issues, from growth theory to financial economics, and in linking consumption/savings behaviour to investment theory. Many previous studies that have measured the return on capital (or proxies thereof) have done so in the context of one of these issues. In Appendix 1 we provide an expanded literature review that outlines in greater detail the findings of the main papers discussed here, including, where relevant, the implications of their findings for the macroeconomic issue they were addressing. In this section we focus only on how each of these studies dealt with empirical issues related to the measurement of the return on capital.

Much of the existing work in estimating the rate of return on capital comes from the growth theory literature. In this context, Banerjee and Duflo (2005) provide an extensive review of previous studies that have estimated rates of return across developed and developing economies. The growth theory literature has typically followed one of three approaches. The first is to compare returns to financial capital across countries. These studies provide heterogeneous estimates, depending on which financial asset or lending rate is observed. The second approach is to impose a production function (typically Cobb-Douglas) and to estimate the return on capital by regressing $\Delta Y$ on $\Delta K$ for the economy as a whole or for individual firms/sectors. Such studies also provide a wide range of estimates for the return on capital both within and across countries. The third approach is calibration, imposing a functional form on the relationship between capital, labour and the rate of return, calibrating some of the inputs and using more readily available data (such as relative wages) to derive an estimate of the relative rate of return on capital. Banerjee and Duflo argue that each of the three most common approaches is flawed because of the heterogeneity of interest rates that exists within each economy. They argue that a micro-data sector approach is necessary to assess how successful various growth theories are in matching the data.

Mulligan (2002)—in the context of considering the relation between the marginal rate of return and the intertemporal elasticity of substitution (IES)—identifies the same heterogeneity of interest rates within a single economy but draws a different conclusion to Banerjee and Duflo (2005). He argues that, given the existence of a multitude of interest rates, one should not presume that any single financial interest rate represents a good proxy for the whole-economy rate of return (as Hall (1988) implicitly did when he compared US consumption growth with the post-tax yield on US Treasuries). Instead, one needs to measure the whole-economy return on capital directly, by using national accounts data to aggregate profits and capital data across all economic activities. Mulligan argues that the ex-post average yield on

capital closely approximates to the ex-ante marginal rate of return on capital under two key simplifying assumptions: First, that the marginal return on capital equals the average return on capital as implied by the standard neo-classical model. The second assumption relates to expectations formation. The return on a capital asset can be decomposed into a rental rate (or yield) and a capital gain/loss. Mulligan assumes that both the change in the yield and the capital gain/loss (net of depreciation) are unforecastable and with mean zero, implying that the ex-post yield on capital is a good proxy for the ex-ante return.[9] On this basis, Mulligan constructs his measure of the US post-tax yield capital using US Bureau of Economic Analysis data on income and capital. His pre-tax yield measure includes private non-financial corporations, financial corporations and the household sector (only excluding the government sector). Mulligan's capital measure is for fixed assets at current replacement cost (inventories and other "working capital" are not included). In including the household sector, the capital measure therefore includes the replacement-cost value of owner-occupied housing. The post-tax measure is calculated by subtracting direct and indirect taxes on capital income.

Caselli and Feyrer (2007), in a paper that considers the variation in marginal products of capital (MPKs) across rich and poor economies, also argue in favour of the use of 'direct' measures of the return on capital or MPK, rather than relying on proxies or indirect estimates.[10] The authors calculate a range of estimates of the MPK across 53 developed and developing countries at a single point in time. Starting from the standard neo-classical assumption of a constant-return production function and perfectly competitive domestic capital markets, the MPK equals the average return on capital and is given by $MPK = \alpha \frac{Y}{K}$, where $Y$ is real GDP, $K$ is the real capital stock and $\alpha$ is the capital share in GDP. Caselli and Feyrer start by deriving measures of the MPK on this basis, using estimates of $\alpha$ derived by Bernanke and Gurkaynak (2001), who expand upon the work of Gollin (2002), data for $Y$ is taken from the Penn World Tables 6.1 (PWT, Heston, Summers, Aten (2004)) and $K$ is constructed using the perpetual inventory method with investment data that is also taken from the PWT, assuming a constant depreciation rate of 0.06 and taking the initial capital stock, $K_0$, as $I_0/(g+\delta)$ where $I_0$ is the value of the investment series in the first year and $g$ is

[9] Mulligan (2002) does not discuss why this might be a reasonable assumption, stating only that: "In principle, one could test the hypothesis that, other than [the US Bureau of Economic Analysis's] estimate of depreciation, aggregate capital gains are unforecastable, although perhaps the BEA's estimate of the prices of equipment, housing, and other assets are not good enough for such a test" (page 9). One possible intuition for this assumption—which is not discussed by Mulligan—is provided by the efficient market hypothesis, which posits all past market prices and data are fully reflected in the price of a security (Fama (1965)). If it were possible to obtain predictable capital gains from holding a representative piece of capital, then investment would take place to the point that all predictable gains were eliminated, leaving only the yield on capital.

[10] We return to this paper in our discussion of the Lucas paradox in Chapter 2.

the average geometric growth rate for the investment series between the first year with available data and 1970. Caselli and Feyrer then make two adjustments to this basic MPK measure: First, the authors use World Bank estimates on the proportion of total capital that is in land and natural resources to adjust $\alpha$ for the (more narrowly defined) reproducible capital share of output. Second, in using nominal profits and capital stock data, their MPK estimates also take account of differences in the relative price of output and capital across rich and poor countries.

There are a number of limitations with Caselli and Feyrer's estimates: First, in calculating estimates of the marginal product of capital, the authors abstract from cross-country variation in the return on capital that results from capital gains/losses and differences in depreciation rates. Second, their estimates of the capital stock require two simplifying assumptions that are questionable: first, that depreciation rates are equal and fixed across economies (abstracting from any variation in depreciation rates due to compositional differences in the capital stock); and, second, for their estimates of the capital stock they take as a starting assumption that initial capital stock, $K_0$, is given by the steady-state value of $I_0/(g+\delta)$ (whereas low-income economies are likely to be below the steady-state value). While national accounts-based measures of the capital stock are also calculated using a perpetual inventory method, these estimates are typically cross-checked for accuracy through the use of periodic referencing. Third, Caselli and Feyrer are trying to compare the level of the MPK across a large number of countries at a single point in time. But their estimates of $Y$, $K$, $P_y$ and $P_k$ date from 2000, while the estimates of the capital share of income taken from Bernanke and Gurkaynak (2001) date from 1995.

Mello (2009) calculates a range of estimates of the marginal product of capital across 93 countries from 1970 to 2000. His measure of the MPK is similar in form to Caselli and Feyrer's preferred measure in that he allows for cross-country heterogeneity in the capital-output ratio and in the relative price of capital. However, Mello assumes that the capital share of income, $\alpha_i$, is fixed and equal to 0.30 for every country and at every point in time. One consequence of this is that Mello assumes away a principal source of cross-country and time-series variation in the marginal product of capital.

In two separate papers, Walton (2000) and Citron and Walton (2002) collate and compare the yield on capital (net of depreciation, gross of tax) for the private non-financial corporate (PNFC) sector in a selection of European countries, the US, Japan, Australia, Israel, South Africa, Iceland and Singapore. The papers are similar in approach to our own study, but the

authors make limited effort to ensure comparability of the data obtained from the various national sources ("We have not sought to impose a common detailed definition or to check any of the data provided"—Citron and Walton, 2002, page 1). This results in a couple of identifiable inconsistencies. First, the authors base their German yield on capital measures on an annual survey of industries conducted by the Bundesbank ("German Enterprises Profitability and Financing"). This survey is not representative of the economy as a whole, is biased towards manufacturing companies, and uses different definitions of capital and profits to those employed by Germany's national statistics office (*De Statis*). The resulting return on capital measure is 4-5 percentage points lower than the national accounts measure, a bias which also significantly distorts the Euro-zone aggregate measure calculated by Citron and Walton. Another inconsistency is that the yield on capital measure for some countries uses capital employed (fixed assets + working capital) as the denominator, whereas fixed assets are used as the denominator in other cases (such as the US). Finally, the timescale over which the data are compiled is only 12 years (1990-2001), limiting the scope for analysing how rates of return have developed over time.

Broadbent, Schumacher and Schels (2004) compare the yield on capital (net of depreciation, gross of tax) for private non-financial corporations in the US and a selection of European economies from 1987-2003. The data are sourced directly from national statistical agencies and efforts are made to ensure consistent definitions are applied across countries. Broadbent *et al* find that European yields on capital are comparable with those in the US, with the notable exception of Germany. On average, during the 1990s, the authors estimate that the yield on capital averaged 9½% in Germany, 10½% in the US and 12% in the rest of Europe (UK, France, Italy, Spain and Belgium). However, while the yield on capital in Germany was relatively low during the 1990s, the authors find that it had begun to rise in the late 1990s and was now comparable with that of other European countries.

Economists[11] at the European Central Bank (2004) compare Euro-zone and US profitability developments based on various national-accounts-based measures, including the yield on whole-economy capital (net of depreciation, gross of tax) based on combined data for the household, financial and government sectors, as well as private non-financial corporations. The Euro-zone aggregates are calculated using data from 8 of the 16 member states. In calculating their yield on capital measures, the authors make an adjustment for the imputed labour income of the self-employed, as argued by Gollin (2002). This adjustment is critical for the ECB's yield on capital measure, as they include the household sector, where the

[11] Articles in the ECB's *Monthly Bulletin* appear on a no-name basis.

majority of output is from the self-employed and where imputed labour income thus represents a large proportion of total labour income. The adjustment is made by assuming that the imputed compensation per self-employed person equals the compensation per 'regular' employee. The paper presents estimates dating back to 1960 for both the Euro-zone and the US, concluding that the yield on capital was 1-2% lower in the Euro-zone during the 1990s. Although this result appears to contradict the findings of Broadbent *et al*, the difference lies in the country composition of their respective European aggregates. Broadbent *et al* (2004) include the UK (where the yield on capital is high) but strip out Germany, whose low but rising yield is argued to be due to an (effective) subsidy on capital that is shrinking over time. The ECB's Euro-zone aggregate includes Germany but, naturally, excludes the UK. Re-aggregating the Broadbent, Schumacher and Schels (2004) data to calculate a Euro-zone aggregate (based on data for Germany, France, Italy, Spain and Belgium) results in an average yield on capital during the 1990s that was 1% lower than that of the US.

In this paper, we calculate measures for the ex-post rate of return on capital (net of depreciation, gross of interest payments, and both gross and net of taxation) for the PNFC sectors of the 10 largest economies in the world (based on 2005 US$ GDP). In common with papers we have focused on in this review but in contrast with much of the existing literature, each of our measures of the return on capital is 'directly measured' from broadly-based estimates of profitability and the capital stock. The methodology underlying our preferred calculation of the ex-post return on capital has most in common with the ECB's yield measure in that we adjust for differences in the imputed labour income of the self-employed across countries where necessary. However, given that we focus on private non-financial corporates only (where these distortions are typically smaller), the adjustments we have had to make are also typically smaller.

Our database also provides a number of advances on the ECB and other papers discussed in this section:

- The return on capital can be decomposed into a rental rate (or yield) and a capital gain/loss. Our ex-post measures of the return on capital include both components and not just the yield on capital.

- While previous studies have calculated the return on capital for individual countries or small groups of countries, we are aware of no pre-existing work that has applied a common methodology to derive comparable rates of return for the 10 largest economies. We use a number of different data sources to extend our time-series data

as long as possible. The database runs for more than one quarter of a century (1981-2008) for all ten countries and, in some cases, for considerably longer.[12]

- We are more comprehensive in our efforts to impose a common methodology in calculating whole-economy rates of return across countries. In addition to adjusting for imputed labour income of the self-employed (as the ECB study did), we explore the sensitivity of the return on capital measures to different methods of calculating the capital stock.

- Given a broad and comparable dataset (covering more than three-quarters of global output in US Dollar terms), we can combine individual return on capital results into an estimate of the global rate of return on capital from 1981-2008 for the first time.

[12] The United States database commences in 1929, the UK database in 1949 and the France database in 1971.

## Section 3: Conceptual Issues and the Measurement of the Return on Capital

### 3.1 Capital Accumulation and the Rate of Return in Neo-classical Theory

In neo-classical theory, the equilibrium between savings and investment decisions is determined by 'the' interest rate. It is determined by the market clearance between, as Fisher (1930) put it, the impatience to spend income versus the opportunity to invest: "The more we invest and postpone our gratification, the lower the investment opportunity rate becomes, but the greater the impatience rate; the more we spend and hasten our gratification, the lower the impatience rate becomes but the higher the opportunity rate...Between these two extremes lies the equilibrium point which clears the market, and clears it at a rate of interest registering (in a perfect market) all impatience rates and all opportunity rates."

Jorgenson (1963) presented a testable theory of investment behaviour based on neo-classical principles of optimal capital accumulation, and in this section we set out a version of Jorgensen's model, which provides the framework that we use to calculate the return on capital.

Following Jorgenson (1963), let output in time $t$ be related via some production function to labour employed ($L$) and the capital stock ($K$):

$$Y_t = F(L_t, K_t) \tag{1}$$

The capital accumulation relationship, in discrete time, is given by

$$K_{t+1} - K_t = I_t - \delta K_t \tag{2}$$

Let $w$ be the wage rate of labour $L$ and $p$ the price of a unit of capital $I$. We set the numeraire as the price of output $Y$ and normalise it to one. Net revenue is then given by

$$R_t = Y_t - w_t L_t - p_t I_t \tag{3}$$

Then, the net worth of the firm, $V$, is given by the sum of discounted net revenues

$$V_i = \sum_{t=i}^{\infty} \left( \frac{1}{1+r_t} \right)^t [Y_t - w_t L_t - p_t I_t] \qquad (4)$$

Where $r_t$ is the rate of interest in time *t*.

In neo-classical theory, the criterion for optimal capital accumulation is to maximise the present value of the firm. The optimisation problem therefore becomes

$$\max \quad V_i = \sum_{t=i}^{\infty} \left( \frac{1}{1+r_t} \right)^t [Y_t - w_t L_t - p_t I_t]$$

$$\text{s.t.} \quad Y_t = F(L_t, K_t)$$

$$K_{t+1} - K_t = I_t - \delta K_t$$

$$K_t \geq 0$$

for some initial capital stock $K_0$.

To solve the problem we use optimal control theory. To maximise (4), subject to the constraints (1) and (2), consider the current-value Hamilitonian

$$H_t = F(L_t, K_t) - w_t L_t - p_t I_t + q_t (I_t - \delta K_t) \qquad (5)$$

where $q_t$ is the current-value co-state variable, representing the shadow price of capital.

The marginal productivity conditions for the optimal capital path, using employment *L* and investment *I* as control variables, and *K* as our state variable are

$$\partial H_t / \partial I_t = - p_t + q_t = 0 \qquad (6)$$

$$\partial H_t / \partial L_t = F_L - w_t = 0 \qquad (7)$$

$$\partial H_t / \partial K_t = - \partial q_t / \partial t + r_t q_t = F_K - q_t \delta \qquad (8)$$

$$\partial H_t / \partial \lambda_t = \partial K_t / \partial t = I_t - \delta K_t \qquad (9)$$

Re-arranging condition (7) gives $F_L = w_t$, implying that labour is employed until its marginal product is equal to the wage.

Condition (6) implies that $p_t = q_t$, that is, the shadow price of capital is equal to the price of a unit of investment and, therefore, $\partial p_t / \partial t = \partial q_t / \partial t$.

Re-arranging (8) gives:

$$\partial q_t/\partial t - r_t q_t = - F_k + q_t \delta$$

which can be re-arranged to provide a solution to the marginal product of capital (MPK)

$$F_K = q_t [r_t + \delta - (\partial q_t / \partial t) / q_t]. \qquad (10)$$

Jorgenson labeled this the 'real user cost of capital', $c$. The condition of optimality implied by (10) is that the firm acquires capital up until the point where the value of the gross marginal product of capital, $F_K$, is equal to the real user cost, $r_t q_t + \delta q_t - \dot{q}_t$, or simply $c$. This term includes the opportunity cost of lending it out ($r_t$), the depreciation per unit per period of time ($\delta$), minus the capital gain ($(\partial q / \partial t) / q$ or $\dot{q}/q$).

If we suppose further that the production function takes Cobb-Douglas form, with elasticity of output with respect to capital of $\alpha$, then the optimal capital stock, $K^*$, is given by

$$K^* = \alpha \frac{Y}{c}. \qquad (11)$$

So the optimal capital stock depends positively on $Y$ (and on the price of output which, in this case, was fixed as the numeraire) and negatively on $c$ and the marginal product of capital is given by

$$MPK = c = \alpha \frac{Y}{K^*} \qquad (12)$$

Expressing (10) in rates, $F_K / q_t = r_t + \delta - (\partial q_t / \partial t) / q_t$ and re-arranging provides the 'no-arbitrage condition'

$$r_t = F_K / q_t - \delta + (\partial q_t / \partial t) / q_t . \qquad (13)$$

Equation (13) implies that, with full optimization, the gross marginal product of capital, $F_K/q$, less depreciation, $\delta$, plus the capital gain is equal to the financing rate, $r_t$, or 'the' interest rate in this model. Introducing capital adjustment costs, taxes, risky returns and imperfect competition will complicate the model and allow for different rates of return for different types of assets. But (13) provides the basic framework for measuring the rate of return.

The inclusion of the real capital gain (or loss) is a key element of the return to investment. For aggregate capital, the capital gain term corrects for any divergence between the capital goods and consumer prices. To omit it would be to ignore an element that materially affects the future real consumption value of any investment.

The importance of including the real capital gain in the return to physical capital (ROC) calculation is perhaps clearer if we draw an analogy with the return to quoted equities: to include only the yield in the return on capital while ignoring the real capital gain is analogous to including only the dividend yield in the return to an equity investment, while ignoring the change in the share price.

### 3.2 The rate of return on capital calculations

Following (13), the return on capital is composed of three elements—the gross yield on capital, the depreciation rate and the capital gain—which we reduce to the net yield and the capital gain. Ex-post returns are given by the realised values of these two parts, ex-ante returns by the expectations of both. In this paper, we derive estimates of ex-post rates of return.

Translating (13) into national accounts concepts, we obtain the following calculation of the rate of return on capital, $r_t^K$, that is net of depreciation but gross of taxes and is expressed in rates

$$r_t^K = \frac{\Pi_t}{P_{t-1}^K K_{t-1}} + \left( \frac{P_t^K P_{t-1}^C}{P_{t-1}^K P_t^C} - 1 \right). \qquad (14)$$

$\frac{\Pi_t}{P_{t-1}^K K_{t-1}}$ is the operating surplus net of depreciation in period *t* expressed as a ratio of the nominal net capital stock at the end of period *t-1*, $P_{t-1}^K K_{t-1}$, which is given by the product of the real capital stock, $K_{t-1}$, and the capital stock (at replacement cost) deflator, $P_{t-1}^K$. $P_t^C$ is the household consumption deflator at time *t*. The first term in the RHS of equation (14) represents the net yield on capital, while the second term represents the real capital gain (loss) from holding a representative piece of capital from the start to the end of period *t*. $r_t^K$ is expressed in percentage terms. We also calculate a ROC measure that is net of corporate taxation, $r2_t^K$.

To understand why the calculation takes this form, consider a representative household in period *t-1* facing the choice of consuming $P_{t-1}^K K_{t-1}$ or investing it in period *t*. If the household chooses to invest, it forgoes the consumption of $P_{t-1}^K K_{t-1}$. But the ex-post, additional return from doing so is given by $\frac{\Pi_t}{P_{t-1}^K K_{t-1}}$, the profits in period *t* as a fraction of the capital invested in period *t-1*, plus $\frac{P_t^K P_{t-1}^C}{P_{t-1}^K P_t^C} - 1$, the fractional change in real capital prices during the period *t* (as measured by the capital stock deflator deflated by the household consumption deflator). Moving the decision on by one period, the sum that the representative household can choose to invest or consume at the end of period *t* is then given by $\left(1 + r_t^K\right) P_{t-1}^K K_{t-1}$, while the sum at the end of period *t+1* is given by $1 + r_{t+1}^K \left( \left(1 + r_t^K\right) P_{t-1}^K K_{t-1} \right)$, and so forth.

To calculate the real capital gain term, we deflate capital prices with the household consumption deflator, as the choice facing households/firms in consumer/investment theory is between deferring consumption today for potentially greater consumption tomorrow.[13] Note that we do not deflate the yield on capital, as it is already a 'real' concept, denoting the flow of profits in period *t* that is returned to the investor as a fraction of the capital stock owned at the end of period *t-1*.

[13] The consumer price index could be used as a similarly suitable deflator.

Previous studies that have calculated the return on capital using national accounts data and national statistical agencies that report official estimates of the 'return on capital' have ignored the capital gain element of the return on capital calculation, reporting instead the yield on capital as being the 'return on capital'.[14] One of the key contributions of this paper is that we combine the yield and estimates of the capital gain/loss to report correctly national-accounts-based return on capital data.

For some economies we have had to adjust the inputs into our gross- and net-of-taxation return on capital measures to ensure comparability. However, the underlying formulae determining how the inputs are combined to calculate gross- and net-of-taxation ROCs are unchanged throughout this paper. Where there is a difference between our gross and net measures is in the calculation of the yield.

The yield on capital, $u_t^K$, net of depreciation but gross of corporation taxes is given by:

$$u_t^K = \frac{\Pi_t}{P_{t-1}^K K_{t-1}} = \frac{NetOperatingSurplus_t^{PNFC}}{NomCapital_{t-1}^{PNFC}}$$

$$= \frac{(GVA_t^{PNFC} - L_t^{PNFC} - TP_t^{PNFC} - Kcons_t^{PNFC})}{Capital_{t-1}^{PNFC}} \qquad (15)$$

The yield on capital net of depreciation and net of corporation taxes ($u2_t^K$) is given by:

$$u2_t^K = (1-\tau_t)u_t = \frac{(GVA_t^{PNFC} - L_t^{PNFC} - TP_t^{PNFC} - Kcons_t^{PNFC} - Tcorp_t^{PNFC})}{Capital_{t-1}^{PNFC}} \qquad (16)$$

Where $GVA$ = Gross Value Added or total resources, $L$ = total compensation of employees, $TP$ = taxes (less subsidies) on production, $Kcons$ = capital consumption and $Tcorp$ = corporation taxes paid on profits. The capital stock measure includes all physical,

[14] Mulligan (2002) is one exception in that he discusses the capital gain/loss element of the return on capital. However, he goes on to assume that the both capital gain/loss and changes in the yield follow a random walk, so that the expected return on capital can therefore be reduced to the ex-post net yield on capital. Mulligan (2002) does not discuss why this might be a reasonable assumption but, as we discussed in the introduction, the (weak form) efficient market hypothesis provides one such justification.

reproducible capital. The measure is net of past depreciation and is calculated at replacement cost.

The capital gain/loss element of the calculation is equivalent in our gross and net measures. We do not apply capital gains taxes to the capital gain/loss element of the calculation (as one might do to a financial instrument) because the concept of capital gain/loss in national accounts data is somewhat different to the concept in financial economics. Capital gains/losses in a national accounts context refer to changes in the current replacement cost; they do not refer to potentially taxable changes in the book or market value of the capital.

### 3.3 Data sources and coverage

Throughout this piece we have based our calculations on national accounts data sourced directly from the national statistical agencies. We measure the rates of return on capital for the 10 largest economies in the world in terms of 2005 US$. These are (in decreasing order of size) the United States, Japan, Germany, China, UK, France, Italy, Canada, Spain and South Korea. Together, these economies account for more than three-quarters of the world's GDP. In Appendix 2 we set out detailed information for each country on where the data are sourced, adjustments that have been made and any data issues specific to that country.

In our return on capital measure, we focus on the private non-financial corporations (PNFCs), excluding the household sector, the public sector and the financial sector. The PNFC sector typically accounts for a little over half of whole-economy output in developed economies. There are both conceptual and practical reasons as to why we have excluded the other sectors. The conceptual reasons are that the numerator in the return on capital equation (i.e. profits) has little economic meaning in the public sector, while the denominator (i.e. physical capital) is of limited relevance to the profitability of the financial sector.[15] In excluding the financial sector, our measure is also free from any distortions to profitability that resulted from the increase in financial sector leverage in the years leading up to the 2007/08 financial crisis.

The practical reason for focussing on the PNFC sector is that this is where the statistical measurement of profits and capital stocks is most accurate. In the household sector, profits and labour income of the self-employed are lumped together in a category called 'mixed

[15] One distortion to the return on capital in the financial sector, for instance, is that it has become increasingly common for financial institutions to sell and lease back the premises they occupy, in order to minimise their physical capital and maximise their return on equity. The value of financial firms is more closely tied to intangibles, such as human capital. For an interesting application of search models to the valuation of companies with limited physical capital, see Yashiv (2005).

income' and, in calculating whole-economy capital and labour income shares, the standardised national accounts practice, as set out under the SNA93/ESA95 convention, is to designate this mixed income as part of capital income.[16] However, as a large proportion of this mixed income is the imputed labour income of the self-employed, this practice results in the overstatement of the economy's capital income share. Moreover, the distortion is typically bigger in lower-income economies where the share of self-employment is generally higher (Gollin (2002)).[17] In concentrating on the PNFC sector, which only considers firms with turnover above a certain threshold, we limit this distortion.

We calculate separate gross- and net-of-corporation-tax rates of return. Both measures are of interest, as each is more relevant for different groups of individuals and, therefore, of greater relevance in addressing different groups of questions. The gross-of-taxation rate of return is the relevant rate for calculating the rate of return to society as a whole. But the net-of-taxation rate of return is the more relevant measure for domestic investors. Thus, this is the more relevant rate in exploring the relation between the intertemporal elasticity of substitution (IES) and the marginal rate of return.[18]

### 3.4 Benefits of using national accounts data

The use of national accounts data has a number of advantages over company accounts data:

*Greater consistency across countries:* Although there are some differences in statistical treatments across countries, national accounts data based on the ESA95/SNA93 standards are more readily comparable than aggregated company accounts data, having greater consistency across countries and over time (although the comparability of the company accounts data has been improved by the recent adoption of agreed International Accounting Standards).

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[16] The SNA93/ESA95 (System of National Accounts 1993/European System of Accounts 1995) is an internationally agreed methodology for the compilation of national accounts data, prepared jointly by the IMF, the OECD, the World Bank and the United Nations, and adopted by the European Union. It superseded the SNA's for 1968 and 1953.

[17] One reason for this is that agriculture typically represents a larger share of output in poor countries and farmers are typically self-employed.

[18] The issue of whether we should subtract the effective marginal corporate tax rate or the average corporate tax rate is analogous to the issue of whether we should measure marginal or average rates of return. For the IES question, the marginal net-of-taxation rate of return would be preferable but, under certain assumptions, should equal the average rate. Given the existence of a multitude of tax breaks available to companies, calculating comparable marginal effective tax rates is much more difficult than calculating average corporate tax rates.

*Greater consistency across time:* If national accounts conventions change, historical data are typically provided on a consistent basis. The same is generally not true of company accounts data.

*Reliability:* There is evidence that national accounts data are simply more reliable than company accounts data. During the equity bubble of the late 1990s, a substantial gap developed in many countries—particularly the US—between corporate profits as measured by aggregated company accounts and corporate profits as measured by national accounts. After the equity bubble began to burst in 2000, this gap was closed by the downward adjustment of aggregated company accounts data.

*Coverage:* National accounts data cover the whole corporate sector rather than just quoted companies.

*Measurement of capital:* Company accounts measure capital at book value (the prices at which the assets were purchased), while national accounts data measure them at current replacement cost.

### 3.5 The Operating Surplus and its Measurement

The gross and net operating surplus measures are calculated before the deduction of interest payments paid and received (i.e. they are gross of net interest payments). Net interest payments are classified as 'property income' (income earned from financial investments) within national accounts, rather than 'trading profits'. Equally, in the denominator of the yield on capital measure, the capital stock itself does not include cash balances.

According to SNA93/ESA95 guidelines, it is permissible to calculate the operating surplus as a residual in national accounts data (subtracting labour compensation, taxes/subsidies and capital consumption from output), and this is how the mixed income in the household sector accounts is typically calculated. Calculated in this way, profits data will, therefore, include distortions associated with the mis-measurement of the other variables. However, for the majority of the countries we consider, the operating surplus for the PNFC sector is measured independently using corporate tax returns. This is another advantage of focusing on the PNFC sector only.

Probably the biggest data issue in correctly measuring the operating surplus relates to the treatment of the imputed labour income of the self-employed. In many small firms, the

proprietor of the firm will also provide a significant proportion of the labour input: a dentist may employee a dental assistant but much of the labour in the dental practice is her own. The national accounts treatment of the dental practice is the same as it is for other firms—to derive the firm's net operating surplus, the labour compensation of the employee (the dental assistant) is subtracted along with any taxes (subsidies) on production and capital depreciation. But much of what is left in the operating surplus of this small firm is, in fact, the imputed labour income of the dentist. The treatment of this mixed income as part of the operating surplus results in the overstatement of profit shares in national accounts data (Gollin (2002)).

The problem is most acute in the household sector accounts, where the firms are typically 'sole traders', who are both the owners of the firm and its primary source of labour. In the household sector accounts, the inclusion of the category 'mixed income'—which includes both the profits and the imputed labour income of the self-employed—is an explicit recognition by statisticians that it is difficult to separate one from the other. The most common practice of dealing with this measurement issue is to simply reclassify 'mixed income' as capital income. This is certainly straightforward but it is incorrect.

The problem is less severe in the private non-financial corporate (PNFC) sector where, by definition, the share of imputed labour income is much smaller. In Appendix 2 we outline how the distinction is made between the household and the PNFC sector in each country. In some countries the distinction is formally made on the basis of size: in the UK, for instance, the cut-off is determined by whether the enterprise is VAT-registered or not, and this is determined by annual turnover. In other countries, there is a legal distinction between the companies and sole traders, the practical consequence of which is that only firms above a certain size appear in the PNFC accounts. On either distinction, the imputed labour income of the PNFC sector as a percentage of total GVA will be much smaller than in the household sector. For some countries (most notably France) there remains the potential for distortion and, in these cases, we have taken care to adjust our estimates to ensure full cross-country comparability. These adjustments are made on a case-by-case basis and outlined in Appendix 2.

### 3.6 Physical Capital and its Measurement

In economic theory, capital is typically defined by the purpose of the expenditure in the context of an optimal consumption plan derived from the maximisation of an intertemporal utility function (Weitzman (1976)). Solving the optimisation problem determines the

consumption and savings choices of households over time, which in turn determines the level of investment in capital. Resources that increase future consumption at the expense of current consumption qualify as investment in the capital stock.

Armed with this definition, there remain some grey areas where judgement is required. The measure of capital stock we use is a measure of the replacement cost of fixed assets at the end of the time period. We do not include inventories, cash or net short-term debt, elements that are sometimes described as 'working capital'.[19] There is both a conceptual and a practical reason why we exclude these components. The conceptual reason is that inventories and cash do not clearly represent a planned deferral of present consumption—the accumulation of inventories is often unplanned and cash is used to facilitate present consumption. The practical reason is that there are differences in how inventories and cash are accounted for across countries. Excluding inventories increases the comparability of our data and, in some cases, the length of data as well.

The capital stock measure we use also excludes the value of land. Taking a factory as an example, the value of re-constructing the building and replacing the machines within the factory is included in our measure of reproducible capital, but the value of the land upon which the factory sits is excluded. Caselli and Feyrer (2007) argue that, in deriving MPK estimates, it is important to include the value of land in the measure of the capital stock (or, alternatively, to adjust downwards the share of income accruing to reproducible capital). This is because relatively poor countries tend to have a larger proportion of total capital in land and natural resources, and so the exclusion of land will result in over-estimating rates of return in poor economies. We have not calculated an additional measure of the return on capital that is adjusted for the proportion of total capital that is in land, as national statistical agencies typically do not provide such estimates, and the cross-sectional estimates used by Caselli and Feyrer are not suitable for the calculation of time-series data. However, the potential for cross-country bias as a result of this omission is limited by our focus on the private non-financial sector (because this excludes most of the agricultural sector that gives rise to mis-measurement of MPK estimates discussed by Caselli and Feyrer).[20]

The capital stock measure we use does not include the value of intangibles. Corrado, Hulten and Sichel (2006) argue that expenditure on intangibles such as software spending, research and development, and firm-specific capital should be treated in national accounts as

[19] The combination of fixed assets and working capital is sometimes described as capital employed.
[20] Agriculture accounts for a greater share of output in poor economies and this gives rise to the mis-measurement of MPK estimates if land is not included as part of capital.

investment rather than, as is the common practice, an intermediate expense. Their argument is that expenditure on intangibles is equivalent in capital theory to other investment expenditure, in that it represents the deferral of consumption today in the expectation of increased consumption tomorrow. National statisticians have so far shied away from classifying intangibles as investment—because of the practical difficulties in measuring the value of intangibles rather than any conceptual opposition to their inclusion. As national accounts data do not include intangibles as investment, neither are they included in our rate of return on capital measure. The distortion relative to the 'true' estimate of the rate of return is limited by the fact that both the denominator (the measured capital stock) and the numerator (measured profits) are under-measured by not classifying intangibles as investment.[21] Moreover, as the principal objective of our empirical work in this paper is to obtain rates of return measures that are comparable across economies, it is relevant for this purpose that the distortion applies to all 10 economies in our sample.[22]

One of the biggest challenges in this paper is collating a long times series of comparable capital stock data. Where available, we have used official national accounts estimates of capital stocks, adjusting the data for any methodological differences that may apply. National accounts measures of the capital stock are derived by aggregating sector-specific investment data and depreciation rates using the perpetual inventory method. These estimates are also typically cross-referenced for accuracy through periodic stock-taking. Such estimates are likely to be more accurate than 'top-down' estimates derived using whole-economy (rather than sector-specific) investment data, and assuming a single depreciation rate across different countries and different types of capital.

There are official capital stock measures for 9 of the 10 countries in our sample—South Korea is the exception—and, for some of the 9 economies for which there are official estimates, these are not available for every year from 1981-2008. Therefore, to fill in the gaps where official data are not available, and as a cross-check to the official estimates, we also calculate a second, independent capital stock measure based on a perpetual inventory method of calculation. This is calculated as $K_t = (1-\delta)K_{t-1} + I_t$, where $K_t$ is the capital stock at the end of period $t$, $I_t$ is the investment in time $t$, and $\delta$ is the depreciation rate (which is

[21] In the national accounts framework, reclassifying software from a business expense to investment also raises profitability and saving. The investment is deemed to have been made out of retained profits.

[22] The one partial exception to this is in the US, where the BEA now classifies software expenditure (but not R&D expenditure or other intangibles) as investment. The impact on the measured rate of return is likely to be small: in 2005 software accounted for only 1.3% of the US capital stock, while measured profits are also higher due to its classification as investment rather than as an intermediate expense.

assumed to be constant over time and equal across countries). The perpetual inventory method requires an initial value of the capital stock, $K_0$. A common solution to this problem (see Easterly and Levine (2001), Caselli and Feyrer (2007)) is to assume that the economy was in the steady state in time zero and that the steady-state capital-to-output ratio is given by $k=K/Y$, the steady state growth rate is given by $g$, and the steady-state investment rate is given by $i=I/Y$. Under the assumption of the steady state, the capital accumulation equation implies that $k=i/[g + \delta]$, and $K$ can then be calculated by the starting output value, $Y_0$. While this measure is simpler to calculate and circumvents some of the measurement issues surrounding the directly reported measures, there are also disadvantages. First, some differences in depreciation rates are warranted if they reflect genuine differences in the types of capital. Second, the use of an assumed starting-point estimate of the capital stock will bias the early readings of the return on capital calculation. This would be less important if we were only interested in the latest readings, but we are also interested in the development of the return on capital over time. Therefore, when official capital stock data are reported by the national statistical agencies, we use these data as our preferred measure.

**Section 4: Results**

In this section we provide a summary description of the main characteristics of our estimates. In Appendix 3 we set out more detailed results on a country-by-country basis.

Table 1 provides some summary results for $u_t^K$ (the yield on capital, net of depreciation but gross of taxation), $u2_t^K$ (the yield on capital, net of depreciation and corporation tax), the capital gain/loss, and $r_t^K$ (the return on capital, net of depreciation but gross of taxation) over the period 1981-2008. South Korea has had the highest mean ex-post return on capital over the entire sample (17.1%), while France has had the lowest (8.5%). However, the return on capital has typically varied significantly over the sample. Italy's, for instance, whose mean return on capital was the second-highest over the 28-year sample as a whole, has recorded relatively low returns in the past five years. The difference between pre- and post-tax returns is 3.0% on average, with the difference ranging from 1.9% (France) to 4.1% (Spain) over the sample. We find a small positive correlation (+0.35) between the mean and the standard deviation of ex-post returns (see Figure 1).

Is there evidence of convergence in rates of return across countries over time? In the growth accounting literature, Barro and Sala-i-Martin (1995) draw a distinction between σ-convergence (when the dispersion of real per capita income across a group of economies falls over time) and β-convergence (when the partial correlation between growth in income over time and its initial level is negative). For the return on physical capital, σ-convergence would imply a reduction in the dispersion of rates of return across economies over time, while β-convergence would imply that the partial correlation between the change in the rate of return and its initial level is negative.

We find no evidence of σ-convergence in cross-country returns on capital. Figure 2 displays the standard deviation of the distribution of $r_t^K$ and $u_t^K$ since 1981. Although the standard deviations of both distributions fell somewhat during the 1980s and 1990s, the distribution of returns widened significantly during the 2000s.

We do find some evidence of β-convergence in rates of return. The correlation coefficient of $(r_{1981i}^K - r_{1981W}^K)$ with $(r_{2008i}^K - r_{1981i}^K)$ across the 10 sample economies is -0.78. The equivalent correlation coefficient for $u_t^K$ is -0.74. However, this may simply be picking up the fact that the return on capital tends to be mean-reverting. To guard against this, we consider five-year

averages, measuring the correlation coefficient of $(r^K_{1981-85i} - r^K_{1981-85W})$ with $(r^K_{2004-08i} - r^K_{1981-85i})$. The correlations are still negative for $r^K_t$ $\rho$ = -0.82, while for $u^K_t$ $\rho$ = -0.64, suggesting some β-convergence. In Chapter 2, we consider the relation between cross-country returns and income per capita levels.

We find no evidence that the correlation of ex-post returns is rising over time. Table 2 displays the correlation of each economy's returns with global return for the whole sample (1981-2008) and for two sub-samples (1981-1994, 1995-2008). The simple average of the correlations actually fell by 0.14 between the first and the second periods. Four European economies—the UK, France, Italy and Spain—witnessed a significant decline in the correlation with global returns. Table 2 also displays the results from our principal components analysis of the extent to which the variance of each country's returns is accounted for by the fluctuations in global returns. We find that more than half the variance in each country's returns is accounted for by variations in the global return, with the 'global component' ranging from a low of 0.57 for Korea to a high of 0.87 for the US.[23]

Table 3 provides the pair-wise correlation of $r^K_t$ for each of the 10 countries computed for the years 1981-2008. The correlation coefficients are typically low (the average pair-wise correlation is 0.14 and the correlation coefficients for many country pairings are negative) and varied. Such low correlations suggest that individual returns are strikingly idiosyncratic.

In Figure 5 we display the rate of return in the US, Europe (a capital-stock-weighted average of Germany, UK, France, Italy and Spain) and Asia (a capital-stock-weighted average of Japan, China and South Korea). Asian returns have, on average, been highest (with a mean of 12.4) but also the most volatile (with a standard deviation of 3.3). US and European returns have been very similar over the sample (averaging 10.4% in the US and 10.0% in Europe), while US returns have been somewhat more volatile (with a standard deviation of 2.5 vs. 2.0).

Figures 6-8 provide a breakdown of the return on capital for Europe, Asia and North America (US and Canada).

Three important attributes of our database are its comprehensiveness (combining data for the 10 largest economies in the world, on a comparable basis over 28 years); its cross-country

[23] The high reading for the US is partly attributable to its large weight within the global return on capital measure (around 33% over the sample as a whole). Excluding the US, the highest 'global component' reading is for Germany (0.84).

consistency; and, that we have included both the yield on capital and the capital gain/loss within our return on capital calculations. Because our database covers more than 75% of global GDP, we are able provide an estimate of the global return on physical capital for the first time. Figure 3 displays our results for the global $r_t^K$ and $u_t^K$, based on the capital-stock-weighted results for the 10 economies. Note that the inclusion of the real capital gain term materially alters the performance of the global return on capital from the global yield on capital, because the performance of real capital prices has changed substantially over the sample (Figure 9). For most of the past 25 years real capital prices have been declining, but the speed which they have declined has slowed over time and, since 2003, real capital price inflation has turned positive.

Why has this reversal in capital prices relative to consumer goods prices taken place? One possible explanation for the turnaround is the integration of the large emerging markets—most notably China—into the global economy in the past ten years.[24] The size of these countries implies that their integration into the global economy has the potential to affect relative prices across the world in a manner that was not true during the emergence of smaller developing economies. With low capital:labour ratios and high natural growth rates, this has resulted in a sharp increase in the world's effective labour supply, pushing down the relative price of labour (and consumer goods), while raising the relative price of capital goods. We discuss the effects of the integration of China and other emerging markets on rates of return in Chapter 3 of this thesis.

In Figure 4 we display the global $r_t^K$ along with its trend (based on a Hodrick-Prescott filter). Although the global return on capital is highly cyclical, there appears to have been a significant increase in the trend return since the turn of the century.

[24] Freeman (2007) estimates that the integration of China, India and the former Soviet Bloc economies into the world economy resulted in a doubling of the global workforce between 1985 and 2000.

**Section 5: Conclusions**

In this paper we have presented a comprehensive and comparable database of returns on physical capital, combining data for the 10 largest economies over a period spanning at least 28 years in every case. Our database of rates of return includes both the yield on capital and, in contrast with the majority of previous studies, a term capturing the real capital gain/loss from holding a representative piece of capital. Because our database covers more than 75% of global GDP, we are able to compute a reasonable estimate of the global return on physical capital for the first time.

Based on this database of returns, we find that:

1. There is significant cross-country variation in the level of the return on capital. Moreover, we find no evidence of σ-convergence (a decline in the dispersion of rates of return) within our 10-country sample.

2. The time-series correlations of cross-country returns are typically low, with pair-wise correlation coefficients that are negative in many cases. We find no evidence that the correlation of ex-post returns is rising over time. The conclusion that correlations in rates of return across countries are low and varied appears to stand in the face of the large body of evidence of increased international capital market integration (see, for instance, Obstfeld and Taylor's (2004)). However, as Mulligan (2002) highlighted, there is evidence of significant differences between different rates of return *within* countries (i.e. which cannot be explained by an absence of *international* capital market integration). It is possible, therefore, that there could remain large differences in rates of return on whole-economy capital across countries, even while there was convergence in rates of return to comparable types of capital (such as Obstfeld and Taylor's (2004) observed collapse in the spread between onshore and offshore interest rate products).

3. There was a significant increase in the global return on physical capital during the 2000s. Although there was a cyclical decline in returns in 2008, as a consequence of the 2007/08 financial crisis, the global return on capital nonetheless remains above its long-term average. This finding challenges the widespread view that returns on all assets were driven lower by a emerging market 'savings glut' in the years leading up to the 2007/08 financial crisis[25]—a subject we discuss in Chapter 3. It also presents a conundrum as to why global business

[25] See, for instance, Bernanke (2005)

investment has been so weak since the bursting of the dot-com bubble, despite historically high levels of profitability and low real interest rates.

4. There has been a small positive correlation between average ex-post returns and the volatility of those returns. Returns in Asia (based on a capital-stock-weighted average of Japan, China and South Korea) have, on average, been highest but also the most volatile. European returns (based on a capital-stock-weighted average of Germany, UK, France, Italy and Spain) have been comparable to those in the US and somewhat less volatile.

**Appendix 1: Expanded Literature Review**

**1. Mulligan, C., 2002, "Capital, Interest, and Aggregate Intertemporal Substitution", *NBER Working Papers*, No. 9373.**

The supply of capital through the savings decisions of households and the demand for capital through the investment decisions of firms is, in consumer and investment theory, coordinated by 'the' interest rate. Yet, famously, Hall (1988) finds little evidence of correlation between US consumption growth and interest rates as measured by the yield on US Treasuries ("It simply cannot be said that the relation between the real return and the rate of change of consumption supports strong intertemporal substitution", Hall, 1988, pg. 353).

Mulligan (2002) argues that the failure to find a good relation between the two is because 'the' interest rate is not a bond yield (or any other single financial interest rate) but is better measured as the expected marginal return on a representative piece of capital. Mulligan argues that the latter—which, under some simplifying assumptions, can be directly measured from national accounts data—is the best measure of the expected return of the economy's 'aggregate portfolio' of investments.

Mulligan's two key simplifying assumptions are: First, that the marginal return on capital equals the average return on capital as implied by the standard neo-classical model with a constant-return production function and perfectly competitive domestic capital markets. The second relates to expectation formation. The return on a capital asset can be decomposed into a rental rate (or yield) and a capital gain/loss. Mulligan posits that both the change in the yield and the capital gain/loss (net of depreciation) are unforecastable, with mean zero, and can therefore be ignored. Based on these two assumptions, Mulligan argues that the ex-post average yield on capital closely approximates to the ex-ante marginal return on capital.

Mulligan constructs his measure of the post-tax yield on US whole-economy capital from Bureau of Economic Analysis data on income and capital. His pre-tax yield measure is calculated similarly to our own measure but, in addition to non-financial corporations, he also includes financial corporations and the household sector (only excluding the government sector). Mulligan's capital measure is for fixed assets at current replacement cost (inventories and other 'working capital' are not included). In including the household sector, the capital measure therefore includes the replacement-cost value of owner-occupied housing. The post-tax measure is calculated by subtracting from direct and indirect taxes on capital income.

Using this measure of the US post-tax rate of return, Mulligan then estimates the equivalent equation to Hall (1998):

$$\ln\frac{C_t}{C_{t-1}} = \sigma(1-\tau_t)r_t + \varepsilon_t - \rho_{t-1}$$

Where $\sigma$ is the intertemporal substitution parameter, $(1-\tau_t)r_t$ is the after-tax return on capital, $\varepsilon_t$ includes errors in forecasting consumption and capital's return, and $\rho_{t-1}$ is the time preference parameter in the standard Bellman (1957) equation. Estimated in this way, Mulligan suggests that there is evidence that the US intertemporal marginal rate of substitution and the US post-tax marginal product of capital co-move.

**2. Banerjee, A. and E. Duflo, 2005, "Growth Theory through the Lens of Development Economics," in P. Aghion and S. Durlauf, eds., *Handbook of Economic Growth*, North-Holland Press (2005).**

Much of the existing work in estimating the rate of return on capital comes from the growth theory literature. Banerjee and Duflo (2005), in a wide-ranging paper that uses evidence from micro-development literature to argue that the standard growth theory assumption of an aggregate production function generating a single rate of return for each economy is unrealistic, extensively review the existing literature on marginal rates of return across developed and developing economies.

According to the authors, the literature has typically followed one of three approaches. The first is a cross-country comparison of returns to *financial* capital. These studies provide heterogeneous estimates, depending on which financial asset or lending rate is observed. The second is to posit a production function (typically Cobb-Douglas) and to estimate the return on capital by regressing $\Delta Y$ on $\Delta K$ for the economy as a whole or for individual firms/sectors. Such studies also provide a wide range of estimates for the return on capital both within and across countries. This approach, the authors argue, also presents serious methodological issues, such as missing variable bias (for instance, at a firm/sector level the decision to carry out an investment will be positively correlated with the expected return). The third approach is calibration, imposing a functional form on the relationship between capital, labour and the rate of return, calibrating some of the inputs and using more readily available data (such as relative wages) to derive an estimate of the relative rate of return on capital.

The principal point of the paper—that there is enormous heterogeneity of interest rates within an economy—is similar to that made by Mulligan (2002) but the implication that they draw from this is markedly different. Banerjee and Duflo conclude that these differences cast doubt on the standard neo-classical growth theory assumption of an aggregate production function generating a single rate of return for the economy as a whole, arguing that the additional complication posed by the heterogeneity of interest rates within an economy "poses problems for old and new growth theories alike". On the other hand Mulligan argues that, given the existence of a multitude of interest rates within an economy, one should not presume that any single financial interest rate represents a good proxy for the whole-economy rate of return and that one should instead focus directly on the whole-economy return.

We favour Mulligan's approach in this regard. The use of a directly-measured, broad-based return on capital measure does not require the existence of a single production function with a single interest rate. Only that it is possible to combine profits and capital stock data across a large number of industries to provide sensible aggregate returns data. We would argue that this—less demanding—assumption is more reasonable.

**3. Caselli, F. and J. Feyrer, 2007, "The Marginal Product of Capital", Quarterly Journal of Economics, May 2007, Vol. 122, No. 2: 535-568**

Caselli and Feyrer calculate a range of estimates of the marginal product of capital across 53 developed and developing countries. Using the standard neo-classical assumption of a constant-return production function and perfectly competitive domestic capital markets, they calculate a number of different measures of the marginal product of capital (MPK) based on the variations of the competitive equilibrium condition:

$$MPK = \alpha \frac{Y}{K}$$

where Y is real GDP, K is the real capital stock and $\alpha$ is the capital share in GDP.

Data for Y is taken from the Penn World Tables 6.1 (PWT, Heston, Summers, Aten (2004)), K is constructed using the perpetual inventory method with investment data that is also taken from the PWT, assuming a constant depreciation rate of 0.06 and taking the initial capital stock, $K_0$, as $I_0/(g+\partial)$ where $I_0$ is the value of the investment series in the first year and

g is the average geometric growth rate for the investment series between the first year with available data and 1970.[26]

The authors calculate three different estimates of the MPK, with the differences between these measures lying in their calculation of $\alpha$ and in the treatment of prices for capital and consumption goods:

- They produce a "naïve" estimate, $MPKN = \alpha_w \frac{Y}{K}$, that uses the total share of capital (including land and natural resources) and does not account for difference in the price of capital and output goods. The estimated total capital share in this calculation, $\alpha_w$, is taken from cross-country estimates derived by Bernanke and Gurkaynak (2001), who build upon the work of Gollin (2002). Based on this measure, Caselli and Feyrer find that the MPK is typically much higher in poor countries (mean 27.2%) than it is in rich countries (mean 11.4%).

- The second MPK calculation, $MPKL = \alpha_k \frac{Y}{K}$, is based on an estimate of the (more narrowly defined) reproducible capital share of output. The narrower reproducible-capital share, $\alpha_k$, is estimated by scaling down the total capital share, $\alpha_w$, with World Bank estimates on the proportion of total capital that is in land and natural resources.

- Their third (and preferred) estimate, $PMPKL = \alpha_k \frac{P_y Y}{P_k K}$, also takes account of the relative price output and capital (i.e. it is based on nominal output ($P_y Y$) and the nominal capital stock ($P_k K$)). On this measure, they find that the average MPK in poor economies is actually lower than in rich economies, with a mean of 6.9% vs. 8.4%.

Based on their findings, Caselli and Feyrer argue that there is no prima facie support for the view that international credit frictions play a major role in preventing capital flows from rich

[26] This is equivalent to Easterly and Levine's (2001) assumption for the starting capital value, $K_0$, given by k=i/[g + $\partial$ ] where k=K/Y and i=I/Y.

to poor countries. Lower capital-output ratios in poor countries are instead due to lower efficiency and fewer complementary factors, as well as a relatively high cost of capital.

We discuss Caselli and Feyrer's findings as they relate to the Lucas paradox in Chapter 2, and we restrict our comments here to their estimates of the MPK. A number of issues arise with Caselli and Feyrer's estimates of the MPK, some more important than others. First, in calculating estimates of the MPK, the authors abstract from cross-country variation in the return on capital that result from differences in depreciation rates and capital gains/losses. Second, their estimates of the capital stock require two simplifying assumptions that are questionable: first, that depreciation rates are equal and fixed across economies (abstracting from any variation in depreciation rates due to compositional differences in the capital stock); and, second, for their estimates of the capital stock they take as a starting assumption that initial capital stock, $K_0$, is given by the steady-state value of $I_0/(g+\delta)$ (whereas low-income economies are likely to be below the steady-state value). While national accounts-based measures of the capital stock are also calculated using a perpetual inventory method, these estimates are cross-checked for accuracy through the use of periodic referencing. Third, Caselli and Feyrer are trying to compare the level of the MPK across a large number of countries at a single point in time. But they do so using inputs from a number of different sources and relating to different time periods: their estimates of Y, K, $P_y$ and $P_k$ date from 2000, while the Bernanke and Gurkaynak (2001) estimates of the capital share date from 1995.

**4. Mello, M., 2009, "Estimates of the Marginal Product of Capital, 1970-2000," *B.E. Journal of Macroeconomics*: Vol. 9 : Iss. 1 (Topics), Article 16.**

Mello (2009) calculates a range of estimates of the marginal product of capital across 93 countries from 1970 to 2000. His measure of the MPK is similar in form to that of Caselli and Feyrer (2007) but he extends their work to provide a time-series dimension to his analysis. As with Caselli and Feyrer, Mello allows for cross-country heterogeneity in the capital-output ratio and in the relative price of capital but, unlike them, he assumes that the capital share of income, $\alpha_i$, is fixed and equal to 0.30 for every country and at every point in time. With MPK estimates derived on this basis, Mello concludes that "differences in the marginal product of capital were significant in the 1970s, decreased substantially in the 1980s, and were negligible in the 1990s."

One effect of assuming a capital share of income that is equal and fixed across every country is that Mello assumes away a principal source of cross-country and time-series variation in the marginal product of capital. In Appendix 3 we provide a country-by-country comparison of our estimates of the return on capital with estimates of the yield on capital and the MPK obtained by other studies, including those of Mello. As we illustrate at that stage, there is very little time-series variation in Mello's results.

The principal drawback of Mello's database—one which is common to Caselli and Feyrer's—is that he assumes away many of the potential sources for cross-country variation that might give rise to the heterogeneity that he is attempting to consider. For instance, he assumes equal capital shares, equal depreciation rates and, in focusing on the MPK, he ignores real capital gains/losses.

**5. Gollin, D., 2002, "Getting Income Shares Right", *Journal of Political Economy*, Vol. 110, No.2, pp. 458-474.**

In the household sector, the profits and labour income of the self-employed are lumped together in a category called 'mixed income'. In calculating whole-economy capital and labour income shares, the common practice is to designate mixed income as part of capital income. Gollin (2002) argues that, as a large proportion of this mixed income is the imputed labour income of the self-employed, this practice results in the overstatement of the economy's capital income share.

Furthermore, Gollin argues that the distortion is typically bigger in lower-income economies where the share of self-employment is generally higher. In doing so, Gollin follows the work of Kravis (1962), who argued that the (measured) capital share of income in GDP was shrinking over time as a result of long-term shifts in the structure of the economy—away from agriculture and self-employment, and towards organised industrial labour. Because the distortion is bigger in countries with more self-employment, this tends to distort relative comparisons of the capital income share between developed and under-developed economies.

Gollin proposes adjusting income shares either by splitting mixed income along the same capital and labour income shares that exist in the remainder of the economy or, preferably, by subtracting from mixed income an imputed labour income share based on the wage cost of a full-time equivalent employee.

How does Gollin's paper relate to Caselli and Feyrer's (2007) arguments about the overstatement of the marginal product of capital in under-developed economies? Gollin (2002) argues MPKs are overstated in poor countries because the capital share of income is overstated in under-developed economies because of the greater importance of mixed income in those economies. Caselli and Feyrer (2007) argue that, once one has adjusted for this effect, the MPK in under-developed economies is still overstated because the capital-to-output ratio in these countries is understated (by the non-inclusion of land and resources capital).[27]

It is worth emphasising that the distortion Gollin refers to is much less severe in the corporate sector which, by definition, excludes the small businesses where self-employment is high. Therefore, in focusing on the private non-financial sector, our estimates of the return on capital largely avoid the distortions to which Gollin refers and, where necessary, we have adjusted our estimates for the different treatment of mixed income.

**6. Walton R., 2000, "International Comparisons of Company Profitability", *Office of National Statistics Economic Trends*, No. 565; and,**
**Citron, L. and R. Walton, 2002, "International Comparisons of Company Profitability", *Office of National Statistics Economic Trends*, No. 587.**

Walton (2000) and Citron and Walton (2002) collate and compare the yield on whole-economy capital for the non-financial sector in a selection of European countries, the US, Japan, Australia, Israel, South Africa, Iceland and Singapore. For Canada and Mexico they calculate the yield on equity, a proxy for the yield on capital.

These papers are similar in purpose and approach to this paper, but the authors make no effort to ensure comparability of the data obtained from the various national sources ("We have not sought to impose a common detailed definition or to check any of the data provided"—Citron and Walton, 2002, page 1). This results in a couple of identifiable inconsistencies. For example, the authors base their German yield on capital measures on a regular survey of industries conducted by the Bundesbank ("German Enterprises Profitability and Financing"). This survey is not representative of the economy as a whole, is biased towards manufacturing companies, and uses different definitions of capital and profits to what is calculated by Germany's national statistics office (*De Statis*). The resulting return on capital measure is 4-5 percentage points lower than the national accounts measure, a bias which also significantly

[27] Note that, although the distortion Caselli and Feyrer (2007) identify affects the capital-labour ratio (K/Y), they correct it by adjusting $\alpha$ rather than K/Y.

distorts the Euro-zone aggregate measure calculated by Citron and Walton. Another inconsistency is that the yield on capital measure for some countries uses capital employed (fixed assets + working capital) as the denominator, whereas fixed assets are used as the denominator in other cases (such as the US). Finally, the earliest starting date for their comparisons is 1990, limiting the scope for time-series analysis.

**7. Broadbent, B., Schumacher, D., and S. Schels, 2004, "No Gain Without Pain—Germany's Adjustment to a Higher Cost of Capital", *Goldman Sachs Global Economics Paper*, No. 103.**

Broadbent, Schumacher and Schels (2004) compare the yield on capital for private non-financial corporations in the US and a selection of European economies (Germany, UK, France, Italy, Spain and Belgium) from 1987-2003. The data are sourced directly from national statistical agencies and efforts are made to ensure consistent definitions are used across countries.

The authors find that European yields on capital are comparable with those in the US, with the notable exception of Germany. On average, during the 1990s, the authors estimate that the yield on capital averaged 9½% in Germany, 10½% in the US and 12% in the rest of Europe (UK, France, Italy, Spain and Belgium). However, while the rate of return in Germany was relatively low during the 1990s, the authors find that it had begun to rise in the late 1990s and was now approaching European levels.

The authors dispute the commonly held explanation that the relatively low profitability of German companies is related to union power, arguing that it is difficult to reconcile with the Germany's relatively high capital-output ratio. Although unions can, in principle, increase labour's share of national income, for a given cost of capital, this would normally lead to less not more investment. Instead, Broadbent *et al* argue that Germany's traditionally low rate of return on capital and relatively high capital-output ratio were due to an (effective) subsidy on the cost of capital from Germany's state-owned banks. Prior to the start of EMU, the gross cost of capital was one-fifth lower in Germany than in the rest of Europe on their estimates. Moreover, the removal of this effective subsidy (driven by a combination of EU competition rules, the Basel II banking accord and greater transparency of the cost of capital within EMU) could also explain Germany's rising rate of return and declining capital-output ratio from the late-1990s onwards.

The argument that the capital-output ratio is highly sensitive to the cost of capital mirrors the point made by Caselli and Feyrer (2007), who argue that a key reason why the capital-output ratio is typically low in poor countries is because the cost of capital is relatively high.

**8. European Central Bank, 2004, "Measuring and Analysing Profit Developments in the Euro Area", *ECB Monthly Bulletin*, January 2004.**

Economists[28] at the European Central Bank (2004) compare Euro-zone and US profitability developments based on various national-accounts-based measures, including the yield on whole-economy capital (including the household, financial and government sectors, as well as private non-financial corporations). The Euro-zone aggregates are calculated using data from 8 of the 12 member states.

In calculating their (net of depreciation) yield on capital measures for the Euro-zone and the US, the authors make an adjustment for the imputed labour income of the self-employed. This adjustment is more critical for the ECB's yield on capital measure, as they include the household sector where the proportion of self-employment is high. The adjustment is made by assuming that the imputed compensation per self-employed person equals the compensation per 'regular' employee (consistent with Gollin (2002)). This is the only adjustment made to harmonise the European and US profitability measures.

The paper presents estimates dating back to 1960 for both the Euro-zone and the US, concluding that the yield on capital was 1-2% higher in the US during the 1990s. The authors note that the yield on capital rose steadily through the 1990s in both the Euro-zone and the US. On first observation, this appears to be much more downbeat on Europe's relative profitability than the findings of Broadbent, Schumacher and Schels (2004). But most of the difference is accounted for by differences in the countries included in the 'European' aggregate. Broadbent, Schumacher and Schels (2004) include the UK (where the yield on capital is high) but strip out Germany, whose low (but rising) yield is argued to be due to special factors. The ECB's Euro-zone aggregate includes Germany but, obviously, excludes the UK. Re-aggregating the Broadbent, Schumacher and Schels (2004) data to calculate a Euro-zone aggregate (based on data for Germany, France, Italy, Spain and Belgium) results in an average yield on capital during the 1990s that was 1% lower than that of the US.

[28] Articles in the ECB's Monthly Bulletin appear on a no-name basis.

**Appendix 2: Notes on Data Sources and Issues by Country**

**United States**

Profits data taken from Bureau of Economic Analysis, National Income and Product Accounts, Table 1.14 ("Gross Value Added of Domestic Corporate Business in Current Dollars and Gross Value Added of Non financial Domestic Corporate Business in Current and Chained Dollars").

$NetOperatingSurplus_t^{PNFC}$ is given in line 24 (note that this measure does not deduct net interest payments). $NetOperatingSurplus_t^{PNFC}$ is a function of GVA (line 17), labour compensation (line 20), taxes and subsidies on production (line 23) and consumption of fixed capital (line 18). Corporate taxes of private non-financial corporations (PNFCs) are given by line 28.

The United States primary income accounts for the PNFC sector are constructed on a 'bottom-up' basis with GVA constructed as the sum of the (independently-measured) labour compensation, taxes/subsidies and operating surplus data. Thus, the GVA data include a residual measurement error from the other inputs but the operating surplus data do not.

The distinction between the PNFC sector and the household sector in the US is dictated by their legal entity or taxable status—are they registered as a corporation or as a sole proprietor/partnership? Historically, the main incentive to register as a corporate was to achieve limited liability status, while the principal cost was a higher tax and administrative burden. Both the incentive and the costs have been reduced somewhat by the widening of limited liability status and tax changes. In practical terms, it was and remains the case that the net gain/loss of registering for corporate status is largely determined by the company's size. However, the distinction between the PNFC sector and the household sector is not formally drawn on the basis of size, as it is in the UK for instance. Within the PNFC sector, no adjustment is made for the imputed labour income of the owners of capital.

Net capital stock data are taken from the Bureau of Economic Analysis, Fixed Assets, Table 6.1 ("Current-Cost Net Stock of Private Fixed Assets by Industry Group and Legal Form of Organization"), line 4. This series does not include inventories.

The nominal capital gain is given by the change in the capital stock deflator (nominal capital stock value/real capital stock value) measured at replacement cost. Real capital stock values are taken from line 4 of table 6.2.

**Japan**

The source for Japanese data is the Cabinet Office (the link to the national accounts' data website is: http://www.esri.cao.go.jp/en/sna/menu.html#93sna). Most of the information contained within this website is published both in English and Japanese.

Under "Annual Report on National Accounts/平成16年度国民経済計算" there is a link to the latest annual data ("Annual Report on National Accounts of 20.."). Then, under Section 2, there is a link to "Income and Outlay Accounts classified by Institutional Sectors/制度部門別所得支出勘定" which contains a spreadsheet containing all the inputs required to calculation the numerator of the YIELD measures for PNFCs. Note that there is separate data broken down by fiscal year (April – March) and calendar year.

Capital stock data is also found with the annual national accounts section, under "Part 2 Stock /Supplementary tables/(1)Closing stocks of net fixed assets (第２部ストック編/参考表/(1)純固定資産の構成)". This table provides constant capital stocks and deflators broken down in two ways: first, by type of asset for the whole economy; and second, by institutional sector.

Note that the Japanese effective depreciation rate was unusually high during the 1990s. This reflects widespread write-offs following the over-investment boom of the 1980s.

**Germany**

The source for Germany's data is the Federal Statistical Office (*De Statis*). Note that, while DeStatis do provide some basic data in English, the data we require are only provided in German.

Institutional sector accounts data (konten der volkswirtschaftlichen) for non-financial corporations (nichtfinanzielle kapitalgesellschaften) can be found via the "Statistics Shop" (Go to http://www.destatis.de/e_home.htm / then click into "Statistics Shop" on the right-hand side / then type "vgr" under "Schnellsuche" (high-speed search) on the left-hand side /

the first product that comes up under this search is the latest set of annual national accounts (Inlandsproduktsberechnung Detaillierte Jahresergebnisse - FS 18 R 1.4) which can be downloaded for free / the sector accounts data appear in Table 1 of this document).

*De Statis* publish annual datasets on gross and net fixed assets ("Anlagevermögen") broken down into 85 industrial sectors in both current replacement prices ("Wiederbeschaffungspreise") and constant (2000) prices. These datasets have data for total fixed assets and also are broken into machinery and equipment and buildings/structures, and are available from 1991 onwards. The data are available from the same annual national accounts publication referred to above. Table 3.1.3 contains whole-economy capital stock data. Line 20 (Alle Anlagegüter) provides net fixed assets in current price Euros. Line 40 provides the same data in 2000 Euros. Alternatively, the same data are available from the GENESIS databank system (https://www-genesis.destatis.de/genesis/online/logon). The capital stock table numbers are 81000-0116, -0117 & -0118. The depreciation table is 81000-0107. The raw data refer to the value of stocks at the beginning of the year. The capital stock data provided do not correspond directly into the sectoral definitions provided by SNA93/ESA95. However, within the Federal Statistical Office's sector accounts, data on gross and net capital formation for PNFCs and the whole economy are published, and GVA data are published. Using these data along with the whole-economy capital stock data, we estimate two PNFC capital stock measures. The first—preferred—is made by scaling the whole-economy capital stock by the post-unification average of PNFC investment as a share of total investment. The second measure has an identical post-unification starting point for the capital stock as the previous method but it evolves according to a perpetual inventory method using PNFC net investment data and the whole-economy estimate of the capital stock deflator. In practice the difference between the two capital stock measures is less than 1%.

Data for West German PNFC operating surplus and capital stocks prior to 1991 are calculated in the same manner.

Note that similar ROC-type calculations can be made using data calculated by the Bundesbank. However, the data supplied are simply a survey of companies and are not representative of the economy as a whole. The Bundesbank data are produced in occasional editions of the Monthly Bulletin (see Deutsche Bundesbank (October 2005) for instance). They appear in the balance sheet and income statements for German enterprises (Bilanz und Erfolgsrechnung deutscher Unternehmen nach Wirtschaftsbereichen). Separate data are produced for the manufacturing sector and for "All Economic Sectors". The latter includes manufacturing (including mining and quarrying), construction, wholesale and retail trade,

transport (excluding railways) and business-related services. However, other sectors are not included (hotels/restaurants, energy production and financial services). More fundamentally, the definition of capital stock used does not coincide with the national accounts definition.

**China**

The source of the income and capital stock data is China's National Bureau of Statistics (http://www.stats.gov.cn/english/).

Three recent studies—Liang (2006), Hofman and Kuijs (2006) and Bai, Hsieh and Qian (2006)—have used NBS data to measure China's rate of return on physical capital and other related profitability measures (we discuss our results in the context of these other studies in Appendix 3). Two principal data sources from within NBS's databank have been used:

**NBS annual national accounts data:** Estimates based on unadjusted national accounts data provide rates of return that are relatively low. Bai, Hsieh and Qian (2006) argue that the reason for these low rates of return is due to the over-measurement reproducible capital, because of the inclusion of land and expenditure on used machinery as part of fixed investment. (Liang (2006) makes the separate point that expenditure components other than fixed investment and—consumers' expenditure in particular—are under-measured, further raising the measured investment-to-GDP ratio.) Bai, Hsieh and Qian (2006) instead base their estimate of the capital stock on a separate, less commonly used measure of GFCF that is also produced by the NBS. This measure is only available annually but it has the advantage not including the value of land, etc.

**NBS annual company survey:** Liang (2006) and Hofman and Kuijs (2006) also argue that Chinese national accounts data under-record the return on capital by over-recording the investment-share of GDP. They argue that an annual company survey conducted by the National Bureau of Statistics' provides a more accurate gauge of company profitability because it measures the rate of return directly from companies and, therefore, is not susceptible to the issues of over-recording investment/under-recording the other parts of GDP that distort the national-accounts-based estimates. The coverage of the survey is not as universal as national accounts data but it is still wide: over 250,000 listed and unlisted companies are surveyed, that are both privately and state-owned. One disadvantage of the annual company survey is that the NBS only started collecting the data in 1989, while the annual national accounts data dates back to 1978. Note that the NBS has not adopted the

institutional sector definitions provided SNA93 but that the coverage of the annual company survey broadly corresponds to that of the PNFC sector.

The yield of our preferred measure of the return on capital is based on the NBS's annual company survey. We prefer this to a measure based on national accounts data because, while the GFCF measure used by Bai, Hsieh and Qian (2006) may be superior to the alternative fixed investment measure supplied by the NBS, there remains considerable uncertainty regarding the possible mis-measurement of investment and other elements of GDP. However, while the source data we use are the same as that used by Liang (2006) in calculating her return on capital estimates, our results differ from hers as we do not include interest payments and we do include changes in real capital prices. For the years prior to 1978-1989, we assume that the yield varied in line with the estimates of Bai, Hsieh and Qian (2006).

The NBS produce deflators for both the capital stock and consumers' expenditure, allowing us to calculate our standard estimate of real capital stock prices. However, real capital price inflation based on this measure is unusually (and unrealistically) volatile, with a standard deviation over the sample of 5.3%. We instead base our estimate of Chinese real capital prices on the fixed asset investment (FAI) deflator over the GDP deflator, taking the lead from Bai, Hsieh and Qian (2006) in this regard.

**UK**

The source for all data used is the UK's Office of National Statistics. Data are taken from three different publications: the ONS's "Blue Book", the "Profitability of UK Companies" release and "Capital stocks, Capital Consumption and Non-Financial Balance Sheets".

$NetOperatingSurplus_t^{PNFC}$ is given by ONS code LRWM, which is equivalent to the pre-1965 series FACU. $NetOperatingSurplus_t^{PNFC}$ is a function of GVA (FARR), labour compensation (FBDA), taxes and subsidies on production (FACQ+JQJW) and consumption of fixed capital (BGXZ).

Corporate taxes of private non-financial corporations (PNFCs) are given by ONS code FCCP, for which history exists back to 1960. This series covers corporation, petroleum revenue and advanced corporation tax payments.

Each of the inputs into the primary income accounts (GVA, labour compensation, taxes/subsidies, depreciation and the net operating surplus) are measured independently. The operating surplus is not measured by residual—it is measured primarily through Inland Revenue receipts and an annual survey of businesses. Each of the independently-measured inputs (including GVA itself) is then "balanced", effectively averaging out any measurement errors.

The cut-off between the PNFC sector and the household sector is made on the basis of VAT registration. VAT-registered companies appear in the PNFC accounts, non-VAT-registered firms appear in the household accounts. Whether a company needs to be VAT-registered or not is based on the size of annual turnover. In 2005, this threshold was set at £60,000 and it rises broadly in line with inflation.

PNFCs gross capital stock is given by the series GUBO, while net capital stock is given by CIXH. It is a year-end measure. These series date back to 1948 and do not include the book value of inventories. The capital stock data are estimated by perpetual inventory method with detailed investment data and depreciation rates dictated by the composition of the capital stock. This series is then cross-checked through periodic stock-taking.

The ONS publish estimates of the yield on capital in the "Profitability of UK Companies" release which use as the denominator net and gross capital *employed* (i.e. including the book value of inventories) rather than capital stocks. These series date back to 1965 and the respective codes are LRWT for gross capital employed and LRWU for net capital employed. We have decided to exclude the book value of inventories because it makes our results comparable to those of other countries and it provides us with a longer time series for the UK. In practice, the inclusion or exclusion of inventories affects the level of the rate of return but, as inventories are relatively stable over time, has little impact on changes in the rate of return.

The nominal capital gain is given by the change in the capital stock deflator (nominal capital stock value/real capital stock value) at replacement cost.

**France**

The source of French data used is INSEE, France's national statistics agency. Each of the data series used is taken from INSEE's Annual National Accounts (http://www.insee.fr/en/indicateur/cnat_annu/base_2000/cnat_annu_2000.htm). The income accounts data for Non-Financial Corporations (Compte des sociétés non financières) can be

found under the Institutional Sectors (Secteurs Institutionnels) accounts. The data are contained in Table 3.101 " Compte des sociétés non financières" (Accounts of non-financial companies). This table includes the operating statement (Compte d'exploitation) of the PNFC sector, including sectoral data for GVA (Valeur ajoutée brute), total labour income (Salaires et traitements bruts + Cotisations soc. effectives à la charge des employeurs + Cotisations soc. imputées à la charge des employeurs + Impôts sur les salaires et la main d'oeuvre), taxes less subsidies on production (Impôts divers sur la production - Subventions d'exploitation), to give a gross operating surplus (Excédent brut d'exploitation). In France, data on the operating surplus are independently measured from corporate tax returns, they are not measured by residual.

Capital stock data can be found under the section "Fixed capital and consumption of fixed capital" (Capital fixe et consommation de capital fixe) of Goods and Services (Biens et services). Table 2.607 includes consumption of fixed capital in current prices (Consommation de capital fixe par secteur institutionnel à prix courants). Table 2.655 includes net capital stock data at current prices valued at the end of the year (Capital fixe net par branche total en fin d'année des sociétés et des entreprises individuelles non financières, à prix courants). Table 2.611 includes net capital stock at constant prices valued at the end of the year (Capital fixe net par branche total en fin d'année des sociétés et des entreprises individuelles non financières, en volume). Table 2.643 includes data on gross capital stocks (Capital fixe brut par branche total (AN.11) en fin d'année des sociétés et des entreprises individuelles non financières, à prix courants).

Note, however, that the capital stock data includes the capital of the self-employed (entreprises individuelles) along with non-financial corporations (sociétés). INSEE report separate primary income accounts for non-financial firms and the self-employed but do not report separate capital stock measures. We use separate data on the consumption of fixed capital for non-financial corporations and non-financial self-employed, taken from Table 2.607, in order to scale the capital account data downwards. This assumes that depreciation for non-financial corporations and non-financial self-employed is proportionate to their respective capital stocks.

**Italy**

The source of the Italian data is ISTAT (http://www.istat.it/). Italian annual non-financial corporate (Società non Finanziarie) accounts – including GVA, labour compensation, taxes less subsides on production, net operating surplus and taxes on income – are only available on

the Italian language version of ISTAT's website. National income accounts broken down by institutional sector ("Conti economici nazionali per settore istituzionale") can be found at the following link: http://www.istat.it/salastampa/comunicati/non_calendario/20070719_00/ . In this page in area download "Serie storiche" for the full set of annual data from 1999 onwards.

ISTAT does not produce capital stock data broken down by institutional sector. Our main capital stock measure is based on the perpetual inventory method, using net investment data for PNFCs and whole-economy investment prices as a proxy for PNFC capital stock prices. Our starting capital stock, $K_0$, for the year 1979, uses a steady-state starting assumption for the capital stock, $K_0 = I_0/(g+\partial)$ where $I_0$ is the value of the investment series in the first year, g is the average geometric growth rate for the investment series between the first and final years, and $\delta$ is the depreciation rate. The resulting series provides a capital-output ratio that rises gradually and an implicit depreciation rate that also rises from 6.6 in 1980 to 7.3 by the mid-2000s, also in line with international trends.

ISTAT also calculates institutional accounts data for the period 1980-2004 based on an older methodology. Comparing the rate of return calculations for the overlapping period (1999-2004), we find that there is a level effect but that the changes from year to year are very similar. We feel comfortable, therefore, splicing the rate of return data based on these older series for the years prior to 1999.

**Canada**

The source of the Canadian data is Statistics Canada (www.statcan.ca). The data can be retrieved from the CANSIM database (from the blue menu at the top of the page, select "Our Products and Services", then under the heading "Access our online databases", click on "CANSIM", then select "Subject" and click on "Continue"). Note that Canadian SNA does not strictly follow the SNA93/ESA95 template although, in practice, the differences are small.

The primary income accounts data and the capital stock estimates can be found in the "Quarterly balance sheet and income statement" (select "Total, non-financial industries (excluding management of companies and enterprises"—Table 187-00011,5,14). The net capital stock data includes capital investments in affiliates as the profits of these affiliates are included in the operating surplus.

The data for net profits of non-financial corporations only starts in 1988 (although the capital stock data for non-financial corporations dates back to 1961). There is, however, whole economy profits data prior to 1988 and the link between this series and the NFC net profits is reasonably close in the post-1988 data (the correlation of annual growth rates from 1988-2005 is +0.94). We use the whole economy profits data to extend the NFC profits series by assuming that NFC profits are a fixed fraction of whole economy profits, where the fraction is based on 1988 data.

Statistics Canada publish an official measure of the "Return on Capital Employed for Non-Financial Industries" (under "Business enterprises" there appears Table 187-0002, "Quarterly statement of changes in financial position, by North American Industry Classification System (NAICS), selected financial ratios.") As discussed in the main text, this measure—like other official estimates of the return on capital that we have come across—is actually a measure of the *yield* on capital. The calculation is also quite different from our own yield measures. The numerator is the profit before extraordinary gains and interest on borrowing net of tax and the denominator is total borrowing plus loans and accounts with affiliates plus total equity. In level terms, this calculation is substantially lower than our yield calculation. However, the annual correlation of the two measures is high at 0.93 between 1990 and 2005.

**Spain**

The source for the income accounts of Spanish data is the Instituto Nacional de Estadística de España (http://www.ine.es/). On INE's website, the income accounts data for Spanish Non-Financial Corporations appear can be found in the National Accounts (Cuentas Económicas) section: go to "Quarterly non-financial accounts for the Institutional Sectors" (Cuentas Trimestrales no financieras de los sectores institucionales) and then "Detailed accounts for the institutional sectors" (Cuentas detalladas de los sectores institucionales) and then click on the spreadsheet non-financial companies (Sociedades no financieras). This spreadsheet provides data on the primary distribution of income accounts of non-financial corporations, including all the components required for the numerator of our yield calculations. The data provided here date from 1999 onwards and are calculated using 2000 as a base year. Comparable data for years before 1999 can be found in a separate section containing historical data from previous base years. 1995-1999 data comes from base-95, while 86-96 comes from base-86 (note that the latter are calculated in pesetas). There is an overlap between each of the base-year estimates that allows the each of the series to be spliced into continuous estimates.

Estimates of the net capital stock are provided by Banco de España. From the Banco de España home page (http://www.bde.es/homee.htm), go to "Central Balance Sheet Data" and then "Quarterly report and Annual Report" and then under Chapter 3 go to the section "Sub-sector of non financial corporations" and the data appears in Table 3.15.

These capital stock estimates are calculated in a manner consistent with separate base-year estimates provided by INE, reducing any distortion of moving from one base-period to the next. However, prior to 1995, we have had to estimate our own measure of the net capital stock. For this earlier period, we have experimented with two different measures: one based on net capital formation data and an assumption about capital prices based on the investment deflator. However, this measure resulted in a large swing in the implicit depreciation rate between the mid-1980s and the mid-1990s. Our second measure—which is our preferred measure—is based on estimates of consumption of fixed capital and assumes a constant depreciation rate. Estimates of the real capital gain/loss are based on the GFCF deflator.

Banco de España publishes a related yield on capital stock measure. There are a number of differences between this measure and our $u_t^K$ measure but the most important is that the Banco de España measure includes the financial revenue from investments in the numerator and the equity value of outside investments in the denominator. The Banco de España data can be found here: http://www.bde.es/infoest/htmls/capit15e.htm .

**South Korea**

The source for the South Korea data on PNFC income and capital consumption is The Bank of Korea (Go to http://www.bok.or.kr/eng/index.jsp, click on 'Economic Statistics System' on the lower portion of the page. The click on 'National Accounts' (국민소득) and, under National Accounts, click on "Consolidated Account for the Nation" to bring up the details. Finally, click on 'Income Accounts by Institutional Sectors (Annual, at Current Price)' or Click on 'Capital Accounts by Institutional Sectors (Annual, at Current Price)')

The Korean National Statistics Office provide an estimate for PNFC gross and net fixed assets broken down into tangible fixed assets and stocks for one year only – 1997 [see KOSIS (Korean Statistician Information System – http://kosis.nso.go.kr/eng/index.htm) > National Accounts > National Wealth]. Our main Korean capital stock measure is calculated using 1997 data as a base and deriving data for the years before and after that based on capital

consumption data for PNFCs capital flow accounts and assuming a trend rise in the depreciation rate in line with the global average.

We have tried three alternative methodologies to our preferred methodology but found the results of these to provide unrealistic capital-to-output ratios:

1. Again using 1997 data as a base, we calculated a capital stock series based on the perpetual inventory method and using net investment data from the PNFC capital flow accounts and using whole-economy investment prices as a proxy for PNFC capital stock prices. However, it appears that the whole-economy investment deflator is not a good proxy for PNFC capital stock prices in the long run, as the series derived in this way produces *negative* stocks of capital in the late 1970s.

2. A second alternative estimate is based a steady-state starting assumption for the capital stock, $K_0$, as $I_0/(g+\partial)$ where $I_0$ is the value of the investment series in the first year, g is the average geometric growth rate for the investment series between the first and final years, and $\partial$ is the depreciation rate. Thereafter, we assume that the depreciation rate is constant and that PNFC capital stock grows in line with PNFC capital stock depreciation. The resultant depreciation rate is 0.058, close to the 0.06 fixed rate assumed by Caselli and Feyrer (2007).

3. A third alternative makes the same starting capital stock assumption and uses the perpetual inventory method along with net PNFC investment data and the whole-economy investment deflator rather than PNFC capital price changes. This method falls foul of the same problem as alternative 1: because the whole-economy investment prices rise too much, this method results in an unrealistically large rise in the capital-output ratio.

We base our estimates of annual capital gain/loss on the whole-economy investment deflator deflated by the consumption deflator.

**Appendix 3: Individual Country Data Analysis**

In this appendix we set out our results on a country-by-country basis, with a brief description and interpretation of the results. The discussion should be viewed in conjunction with ten pages of figures and tables that appear at the very end of this chapter, each dedicated to one country in our sample. Those pages contain the following exhibits:

1. A figure displaying the $r_t^K$ and $u_t^K$ measures over the entire sample for that country.

2. A figure displaying the annual change in real capital stock prices (capital stock prices deflated with the consumer expenditure deflator).

3. A figure comparing our $r_t^K$ and $u_t^K$ results with the results of previous studies considering the yield on capital or simplified MPK estimates.

4. A table providing some summary statistics, including the mean and standard deviation of $u_t^K$, $u2_t^K$, K Gain/Loss and $r_t^K$. In this table we also display the results of an Augmented Dickey-Fuller unit root test for stationarity. Although each of these variables should be stationary in the long run, it is interesting to observe whether their mean or variance varies over shorter intervals. Are shocks to returns permanent (have a unit root) or are rates of return mean-reverting (stationary) even in the relatively short run? The table displays the MacKinnon (1996) one-sided probability values of rejecting the null hypothesis that the series has a unit root (follows a random walk) when it is true. A low probability indicates a high degree of confidence that the series is stationary. Note that, given the small sample that exists for many of these variables, there is a high risk of type 2 errors (not rejecting the hypothesis when it was false).

**US:** The biggest fluctuations in the US $r_t^K$ and $u_t^K$ measures occurred between the Great Depression and the Second World War, when returns moved from record lows to record highs. The $r_t^K$ reached a record high in the early 1950s, and fluctuated around a steadily decreasing trend to reach an all-time low during the Volcker recession of the early 1980s. Since the 1980s, however, there has been a gradual upward trend and in 2005 the return on capital reached its highest level since 1974.

We reject the null hypothesis that $u_t^K$ and $u2_t^K$ had a unit root from 1981 (at the 5% interval). But we do not reject the hypothesis for $r_t^K$ or the capital gain/loss from 1981 onwards.

**Japan:** The Japanese sample starts in the 1980, with $u_t^K$, $u2_t^K$ and $r_t^K$ all reaching a peak at the height of the late-1980s boom. Each declined steadily during the 1990s before stabilising at a relatively low level in the 2000s.

We do not reject the null hypothesis that $u_t^K$, $u2_t^K$, the K Gain/Loss or $r_t^K$ has a unit root, based on data from 1981 to 2005.

**Germany:** Pan-German data commenced in 1991 following German unification but we have spliced West-German data on to the Pan-German series for the years 1980-1991. The return on capital reached a high of 11.7% in the year of unification, boosted in particular by a sharp rise in real capital prices in that year. But, once the unification bubble had burst, returns fell sharply thereafter.

Consistent with the findings of Broadbent, Schumacher and Schels (2004), however, we find that $u_t^K$, $u2_t^K$ and $r_t^K$ have been steadily rising since the mid-1990s from a relatively low level. Reflecting this trend over this relatively short sample, we do not reject the hypothesis that $u_t^K$, $u2_t^K$ and the K Gain/Loss have unit roots. However, the null hypothesis is rejected for $r_t^K$ at the 5% level.

**China:** The issue of Chinese profitability has been the subject of a number of recent studies focussing on the possibility of over-investment in that economy (Bai, Hsieh and Qian (2006), Liang (2006), Hofman and Kuijs (2006), and Shan (2006)). A commonly-held view, one espoused by Shan (2006), is that Chinese corporate profitability is relatively low due to inefficient, state-directed investment. However, Bai, Hsieh and Qian (2006) and Liang (2006) derive estimates of the yield on capital and Hofman and Kuijs (2006) consider profit shares to argue that Chinese corporate profitability is high and rising.

Our findings, which are based on a National Bureau of Statistics' annual company survey (covering over 250,000 listed and unlisted companies, both privately and state-owned), suggests that the Chinese return on capital rose sharply from the mid-1990s onwards. Liang's

(2006) measure of the yield on capital is based on data taken from the same survey but her measure includes interest payments while excluding real capital price changes. Bai, Hsieh and Qian (2006) base their rate of return calculations on annual national accounts data and estimates of the capital share of income. They obtain much higher estimates of the return on capital during the 1990s, although these measures converge in the 2000s. According to all of these measures, the rate of return has risen quite sharply since the early 2000s. This is notable, as it suggests that the frequently-expressed concerns regarding the possibility of over-investment in China may be misplaced.

In the chart of real capital prices, we display both the fixed asset investment (FAI) deflator deflated by the GDP deflator and the capital stock deflator deflated by the consumers' expenditure deflator. We do not reject the hypothesis that $u_t^K$ and $r_t^K$ have unit roots, based on data from 1981-2005. However, the null hypothesis is rejected for the K Gain/Loss at the 5% level.

**UK:** Our sample for the UK dates back to the late-1940s when the yield and return on capital were exceptionally high. Two factors help to explain the high returns of the post-war period. First, much of the UK's capital stock was destroyed in World War II. Second, exceptionally high rates of capital taxation in the years after the war discouraged investment. For the years 1947-48, for instance, investment income over £5,000 was taxed at 50%, companies were subject to income tax at 45% and there was a surtax of 52.5%, providing an effective tax rate of 147.5%! Corporation Tax on company profits and Capital Gains Tax on long-term gains were introduced in 1965 to replace income tax and various 'special' taxes. But corporation tax rates were then raised above 50% in the early 1970s, only declining slowly in the 1980s. There was a sharp decline in the $r_t^K$ and $u_t^K$ measures during the first oil crisis and again in the early 1990s. Thereafter, the return on capital has risen substantially.

We do not reject the hypothesis that $u_t^K$ and $u2_t^K$ have a unit root over the whole sample (1950-2008) but, from 1981 onwards, we do reject the hypothesis for $u_t^K$. We reject the hypothesis for the K Gain/Loss and $r_t^K$ at the 5% level over both time periods.

**France:** As discussed in Appendix 2, our preferred measure of the French rate of return is adjusted downwards to exclude part of the mixed income of certain sole-traders that appear within the PNFC accounts. $u_t^K$ and $r_t^K$ were weak in the early 1980s but climbed sharply to

a sample high in the late-1980s/early-1990s. $u_t^K$ and $r_t^K$ have declined in recent years from a local high reached in 1999.

From 1981 onwards we reject the hypothesis that the $u_t^K$ and $r_t^K$ have a unit root at the 5% level. We do not reject the hypothesis for $u2_t^K$ and K Gain/Loss.

**Italy:** Historically the rate of return on capital has been relatively high in Italy, consistently surpassing that of the EU5 and the US until very recently, but it has fallen significantly since 2000 as high real wage growth has eaten into Italy's profit share.

We do not reject the hypothesis of a unit root in $u_t^K$ and $u2_t^K$. We do reject the hypothesis for the K Gain/Loss at the 1% level and for $r_t^K$ at the 10% level.

**Canada:** Canadian returns were relatively high in the 1980s and from the mid-1980s onwards. Between these two periods, however, returns fell very sharply in the early-1990s downturn. This decline in the ROC was part of a global phenomenon but the decline was especially marked in Canada. Statistics Canada produces an 'official' measure of the yield on capital. Although the correlation with our yield on capital measure is high (with a correlation coefficient of 0.93 based on annual data from 1990), the level of their measure is lower because they also subtract interest payments from their measure of profits.

Canadian returns are reasonably highly correlated with those of the US, with a pair-wise correlation coefficient between the respective $r_t^K$ measures of 0.56. This compares with an average cross-country correlation of 0.14.

**Spain:** Over the sample as a whole (1981—2008) Spain's return on capital averaged more than the global average (11.0% vs. 10.7%). But, from the early 2000s onwards, Spain's return on capital has declined sharply, as rising real labour costs have eaten into margins, and in 2008 it had the lowest return on capital within our sample.

Our estimate of Spain's yield on capital is comparable in level terms with the estimates of Broadbent, Schumacher and Schels (2004) and with a correlation coefficient based on annual data of +0.90. However, our results are markedly different from the previous estimates of Walton (2002). The correlation with the Banco de España yield measure—which is based on a different calculation to out own—is +0.35.

**South Korea:** The rate of return on capital in Korea was relatively high during the 1970s and 1980s (reaching a peak of over 20% in 1980), as one would expect of a rapidly developing country. The return on capital eased lower during the 1990s before falling sharply following the Asian crisis of 1998. It has recovered sharply since 2000.

We do not reject the hypothesis that $u_t^K$, $u2_t^K$ or $r_t^K$ have a unit root. But we do reject the hypothesis for real investment prices at the 1% level.

Table 1: Comparison of Results Across Countries (1981-2008)

| | | $u^K$ | $u2^K$ | K Gain/Loss | $r^K$ |
|---|---|---|---|---|---|
| US | Mean | 10.7 | 8.3 | -0.3 | 10.4 |
| | St.Dev | 1.3 | 0.9 | 1.7 | 2.5 |
| Japan | Mean | 12.6 | 9.1 | -0.8 | 11.9 |
| | St.Dev | 3.5 | 2.5 | 1.8 | 3.4 |
| Germany | Mean | 9.0 | 9.2 | -0.1 | 8.9 |
| | St.Dev | 1.8 | 1.5 | 1.7 | 2.7 |
| China | Mean | 12.0 | | -0.3 | 11.7 |
| | St.Dev | 5.8 | | 2.3 | 5.5 |
| UK | Mean | 14.6 | 10.9 | -2.1 | 12.5 |
| | St.Dev | 2.2 | 2.1 | 2.3 | 4.0 |
| France | Mean | 8.8 | 6.9 | -0.3 | 8.5 |
| | St.Dev | 1.7 | 1.6 | 1.5 | 2.7 |
| Italy | Mean | 13.2 | 10.6 | -0.6 | 12.6 |
| | St.Dev | 1.6 | 1.4 | 1.2 | 1.9 |
| Canada | Mean | 11.2 | 7.7 | -0.8 | 10.9 |
| | St.Dev | 2.5 | 1.5 | 1.9 | 3.6 |
| Spain | Mean | 11.2 | 7.0 | -0.1 | 11.0 |
| | St.Dev | 2.0 | 2.0 | 1.7 | 2.1 |
| Korea | Mean | 18.1 | 15.8 | -1.0 | 17.1 |
| | St.Dev | 3.9 | 4.1 | 1.8 | 4.2 |

Notes: Authors calculations—see Section 3 for details on methodology and sources. German $u2^K$ data are for Pan-Germany (1991-2008) only. Because German yields rose over the duration of the sample, the post-tax yield for 1991-2008 is marginally higher than the pre-tax yield for 1981-2008. There is no $u2^K$ measure for China because of the difficulty in obtaining reliable corporate taxation data. Canadian $u2^K$ data commence in 1989. Spanish $u2^K$ data commence in 1995.

Table 2: Joint Behaviour of $r^K$ with Global $r^K$

| | Correlation with Global ROC1 | | | | Principal Components Analysis with Global $r^K$ |
|---|---|---|---|---|---|
| | 81-08 (1) | 81-94 (2) | 95-08 (3) | Col 3-2 (4) | (5) |
| US | 0.75 | 0.73 | 0.80 | 0.07 | 0.87 |
| Japan | 0.32 | 0.72 | 0.80 | 0.08 | 0.66 |
| Germany | 0.69 | 0.60 | 0.76 | 0.17 | 0.84 |
| China | 0.58 | 0.66 | 0.63 | -0.02 | 0.79 |
| UK | 0.62 | 0.66 | 0.55 | -0.11 | 0.81 |
| France | 0.64 | 0.80 | 0.21 | -0.59 | 0.82 |
| Italy | 0.25 | 0.63 | -0.49 | -1.13 | 0.62 |
| Canada | 0.60 | 0.42 | 0.81 | 0.39 | 0.80 |
| Spain | 0.18 | 0.75 | -0.36 | -1.11 | 0.61 |
| Korea | -0.14 | -0.41 | 0.43 | 0.84 | 0.57 |
| EU5 | 0.80 | 0.91 | 0.63 | -0.28 | 0.90 |
| Asia | 0.43 | 0.74 | 0.78 | 0.03 | 0.72 |

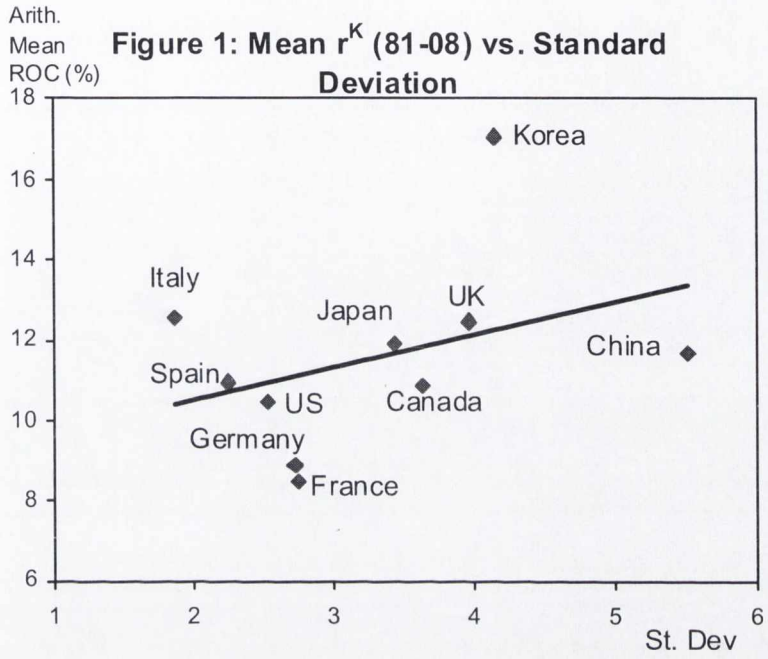
Notes: Authors calculations—see Section 3 for details on methodology and sources. In Column 5 we report the variance in each country's returns that is accounted for by variations in the global return, based on Principal Components Analysis.

Table 3: Cross Correlation of $r^K$ Results 1981-2008

| | US | Japan | Germany | China | UK | France | Italy | Canada | Spain | Korea |
|---|---|---|---|---|---|---|---|---|---|---|
| US | 1.00 | **-0.18** | 0.37 | 0.14 | 0.51 | 0.52 | 0.36 | 0.56 | 0.00 | **-0.28** |
| Japan | | 1.00 | 0.01 | 0.42 | 0.01 | **-0.24** | **-0.10** | 0.02 | 0.28 | 0.48 |
| Germany | | | 1.00 | 0.51 | 0.29 | 0.66 | **-0.05** | 0.34 | **-0.10** | **-0.22** |
| China | | | | 1.00 | 0.49 | 0.16 | **-0.39** | 0.53 | **-0.18** | 0.23 |
| UK | | | | | 1.00 | 0.42 | 0.02 | 0.69 | 0.06 | **-0.22** |
| France | | | | | | 1.00 | 0.43 | 0.26 | 0.31 | **-0.56** |
| Italy | | | | | | | 1.00 | 0.00 | 0.57 | **-0.36** |
| Canada | | | | | | | | 1.00 | **-0.24** | 0.02 |
| Spain | | | | | | | | | 1.00 | **-0.32** |
| Korea | | | | | | | | | | 1.00 |

Notes: Authors calculations—see Section 3 for details on methodology and sources. The Table presents simple pairwise correlation coefficients. The bolding of a figure highlights a negative correlation coefficient.

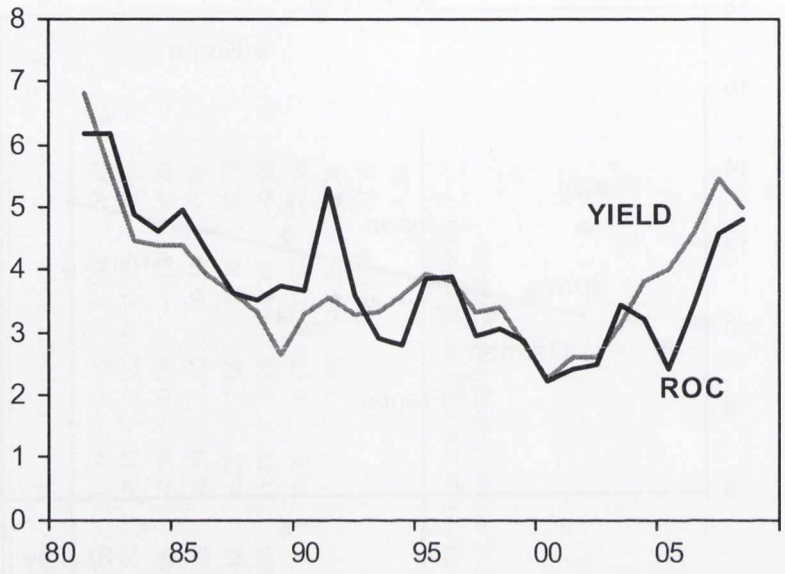
**Figure 1: Mean $r^K$ (81-08) vs. Standard Deviation**



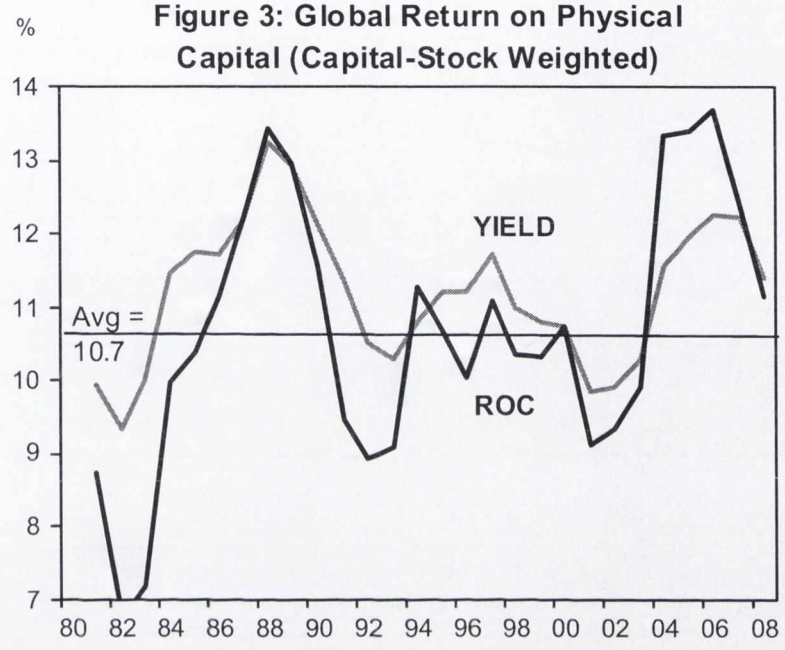

Notes: Author's calculations based on national accounts data. See Section 3 for more details.

**Figure 2: Sigma Convergence**

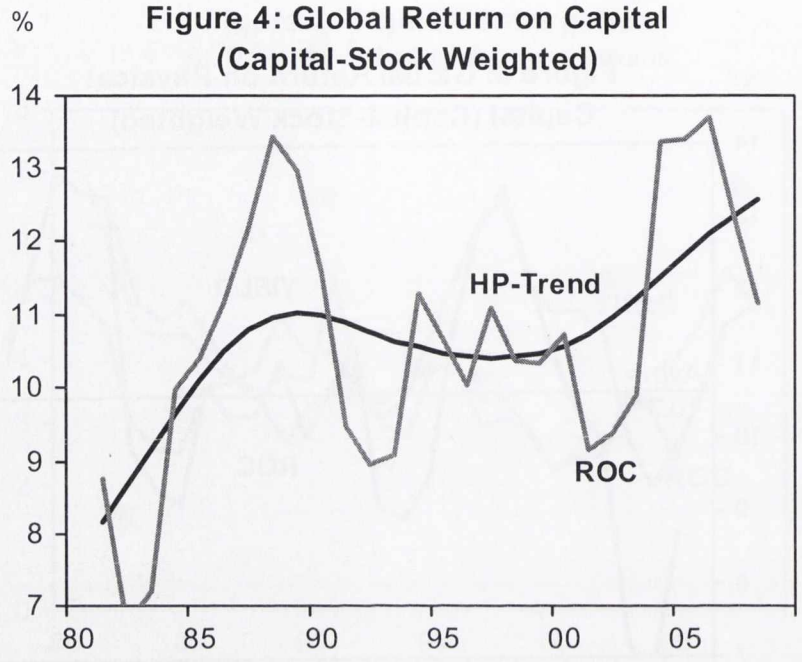
St. Deviation of the Distribution of Returns




Notes: Author's calculations based on national accounts data. See Section 3 for more details of data and Section 4 for discussion of results.

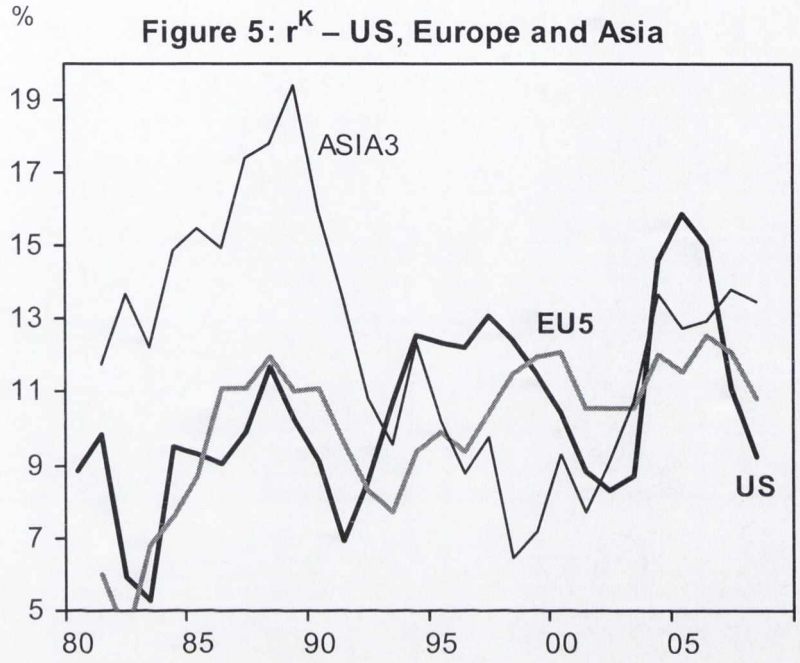



Notes: Author's calculations based on national accounts data. See Section 3 for more details.

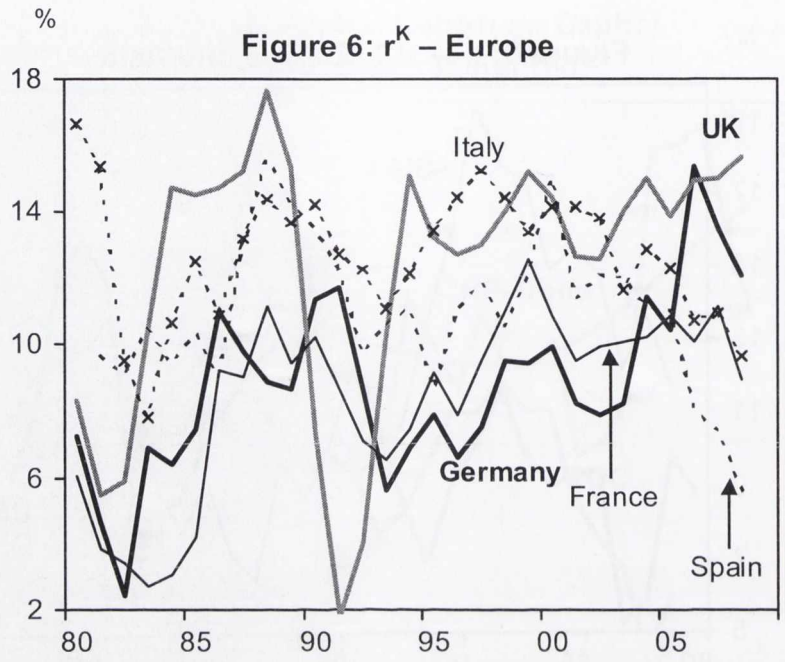



Notes: Author's calculations based on national accounts data. See Section 3 for more details of data and Section 4 for discussion of results.

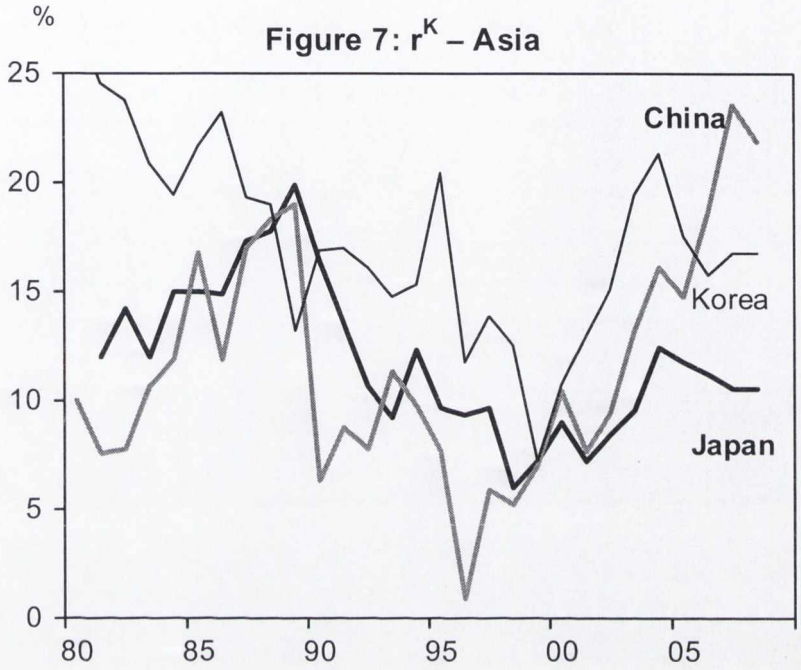
**Figure 5: $r^K$ – US, Europe and Asia**



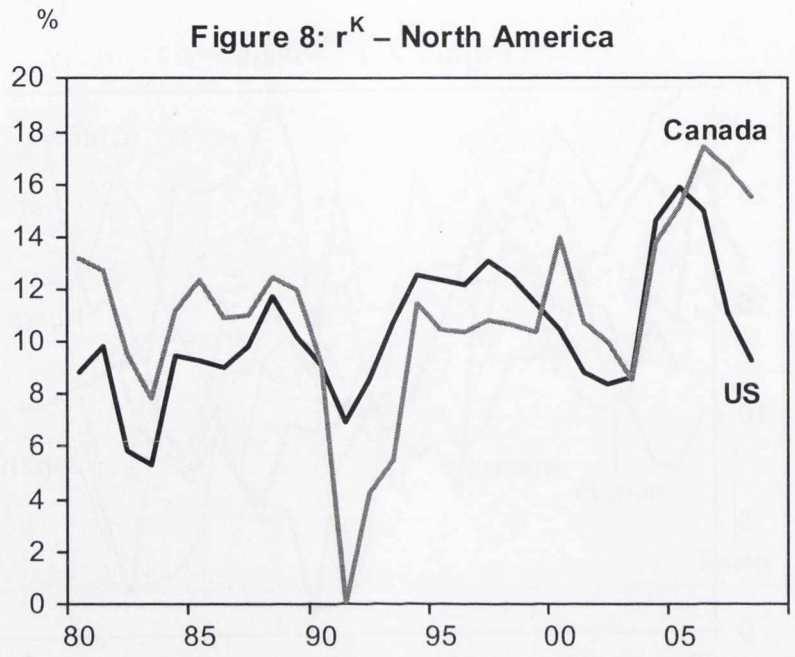

Notes: Author's calculations based on national accounts data. See Section 3 for more details.




Notes: Author's calculations based on national accounts data. See Section 3 for more details.

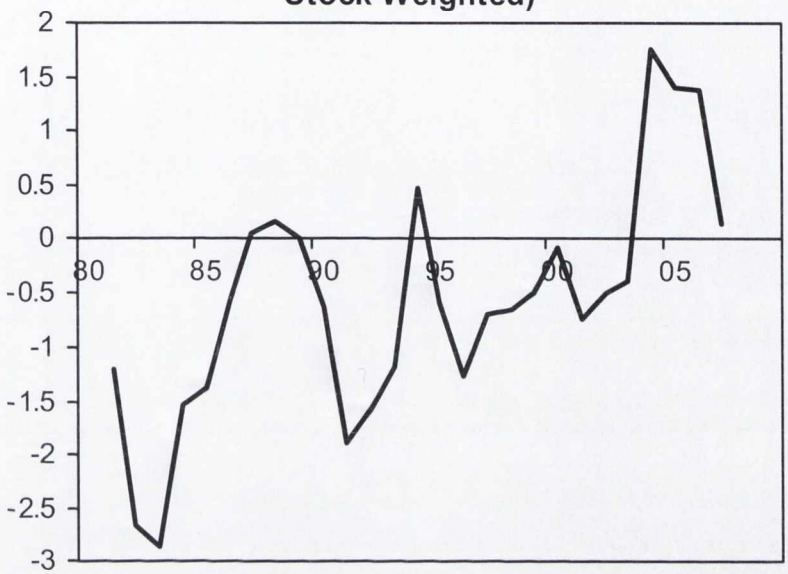



Notes: Author's calculations based on national accounts data. See Section 3 for more details.



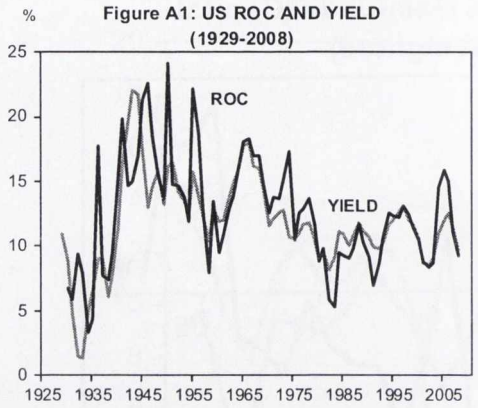

Notes: Author's calculations based on national accounts data. See Section 3 for more details.

%YOY **Figure 9: Global K Gain/Loss (Capital-Stock Weighted)**

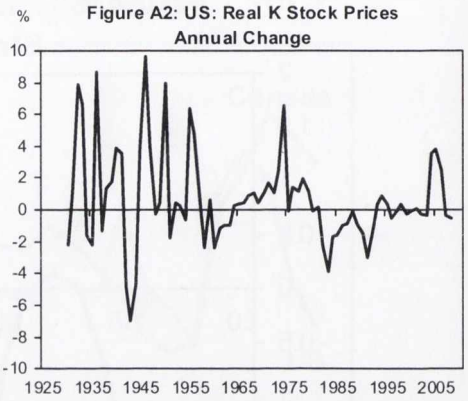



Notes: Author's calculations based on national accounts data. See Section 3 for more details.

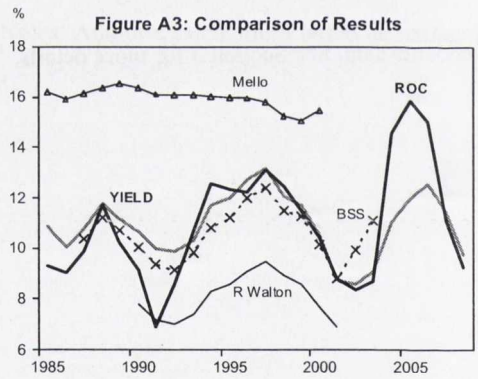
## United States




Notes: Sample 1929-2008. Author's calculations based on national accounts data. See Section 3 for more details.




Notes: Sample 1929-2008. Author's calculations based on national accounts data. See Section 3 for more details.



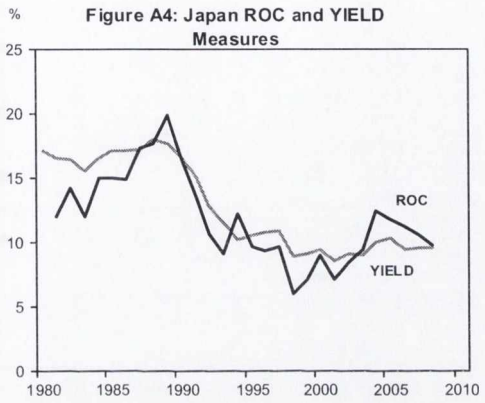

Notes: Sample 1929-2008. Author's calculations based on national accounts data. See Section 3 for more details.

**Table A1: Summary Results: US**

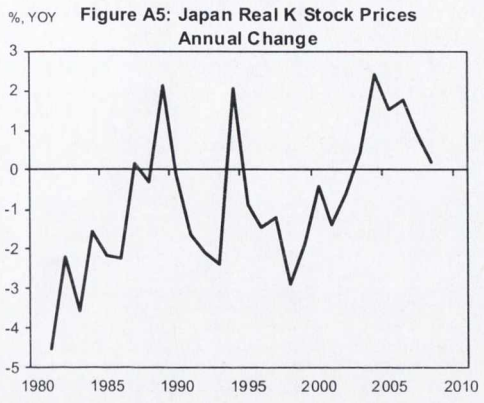
| | | Total Sample 1929-2008 | 1981-2008 |
|---|---|---|---|
| 1 $u^K$ | Mean | 11.9 | 10.7 |
| | Stand. Dev. | 3.7 | 1.3 |
| | Unit Root Test | 0.00 | 0.04 |
| 2 $u2^K$ | Mean | 7.9 | 8.3 |
| | Stand. Dev. | 1.9 | 0.9 |
| | Unit Root Test | 0.00 | 0.05 |
| 3 K G/L | Mean | 0.7 | -0.3 |
| | Stand. Dev. | 3.0 | 1.7 |
| | Unit Root Test | 0.00 | 0.49 |
| 4 $r^K$ | Mean | 12.6 | 10.4 |
| | Stand. Dev. | 4.3 | 2.5 |
| | Unit Root Test | 0.11 | 0.17 |

Notes: The table displays the MacKinnon (1996) one-sided probability values of rejecting the null hypothesis that the series has a unit root (follows a random walk) when it is true. A low probability indicates a high degree of confidence that the series is stationary.

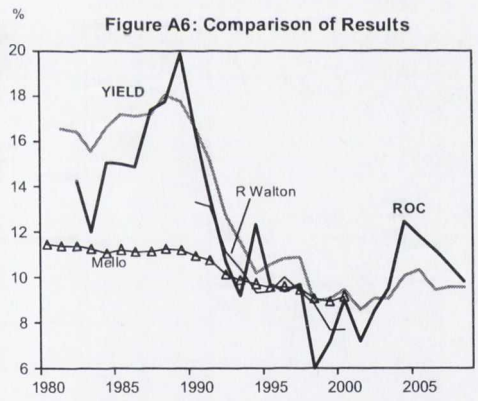
## Japan




Notes: Sample 1980-2008. Author's calculations based on national accounts data. See Section 3 for more details.




Notes: Sample 1980-2008. Author's calculations based on national accounts data. See Section 3 for more details.



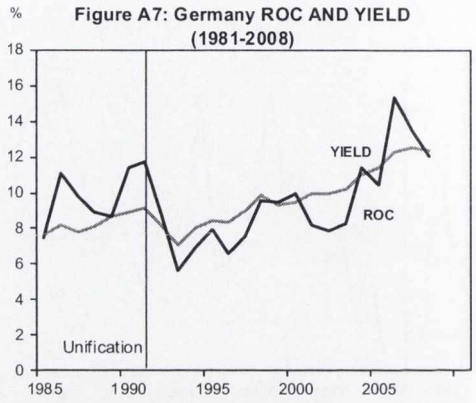

Notes: Sample 1980-2008. Author's calculations based on national accounts data. See Section 3 for more details.

**Table A2: Summary Results: Japan**

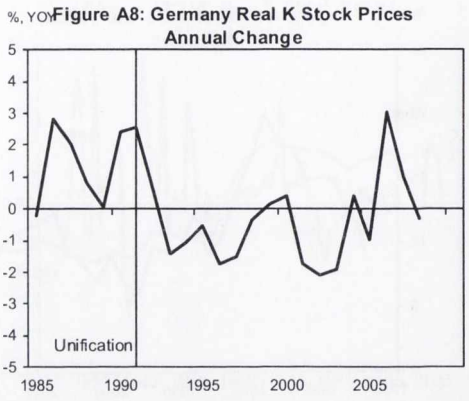
| | | Total Sample 1981-2008 | |
|---|---|---|---|
| 1 $u^K$ | Mean<br>Stand. Dev.<br>Unit Root Test | 12.6<br>3.5<br>0.80 | |
| 2 $u2^K$ | Mean<br>Stand. Dev.<br>Unit Root Test | 9.1<br>2.5<br>0.82 | |
| 3 K G/L | Mean<br>Stand. Dev.<br>Unit Root Test | -0.8<br>1.8<br>0.16 | |
| 4 $r^K$ | Mean<br>Stand. Dev.<br>Unit Root Test | 11.9<br>3.4<br>0.68 | |

Notes: The table displays the MacKinnon (1996) one-sided probability values of rejecting the null hypothesis that the series has a unit root (follows a random walk) when it is true. A low probability indicates a high degree of confidence that the series is stationary.

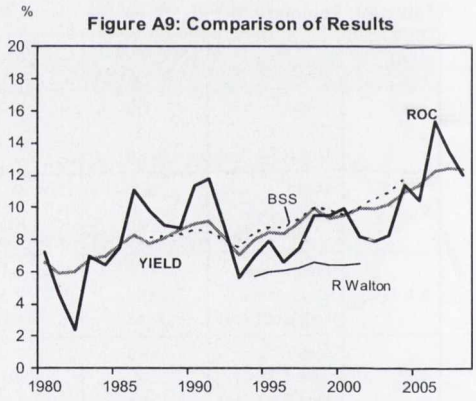
## Germany




Notes: Sample 1981-2008. Author's calculations based on national accounts data. See Section 3 for more details.




Notes: Sample 1981-2008. Author's calculations based on national accounts data. See Section 3 for more details.



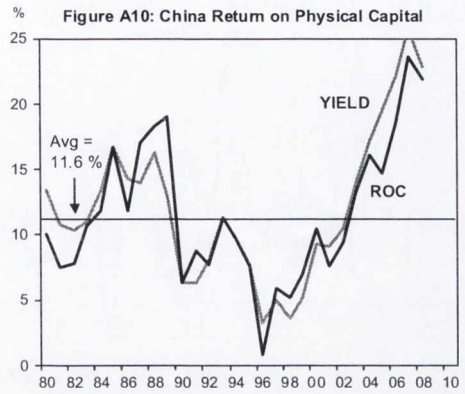

Notes: Sample 1981-2008. Author's calculations based on national accounts data. See Section 3 for more details.

**Table A3: Summary Results: Germany**

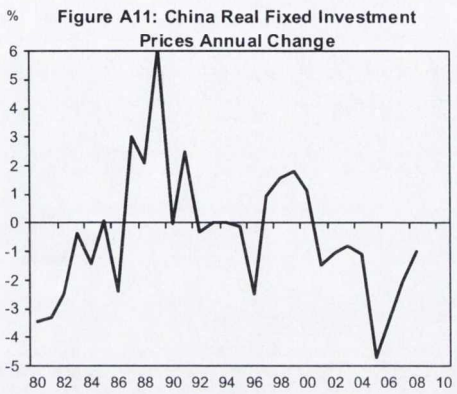
| | | Total Sample 1981-2008 | Pan German 1991-2008 |
|---|---|---|---|
| 1 $u^K$ | Mean | 8.9 | 9.8 |
| | Stand. Dev. | 1.8 | 1.6 |
| | Unit Root Test | 0.94 | 0.96 |
| 2 $u2^K$ | Mean | | 9.2 |
| | Stand. Dev. | | 1.5 |
| | Unit Root Test | | 0.97 |
| 3 K G/L | Mean | -0.1 | -0.3 |
| | Stand. Dev. | 1.6 | 1.5 |
| | Unit Root Test | 0.03 | 0.50 |
| 4 $r^K$ | Mean | 8.8 | 9.5 |
| | Stand. Dev. | 2.7 | 2.5 |
| | Unit Root Test | 0.02 | 0.02 |

Notes: The table displays the MacKinnon (1996) one-sided probability values of rejecting the null hypothesis that the series has a unit root (follows a random walk) when it is true. A low probability indicates a high degree of confidence that the series is stationary.

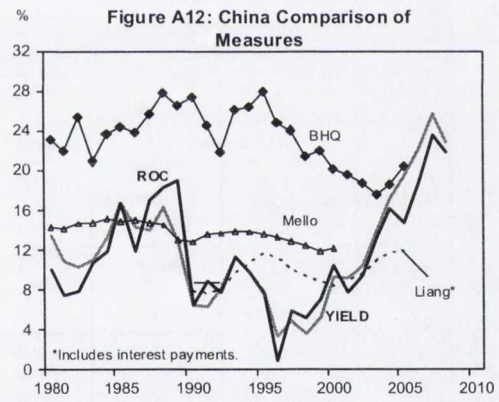
## China




Notes: Sample 1981-2008. Author's calculations based on national accounts data. See Section 3 for more details.




Notes: Sample 1981-2008. Author's calculations based on national accounts data. See Section 3 for more details.



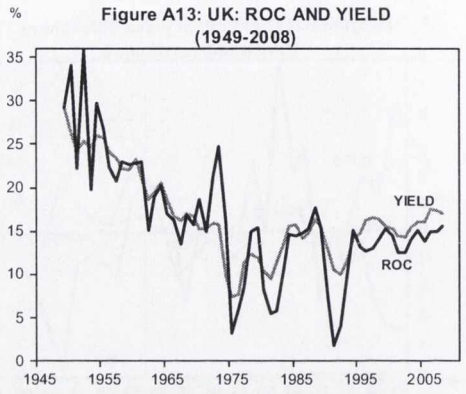

Notes: Sample 1981-2008. Author's calculations based on national accounts data. See Section 3 for more details.

**Table A4: Summary Results: China**

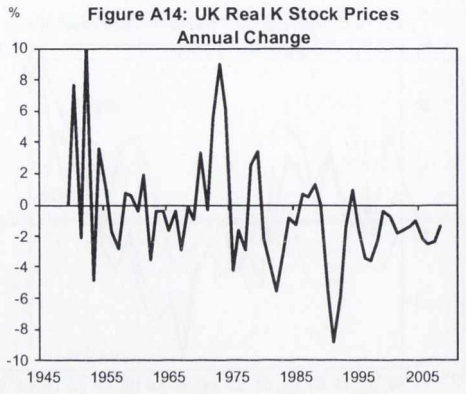
| | | Total Sample 1981-2008 | |
|---|---|---|---|
| 1 $u^K$ | Mean<br>Stand. Dev.<br>Unit Root Test | 12.0<br>5.8<br>0.47 | |
| 2 $u2^K$ | Mean<br>Stand. Dev.<br>Unit Root Test | | |
| 3 K G/L | Mean<br>Stand. Dev.<br>Unit Root Test | -0.3<br>2.3<br>0.02 | |
| 4 $r^K$ | Mean<br>Stand. Dev.<br>Unit Root Test | 11.7<br>5.5<br>0.21 | |

Notes: The table displays the MacKinnon (1996) one-sided probability values of rejecting the null hypothesis that the series has a unit root (follows a random walk) when it is true. A low probability indicates a high degree of confidence that the series is stationary.

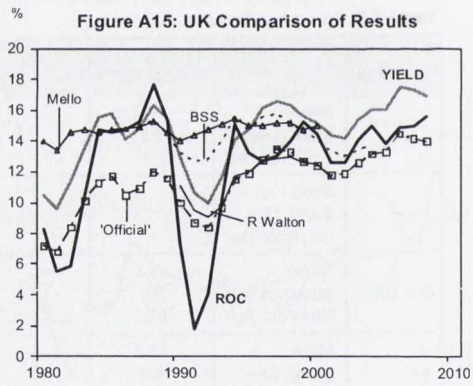
**UK**




Notes: Sample 1949-2008. Author's calculations based on national accounts data. See Section 3 for more details.




Notes: Sample 1949-2008. Author's calculations based on national accounts data. See Section 3 for more details.




Notes: Sample 1949-2008. Author's calculations based on national accounts data. See Section 3 for more details.

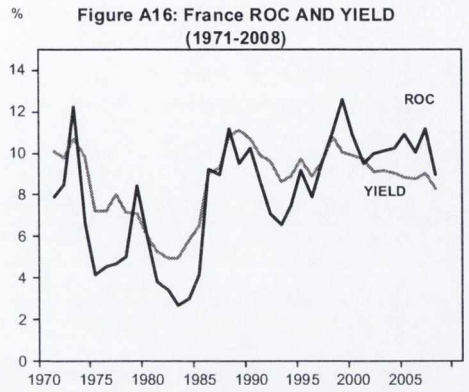
**Table A5: Summary Results: UK**

| | | Total Sample 1949-2008[1] | 1981-2008 |
|---|---|---|---|
| 1 $u^K$ | Mean | 16.5 | 14.6 |
| | Stand. Dev. | 4.7 | 2.2 |
| | Unit Root Test | 0.24 | 0.04 |
| 2 $u2^K$ | Mean | 11.6 | 11.0 |
| | Stand. Dev. | 3.1 | 2.1 |
| | Unit Root Test | 0.11 | 0.15 |
| 3 K G/L | Mean | -0.6 | -2.1 |
| | Stand. Dev. | 3.5 | 2.3 |
| | Unit Root Test | 0.01 | 0.00 |
| 4 $r^K$ | Mean | 15.9 | 12.5 |
| | Stand. Dev. | 6.7 | 4.0 |
| | Unit Root Test | 0.04 | 0.00 |

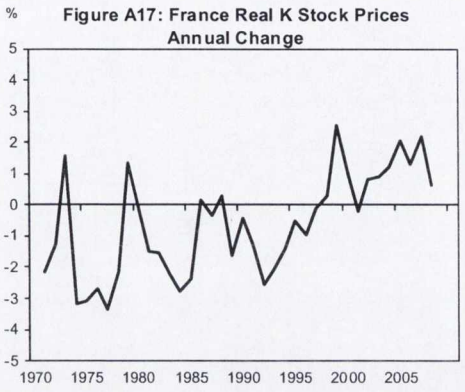
[1] YIELD2 sample starts 1960.

Notes: The table displays the MacKinnon (1996) one-sided probability values of rejecting the null hypothesis that the series has a unit root (follows a random walk) when it is true. A low probability indicates a high degree of confidence that the series is stationary.

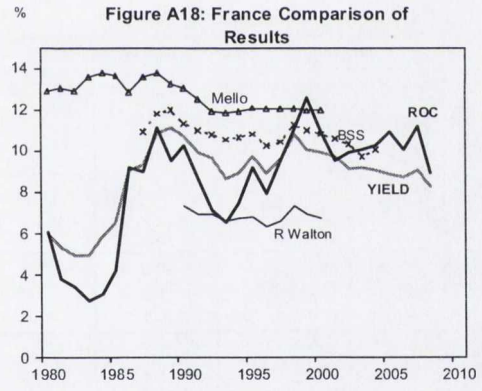
## France




Notes: Sample 1971-2008. Author's calculations based on national accounts data. See Section 3 for more details.




Notes: Sample 1971-2008. Author's calculations based on national accounts data. See Section 3 for more details.



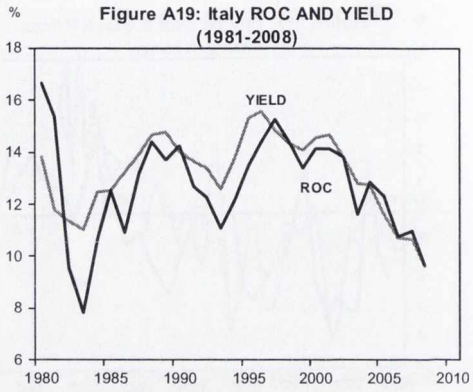

Notes: Sample 1971-2008. Author's calculations based on national accounts data. See Section 3 for more details.

**Table A6: Summary Results: France**

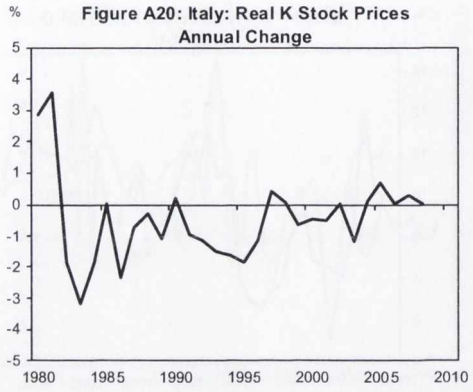
| | | Total Sample 1971-2008 | 1981-2008 |
|---|---|---|---|
| 1 $u^K$ | Mean | 8.7 | 8.8 |
| | Stand. Dev. | 1.7 | 1.7 |
| | Unit Root Test | 0.00 | 0.00 |
| 2 $u2^K$ | Mean | | 6.9 |
| | Stand. Dev. | | 1.6 |
| | Unit Root Test | | 0.43 |
| 3 K G/L | Mean | -0.6 | -0.3 |
| | Stand. Dev. | 1.7 | 1.5 |
| | Unit Root Test | 0.49 | 0.46 |
| 4 $r^K$ | Mean | 8.1 | 8.5 |
| | Stand. Dev. | 2.8 | 2.7 |
| | Unit Root Test | 0.01 | 0.03 |

Notes: The table displays the MacKinnon (1996) one-sided probability values of rejecting the null hypothesis that the series has a unit root (follows a random walk) when it is true. A low probability indicates a high degree of confidence that the series is stationary.

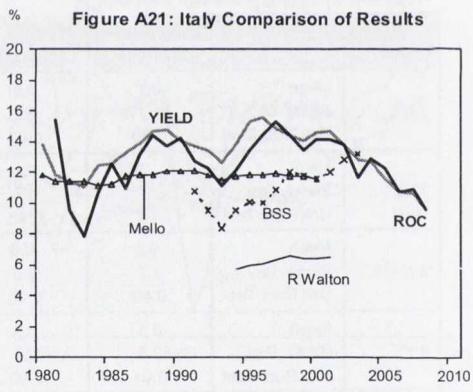
## Italy




Notes: Sample 1981-2008. Author's calculations based on national accounts data. See Section 3 for more details.




Notes: Sample 1981-2008. Author's calculations based on national accounts data. See Section 3 for more details.



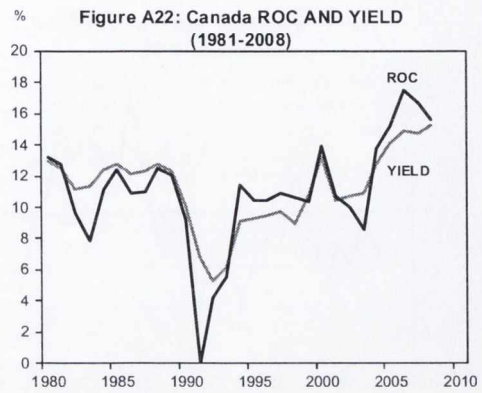

Notes: Sample 1981-2008. Author's calculations based on national accounts data. See Section 3 for more details.

**Table A7: Summary Results: Italy**

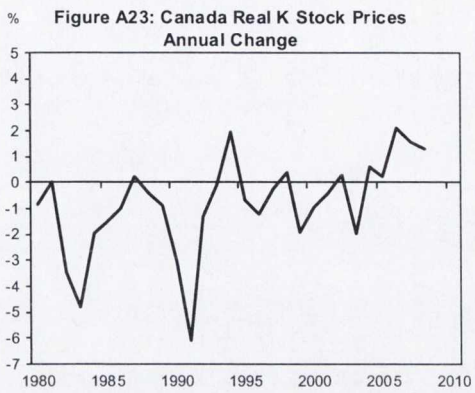
| | | Total Sample 1981-2008 | |
|---|---|---|---|
| 1 $u^K$ | Mean<br>Stand. Dev.<br>Unit Root Test | 13.2<br>1.6<br>0.17 | |
| 2 $u2^K$ | Mean<br>Stand. Dev.<br>Unit Root Test | 10.6<br>1.4<br>0.39 | |
| 3 K G/L | Mean<br>Stand. Dev.<br>Unit Root Test | -0.6<br>1.2<br>0.00 | |
| 4 $r^K$ | Mean<br>Stand. Dev.<br>Unit Root Test | 12.6<br>1.9<br>0.06 | |

Notes: The table displays the MacKinnon (1996) one-sided probability values of rejecting the null hypothesis that the series has a unit root (follows a random walk) when it is true. A low probability indicates a high degree of confidence that the series is stationary.

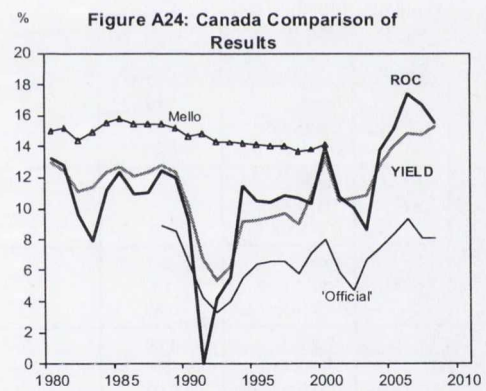
## Canada




Notes: Sample 1981-2008. Author's calculations based on national accounts data. See Section 3 for more details.




Notes: Sample 1981-2008. Author's calculations based on national accounts data. See Section 3 for more details.



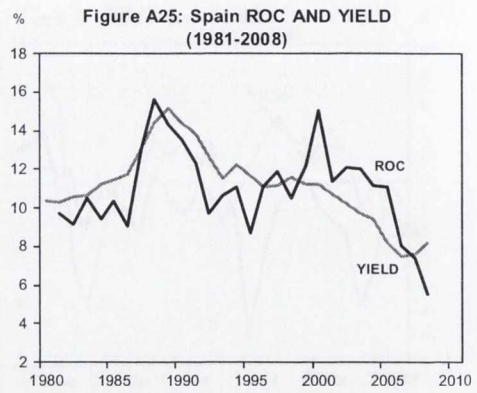

Notes: Sample 1981-2008. Author's calculations based on national accounts data. See Section 3 for more details.

**Table A8: Summary Results: Canada**

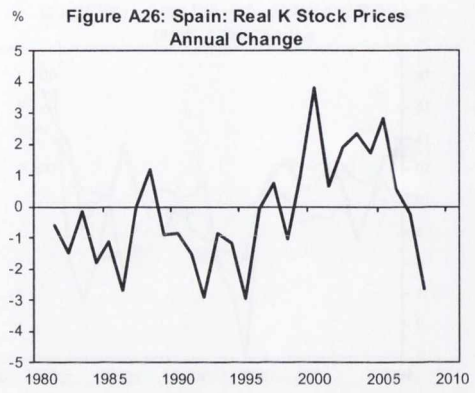
| | | Total Sample 1981-2008 | 1990-2008 |
|---|---|---|---|
| 1 $u^K$ | Mean | 11.2 | 10.7 |
| | Stand. Dev. | 2.5 | 2.9 |
| | Unit Root Test | 0.12 | 0.02 |
| 2 $u2^K$ | Mean | | 7.6 |
| | Stand. Dev. | | 1.4 |
| | Unit Root Test | | 0.17 |
| 3 K G/L | Mean | -0.8 | -0.5 |
| | Stand. Dev. | 1.9 | 1.9 |
| | Unit Root Test | 0.02 | 0.07 |
| 4 $r^K$ | Mean | 10.9 | 10.8 |
| | Stand. Dev. | 3.6 | 4.3 |
| | Unit Root Test | 0.03 | 0.03 |

Notes: The table displays the MacKinnon (1996) one-sided probability values of rejecting the null hypothesis that the series has a unit root (follows a random walk) when it is true. A low probability indicates a high degree of confidence that the series is stationary.

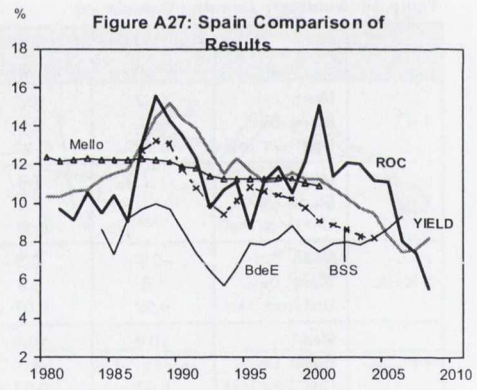
## Spain




Notes: Sample 1981-2008. Author's calculations based on national accounts data. See Section 3 for more details.




Notes: Sample 1981-2008. Author's calculations based on national accounts data. See Section 3 for more details.



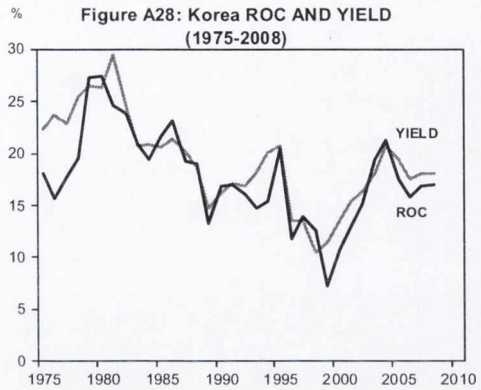

Notes: Sample 1981-2008. Author's calculations based on national accounts data. See Section 3 for more details.

**Table A9: Summary Results: Spain**

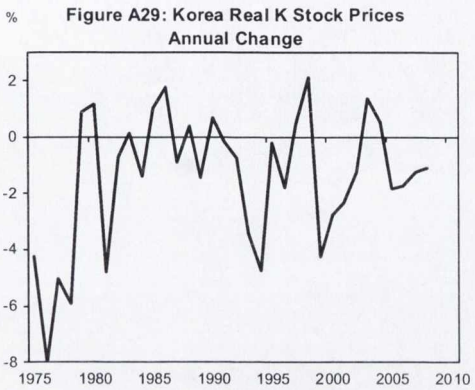
| | | Total Sample 1981-2008 | |
|---|---|---|---|
| 1 $u^K$ | Mean<br>Stand. Dev.<br>Unit Root Test | 11.2<br>2.0<br>0.66 | |
| 2 $u2^K$ | Mean<br>Stand. Dev.<br>Unit Root Test | | |
| 3 K G/L | Mean<br>Stand. Dev.<br>Unit Root Test | -0.1<br>1.7<br>0.88 | |
| 4 $r^K$ | Mean<br>Stand. Dev.<br>Unit Root Test | 11.0<br>2.1<br>0.03 | |

Notes: The table displays the MacKinnon (1996) one-sided probability values of rejecting the null hypothesis that the series has a unit root (follows a random walk) when it is true. A low probability indicates a high degree of confidence that the series is stationary.

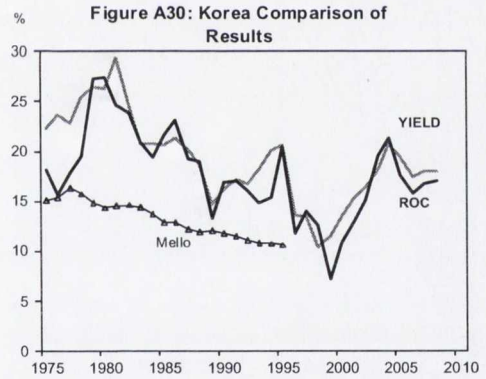
## South Korea




Notes: Sample 1975-2008. Author's calculations based on national accounts data. See Section 3 for more details.




Notes: Sample 1975-2008. Author's calculations based on national accounts data. See Section 3 for more details.




Notes: Sample 1975-2008. Author's calculations based on national accounts data. See Section 3 for more details.

**Table A10: Summary Results: Korea**

| | | Whole Sample 1975-2008 | 1981-2008 |
|---|---|---|---|
| 1 $u^K$ | Mean | 19.2 | 18.1 |
| | Stand. Dev. | 4.4 | 3.9 |
| | Unit Root Test | 0.38 | 0.33 |
| 2 $u2^K$ | Mean | 16.9 | 15.8 |
| | Stand. Dev. | 4.6 | 4.1 |
| | Unit Root Test | 0.43 | 0.24 |
| 3 K G/L | Mean | -1.5 | -1.0 |
| | Stand. Dev. | 2.4 | 1.8 |
| | Unit Root Test | 0.01 | 0.00 |
| 4 $r^K$ | Mean | 17.8 | 17.1 |
| | Stand. Dev. | 4.5 | 4.2 |
| | Unit Root Test | 0.19 | 0.17 |

Notes: The table displays the MacKinnon (1996) one-sided probability values of rejecting the null hypothesis that the series has a unit root (follows a random walk) when it is true. A low probability indicates a high degree of confidence that the series is stationary.

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# Chapter 2: The Return on Capital, the Response of Capital Flows and Convergence


## Abstract

Neo-classical theory suggests that, in the absence of full capital market integration, rates of return should be higher in poor countries than in rich ones and that, reflecting these differences, capital should flow from rich to poor countries. Since Lucas (1990) posed the question "Why doesn't capital flow from rich to poor countries?", a variety of explanations have been put forward. This paradox can be usefully split into two distinct questions: "Are rates of return higher in poor countries?" and "Do capital flows systematically respond to differences in rates of return?", and proposed explanations typically address one of these two questions. Using a new cross-country database of ex-post rates of return on capital, we find considerable and persistent differences in rates of return that are positively correlated with GDP per capita growth and negatively correlated with the level of GDP per capita, as neo-classical theory would predict. However, we find no systematic response to these differences in overall cross-country capital flows, net FDI inflows or net equity inflows. Our findings imply a 'yes' in answer to the question of whether rates of return are higher in low-income countries but a clear 'no' to the question of whether capital flows systematically respond to differences in the rates of return. This does not appear to represent a specific failure of capital to flow from rich countries with low returns to poor countries with high returns—it also represents a failure of capital to flow from rich countries with low returns to rich countries with high returns. Our findings provide evidence against the *fundamentals* explanation of Lucas's paradox. We discuss some alternative explanations for the Lucas paradox—including domestic market imperfections, the relation between savings and growth, and heterogeneity in financial market development—and find evidence of a strong link between growth and capital outflows.

**Section 1: Introduction**

Neo-classical theory suggests that, in the absence of full capital market integration, rates of return should be higher in poor countries than in rich ones and that, reflecting these differences, capital should flow from rich to poor countries. Since Lucas (1990) posed the question "Why doesn't capital flow from rich to poor countries?", various explanations have been put forward for why this does not appear to be the case. The paradox can be usefully split into two distinct questions: "Are rates of return higher in poor countries?" and "Do capital flows systematically respond to differences in the rates of return?", and proposed explanations typically address one of these two questions.

The first group of explanations refer to differences in *fundamentals* affecting the production structure of economies, which have the effect of reducing or even reversing rate of return differentials across rich and poor countries. Lucas (1990) proposes differences in human capital and externalities arising from differences in human capital (i.e., multi-factor productivity) as two such fundamental differences. Within the empirical literature, Caselli and Feyrer (2007) and Mello (2009) provide support to this group of explanations in finding that differences in rates of return between rich and poor countries are not large when measured correctly.

The second group of explanations relies on *international capital market imperfections*. Lucas (1990) suggests that badly-defined property rights in cross-border investments and monopoly control over trade in capital goods are two such imperfections (although, in his analysis, he goes on to reject these explanations). Other possibilities include a higher risk of default on poor country government debt (Gertler and Rogoff (1990)) and 'home bias' in investment related to asymmetric information (French and Poterba (1991)).

Using a new database of ex-post rates of return on capital for the 10 largest economies in the world, covering more than three-quarters of global output, and spanning more than one-quarter of a century, we find considerable and persistent differences in ex-post rates of return on capital across large and (predominantly) rich economies. The differences we find are unlikely to be due to measurement error alone: the data, which have been described in detail in Chapter 1, are based on national accounts data for the private non-financial sector (where profitability and capital stocks are most accurately measured), and have been adjusted for any differences in methodology that exist across countries. Nor can the differences be explained by the distinction between ex-post and ex-ante returns—we find evidence of predictability in

the cross-country variation of ex-post returns—or by differences in the degree of risk attached to returns.

Using panel-data analysis, we find that cross-country differences in rates of return are positively correlated with GDP per capita growth and negatively correlated with the level of GDP per capita, as neo-classical theory would predict. However, we find no systematic response of overall cross-country capital flows to these differences. Within overall capital flows, we separately consider the response of net inflows of foreign direct investment, equity investment and bond investment—the sub-components that one would expect to be most strongly 'return chasing'—but find no measurable response to differences in the return on capital here either.

Our findings imply a 'yes' in answer to the question of whether rates of return are higher in low-income countries but a strong 'no' to the question of whether capital flows systematically respond to differences in the rates of return. This is not specifically a failure of capital to flow from rich countries with low returns to poor countries with high returns. It also represents a failure of capital to flow from rich countries with low returns to rich countries with high returns. For this sub-set of rich economies, levels of human capital are broadly comparable and property rights are well-defined. In other words, the *fundamental* explanations of Lucas's paradox are largely irrelevant for this sub-set of countries. As such, our findings provide evidence against the *fundamentals* explanation of Lucas's paradox.

Although we find no evidence of a systematic response of capital flows to rate of return differentials, the pattern of responses has varied markedly across time and across countries, and there have been periods within our sample when resources have flowed to individual countries or groups of countries with relatively high returns. Asia, for instance, experienced net capital inflows in response to high rates of return from the early-1980s until the late-1990s. However, these inflows were reversed following the 1997/1998 Asian crisis. In instances where 'return chasing' capital flows have become established, it appears to be a fragile characteristic, for which investment shocks and policy changes have long-lasting consequences.

Relative to the existing empirical literature on this subject, we make two important contributions:

- The use of accurate estimates of the return on capital: Obstfeld (1995) argues that the clearest answer to Lucas's puzzle would be provided by a direct comparison of rates

of return on capital. Yet, much of the existing empirical work on this subject focuses on the relation between capital flows and growth (see, for instance, Prasad, Rajan and Subramanian (2007), Gourinchas and Jeanne (2008), Alfaro, Kalemli-Ozcan and Volosovych (2008)). While these studies produce results that are interesting in their own right, they do not directly address the question of whether the absence of capital flows is accounted for by fundamental differences or capital market imperfections. Two recent studies, by Caselli and Feyrer (2007)—C&F thereafter—and Mello (2009), have calculated 'top-down' estimates of the gross marginal product of capital, which abstract from the effects of depreciation and capital gains/losses, and which assume that some inputs into the calculation are fixed and equal across countries. Our estimates of the return on capital take account of the effects of depreciation and capital gains/losses. Moreover, while we impose a common methodology in calculating our estimates of the return on capital, we also allow for true variation in each of the inputs across time and across countries.

- A full cross-sectional and time-series analysis. The analysis of C&F is cross-sectional only, applying to a single date in time. Mello (2009) extends the work of C&F to provide a time-series dimension to his analysis. However, both studies arrange their sample into two groups of 'rich' and 'poor' countries—focusing only on the difference in marginal products of capital (MPKs) between these two groups. In doing so, they average out most of the cross-sectional variation in their samples, before concluding that the difference between MPKs in rich and poor countries were small by the end of the 1990s. This is an important limitation to their analysis, because the range of estimated MPKs obtained by both C&F and Mello is wide. C&F find that whole-economy marginal products of capital ranged from a low of 1% to a high of 17% in 2000, while Mello finds that they ranged from a low of 4% to high of 22%. The overall cross-sectional standard deviation of MPKs in 2000 is 3% for both sets of estimates. C&F conclude that MPKs are "remarkably similar" across countries. Our own view is that the difference between a real return of 1% and 17% is not trivial and that, if capital flows do not respond to such differences, this remains a puzzle worthy of explanation.[1] If such differences were uncorrelated with income levels, then one could argue that this phenomenon, while puzzling, is analytically distinct from the Lucas paradox. However, this is not what we find and, in providing

[1] By way of illustration, $100 invested at 1% over a 10-year period would yield a net gain of $10.50, while $100 invested at 17% over 10 years would provide a net gain of $380.7.

a full cross-sectional and time-series analysis of returns data, we provide a more comprehensive exploration of the subject.

The evidence that capital does not systematically flow towards countries with the highest return on capital has implications that extend beyond the issue of economic growth and convergence. There is a growing body of opinion that 'uphill' capital flows from emerging economies with high internal rates of return to developed economies with low rates of return played an important part in the formation of the 2007/2008 financial crisis. If one subscribes to the view that the 'savings glut' had an important role in the formation of the financial crisis, then understanding why capital does not flow from countries with low rates of return to countries with high rates of return is key to understanding the formation of the financial crisis itself. Indeed, the 'savings glut' that preceded the 2007/08 financial crisis can be viewed as a special case of a much wider phenomenon, with the principal difference being that the emerging markets currently progressing through a period of rapid transition (in particular, China) are much larger than the transition economies of the past. Prior to the conclusion of this paper, we explore some alternatives to the standard *fundamental* and *international capital market imperfections* explanations that may help to explain the failure of capital flows to respond systematically to differences in the return on capital.

One possibility is that the existence of *domestic* market imperfections is an important factor driving persistent differences in rates of return. When economists refer to capital market imperfections in the context of Lucas's paradox, they typically mean international capital market imperfections that stem the flow of investment from one country to the next. But it may be that domestic market imperfections—which drive a wedge between individual country returns available to 'insiders' and the risk-adjusted global rate of return that is available to 'outsiders'—are more important.[2] The difference between the social return on capital and the return on capital available to private investors has been emphasised by the development economist Dani Rodrik (2004a, 2004b). Mulligan (2002) highlights the significant differences between rates of return on physical and financial capital that exist within countries and, in the development literature, Banerjee and Duflo (2005) argue that the heterogeneity of rates of return within economies dwarfs cross-country differences. The domestic market imperfections that drive such differences can exist in product markets (for example, the protection of domestic industries via trade and investment barriers can drive a wedge between the rate of return available to domestic firms and that available to internationally-tradable capital) and in domestic capital markets (monopoly power in the

[2] Outsiders in this context do not necessarily mean foreign investors. There may also be domestic investors who are excluded from accessing the social return on capital.

provision of finance has raised returns on capital in some countries, effective subsidies on capital has lowered it in others, and investment restrictions in some countries make it difficult for external investors to avail of high returns).

Another possibility is that the explanation to Lucas's paradox lies in one of a number of factors influencing net capital flows, which reside entirely outside of the neo-classical framework. Net capital flows are the difference between savings and investment and, in the neo-classical model, the interest rate determines the equilibrium between savings and investment. However, one can identify a number of important factors—other than return differentials—that influence the balance between savings and investment:

- Demographic differences: In a world without capital, one could still have 'capital flows' between countries with heterogeneous population structures, exchanging claims on future income with the purpose of smoothing consumption (Higgins (1990)).

- Savings and growth: In Modigliani's (1970) life-cycle model, rapid growth increases the aggregate level of saving in an economy because the savings of the (relatively rich) young cohorts is greater than the dissaving of (relatively poor) old cohorts. Models with consumption persistence also result in high savings rates in fast-growing economies (Carroll and Weil (1994)). Higher saving in rapidly-growing poor economies than in slow-growing rich economies would result in capital flows that are 'uphill' from the perspective of the neo-classical model. Mankiw, Romer and Weil (1992) have shown that savings ratios are positively correlated with growth, while Prasad, Rajan and Subramanian (2007) and Gourinchas and Jeanne (2008) find a negative correlation between capital inflows and growth among developing economies. Regardless of whether this is due to higher saving leading to higher growth, or higher growth leading to higher saving, the symptom may be dominating 'return chasing' cross-country flows.

- Cross-country differences in the degree of risk aversion: Such differences could result in higher levels of precautionary saving in some economies than in others. One suggestion is that the high household saving rates of emerging economies reflect a high level of individual risk, related to health costs, retirement and the financing of education that are a result of low levels of social protection (Blanchard and Giavazzi (2005)).

- Financial heterogeneity: Caballero, Farhi and Gourinchas (2008a, 2008b) suggest that low levels of financial development in emerging economies lead emerging market investors to seek more trustworthy savings vehicles in the mature financial markets of the developed world, while Mendoza, Quadrini and Rios-Rull (2007) argue that low levels of financial development have a direct impact on savings behaviour.

The lack of response of capital flows to different rates of return may not, therefore, imply the absence of 'return chasing' flows. It could be that variations in savings behaviour across countries—driven by factors that are largely orthogonal to differences in the return on capital—are overriding the incentive to invest where returns are highest.

Although the main purpose of this paper is to consider the joint behaviour of returns on capital and capital flows, we briefly consider the effects on demographics, economic growth and financial development on net capital flows. While other studies have considered the effects of these factors individually, to our knowledge this is the first time that these (potentially competing) effects have been evaluated along side each other. We find strong evidence that higher trend growth results in capital outflows—consistent with the findings of Mankiw *et al* (1992), Prasad *et al* (2007), and Gourinchas and Jeanne (2008)—weak evidence that demographic differences play a role and no evidence that financial development is an important driver of net capital flows. That capital flows 'uphill' from high-growth to low-growth economies runs strongly counter to the predictions of the standard neo-classical model.

The issues discussed in this paper are closely related to a number of other key puzzles in international macroeconomics: the Feldstein-Horioka (1980) puzzle (the high correlation of savings and investment in developed economies); the lack of risk-sharing across countries as displayed by the low correlation in consumption growth (Backus, Kehoe, and Kydland (1992)), and the 'home bias' puzzle in portfolio investment (French and Poterba (1991)).

This paper is structured as follows. In Section 2 we set out a standard neo-classical model of economic growth with separate prices for consumption and capital goods. This model, which contains the implication that investment should flow from capital-rich countries with low returns to capital-poor countries with high returns, also provides a conceptual framework for our rate of return calculations. In Section 3 we provide a detailed discussion of the papers by C&F and Mello (2009), which are most closely related to this study. In Section 4 we describe our database. In Section 5 we set out our main empirical results, providing an assessment of

the *fundamental* and *international capital market imperfections* explanations of the Lucas paradox. In Section 6 we discuss some alternative explanations of the Lucas paradox. Finally, in Section 7, we draw some conclusions.

**Section 2: Conceptual Framework**

In this section we set out a standard neo-classical model for a small open economy. We start with a one-sector model before moving to the two-sector case, in which the relative price of final goods can vary relative to capital goods. Output is produced using capital $K$ and labour $L$ via a Cobb-Douglas production function with constant returns to scale to the aggregate production process but diminishing returns to scale to capital and labour inputs. For country $i$ in time $t$

$$Y_{it} = A_t F(K_{it}, L_{it}) = A_t K_{it}^{\alpha_{it}} L_{it}^{1-\alpha_{it}} \qquad F_K(.) > 0, F_L(.) > 0, F_{KK}(.) < 0, F_{LL}(.) < 0, \quad (1)$$

where $Y$ denotes output, $A$ denotes total factor productivity, and $\alpha$ denotes the capital share of output.

In a one-sector model, with perfectly competitive (domestic) capital markets, the rental rate (or return on) capital gross of depreciation equals the marginal product of capital[3] and is given by

$$MPK_{it} = \alpha_{it} A K_{it}^{\alpha-1} L_{it}^{1-\alpha} = \alpha_{it} \frac{Y_{it}}{K_{it}}. \qquad (2)$$

and the return on capital, net of depreciation rate, $\partial_{it}$, is given by

$$r_{it}^{K} = \alpha_{it} \frac{Y_{it}}{K_{it}} - \partial_{it}. \qquad (3)$$

Implicit within the standard one-sector neo-classical model is the assumption that final consumption goods and capital goods are indistinguishable. Household-firms face the choice of either consuming the homogenous good in period $t$ or using it in the production of that same good for consumption in period $t+1$. In order to provide for the possibility of relative price changes between final consumption goods and capital goods, we move to a two-sector model in which consumption goods are produced using capital. In this case, consider that the choice facing a household-firm in period $t$ is to consume or to invest in a unit of capital for

[3] In Chapter 1 we explicitly solved the optimisation problem for the firm to show why this is the case.

use in the production of the final consumption good. The return from this transaction is given by

$$1+r_{it}^{K}=\frac{P_{it}^{C}\left(MPK_{it}-\partial_{it}\right)}{P_{it}^{K}}+\frac{P_{it+1}^{K}P_{it}^{C}}{P_{t}^{K}P_{it+1}^{C}} \tag{4}$$

where $P_{it}^{C}$ and $P_{it}^{K}$ are the prices of a unit of the final consumption good and the capital good respectively.[4] Substituting in the marginal product of capital derived in (2) provides

$$1+r_{it}^{K}=\frac{P_{it}^{C}\left(\alpha_{it}Y_{it}-\Delta_{it}\right)}{P_{it}^{K}K_{it}}+\frac{P_{it+1}^{K}P_{it}^{C}}{P_{t}^{K}P_{it+1}^{C}} \tag{5}$$

where $\Delta_{it}$ is depreciation expressed as a flow.[5]

The first term on the right-hand side of (5) reflects the amount of the consumer good produced through the use of a unit of capital, while the second term reflects the re-sale value of the unit capital in period *t+1*. In order to make the formulation consistent with the national accounts treatment of profits, we have assumed that depreciation, $\Delta_{it}$, enters the equation via the profits term rather than affecting the re-sale value of capital. This is a plausible alternative treatment of depreciation but, more importantly for our purposes, treating depreciation as a factor that subtracts from profits rather than reduces the re-sale value of capital does not alter our return on capital estimates because we account for both elements in our calculation.

The return on capital, $r_{it}^{K}$, is given by

$$r_{it}^{K}=\frac{P_{it}^{C}\left(\alpha_{it}Y_{it}-\Delta_{it}\right)}{P_{it}^{K}K_{it}}+\frac{P_{it+1}^{K}P_{it}^{C}}{P_{t}^{K}P_{it+1}^{C}}-1 \tag{6}$$

[4] In the literature, the terms 'marginal product of capital' (MPK) and the 'return on capital' are often interchanged quite loosely. However, there are important differences between the two, particularly once one allows for variation in the price of capital relative to consumption goods. The MPK is more closely analogous to the gross yield on capital.

[5] We make a point of retaining the time and country subscripts, despite the 'clutter' that they create, because each of these variables displays time-series and cross-sectional variation. As we discuss in the next section, C&F and Mello (2009) assume that many of these inputs are equal and fixed.

Perfect capital mobility would imply the instantaneous convergence of the marginal product of capital across countries to a common steady-steady value. Hence, for countries $i$ and $j$, and for the world $w$,

$$r_{it}^{K} = r_{jt}^{K} = r_{wt}^{K} \tag{7}$$

If the accumulation of capital takes time, however, diminishing returns to capital in the production process implies that returns will be relatively low in capital-rich economies and relatively high in capital-poor economies, and that resources should therefore flow from rich to poor economies during the transition to the steady state. Indeed, under the standard assumptions of the neo-classical model set out here, investment should *only* take place in relatively poor countries until rates of return are equalised.

As discussed in the introduction, proposed explanations of the Lucas paradox have typically focused either on *fundamental* differences across rich and poor economies—which have the effect of reducing rate of return differentials—or on international capital market imperfections, which impede the flow of resources from countries with low returns to countries with high returns. Many of the proposed explanations of the Lucas paradox can be modelled through a simple departure from the standard neo-classical model.

Within the group of *fundamental* explanations, differences in human capital (Lucas (1990)), accounting for the greater importance of land and natural resources in the production function of poor countries (C&F), and differences in institutional quality (Alfaro, Kalemi-Ozcan and Volosovych (2008)), can all be modelled as a missing factor of production in the standard neo-classical framework.[6] Referring back to the one-sector neo-classical model set out in equation (1), suppose the 'true' production function is not $Y_{it} = A_t F(K_{it}, L_{it}) = A_t K_{it}^{\alpha_{it}} L_{it}^{\alpha_{it}-1}$ but actually takes the form

$$Y_{it} = A_t F(K_{it}, X_{it}, L_{it}) = A_t K_{it}^{\alpha_{it}} X_{it}^{\beta_{it}} L_{it}^{1-\alpha_{it}-\beta_{it}} \tag{8}$$

where $X$ is some third factor in the production process, used in conjunction with capital and labour, and $\beta$ is the denotes the share of $X$ in output. Then the marginal product of capital is

[6] Alfaro et al (2008) model differences in institutional quality as impacting on total factor productivity (A). However, the results are broadly similar.

$$MPK_{it} = \alpha_{it} AK_{it}^{\alpha-1} X_{it}^{\beta_{it}} L_{it}^{1-\alpha}. \quad (9)$$

and, for different levels of $X$ and $\beta$, it is no longer the case that capital flows to the country where $\alpha_{it} AK_{it}^{\alpha-1} L_{it}^{1-\alpha}$ is highest.

Explanations based on international capital market imperfections—including badly-defined property rights in cross-border investments (Lucas (1990)), a higher risk of default on poor-country government debt (Gertler and Rogoff (1990)), 'home bias' in investment related to asymmetric information (French and Poterba (1991)) and differences in the level of capital taxation (Broadbent, Schumacher, and Schels (2004)[7]—can be modelled as driving a wedge between rates of return in different countries. Rather than (7), therefore, we obtain

$$(1-\lambda_i) r_{it}^K = (1-\lambda_j) r_{jt}^K. \quad (10)$$

Within the neo-classical model, imperfect competition in domestic capital markets has the effect of invalidating the assumption that the rental rate of capital equals the marginal product of capital that underlies equation (2). Although the introduction of domestic capital market imperfections undermines a different assumption within the neo-classical model, the effect is analytically similar to the introduction of international capital market imperfections (10), in that it drives a wedge between the rates of return of different countries.

Finally, as discussed in the introduction, other potential explanations for capital not flowing from rich to poor countries assume motivations for cross-border capital flows other than 'return chasing'—such as cross-country heterogeneity in the degree of risk aversion, demographics, etc. Such explanations are not easily accommodated within the neo-classical framework because they break the fundamental principle that the equilibrium between savings and investment is determined by $r_{it}^K$.

[7] Strictly speaking, differences in the rate of capital taxation do not represent a capital market imperfection. However, the effect in driving a wedge between cross-country returns is analogous.

**Section 3: Detailed Review of Caselli and Feyrer (2007) and Mello (2009)**

Obstfeld (1995) argues that a direct comparison of rates of return on capital would provide the clearest answer to Lucas's puzzle. In recent years, there have been two studies that have compared simple whole-economy estimates of the marginal product of capital (MPK).

C&F calculate a range of estimates of the marginal product of capital across 53 developed and developing countries. Under the assumption of a constant-return production function and perfectly competitive domestic capital markets, their preferred MPK measure is given by

$$PMPKL_i = \alpha_i \frac{P_i^C Y_i}{P_i^K K_i} \qquad (11)$$

where $Y_i$ is real GDP in country *i*, $K_i$ is the real capital stock and $\alpha_i$ is the reproducible capital share of whole-economy income, $P_i^C$ the price of final consumption goods in country *i*, and $P_i^K$ is the replacement cost of capital. Estimates of the capital stock are constructed using the perpetual inventory method, assuming a constant depreciation rate of 0.06 and taking the initial capital stock, $K_0$, as $I_0/(g+\delta)$ where $I_0$ is the value of the investment series in the first year and $g$ is the average geometric growth rate for the investment series between the first year with available data and 1970. C&F's preferred MPK measure contains two key innovations: first, the authors adjust Bernanke and Gurkaynak's (2001) cross-country estimates of capital share of income, $\alpha_i$, to account for the proportion of total capital that is in land and natural resources; second, by including the terms $P_i^Y$ and $P_i^K$, the authors adjust for differences in the price of capital relative to the price of final goods across countries. Both of these adjustments have the effect of lowering estimated rates of return on reproducible capital in poor countries relative to those obtained for rich economies. This is because the proportion of total capital that is in land and natural resources is relatively large in low-income economies and the price of capital goods relative to final goods is typically higher. Based on their preferred measure of the marginal product, C&F argue that marginal products of capital are "remarkably similar", and 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 economies".

There are a number of simplifying assumptions underlying C&F's results: First, neo-classical theory implies convergence in the returns on capital (i.e., accounting for differences in

depreciation rates and anticipated capital gains/losses) rather than convergence in gross MPKs. Second, their estimates of the capital stock require two simplifying assumptions: first, that depreciation rates are equal and fixed across economies (abstracting from any variation in depreciation rates due to compositional differences in the capital stock); and, second, for their estimates of the capital stock they take as a starting assumption that initial capital stock, $K_0$, is given by the steady-state value of $I_0/(g+\delta)$ (whereas low-income economies are likely to be below the steady-state value). While national accounts-based measures of the capital stock are also calculated using a perpetual inventory method, these estimates are typically cross-checked for accuracy through the use of periodic referencing. Third, another restriction on their empirical analysis is that it applies to a single point in time.

Mello (2009) calculates a range of estimates of the marginal product of capital across 93 countries from 1970 to 2000. His measure of the MPK takes the same form as C&F's preferred measure, as set out in (11). They allow for cross-country heterogeneity in the capital-output ratio and in the relative price of capital. However, Mello assumes that the capital share of income, $\alpha_i$, is fixed and equal to 0.30 for every country and at every point in time. With MPK estimates derived on this basis, Mello concludes that "differences in the marginal product of capital were significant in the 1970s, decreased substantially in the 1980s, and were negligible in the 1990s."

The estimates of the return on capital used in our analysis are superior to those of C&F and Mello in a number of respects: First, and most obviously, we measure the actual return on capital rather than the gross marginal product of capital, thereby focusing more directly on the variable of interest. Second, while we impose a common methodology in calculating each of the inputs into our return on capital estimates, we also allow for genuine cross-country and time-series variation in these inputs. Third, in focusing on the returns to privately-held capital, we abstract from differences in whole-economy returns that arise from variations in the size, type and structure of government. Fourth, if property rights are ill-defined and profits are at risk of appropriation, then a return on capital measure based on reported profits is more likely to reflect the true return available to investors than one based on 'top-down' estimates of $\alpha$, $Y$ and $K$. Fifth, the potential for measurement error is limited by focusing on returns to the private non-financial sector, where profitability and capital stocks are most accurately measured, and using data that are sourced directly from national accounts sources. Previous studies have shied away from this route because of the difficulty in obtaining comparable data of this sort.

The one notable disadvantage of our database relative to those of C&F and Mello (2009) is that, because of the greater difficulty in deriving our return on capital estimates, we do not have the same breadth of coverage as their databases. Nevertheless, our database covers more than 75% of global GDP, so we do not view this as a critical shortcoming. A second potential disadvantage is that we do not adjust our estimates of the return on capital for the proportion of total capital that is in land and natural resources. However, in focussing on the private non-financial sector, we largely exclude the agricultural sector that gives rise to mis-measurement of MPK estimates discussed by C&F.[8]

While there are substantial differences in the methodologies underlying the respective return on capital calculations, a more fundamental difference we have with the findings of both C&F and Mello (2009) lies in how we have interpreted our results. Both studies split their sample into 'rich' and 'poor' countries, averaged out their results across these two groups and then concluded that the difference between these two averages was small. While this may be true of the averages, the differences found by C&F and Mello between individual economies are substantial. In Table 1 we provide a direct comparison of the results of C&F and Mello (2009), along with our own findings for the rate of return on capital (which we describe in more detail in Section 4). C&F's cross-sectional database is for 2000 and, in that year, there are 48 common readings with Mello.[9] The cross-sectional standard deviation across the shared sample is 3% for both studies. On C&F's preferred measure of the marginal product of capital, the estimated marginal product of capital ranges from a low of 1% (in the case of Burundi) to a high of 17% (in the case of El Salvador). Among OECD economies, the estimated marginal product of capital ranges from a low of 5% to a high of 14%. Mello (2009) finds that MPKs in 2000 ranged from a low of 2% to a high of 22%. The overlap across all three studies is limited because C&F provide a cross-sectional comparison (which does not include Germany, China or Spain), while our database provides annual data over a 28-year period but only for 10 countries. The cross-sectional standard deviations across this more limited common sample are 1% for C&F and 2% for Mello and our own results.

The cross-section variation in returns obtained by C&F and Mello (2009) are not trivial and, if capital flows are not responding to such differences, then it remains a puzzle worthy of explanation. One could argue that, if such returns were uncorrelated with income levels, then the absence of capital flows in response to such large differences—while puzzling—is

[8] Agriculture accounts for a greater share of output in poor economies and this gives rise to the mis-measurement of MPK estimates if land is not included as part of capital.
[9] Most inputs into C&F's calculation of the MPK (Y, K, Py and Pk) date from 2000 but their estimates of the capital share date from 1995. We treat C&F's data as corresponding to the year 2000.

analytically distinct from the Lucas paradox. However, we also find that differences in rates of return are negatively correlated with the level of GDP per capita.

**Section 4: Methodology and Data Sources**

Using national accounts data, we have derived a database of the return on physical capital, $r_t^K$. A detailed account of the database—including data sources for the inputs into the $r^K$ measure—is set out in Chapter 1. The database has the following main attributes: (i) It is comparable across economies; (ii) it covers the 10 largest economies in the world and more than three-quarters of the world's economy; and (iii) it covers more than a quarter of a century in every case (with significantly earlier starting dates for some economies). The economies covered in decreasing order of size are: the United States, Japan, Germany, China, UK, France, Italy, Canada, Spain and South Korea.

Although previous studies have calculated the return on capital for individual countries or small groups of countries, there is little or no pre-existing work in deriving comparable rates of return for all of the major economies. Given a broad and comparable dataset, we can combine individual country ROC results into an estimate of the global ROC for the first time.

We have taken a number of steps to ensure comparability of the ROC measures across countries. For instance, we focus on non-financial corporations where the measurement of profits and capital stocks is most accurate and we have adjusted for differences in the treatment of imputed labour income of the self-employed across countries.

The ROC measures calculated are based on data sourced directly from the ten national statistical agencies. Where official capital stock measures are not available, we have constructed our own estimates using data on investment flows, real investment prices and depreciation.

The return on capital measure, $r_t^K$, that we estimate is composed of yield on capital (net of depreciation) and the capital gain. The calculation is a discrete-time version of Equation (6) and it takes the following form:

$$r_t^K = \frac{\Pi_t}{P_{t-1}^K K_{t-1}} + \left( \frac{P_t^K P_{t-1}^C}{P_{t-1}^K P_t^C} - 1 \right) \qquad (12)$$

where $r_t^K$ is the return on capital in period *t*, $\frac{\Pi_t}{P_{t-1}^K K_{t-1}}$ is the operating surplus net of depreciation in period *t* expressed as a ratio of the nominal net capital stock at the end of period *t-1*, $P_{t-1}^K K_{t-1}$, which is given by the product of the real capital stock, $K_{t-1}$, and the capital stock (at replacement cost) deflator, $P_{t-1}^K$. $P_t^C$ is the household consumption deflator at time *t*. The first term in the RHS of equation (15) represents the net yield on capital, while the second term represents the real capital gain (loss) from holding a representative piece of capital from the start to the end of period *t*. $r_t^K$ is expressed in percentage terms.

To understand why the calculation takes this form, consider a representative household in period *t-1* facing the choice of consuming $P_{t-1}^K K_{t-1}$ or investing it in period *t*. If the household chooses to invest, it forgoes the consumption of $P_{t-1}^K K_{t-1}$. But the ex post, additional return from doing so is given by $\frac{\Pi_t}{P_{t-1}^K K_{t-1}}$, the profits in period *t* as a fraction of the capital invested in period *t-1*, plus $\frac{P_t^K P_{t-1}^C}{P_{t-1}^K P_t^C} - 1$, the fractional change in real capital prices during the period *t* (as measured by the capital stock deflator deflated by the household consumption deflator). Moving the decision on by one period, the sum that the representative household can choose to invest or consume at the end of period *t* is then given by $\left(1 + r_t^K\right) P_{t-1}^K K_{t-1}$, while the sum at the end of period *t+1* is given by $1 + r_{t+1}^K \left(\left(1 + r_t^K\right) P_{t-1}^K K_{t-1}\right)$, and so forth.

Previous studies that have compared the return on capital across countries have typically ignored the capital gain element of the return on capital calculation, reporting instead the yield on capital as being the 'return on capital'. One important innovation of this database is that we have combined the yield and the capital gain (loss) to report correctly the national-accounts-based return on capital data.

The national accounts inputs are inserted into this structure broadly as follows. The net yield on capital is given by:

$$\frac{\Pi_t}{P_{t-1}^K K_{t-1}} = \frac{NetOperatingSurplus_t^{PNFC}}{NomCapital_{t-1}^{PNFC}}$$

$$= \frac{(GVA_t^{PNFC} - L_t^{PNFC} - TP_t^{PNFC} - Kcons_t^{PNFC})}{NomCapital_{t-1}^{PNFC}} \quad (13)$$

Where $GVA$ = Gross Value Added or total resources, $L$ = total compensation of employees, $TP$ = taxes (less subsidies) on production, and $Kcons$ = capital consumption. The capital stock measure includes all physical, reproducible capital. The measure is net of past depreciation and is calculated at replacement cost. The real capital gain (loss) is calculated using the deflators for the capital stock at replacement cost and household consumption deflator, as discussed previously.

## Section 5: Empirical Results

This section is split into two parts which, loosely speaking, address each of the two aspects of Lucas's paradox. In 5.A, we consider whether cross-country differences in returns on capital have been substantial and whether returns are higher in low-income than in high-income countries. We do so in the context of a broader exploration of the determinants of variation in the return on capital, both within and across economies. In 5.B, we consider whether capital flows have been responsive to differences in rates of return.

### 5.A The characteristics and determinants of cross-country and within-country variation in the return on capital

In 5.A.1, we consider whether the cross-country differences in the return on capital have been substantial, whether those differences have been predictable and whether they can be explained by variation in risk. In 5.A.2, we consider the extent to which rates of return have converged over time. In 5.A.3, we consider the relation between the return on capital and explanatory variables provided by neo-classical theory.

#### *5.A.1 Observable characteristics of cross-country variation in the return on capital*

In Table 2, we set out some summary results for our return on capital measure, $r^K$ , for each country from 1981 and 2008. In Column 1, we display the average return for each country over this 28-year period; in Column 2, the mean difference with the global capital-stock-weighted rate of return and, in Column 3, the ranking of the mean returns. We find that the cross-country variation in mean returns was substantial, from a high of 17% for South Korea to a low of 9% for France.[10] Even geographically-neighbouring countries saw substantially different rates of return: France's return on capital averaged 4% less than Italy's over the 28-year sample. A trend-cycle decomposition of the data (results not shown) suggests that the differences in rates of return across countries are not due to differences in the business cycle or caused by other sources of idiosyncratic volatility.[11]

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[10] It is not possible to determine formally whether the observed cross-country variation in rates of return is significant, in the statistical sense, as there is nothing against which to judge their significance other than their own distributions.

[11] We filtered the $r^K$ series with a Hodrick-Prescott (1997) filter, using the suggested $\lambda$ parameter values for annual data. We found that, stripping out the idiosyncratic volatility, substantial differences remain in Hodrick-Prescott filtered rates of return.

Exchange rate fluctuations matter for investors, with interest rate parity implying convergence in (ex ante) rates of return only once expected exchange rate fluctuations are also taken into account. In Column 4 of Table 2, we set out average US-Dollar-denominated returns from 1981 to 2008 and, in Figure 1, we compare mean returns in both US-Dollar and local-currency terms. The currency denomination creates important differences in some cases: Japanese returns have been significantly higher in US-Dollar terms than in local-currency terms, for instance, while Chinese returns have been significantly lower. Taken together, however, the difference in mean returns across countries (as measured by the cross-sectional standard deviation) is higher in US-Dollar terms than in local-currency terms.

Although exchange rate effects matter for investors, the majority of our empirical work focuses on each country's own rate of return for two reasons:

- The causes of exchange rate fluctuations appear to be orthogonal to the factors driving each country's own rate of return. In Column 5 of Table 2 we display the pair-wise correlations between the own-country rate of return relative to the US, $ROC1_{it} - ROC_{USt}$, and annual change in the real exchange rate versus the US from 1981 and 2008. In five cases there has been a positive correlation, in four cases a negative correlation, and, considering all countries together, the correlation coefficient between relative returns and exchange rate moves was +0.04 and not significant.

- Exchange rate fluctuations are difficult to predict (see, for instance, Meese and Rogoff (1983)). By contrast, differences in rates of return on capital across countries have been highly persistent.

Can the differences in each country's own rate of return be explained by variations in risk? In a standard representative-agent asset-pricing model with constant-relative risk aversion (CRRA) preferences, the risk premium for an asset depends on the covariance of the asset's returns with the marginal utility of consumption (Lucas (1978)). Such a comparison is beyond the scope of this paper but, in Column 6 of Table 2, we display the volatility of returns as measured by their standard deviation over the sample. Figure 2 plots the mean results for $r^K$ against their respective standard deviations. A loose positive relation exists between the mean and the volatility of returns, as theory would imply, but the relation is not significant (the t-statistic for the coefficient on the standard deviation based on 10 observations is 1.38). If

exchange rate effects are also taken into account, the positive relation between mean and standard deviation disappears entirely (see Figure 3).

While differences in ex-post returns do not appear to be correlated with risk within the sample, it is difficult to exclude the possibility that investors require a higher ex ante rate of return to compensate for the risk of significant events that occur infrequently. This is the so-called 'Peso problem' (see, for instance, Rietz (1988)), presented by differences in rates of return that appear unjustified over the duration of the sample but only because the risk insured against does not occur within the sample. However, the sample spans 28 years—a period that included a wide range of substantial shocks, from the break-up of the Soviet Union to the Asian crisis and the rise (and fall) of the tech bubble, and the 2007/2008 financial crisis. With such large cross-sectional variation in mean returns, which are unrelated to the volatility of returns over a 28-year period, it is difficult to anticipate the type or magnitude of out-of-sample shock that would justify such large country-specific premia.[12]

With fully-open capital markets, neo-classical theory only implies convergence in expected, risk-adjusted returns. Ex-post returns can continue to differ as a result of stochastic gains and losses. In order to draw conclusions from observed differences in actual returns, it is necessary to infer that these differences were in some sense predictable. To explore this issue, suppose the difference between the rate of return in country $i$ and the global rate of return is given by the AR1 process

$$(r_{it}^K - r_{wt}^K) = c + \phi(r_{it-1}^K - r_{wt-1}^K) + \varepsilon_t \qquad (14)$$

and let us assume, for now, that the adjustment cost of changing the capital stock is zero. If cross-country differences in returns on capital are unpredictable and the adjustment costs are zero, then the difference in period $t$ should be unrelated to the difference in period $t$-$1$ (implying that the coefficient $\phi$ is zero) and the series should fluctuate around zero (implying that the constant $c$ is also zero). In other words, if the differences in rates of return are unpredictable, $r_{it}^K - r_{wt}^K$ should simply be white noise. To test the hypothesis that cross-country differences in the return on capital represent white noise, in Table 3 we provide panel

[12] We do not claim that a sample of 28 years is sufficiently long to preclude the effect that a 'once in a lifetime' catastrophic event—giving (say) a return of -75% in a year—might have on the return demanded of risky assets taken as a whole. One only needs a small Poisson probability of such an event to have (a) a significant effect on ex ante returns but (b) less than a 50% chance of occurring even over 28 years. Rather, our point is that it seems difficult to rationalise how the possibility of such events might explain such large cross-country *differences* in rates of return.

estimation results for the $r^K$ difference in period $t$ regressed on the difference in period $t$-$1$ and a constant. We find that the coefficient on the lagged dependent variable is 0.79 and highly significant.[13] Such a high degree of persistence in cross-country differences seems unlikely to be due only to the existence of adjustment costs in capital.

*5.A.2 Have rates of return converged over time?*

To what extent has there been sigma convergence—a decline in the cross-sectional standard deviation of rates of return on capital—over time? Figure 4 displays the cross-sectional standard deviations of both the yield on capital and the rate of return on capital from 1981 to 2008. Interestingly, there appears to have been considerable sigma convergence during the 1980s and the 1990s, consistent with the findings of Mello (2009). Since the early part of this century, however, the trend towards sigma convergence appears to have been reversed.[14]

What role has exchange rate uncertainty played in the cross-country variation in returns? Although we found that the incorporation of exchange rate fluctuations could not explain the observed differences in returns on capital, eliminating the costs and uncertainties related to foreign exchange might still result in the convergence of returns. The creation of EMU in 1999, which effectively eliminated exchange rate uncertainty between the member states, provides an interesting natural experiment in this regard. Four of the countries within the 10-country sample are the four largest members of EMU (Germany, France, Italy and Spain). Figure 5 compares the sigma convergence for these four countries and for the six non-EMU countries within the sample, indicating no break in the relation. More formally, we tested for a structural break in 1999 through the use of a Chow breakpoint test (results not shown). We found no evidence that EMU resulted in sigma convergence amongst member states in the ten years since 1999.[15]

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[13] We have also carried out the same test for each country individually. We found that the coefficient $\phi$ is significant at the 1% threshold for $r^K$ differences for eight of the 10 countries. The two exceptions were Germany and Spain (for which $\phi$ is significant at the 10% level). While the coefficient $\phi$ is not significantly different than zero for the series of German returns, the estimated constant is significantly negative (at the 5% threshold).

[14] This development has also coincided with an increase in the global equity risk premium—a development we discuss in Chapter 3. The hypothesis that we put forward in that chapter is that these developments are related.

[15] We first ran a simple OLS regression, from 1981 to 2008, using the times series of the cross-sectional standard deviation of EMU4 returns as the dependent variable and the cross-sectional standard deviation of non-EMU returns and a constant as the independent variables. Having first checked that the residuals in this regression performed satisfactorily, we then performed a Chow breakpoint test for a structural break in the estimated relation in 1999. We failed to reject the null hypothesis of no structural break in 1999.

*5.A.3 The relation between rates of return and explanatory variables suggested by neo-classical theory*

Table 4 displays the results of a series of panel-data estimations of the relation between the return on capital, $r^K$, and a selection of explanatory variables provided by neo-classical theory.[16] In Regression 4.1 the return on capital ($r^K$) is the dependent variable, with annual GDP growth, a constant and the lagged dependent included as regressors—we include a lagged dependent variable in each of these regressions as there is significant evidence of serial correlation in its absence. We find a significant positive relation between rates of return and GDP growth, with an estimated long-run coefficient of 1.0.

In the Regression 4.2, we break GDP growth down into changes in GDP per capita and changes in population. We find a strong positive relation between rates of return and GDP per capita growth, this time with a long-run coefficient of 1.2, and a negative estimated coefficient on population growth that is significant at the 5 percent threshold. We have experimented with various lag/lead structures between rates of return and GDP per capita growth. We find a significant relation between rates of return, current GDP per capita growth and GDP per capita growth lagged by one year (results not shown), but no significant relation between $r^K$ and various leads of GDP per capita growth. In a Granger Causality Test, we find that GDP per capita growth Granger-Causes $r^K$ but $r^K$ does not Granger-Cause GDP per capita growth.

Turning to the relation between the return on capital and the level of income, in Figure 6 we plot average rates of return against average GDP per capita levels, with the latter based on PPP exchange rates and expressed as a percentage of US GDP per capita (Conference Board and Groningen Growth and Development Centre (2008)). A negative relation exists between rates of return and GDP per capita levels, consistent with the standard theoretical prediction, but the relation between average returns and average levels of GDP per capita is weak. More formally, in Regression 4.3 we regress the return on capital on the level of GDP per capita in a panel-data estimation. We obtain a negative relation between rates of return and the (relative) level of GDP per capita that is significant at the 10% threshold. Every 10 percentage point convergence with US GDP per capita results, all else equal, in a 0.4 percentage point decline in the return on capital.

[16] As discussed in Section 2, neo-classical theory predicts that, in the case of full capital market integration, ex ante, risk-adjusted returns should converge. However, away from the steady-state, neo-classical theory suggests that differences in these factors can result in cross-country differences in returns.

To test the hypothesis that there are decreasing marginal returns on capital at a whole-economy level, in Regression 4.4 we regress the return on capital on the level of the capital-to-output ratio, the lagged dependent variable and a constant. We do not find a significant relation between the return on capital and the capital-to-output ratio (the estimated coefficient is marginally negative but not significant), suggesting that decreasing marginal returns to capital are limited or non-existent at a whole economy level.

Finally, in Regression 4.5, we include each of the variables together.[17] The coefficients on GDP per capita and population growth have the same sign as previously, with a larger magnitude and are both highly significant. However, the coefficient on the level of GDP per capita is now positive rather than negative. Our interpretation of this result is that, while poor countries tend to have higher returns on capital, they also tend to be relatively fast growing and this is the principal driver of their relatively high returns.

In these estimations we are interested in gauging the structural effects of the selected variables on the return on capital. However, in using annual data, the estimated coefficients may be distorted by cyclical effects. Therefore, in Table 5 we repeat the panel least squares regressions contained in Table 4 but using 5-year averages of the variables rather than annual data. Once again we have included a lagged dependent variable in each of these regressions because of evidence of serial correlation in its absence. Regression 5.1 estimates the relation between the return on capital and GDP. The estimated long-run coefficient on GDP growth using five-year average data drops from 1.0 to 0.6. With fixed adjustment costs in capital and labour, profitability tends to be cyclical and so it is not surprising that the estimated coefficient on growth falls in this way.

In Regression 5.2, we obtain a long-run coefficient on GDP per capita growth of 0.8 and a long-run coefficient on population growth of -2.1. In Regressions 5.3 and 5.4, the estimated coefficients on the level of GDP per capita and the capital-output ratio are negative but not significant. In Regression 5.5 we include each of the variables together. The signs of the coefficients are the same as previously estimated but fail to be significant.

[17] Note that Regressions 4.4 and 4.5 have a slightly smaller sample, so the results are not completely comparable to Regressions 4.1-4.3.

**5.B. Do capital flows respond to differences in rates of return across countries?**

In this section we consider the joint behaviour of returns and capital flows. We consider whether aggregate capital flows have been responsive to differences in the return on capital. We also consider the behaviour of the sub-components for FDI, equity and bond flows.

Standard neo-classical theory implies that capital flows should respond to differences in rates of return, with countries with relatively low rates of return exporting capital to countries with relatively high rates of return. In other words, there should be a negative correlation between rate differentials and current account balances. In Figure 7, we plot the mean difference between country *i*'s rate of return and the global rate of return (based on the $r^K$ measure for the years 1981-2008) against the mean current account positions (expressed as a percentage of GDP). In contrast to the standard theoretical prediction, the data imply a small positive correlation (suggesting that capital has flowed out of economies with relatively high returns into countries with relatively low returns), although the relation between these cross-sectional averages is not significant.

More formally, in Table 6 we explore the relation between capital inflows and relative rates of return by running a series of panel least squares regressions. In each of these regressions we have include a lagged dependent variable because capital flows tend to be persistent: without the lagged dependent variable, the Durbin-Watson statistics imply significant positive serial correlation in the residuals. In 6.1 we regress aggregate capital inflows (the negative of the current account balance) on the difference between the return on capital in country *i* and the global return on capital, along with the lagged dependent variable and a constant. Based on data for 10 countries and across 28 years, the estimated coefficient on the return on capital differential is negative—i.e., the opposite of what neo-classical theory would imply—but not significant. The absence of a significant relation is robust to different lag structures in the rate of return differential and across time (splitting the 1981-2008 sample into two 14-year periods, we find no significant relation in either period). In a Granger-Causality test (with two lags included), we cannot reject the hypothesis that rates of return differentials do not Granger-cause capital flows, but we do reject the hypothesis that capital flows do not Granger-cause rates of return differentials (at a 1% level of significance), suggesting that Granger causality runs from capital flows to rates of return differentials.

In individual country regressions of capital inflows on return differentials, the estimated relation is negative and significant for Canada (at the 1% threshold) and positive and

significant for the US (at the 5% threshold). For all other economies the estimated relation is not significant.

There are components within the capital and financial accounts of the balance of payments for which theory provides no *a priori* expectation of a response to return differentials. Examples include migrants' transfers, debt forgiveness within the capital account and changes in reserve assets within the financial account. By contrast, there is a stronger theoretical prior that foreign direct investment, net equity investment and net bond investment should respond systematically to differences in the return on capital. In Figure 8 we plot the mean return on capital differential against net FDI inflows (note that the prior here is that the slope of this relation 'should' be the opposite of Figure 7 because this is a measure of inflows but a current account surplus implies a capital outflow). The relation between these cross-sectional averages is not significant. In Regression 6.2, we regress net FDI flows as a percentage of GDP on the difference between the rate of return in country *i* and the global rate of return, the lagged dependent variable and a constant. The estimated coefficient on return differentials is essentially zero. This absence of a significant relation is robust to different lag structures. Splitting our sample into two 14-year periods, we also find no significant relation between net FDI and rate of return differentials from 1981 and 1994 and between 1995 and 2008 (results not shown). On a country-by-country basis, we obtain a significant *negative* relation between FDI inflows and the difference between country *i* and the global return on capital for the UK (at the 10% threshold). For all other countries within our sample, the relation is not significant.

One factor that may be counteracting 'return chasing' in FDI flows is the documented link between companies' cash flow and investment (see, for example, Young (1993)). As a result of the additional cost and limited availability of external finance compared with internal finance, profitable firms with strong cash flows tend to invest more at home and abroad which, all else equal, results in a negative correlation between country *i*'s returns and net FDI into country *i*. The absence of a significant relation between net FDI flows to rate of return differentials across the sample as a whole could be the net outcome of offsetting cash flow and 'return chasing' effects.

We then consider the relation between net equity investment and rates of return differentials. Figure 9 plots the mean difference between country *i*'s rate of return and the global rate of return against mean net equity inflows. The data imply a small positive correlation between average net equity inflows and average return differentials—consistent with standard theoretical prediction—but the relation is not significant. In Regression 6.3 we regress net

inward investment in equities on rates of return differentials, the lagged dependent variable and a constant.[18] This panel least squares regression implies a small but insignificant negative relation.[19]

In Regression 6.4 we regress net inward investment in debt instruments as a percentage of GDP on return differentials. Once again, the estimated coefficient on return differentials is close to zero.

Finally, in Regression 6.5, in order to check that our results are not being distorted by cyclical effects, we re-run Regression 6.1 using 5-yearly averages rather than annual data. The results are very similar, with an estimated coefficient on return differentials that is negative but not significant. We have carried out comparable estimations for FDI, equity investment and bond investment, with very similar results (results not shown).

In summation, we find that net capital flows appear to be largely orthogonal to differences in the return on capital. This is true of aggregate capital flows and also of the sub-components—FDI, equity investment and bond investment—which neo-classical theory provides the strongest *a priori* prediction of a response.

[18] We do not have a full sample for this regression, as some countries only report limited data on net equity flows. In particular, there are only four annual readings for net equity investment into China.

[19] Bohn and Tesar (1996) investigated whether US overseas equity investment have been driven by 'return chasing' or 'portfolio rebalancing' using monthly data on US portfolio flows, rejecting the portfolio rebalancing explanation but finding "only partial support for the return-chasing hypothesis" (page 80, paragraph 2). The authors separated US net purchases of foreign equities into a component driven by portfolio rebalancing and a component driven by other factors (including 'return chasing'), and found that US net purchases of equity in country *i* are significantly positively correlated with country *i*'s local capital gains in seven of 22 countries and significantly negatively correlated in none. Regressing US net purchases of equity in country *i* on forecasts of local excess returns based on lagged prediction variables, Bohn and Tesar (1996) obtained a significant positive relation in seven of 22 countries and a significant negative relation in only one. Froot, O'Connell and Seasholes (2001), using daily data on cross-country investment flows, find that net equity flows are strongly influenced by past returns. Our results are not directly comparable with either Bohn and Tesar's (1996) or Froot *et al* (2001) because (1) we consider the response of net equity flows to the return on capital (rather than the return on equity investments); (2) we consider flows across a matrix of countries rather than just considering the allocation of US portfolio flows; and (3) because we have used much lower frequency data. Nevertheless, our results are less supportive of the return chasing hypothesis.

## Section 6: Alternative Explanations for the Lucas Paradox

In this section we discuss some alternative explanations to Lucas's paradox—i.e., other than *fundamentals* and international capital market imperfections. At the end of this section we present a brief empirical evaluation of some these competing explanations.

### *6.A. The role of imperfections in domestic product and labour markets*

The literature on the Lucas paradox, starting with Lucas (1990) himself, focus on the role of international capital market imperfections in causing the paradox. But another possibility is that the market failures exist at a domestic rather than cross-border level. Such failures are domestic in the sense that they drive a wedge between the rates of return available to different groups within an economy rather than simply driving a wedge between the return available to domestic and non-domestic investors—in other words the 'outsiders', who cannot access the social return on capital, are just as likely to be domestic as much as external investors. In the development literature, Banerjee and Duflo (2005) argue that there is enormous heterogeneity of rates of return within a single economy and that this heterogeneity dwarves cross-country differences in returns.

Domestic imperfections can exist in product and capital markets and take a wide range of different forms. Our empirical analysis of how important they have been in driving cross-country differences in returns is limited by this fact, as it is difficult to select one or more variables that would capture the many forms that domestic frictions can take. In this section we discuss some of these distortions and provide examples of economies that appear to have been affected in this way.[20] However, we leave an evaluation of how important they have been in distorting cross-country capital flows to future research.

The protection of domestic industries from competition can result in oligopolist pricing behaviour by domestic incumbents, lowering the capital-to-output ratio, lowering GDP per capita and driving a wedge between individual country returns and the risk-adjusted global rate of return. The protection need not take the form of a simple trade tariff, other possibilities include product market regulations that incumbents to restrictive shopping hours and planning regulations that discourage investment in overseas supply chains. If the protection only applies to domestically-based industries regardless of their ownership, then its effect on return

[20] An additional complication is that some distortions will result in a level shift in the rate of return (implying a permanent differential with no capital flow response), while others may be circumvented over time, resulting in a temporary effect on returns.

on capital differentials can be circumvented through domestic investment or foreign investment in domestically-based firms. However, certain protections may simply favour the incumbent against all newcomers and go hand-in-hand with restrictions on overseas acquisition of the incumbent. If it is implemented effectively, the protection can result in permanently higher rates of returns without capital inflows in response. Within our sample, Italy is often thought of as an economy in which domestic industries are protected in this way.[21]

Excluded markets. Investors may be unable to take advantage of a higher rate of return in one country if restrictions are placed on the ownership of firms. Foreign investment can be excluded or heavily restricted and domestic investment may also be restricted in certain markets. Such restrictions present an insider-outsider outcome, in which the social rate of return is not available to all private investors. China is one example in this regard, as it places restrictions on foreign ownership, making it difficult for overseas investors (and some domestic investors) to take advantage of relatively high returns. This could help to explain why China has both high returns and large capital outflows (Rodrik (2004a, 2004b)).

A state-funded subsidy on investment, although not strictly a capital market imperfection, can have an analytically similar impact on a country's rate of return, raising the capital-to-output ratio, raising GDP per capita (although potentially lowering consumption per capita through the cost of funding the subsidy), and driving a wedge between individual country returns and the risk-adjusted global rate of return. Broadbent, Schumacher and Schels (2004) argue that Germany's low rates of return on capital prior to the start of EMU reflected an effective subsidy on the cost of debt that existed via the state-owned lending institutions (Sparkassen and Landesbanken), for whom investment support rather than profit maximisation was the overriding objective. EU competition policy effectively brought an end to this subsidy, resulting in a period of low investment and rising rates of return in Germany.

Oligopolistic pricing behaviour of banks. One consequence of the investment subsidies administered through Germany's Sparkassen and Landesbanken was that German commercial banks earned unusually low rates of return during this period. Similarly, unusually high rates of return in the banking sector could be indicative of an unusually high cost of finance, raising the hurdle rate for investment decisions and pushing up rates of return in process. The UK is

[21] According to analysis conducted by the OECD, Italy has had the highest level of product market regulation within our sample (Conway et al (2005)).

an example of an economy that combines high costs of finance, a high level of return on equity in the banking sector, and unusually high rates of return on capital.[22]

*6.B. Other Explanations for the Lucas Paradox*

Another possibility is that the explanation to Lucas's paradox lies in one of a number of factors influencing net capital flows that reside entirely outside of the neo-classical framework. Net capital flows are the difference between savings and investment and, in the neo-classical model, the interest rate determines the equilibrium between the two. However, one can identify a number of other factors that might influence the balance between savings and investment. It could be that variations in savings behaviour across countries—driven by factors that are largely unrelated to differences in the return on capital—are overriding the incentive to invest where returns are highest.

- Higgins (1990) argues that demographic differences are an important driver of capital flows, as economies with a relatively high proportion of the population of working age save more than those with a high dependency ratio.

- In Modigliani's (1970) life-cycle model, rapid growth increases the aggregate level of saving in an economy because the savings of the (relatively rich) young cohorts is greater than the dissaving of (relatively poor) old cohorts. Mankiw, Romer and Weil (1992) have shown that savings ratios are positively correlated with growth, while Prasad, Rajan, and Subramanian (2007) and Gourinchas and Jeanne (2008) find a negative correlation between capital inflows and growth. Higher saving in rapidly-growing poor economies than in slow-growing rich economies would result in capital flows that are 'uphill' from the perspective of the neo-classical model (regardless of whether the causation flows from higher growth to higher saving or the other way around).

[22] While margins on residential lending in the UK were generally considered to be very low (prior to the 2007/2008 financial crisis), the same has not been true of commercial lending. A UK Competition Commission report on the supply of banking services to small and medium-sized enterprises concluded that "(In SME banking) the restriction and distortion in price competition in our view has led to excessive prices and profits. The current profits of the clearing banks on services to SMEs are over £2 billion a year and the average return on equity between 1998 and 2000 is 36 per cent compared with an estimated cost of equity of about 15 per cent." (2002, Page 4, Para 1.7). Strictly speaking, this capital market imperfection can be classified as an international capital market imperfection, as firms could circumvent the problem with easier access to overseas financing.

- Caballero, Farhi and Gourinchas (2008a, 2008b) suggest that low levels of financial development in emerging economies lead emerging market investors to seek more trustworthy savings vehicles in the mature financial markets of the developed world, while Mendoza, Quadrini, and Rios-Rull (2007) argue that low levels of financial development have a direct impact on savings behaviour.

- Blanchard and Giavazzi (2005) argue that high household saving rates of China and other emerging economies reflect a high level of individual risk, related to health costs, retirement, and the financing of education. Cross-country differences in the degree of risk aversion could result in higher levels precautionary saving in some economies than in others.

The first three factors can be measured directly and thus lend themselves to empirical analysis. As a measure of demographic cross-country heterogeneity, we use the difference between the working age population (15-65) as a share of the total population in country *i* relative to the (GDP-weighted) global average of the same ratio. To gauge the effect of growth on capital flows, we use a (Hodrick-Precott) trend of GDP per capita growth relative to the global equivalent. We use trend growth rather than annual growth in order to reduce the effect of domestic demand fluctuations on both growth and the current account. For financial development, we follow Mendoza *et al* (2007) in using the difference in the ratio of private-sector lending to GDP in country *i* relative to the global average. The fourth factor—cross-country heterogeneity in risk aversion—is one that we discuss in Chapter 3.

In Table 7 we present panel-data analysis of the relation between capital inflows and each of these variables. As with the estimations set out in the previous section, we have included a lagged dependent variable in each of the regressions to address evidence of serial correlation in the residuals. In 7.1 we regress aggregate capital inflows on the working-age ratio differential, the lagged dependent variable and a constant. The estimated coefficient on the demographics variable is negative—implying net capital outflows when a relatively high proportion of the population is of working age—but just fails to be significant at the 10% threshold. In 7.2, the estimated coefficient on trend growth is negative and significant. The magnitude of the coefficient suggests that every one percent difference in trend growth is matched one-for-one by a 1% of GDP increase in capital outflows in the long-run. In 7.3, the estimated coefficient on this measure of financial development is close to zero. In Regression 7.4 we include each of these variables along with the return on capital differential. We find that the estimated coefficient on trend growth is negative and significant (at the 10% threshold), that the coefficient on the demographics variable is negative but not significant

and we find no role for either relative financial developed or the return on capital differential in driving net capital flows. In 7.5, we regress capital inflows on trend growth and demographics and in 7.6 we repeat this regression using five-year average data. In both cases, we find strong evidence that higher trend per capita growth results in capital outflows (consistent with the findings of Mankiw *et al* (1992), Prasad *et al* (2007) and Gourinchas and Jeanne (2008)) and weak evidence that a relatively high working age ratio results in capital outflows.

**Section 7: Conclusion**

We find that differences in rates of return on capital across large economies have been substantial and predictable. As neo-classical theory predicts, these rate of return differentials have been positively related to GDP per capita growth and to volatility (which we use as a simple proxy for risk), and negatively related to relative levels of GDP per capita. However, the sensitivity to the *level* of GDP per capita is not large.

We find no systematic or consistent relation between rates of return and capital flows, either across countries or across time. Within the breakdown of the capital and financial accounts, we also find that net FDI inflows, net equity investment and net bond investment are unresponsive to return differentials.

Lucas's (1990) question "Why doesn't capital flow from rich to poor countries?" can be split into two distinct questions: "Are rates of return higher in poor countries?" and "Do capital flows systematically respond to differences in the rates of return?". Our results imply a 'yes' in response to the first of these questions and a clear 'no' to the second question.

This is not specifically a failure of capital to flow from rich countries with low returns to poor countries with high returns. It also represents a failure of capital to flow from rich economies with low returns to rich economies with high returns. For this sub-set of economies, levels of human capital are broadly comparable and property rights are well-defined. In other words, the *fundamental* explanations of Lucas's paradox are largely irrelevant. As such, our findings strong provide evidence against this group of explanations of Lucas's paradox.

In Section 6 we discussed some alternative explanations of the Lucas paradox, including domestic capital market imperfections, demographic differences, the interaction between savings behaviour and economic growth and heterogeneity in the degree of financial development. Our empirical analysis of the role played by domestic frictions in distorting capital is restricted by the wide range of forms which such frictions can take and the difficulty in obtaining a measure that would capture some or all these effects. We briefly consider the competing claims of the effects on demographics, economic growth and financial development on net capital flows. We find strong evidence that higher trend growth results in capital outflows, consistent with the findings of Mankiw *et al* (1992), Prasad *et al* (2007) and Gourinchas and Jeanne (2008). High saving in fast-growing economies—irrespective of whether the causation flows from savings to growth or growth to savings—runs strongly counter to the predictions of the standard neo-classical model.

Table 1: Comparison of cross-sectional return on capital results

| | Caselli and Feyrer (2007) | Mello (2009) | Daly (2009) |
|---|---|---|---|
| Measure | PMPKL | PMPK | $r^K$ |
| Year | 2000[1] | 2000 | 2000 |
| Mean (48 countries) | 7.6% | 12.3% | - |
| Standard Deviation (48 Countries) | 3.1% | 2.6% | - |
| US | 9.0% | 15.4% | 10.6% |
| Japan | 8.0% | 9.2% | 9.0% |
| Germany | - | - | 9.9% |
| China | - | 12.2% | 10.4% |
| UK | 9.0% | 15.0% | 15.5% |
| France | 8.0% | 12.0% | 10.9% |
| Italy | 8.0% | 11.6% | 14.0% |
| Canada | 7.0% | 14.1% | 13.9% |
| Spain | | 10.9% | 15.0% |
| Korea | 10.0% | 10.6% | 10.7% |
| Mean (7 countries) | 8.4% | 12.3% | 12.0% |
| Standard Deviation (7 countries)[2] | 1.0% | 2.4% | 2.4% |

Notes: [1] Caselli and Feyrer (2007) provide a cross-section of estimates of the MPK. Most inputs (Y, K, Py and Pk) in this calculation date from 2000 but their estimates of the capital share date from 1995. We treat Caselli and Feyrer's data as corresponding to the year 2000; [2] The standard deviation calculation only includes countries for which data is available across all three measures.

Table 2: Summary results for the return on capital ($r^K$), 1981-2008

| | (Arith) Mean return 1 | Diff. with Global (Mean) 2 | Rank of Col 1 (High to Low) 3 | Mean return (US Dollar) 4 | Correlation coeff. Ri-Rus, ExRate[1] 5 | Standard deviation of returns 6 | Rank of Col 6 (Low to High) 7 |
|---|---|---|---|---|---|---|---|
| US | 10.4 | -0.2 | 8 | 10.4 | NA | 2.5 | 3 |
| Japan | 11.9 | 1.2 | 4 | 15.3 | 0.17 | 3.4 | 6 |
| Germany | 8.9 | -1.8 | 9 | 10.6 | 0.41 | 2.7 | 4 |
| China | 11.7 | 1.0 | 5 | 6.8 | -0.11 | 5.5 | 10 |
| UK | 12.5 | 1.8 | 3 | 12.0 | 0.17 | 4.0 | 8 |
| France | 8.5 | -2.2 | 10 | 9.0 | 0.41 | 2.7 | 5 |
| Italy | 12.6 | 1.9 | 2 | 11.7 | -0.07 | 1.9 | 1 |
| Canada | 10.9 | 0.2 | 7 | 11.3 | 0.12 | 3.6 | 7 |
| Spain | 11.2 | 0.4 | 6 | 10.1 | -0.05 | 2.1 | 2 |
| Korea | 17.1 | 6.4 | 1 | 15.5 | -0.15 | 4.2 | 9 |
| Whole sample | 10.7 | | | | 0.04 | 1.8 | |

Notes: [1] Column 5 displays the pair wise correlations between the own-country rate of return relative to the US and the annual change in the real exchange rate versus the US from 1981 and 2008.

Table 3: Panel least squares regression results for persistence in cross-country differences

Dependent variable is ($r^K i - r^K w$), 1981-2008

| | (1) |
|---|---|
| Constant | 0.17 |
| | (1.23) |
| ($r^K i - r^K w$) | 0.79 |
| | (22.13)*** |
| Adj R2 | 0.64 |
| N | 270 |
| DW | 2.03 |

Notes: Total panel (balanced) observations before adjustments = 280. T-statistics in parentheses. ***, **, * denote significance at the 1, 5 and 10 percent levels respectively. DW stands for Durbin-Watson statistic.

Table 4: Panel least squares regression results for return on capital

Dependent variable is ROC, 1981-2008

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| Constant | 2.23<br>(5.28)*** | 2.65<br>(6.11)*** | 3.5<br>(5.23)*** | 3.7<br>(3.65)*** | -0.2<br>(-0.09) |
| ROC(-1) | 0.73<br>(20.61)*** | 0.73<br>(21.02)*** | 0.77<br>(20.77)*** | 0.70<br>(13.03)*** | 0.71<br>(14.9)*** |
| DY | 0.28<br>(5.99)*** | | | | |
| DY_PC | | 0.33<br>(6.89)*** | | | 0.58<br>(6.70)*** |
| DPOP | | -0.68<br>(-2.33)** | | | -0.99<br>(-2.74)*** |
| YPC | | | -0.01<br>(-1.74)* | | 0.04<br>(2.96)*** |
| K/Y | | | | 0.00<br>(-0.45) | 0.00<br>(-0.02) |
| Adj R2 | 0.67 | 0.69 | 0.63 | 0.49 | 0.60 |
| N | 270 | 270 | 270 | 177 | 177 |
| DW | 1.90 | 1.97 | 1.92 | 1.75 | 1.84 |

Notes: Total panel (balanced) observations before adjustments = 280. T-statistics in parentheses. ***, **, * denote significance at the 1, 5 and 10 percent levels respectively. DY is the annual change in real GDP. DY_PC is the annual change in GDP per capita. DPOP is the annual change in population. YPC is the level of GDP per capita. K/Y is the capital-output ratio. DW stands for Durbin-Watson statistic.

Table 5: Panel least squares regression results for return on capital

Dependent variable is ROC, 1981-2005 (5 yearly averages)

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| Constant | 6.65 | 7.37 | 8.7 | 10.6 | 4.0 |
| | (4.71*** | (5.23)*** | (4.22)*** | (4.05)*** | (0.49) |
| ROC(-1) | 0.35 | 0.36 | 0.38 | 0.17 | 0.23 |
| | (2.91)*** | (3.08)*** | (3.05)*** | (0.96) | (1.26) |
| DY | 0.38 | | | | |
| | (2.49)** | | | | |
| DY_PC | | 0.49 | | | 0.36 |
| | | (3.10)*** | | | (0.93) |
| DPOP | | -1.37 | | | -0.82 |
| | | (-1.59) | | | (-0.73) |
| YPC | | | -0.02 | | 0.04 |
| | | | (-0.96) | | (0.79) |
| K/Y | | | | -0.01 | 0.01 |
| | | | | (-0.70) | (0.42) |
| Adj R2 | 0.25 | 0.30 | 0.16 | 0.04 | -0.10 |
| N | 40 | 40 | 40 | 35 | 35 |
| DW | 1.78 | 1.88 | 1.94 | 2.03 | 2.24 |

Notes: Total panel (balanced) observations before adjustments = 50. T-statistics in parentheses. ***, **, * denote significance at the 1, 5 and 10 percent levels respectively. DY is the annual change in real GDP. DY_PC is the annual change in GDP per capita. DPOP is the annual change in population. YPC is the level of GDP per capita. K/Y is the capital-output ratio. DW stands for Durbin-Watson statistic.

Table 6: Panel least squares regression results for capital flows response (1981-2008)

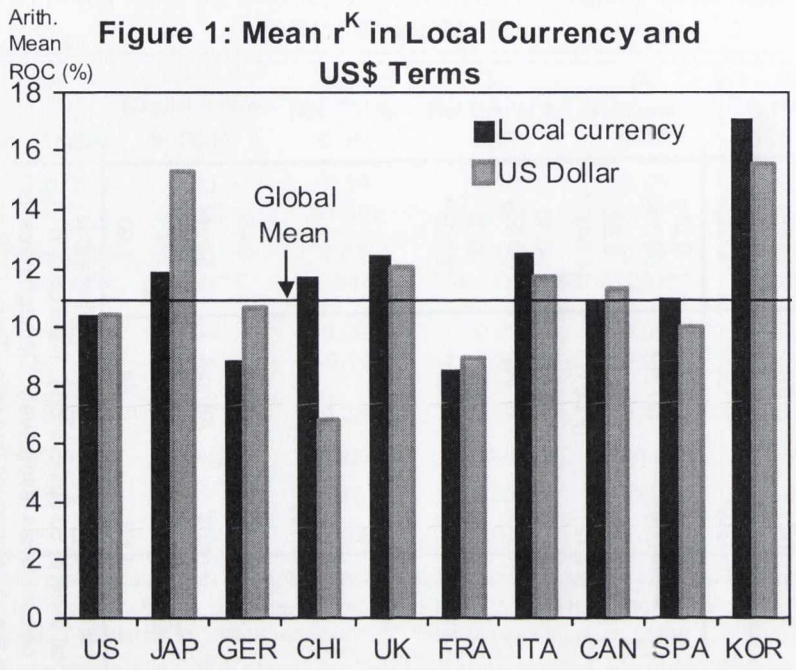
| Dependent variable | (1) Capital Inflow % GDP[1] | (2) Net FDI % GDP | (3) Net Equity % GDP | (4) Net Debt % GDP | (5) Capital Inflow % GDP[1] |
|---|---|---|---|---|---|
| Constant | -0.01 | -0.14 | -0.10 | 0.55 | -0.08 |
| | (-0.09) | (-1.50) | (-0.88) | (2.97)*** | (-0.22) |
| Lagged dependent variable | 0.90 | 0.63 | 0.37 | 0.39 | 0.51 |
| | (27.72)*** | (12.88)*** | (6.77)*** | (6.28)*** | (2.82)*** |
| $(r^{K}i-r^{K}w)$ | -0.04 | 0.00 | -0.01 | 0.00 | -0.01 |
| | (-1.36) | (-0.14) | (-0.36) | (0.05) | (-0.06) |
| Adj R2 | 0.75 | 0.38 | 0.12 | 0.16 | 0.14 |
| Frequency | Annual | Annual | Annual | Annual | 5-year |
| N | 269 | 269 | 225 | 248 | 40 |
| DW | 1.68 | 2.03 | 2.04 | 2.11 | 1.92 |

Notes: Total panel (balanced) observations before adjustments = 279, with the exception of (5) which is based on 5-year averages (from 1981 to 2005) and has a total panel of 50 observations. T-statistics in parentheses. ***, **, * denote significance at the 1, 5 and 10 percent levels respectively. DW stands for Durbin-Watson statistic. [1] In order to make the interpretation of coefficients consistent across each of the regressions in Table 5, we use capital capital inflows (the negative of the current account balance) as the dependent variable.

Table 7: Panel least squares regression results for capital flows response (1981-2007)

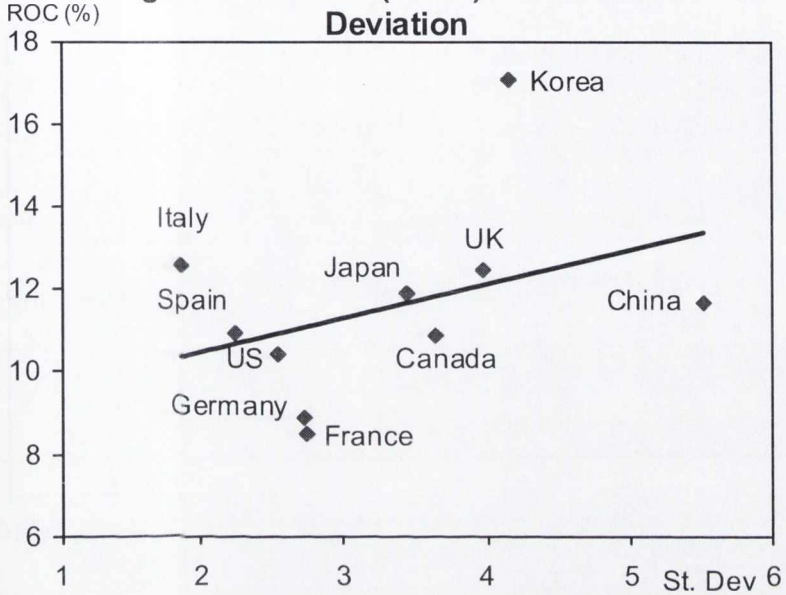
| Dependent variable | (1) Capital Inflow % GDP | (2) Capital Inflow % GDP | (3) Capital Inflow % GDP | (4) Capital Inflow % GDP | (5) Capital Inflow % GDP | (6) Capital Inflow % GDP |
|---|---|---|---|---|---|---|
| Constant | -0.08 | 0.02 | -0.06 | -0.01 | -0.02 | 0.07 |
| | (-0.79) | (0.17) | (-0.57) | (-0.06) | (-0.26) | (-0.18) |
| Lagged dependent variable | 0.88 | 0.88 | 0.90 | 0.89 | 0.87 | 0.82 |
| | (23.18)*** | (26.56)*** | (25.37)*** | (22.72)*** | (22.61)*** | (4.84)*** |
| Demographics | -0.08 | | | -0.05 | -0.07 | -0.10 |
| | (-1.55) | | | (0.95) | (1.30) | (-0.55) |
| Trend GDP Per Capita Growth | | -0.10 | | -0.08 | -0.08 | -0.37 |
| | | (-2.14)** | | (1.65)* | (1.86)* | (2.22)** |
| Financial Development | | | 0.00 | 0.00 | | |
| | | | (-0.01) | (-0.36) | | |
| $(r^{K}i-r^{K}w)$ | | | | 0.00 | | |
| | | | | (-0.10) | | |
| Adj R2 | 0.72 | 0.75 | 0.71 | 0.73 | 0.72 | 0.45 |
| Frequency | Annual | Annual | Annual | Annual | Annual | 5-year |
| N | 259 | 259 | 259 | 259 | 259 | 40 |
| DW | 1.64 | 1.67 | 1.66 | 1.68 | 1.64 | 1.90 |

Notes: Total panel (balanced) observations before adjustments = 269, with the exception of (6) which is based on 5-year averages (from 1981 to 2005) and has a total panel of 50 observations. T-statistics in parentheses. ***, **, * denote significance at the 1, 5 and 10 percent levels respectively. 'Demographics' is the difference between the working age ratio in country i and the global working age ratio. 'Trend GDP pc growth' is the difference between the Hodrick-Precott trend of GDP pc growth and the global equivalent. Financial development is the difference in the ratio of private sector lending to GDP in country i relative to the global average. DW stands for Durbin-Watson statistic.

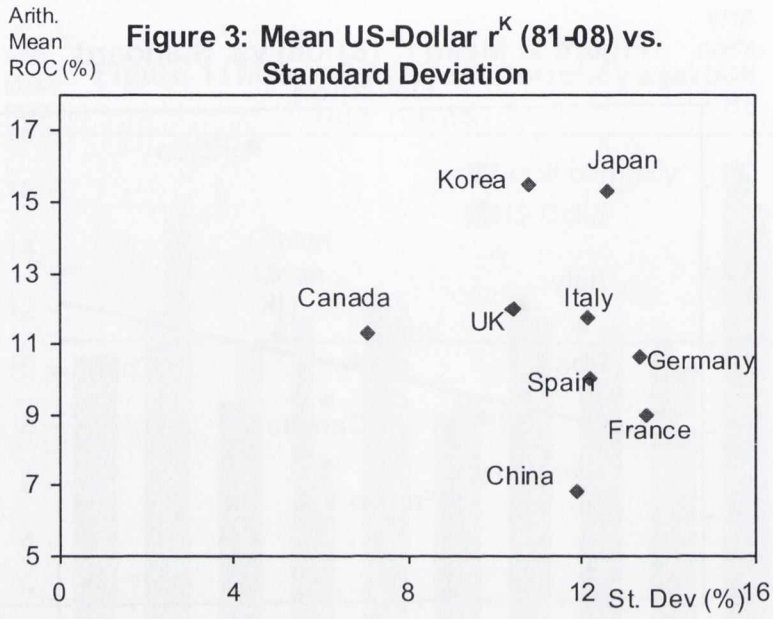



Notes: Author's calculations based on national accounts data. See Section 5 for more details.

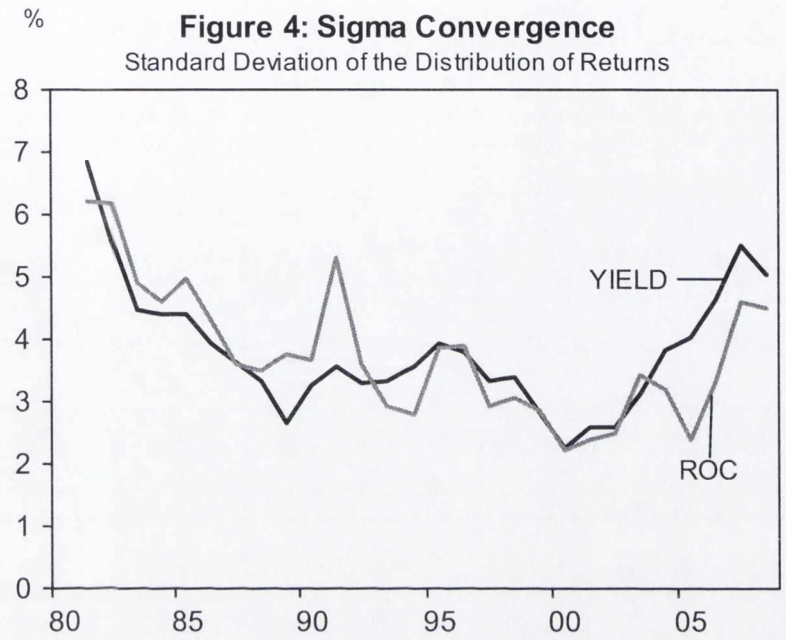
**Figure 2: Mean $r^K$ (81-08) vs. Standard Deviation**




Notes: Author's calculations based on national accounts data. See Section 5 for more details.



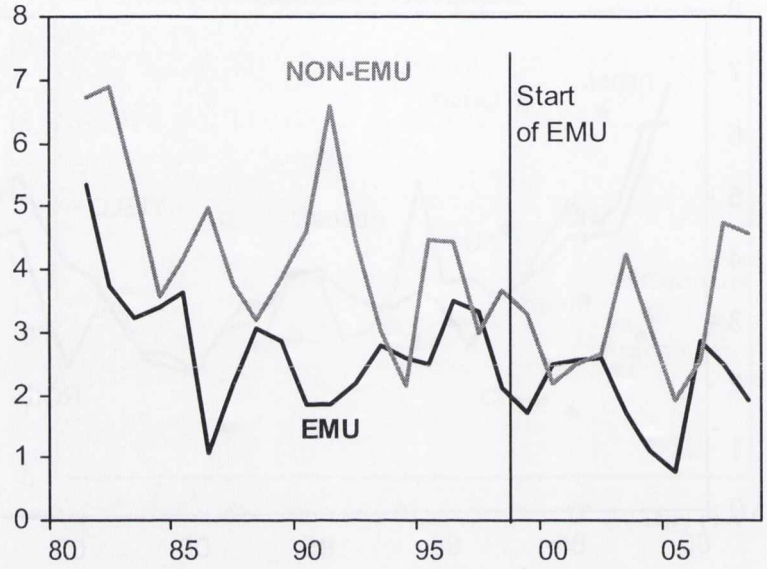

Notes: Author's calculations based on national accounts data. See Section 5 for more details.



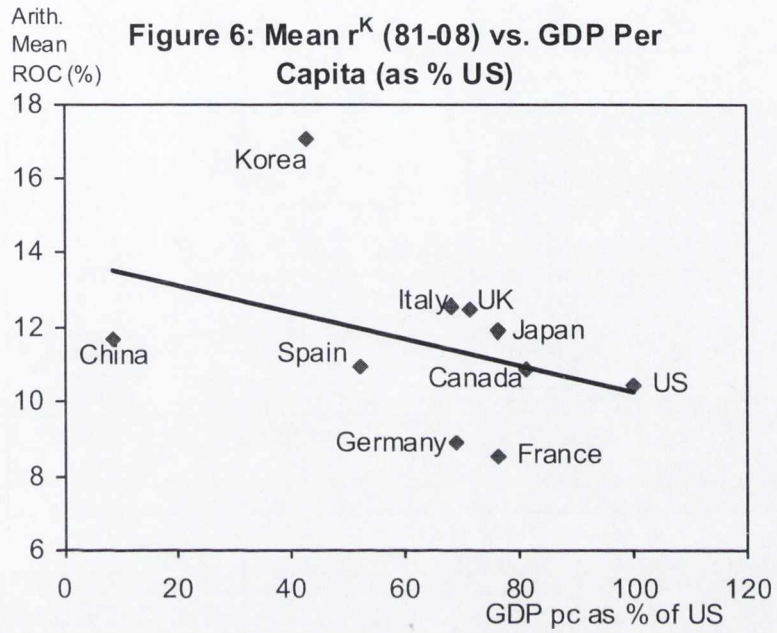

Notes: Author's calculations based on national accounts data. See Section 5 for more details.

**Figure 5: Sigma Convergence in EMU**

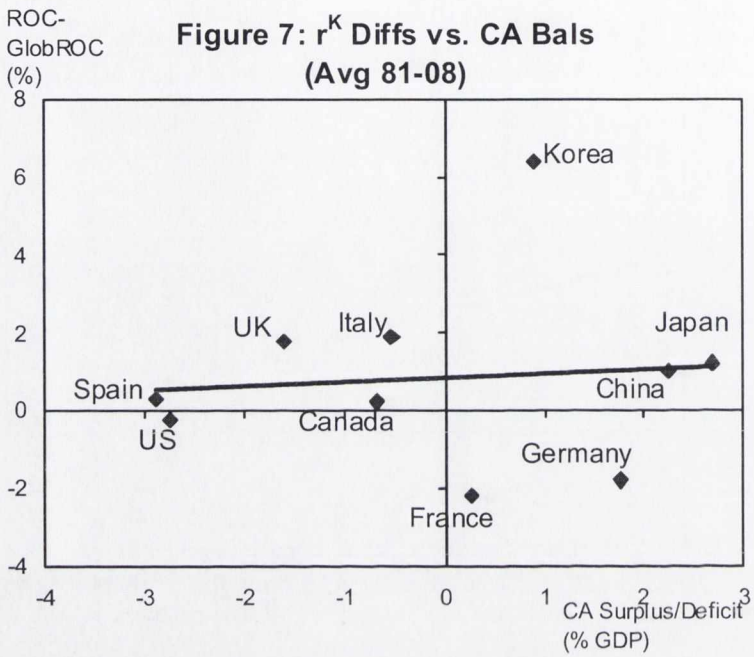
St. Deviation of the Distribution of ROC




Notes: Author's calculations based on national accounts data. See Section 5 for more details.

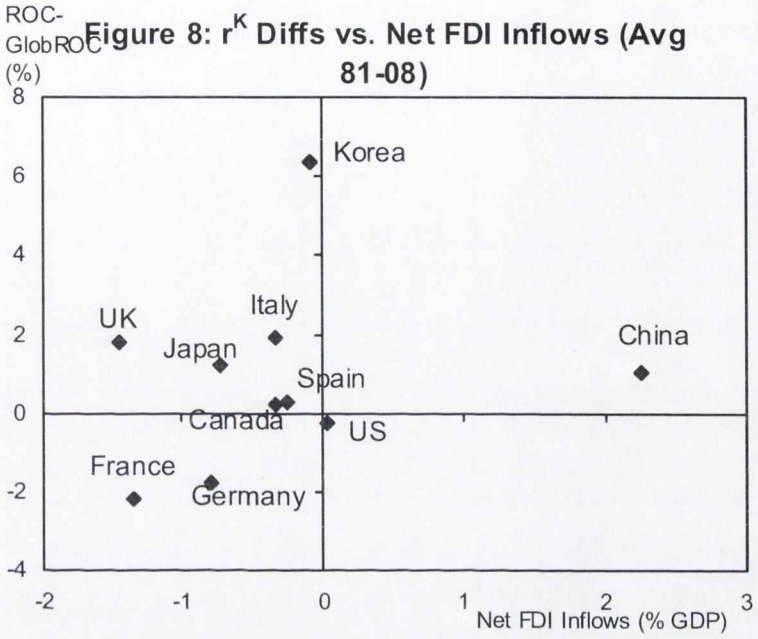



Notes: Author's calculations based on national accounts data. See Section 5 for more details.

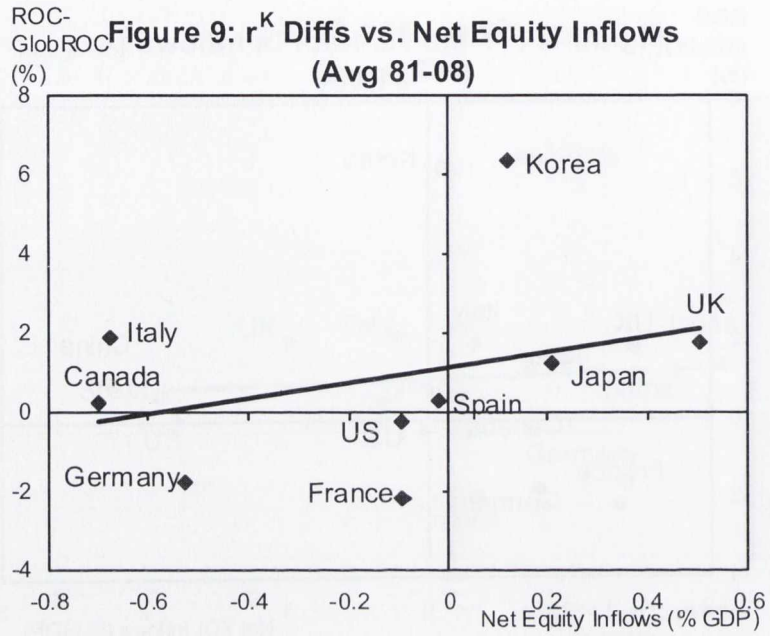



Notes: Author's calculations based on national accounts data. See Section 5 for more details.

**Figure 8: $r^K$ Diffs vs. Net FDI Inflows (Avg 81-08)**




Notes: Author's calculations based on national accounts data. See Section 5 for more details.




Notes: Author's calculations based on national accounts data. See Section 5 for more details.

# Chapter 3: The Savings Glut and the Rise in the Global Equity Risk Premium


## Abstract

There is a growing body of opinion that macro imbalances played an important part in the formation of the 2007/2008 financial crisis. According to this account, excessive saving in the emerging world held down real interest rates and facilitated a boom in credit. However, in the years preceding the crisis, the global economy was also characterised by rising returns on physical capital and increased equity risk premia, two features that the standard imbalances (or 'savings glut') story cannot easily account for. We argue not that the savings glut account is wrong but that, by neglecting emerging market (EM) portfolio preferences (the composition of that saving), it is incomplete. Either because EM investors have been genuinely more risk-averse or because they were institutionally constrained in that way, a higher proportion of their *ex-ante* saving went into fixed-income assets, as opposed to equity. We suggest that higher *ex-ante* saving in large emerging markets and high levels of risk aversion are related, and that this connection explains both low bond yields and high returns on risky capital.

## Section 1: Introduction

Much of the coverage of the 2007/2008 financial crisis has focused on the financial system itself—the oversupply of mortgage lending, the contribution of wholesale capital markets (including derivatives) to that process and the failure of regulators to curb it. There is, however, an alternative—or at least a supplementary—view, which focuses instead on the high level of saving in the emerging world. According to this account, the credit boom that preceded the bust was fuelled by a sustained period of low risk-free real interest rates, and these low rates were in turn the result of unusually high savings rates in the emerging world. In other words, one should think beyond the proximate source of lending and ask instead about the ultimate source of finance for developed-country borrowers.

This is not a recent idea. Policymakers expressed concern about low risk-free rates, and their connection with macroeconomic imbalances, long before the credit crunch. Alan Greenspan (2005), the former chairman of US Federal Reserve, first referred to the 'conundrum' of low bond yields, and later that year current chairman Ben Bernanke (2005) suggested that an emerging-world 'savings glut' might be responsible. But the role of imbalances has gained more currency since the crunch began and the view that EM saving set the stage for the credit boom is now more widespread.[1]

We do not question this view in this paper. We think there is considerable evidence that national saving rates have been surprisingly high in much of the emerging world and that this had important effects on behaviour in the developed world. Appealing as it is, however, we argue that the account is also incomplete, because it fails to distinguish between different kinds of assets or to explain the striking divergence in their yields. While bond yields have declined significantly over the past decade, actual returns on risky capital, yields on quoted equity and ex-ante equity risk premia have all risen substantially. This suggests that there was something important not just about the level of EM saving but about its composition (i.e., EM portfolio preferences) as well.

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[1] There is a large and growing literature on the link between current account imbalances and the 2007/2008 financial crisis, and the most relevant papers are discussed in Section 2. Within the academic literature, this paper is most closely related to the work of Caballero, Farhi and Gourinchas (2008a, 2008b), and to the literature on insurance-driven foreign exchange reserve accumulation (Feldstein (1999), Greenspan (1999) and Obstfeld, Shambaugh and Taylor (2008)). While there are important differences between these papers and across the broader 'savings glut' literature, the common feature that they all share is the implication that high levels of precautionary saving in emerging economies led to a *generalised* decline in yields across all assets. None can account for high rates of return on physical capital and a rise in the ERP that we observe. Many of the ideas discussed in this paper were also discussed in a closely-related, non-technical paper "The Savings Glut, the Return on Capital and the Rise in Risk Aversion", published under the *Goldman Sachs Global Economics Paper* series (2009).

There are four key stylised facts about the behaviour of the world economy in the years leading up to the start of the crisis (in late-2007) that any reasonably complete hypothesis should be able to account for. The first two are well-known; the second two have received less attention.

Fact 1: Global current account imbalances increased sharply from the turn of the century until the onset of the credit crunch.

Figure 1 displays the average absolute current account imbalance for the 10 largest economies in the world and for the G20. During the 1990s, the average absolute current account imbalance for a G20 economy was 2.3% of GDP. In the three-year period from 2006 to 2008, the average imbalance had risen to 5.4% of GDP.

Not only has the size of the current account imbalances been unusual but the pattern of countries running deficits and those running surpluses is also the opposite of what one would normally expect. Neo-classical theory posits that emerging economies—with relatively low capital intensity, high rates of return and the prospect of higher income levels in the future—should save less than they invest and, therefore, run a current account deficit.[2] Developed economies—with mature capital stocks and low internal rates of return—would typically be expected to save more than they invest and, therefore, to run a surplus.

Yet, from 2000 onwards, emerging economies collectively began to save significantly more than they invested, while the major advanced economies began to run large current account deficits (Figure 2). Part of this development can be explained by the effect of rising oil prices on resource-rich economies: the Saudi Arabian current account position, for instance, moved from being broadly in balance around the turn of the century to running a surplus worth more than 30% of GDP in 2008. But many non-resource-rich emerging economies also saw an improvement in their current account positions: China's surplus rose from 1½% of GDP in 2000 to 10% of GDP in 2008.

Among the major advanced economies, the US, Spain, France, Italy and Canada each experienced a sizeable deterioration in their current account balances between 2000 and 2008;

[2] This is true of models that assume diminishing marginal returns to capital. The alternative view, embedded in so-called 'endogenous growth' models of economic development, is that marginal returns are constant. If returns do not diminish as an economy develops, there would be no reason to expect emerging economies either to grow faster or to attract capital (run deficits) from the rest of the world.

the UK's current account balance remained stable (but in deficit), while Germany and Japan both bucked the trend with rising surpluses.

Fact 2: There was a global decline in yields on all forms of debt, including government bonds, corporate bonds and securitised debt.

Many accounts of the credit crunch point to the boom in private-sector credit instruments, and the narrowing of their spreads, ahead of the crisis (Brunnermeier (2009)). Seen over a longer-term perspective, however, spreads were not that low, at least in simple cash markets (Figure 3 displays the spread on long-term US Baa corporate bond yields over US Treasury bonds).

The more important driver of low yields on risky fixed-income assets was the protracted fall in risk-free rates. Figure 4 plots 10-year estimated real, *ex-ante* government bond yields for the US, Euro-zone and UK from the early-1970s onwards. The development of inflation-linked government bond markets means that these rates are now directly observable, and we have extended the duration of the historical data based on an estimated relation with nominal bond yields, current and lagged inflation, and real, *ex-ante* bond yields in other markets.[3]

Fact 3: The 2000s saw a sharp increase in the global return on physical capital.

At this stage the 'savings glut' hypothesis comes to an end. As it fails to distinguish between different kinds of assets, the savings story in its simplest form would predict lower yields on everything—underlying productive capital and the securities that finance it (bonds and equities alike).

What actually occurred was something very different. Using the cross-country database of returns on physical capital across the 10 largest economies in the world that we set out in Chapter 1 of this thesis (and briefly described again in Section 4), we consider the return on capital measures for the world and, individually, for the US, China and Europe. Two clear patterns emerge:

- First, far from declining, in line with real bond yields, the global return on capital (ROC) (Figure 5) has trended up over the past decade or so. Even in 2008, by which stage the financial crisis had begun to hit profits materially, the global ROC remained above its long-term average.

[3] The methodology underlying this calculation is set out in more detail in Section 4.

- Second, rates of return in the key emerging economies are indeed higher than in the developed world. These are not risk-adjusted returns, of course. But the pattern confirms that the net savings coming from China, for example (Figure 6), were indeed 'uphill'[4]—perversely, on the face of it, they came from an economy with high internal rates of return and went to fund capital on which returns were significantly lower (Figures 7 & 8 are for the US and Europe, respectively).

Fact 4: There was an increase in the global equity risk premium.

Reflecting the rise in the return on capital and 10 years in which nominal equity prices in most developed economies have declined, the earnings yield on global equities (the inverse of the price-earnings ratio) has risen sharply since the turn of the century, even while real bond yields have been falling (Figure 9). Yields on equities and bonds declined together from the mid-1980s until the turn of the century. Thereafter, real bond yields continued to decline but the yield on equities began to rise.

There is a close link in finance theory between the yield on risky and riskless assets, which is tied down via the CAPM model (Black, Jensen and Scholes (1972)). Under specific conditions set out in Campbell (2008), the spread between the yield on equities and the yield on bonds is equivalent to the equity risk premium (ERP).[5] In Section 4 we set out a more conventional measure of the global *ex-ante* ERP that we have estimated, the results of which are represented in Figure 10. Based on this measure, the global ERP has risen very sharply since the start of the crisis—a development that is consistent with a higher risk of company failure and greater uncertainty over future returns. However, the upward trend in the ERP had started much earlier than the crisis, in 1999/2000.

High *ex-ante* savings rates in the emerging world cannot, on their own, account for all four key trends in global financial flows and asset yields set out here. The rise in the global return on physical capital and the global ERP defies any straightforward explanation provided by the 'savings glut' hypothesis—it would explain why yields in general might have fallen, but not the divergence between bond yields and the return on risky capital.

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[4] See also Liang (2006).

[5] Using the Gordon (1962) growth model as a starting point, Campbell (2008) shows that, under specific conditions, the earnings yield equals the expected return on equity in long-run equilibrium. Subtracting the real risk-free rate (i.e., the spread between the earnings yield and real government bond yields) therefore provides a simple estimate of the *ex-ante* ERP.

We offer an alternative—or supplementary—explanation of these trends to the standard 'savings glut' hypothesis. Specifically, we suggest that the emergence of China and other large emerging economies had three relevant effects on the global economy:

- The integration of the large emerging markets into the global economy, with low capital:labour ratios and high natural growth rates, resulted in a sharp increase in the world's effective labour supply.[6] With capital stocks that are relatively fixed in the short run, this had the effect of boosting the global return on physical capital.

- Consistent with the 'savings glut' hypothesis, the increase in desired saving from large emerging economies contributed to lower yields on all fixed-income assets, including government bonds, corporate bonds and securitised debt.

- Reconciling these two trends—the rise in yields on risky capital and the decline in risk-free interest rates—was an effective shift in the global aversion to risk. Either because EM investors have been genuinely more risk-averse (something that would normally be consistent with higher rates of saving), or because they were institutionally constrained in that way, a higher proportion of their *ex-ante* saving went into fixed-income assets, as opposed to equity. This had the result of raising the 'effective' ERP across the world.

The first of these three effects is not surprising. It is what neo-classical theory would imply from the combination of a period of rapid productivity growth in the emerging world (newly unshackled from central planning but still with low levels of invested capital, relative to its workforce) and the opening up of capital markets between these fast-growing new markets and the capital-rich economies of the developed world. Because faster productivity growth and scarcer capital (relative to labour) both raise investment demand, one would normally expect the general level of yields and (*ex-ante*) asset returns to rise while the capital:output ratio adjusted to the new equilibrium.[7]

Seen in that light, the rise in the global rate of return is unsurprising, and the decline in bond yields even more of a 'conundrum'. Reconciling the two trends requires, at the least, a distinction between different kinds of assets, and this is something on which the simple

[6] Freeman (2007) estimates that the integration of China, India, and the former Soviet Bloc economies into the world economy resulted in a doubling of the global workforce between 1985 and 2000.
[7] Many of these issues were discussed by Wilson (2007), in which the author emphasised the 'trade integration' aspect of the emergence of China and other emerging markets, whereas we focus more on the effect of increased labour supply.

'savings glut' hypothesis is silent.[8] More specifically, it requires an explanation as to why the spread between the underlying return on capital and the return on bonds—the premium on risky capital—rose so strongly.

The suggestion in this paper is that EM portfolio preference may be part of the answer and, specifically, that there is some connection between higher savings rates in large emerging markets and high levels of risk aversion. This connection, which exists in many theoretical models of consumer behaviour, could jointly explain both low bond yields and high returns on risky capital. Either because EM investors had a fundamental preference for debt over equity, or because institutional constraints amounted to the same, the rise of China and other large emerging economies shifted global portfolio preference away from equity and towards debt. In effect, the marginal investor became more risk-averse and the 'savings glut' went hand-in-hand with a rise in the effective global ERP.[9]

This would explain the broad trends in financial market prices over recent years. But there is also independent evidence of these differing portfolio preferences. In a detailed analysis of the net asset positions of China and India, for example, economists Lane and Schmuckler (2006) show that the net investment positions of both are essentially 'short equity, long debt'.[10]

The remainder of this paper is organised as follows. In Section 2 we review some related literature. In Section 3 we set out the theoretical intuition underlying our view that the increasing importance of risk-averse investors in emerging economies explains both an increase in global *ex-ante* saving and a rise in the global ERP. In Section 4 we set out the methodology and data sources underlying our calculations of the return on physical capital and the *ex-ante* equity risk premium. In Section 5 we set out our empirical results. Finally, in Section 6 we draw some conclusions.

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[8] Caballero et al (2008a, 2008b) distinguish between different types of assets but they argue that each is susceptible to rotating ('whac-a-mole') booms and busts as emerging savers strive for relatively safe and liquid assets.

[9] The economics of 'portfolio choice theory', in which investors have heterogeneous risk appetite and investment opportunities, provides important insights in this regard. When wealth is redistributed around the world, it changes the price of assets because people in different countries have different preferences and different investment opportunities. This analysis provides results that differ in some respects from the standard representative-agent models on which most finance theory is based.

[10] Mendoza, Quadrini, and Rios-Rull (2007) argue that global imbalances and the skew towards debt in the portfolios of emerging markets are the result of international financial integration among countries with heterogeneous financial markets. Garzarelli et al (2006) argue that China's debt capital market (DCM) maturation has not matched the country's economic performance over the past decade.

## Section 2: Literature Review

### 2.a The 'savings glut' literature

There is now a wide and growing literature linking the formation of the 2007/2008 financial crisis to the increase in global current account imbalances that preceded it. The debate over the meaning and significance of these imbalances pre-dated the financial crisis itself. Bernanke (2005) suggested that the rise in global current account imbalances and, in particular, the widening in the US current account deficit from the mid-1990s onwards was due to a 'savings glut', one that resulted from large developing economies such as China becoming net suppliers of credit to international capital markets, rather than net users. As evidence to support this view, Bernanke cited the parallel decline in real bond yields, arguing that this was more consistent with emerging economies saving—and not US spending—being the driving force behind the growth in imbalances. Bernanke, who viewed this interpretation as relatively benign at that time, was nevertheless among the first to establish a link between emerging market saving, the US current account deficit and low global interest rates.[11]

Dooley, Folkerts-Landau and Garber (2003, 2009) argue that the build-up of current account surpluses by Asian emerging economies reflects a policy choice on their part, the purpose of which is to support export growth through the maintenance of a relatively weak real exchange rate. The authors view the pattern of Asian emerging economies accumulating foreign reserves to manage their exchange rates as representing an effective revival of the Bretton Woods system.

Figure 11 provides a 'below the line' breakdown of net capital flows from emerging economies from 2000 to 2008. The accumulation of net overseas assets has been entirely accounted for by public-sector acquisitions—the private sector has witnessed capital inflows—and has been principally channelled into reserves (and held in the form of government bonds). By far the largest part of this outflow is accounted for by Asian reserves accumulation. In the years immediately preceding the financial crisis (2006-2007), commodity producers played a more important (but still secondary) role.

[11] The number of policymakers that have attributed a role to current account imbalances in the formation of the financial crisis has grown since the crisis began. For instance, ECB Council member Lorenzo Bini Smaghi (2008) has suggested that they represented "two sides of the same coin", while former US Treasury Secretary Henry Paulson (2009) has said that "super-abundant savings from fast-growing emerging nations such as China and oil exporters...put downward pressure on yields and risk spread everywhere".

One difficulty with the 'Bretton Woods II' argument, however, is that in order to suppress the real exchange rate, one must go further than establishing a nominal fix. It is necessary to depress real domestic demand (i.e., sustain high saving rates) as well. If savings rates are not also influenced by policy, then fixing the nominal rate would quickly lead to an appreciation of the real exchange rate via higher inflation.

Feldstein (1999) and Greenspan (1999) also suggest that the channelling of Asian savings into foreign exchange reserves has represented a policy choice, but that this choice was driven by a self-protection motive in the aftermath of the 1997/1998 Asian crisis. The process of accumulating foreign-currency-denominated deposits and bonds was driven by the goal of 'self-insuring' against any future currency crisis by amassing foreign currency that could be used to defend the exchange rate, fund imports and repay foreign borrowing. But it is difficult to rationalise the extent of reserves accumulation with reference only to the flight risk of external short-term capital.[12] Obstfeld, Shambaugh and Taylor (2008) suggest that, in addition to addressing the threatened flight of external short-term capital, the rapid growth of international reserves in emerging economies can be explained by the need to insure against the possibility of domestic financial liabilities being converted into foreign currency. This threat of 'double drain', it is suggested, can better explain the rapid growth in foreign exchange reserves.

Caballero, Farhi and Gourinchas (2008a, 2008b) suggest that the build-up of global current account imbalances can be understood as a consequence of asymmetries in financial development and growth prospects across different regions of the world. They argue that the 1997/1998 Asian crisis, followed by a subsequent period of rapid growth in emerging economies, resulted in a significant increase in precautionary saving in the developing world. Capital flows were reoriented from emerging economies towards the broader and deeper financial markets of the developed world. These flows, it is held, should be viewed as a private-sector response to a lack of trustworthy savings vehicles in the relatively immature domestic financial markets of emerging economies. Caballero *et al* argue that this "chronic excess demand for assets" has resulted in a series of bubbles, from the equity bubble of the late-1990s to the housing and credit bubbles that preceded the 2007/2008 financial crisis (2008b, page 5). No distinction is made within their model between different types of assets (fixed income, equity, physical capital) or between different risk premia. Indeed, as Reinhart (2008) highlights, the model assumes perfect foresight and has no concept of risk premia.

[12] According to the People's Bank of China (2009), Chinese foreign exchange reserves reached $2.13 Trillion (or 49% of 2008 GDP) in June 2009.

One critique of the Caballero *et al* thesis is that the high whole-economy savings rates of China and the major commodity producers have been accounted for by public rather than private saving (Reinhart (2008)). Figure 12 provides an 'above the line' sectoral breakdown of gross Chinese savings. However, it is possible that the importance of public institutions in the allocation of saving is itself an (endogenous) reflection of their low level of economic development.

In terms of addressing why there has been a bias in their portfolio allocation towards fixed income assets and away from equity and physical capital (identified by Lane and Schmukler (2006)), a separate possibility is that this skew is the outcome of restricted investment opportunity—resulting from segmentation in the market for global capital—rather than the outcome of a portfolio preference for debt. One reason why returns on capital could have remained high and variable across the global economy is that private investors—and, in particular, foreign private investors—are often restricted from accessing the return on capital produced. The difference between the social return on capital and the return on capital available to private investors has been emphasised by the development economist Dani Rodrik (2004a, 2004b) in a separate context.[13] Market segmentation can operate in both directions: restrictions and conditions are imposed on foreign direct investment from the developed world into emerging economies, and there are also restrictions on the investments made by emerging economies into the developed world. Because much of the saving of emerging economies is channelled through government entities, and because these are often restricted from making large equity investments in developed economies, the savings of emerging economies are effectively constrained from being invested in overseas equity. The issue of whether the aggregate portfolio allocation of emerging economy investors reflects restricted investment opportunity has not been widely explored in the academic literature but it may still have contributed to the asymmetry in observed investment positions.

Although there are important differences between the papers reviewed in this section, the works by Dooley et al (2003, 2009), Obstfeld et al (2008) and Caballero et al (2008a, 2008b) all share a number of common features that identify them as part of a wider 'savings glut' literature. Each subscribes to the view that emerging market saving prompted the growth of current account imbalances, rather than being the passive counterpart of developed economy spending. Each provides a rationale as to why capital flowed from emerging economies to the developed world and, in the case of Dooley et al (2003, 2009) and Obstfeld et al (2008), they also provide a rationale as to why those flows were channelled into foreign exchange

[13] This distinction may be important in understanding why an economy, such as China, has both a high return on capital and significant capital outflows.

reserves. Finally, each shares the implication that high levels of precautionary saving in emerging economies led to a generalised decline in yields across all assets.

Our paper shares features of all of these papers, in particular the works of Caballero et al (2008a, 2008b) and of Obstfeld, Shambaugh and Taylor (2008). Specifically, we subscribe to the view that the rise in global current account imbalances was the outcome of high precautionary saving in large emerging economies. Where we differ, however, is in the suggestion that the rise in precautionary saving in the emerging world resulted in a generalised decline in yields on all assets. In this paper we show that this was not the case: whereas bond yields fell, there was an increase both in the global rate of return on physical capital and the global ERP in the years leading up to the crisis (an issue we explore more formally in Section 5). We are agnostic as to whether the rise in precautionary saving in emerging economies reflects a choice made by the private sector, by the public sector or by both. Nor, indeed, do we preclude the possibility that the skew towards fixed-income assets over equity-related assets is the result of investment restrictions rather than portfolio preference. Rather, we rely on there being some relation between higher savings rates in large emerging markets and increased risk aversion, one which has resulted in both capital outflows from large emerging economies and a rise in the 'effective' ERP.

**2.b The role of monetary policy in the crisis**

An alternative hypothesis to the 'savings glut' literature holds that excessively easy monetary policy played an important role in the formation of the financial crisis. White (2006) argues that monetary policy in the US and Europe remained too loose in the mid-2000s and, more generally, that central banks should use monetary policy to tackle asset bubbles. Bracke and Fidora (2008), meanwhile, find that monetary shocks may have been a more important driver of real and financial imbalances than any savings glut.

We consider there to be several problems with the idea that loose monetary policy was the principal cause of the credit boom (or the crisis that has followed).

- Fundamentally, it would contradict basic principles about the long-run effects of policy. Monetary policy is generally thought to have only temporary effects on real quantities, including real interest rates. But the fall in real bond yields started too soon, has persisted for too long and has occurred too far out on the yield curve for monetary policy to be the primary cause (Figure 4).

- The one thing that monetary policy can affect sustainably—inflation—didn't get out of control.

- The asset boom, to the extent there was one, was extremely localised, contradicting the view that overly-loose monetary policy drove a generalised bubble in risky assets.

There may be something to a more subtle version of this argument, namely that bonds benefited from more stable and credible regimes for monetary policy. By reducing the prospective volatility of demand and short-term rates, it is possible that more credible policy helped to reduce the risk premium on longer-dated debt, including indexed debt.

But it is also difficult to reconcile this view with the sequence of events. Real yields continued to trend downwards during the 2000s, long after inflation expectations had stabilised, and even after central banks began to raise official interest rates from 2004. It was precisely this development that Alan Greenspan (2005) described as the 'bond conundrum'. We think this 'conundrum' demands a real, not a monetary, explanation. And, foremost among those explanations, the high savings rates in key parts of the emerging world seem the most plausible.

**Section 3: Model**

The key proposition in this paper is that the increasing importance of (risk-averse) emerging market investors can jointly explain both the global savings 'glut' and an observed increase in the global equity risk premium. In this section, we set out the theoretical intuition as to why precautionary saving and risk aversion are likely to be linked. We start first with a representative-agent model of household behaviour, in which the parameters are interpreted as the aggregated values across heterogeneous agents. We use the model to consider the case in which there are two classes of investors, with one group ('China') more risk-averse than the other ('US'), and then gauge the effect on savings behaviour and asset prices of increasing the weight assigned to the more risk-averse group. We then discuss whether the results obtained from this model are more generally applicable to multi-agent models that explicitly solve for heterogeneous risk preferences, and provide an overview of the asset-pricing implications of such models. Relative to the baseline set-up derived from a representative-agent model, the implication from explicitly heterogeneous models appears to strengthen the conclusion, in that they suggest that the introduction of a group of risk-averse investors will have a larger impact on the global ERP than their rising income share alone would imply (Wang (1996), Blume and Easley (2006), Kogan, Makarov and Uppal (2007)).

We start from the assumption that there are two classes of investors, one more risk-averse than the other, and that both groups maximise an instantaneous utility function with constant relative risk aversion (CRRA) preferences of the form

$$u(C(t)) = \frac{C(t)^{1-\theta_i}}{1-\theta_i} \quad , \theta_i > 0 \qquad (1)$$

where $C(t)$ is consumption per worker and $\theta_i$, equal to $-Cu''(c)/u'(C)$, is the coefficient of relative risk aversion for each agent (and the inverse of the elasticity of intertemporal substitution). The use of a constant relative risk-aversion utility function is common in the literature exploring the relation between consumption behaviour and asset pricing (see, for example, Mehra and Prescott (1985, 2008), Lucas (1978), and Cochrane (2005)).[14]

[14] Mehra and Prescott (2008) describe the constant relative risk-aversion utility function as the "preference function of choice" in such studies (2008, page 16). An appealing property of the CRRA utility function is that it is scale invariant, meaning that the equilibrium return process is stationary even if the levels of aggregate variables increase.

The more risk-averse group in this model has a risk-aversion parameter of $\theta_1$ and, for the less risk-averse group, this parameter takes a value of $\theta_2$, with $\theta_1 > \theta_2$. We assume that individual risk-preference parameters can be aggregated across the system as a whole and that the collective parameter, $\bar{\theta}$, is equal to the weighted arithmetic mean of the individual risk preferences on the basis

$$\bar{\theta} = \sum_{1}^{n} w_i \theta_i \qquad (2)$$

where $w_i$ $(0 \leq w_i \leq 1)$ represents the share of total income assigned to each agent in the system and $\sum_{1}^{n} w_i = 1$.

A key issue is whether it is reasonable to aggregate risk preferences across heterogeneous agents in this fashion. Constantinides (1982) shows that, in a competitive equilibrium with complete securities markets, the preferences of the aggregate utility function are equivalent to the weighted average of the preferences of the individual agents in the economy. Later in this section we discuss the implications for asset pricing and saving of loosening this assumption.[15]

With preferences that can be aggregated in this fashion, it is possible to derive a collective utility function across heterogeneous agents for the system, which is given by

$$u(C(t)) = \frac{C(t)^{1-\bar{\theta}}}{1-\bar{\theta}} \quad , \bar{\theta} > 0 \qquad (3)$$

One important property of CRRA risk preferences is that $u'''(C(t)) > 0$, implying a positive motive for precautionary saving that is increasing in $\theta_i$. In the model set out here, therefore, the more risk-averse group ('China') has a stronger ex-ante demand for saving than the less risk-averse group ('US').

[15] Given the existence of capital controls in economies such as China and incomplete risk sharing across markets more generally, it is clearly not the case that there is a single, complete global financial market. We make the assumption of being able to aggregate preferences in this fashion to illustrate the effect of increasing the importance of a group of risk-averse investors in such a benchmark setting. We then go on to discuss the implications of loosening this assumption.

We now adapt a representative-agent model set out by Romer (2001) to derive a relation for the aggregate equity risk premium for this model. With constant-relative-risk-aversion utility, the aggregate Euler equation (which sets out the intertemporal first-order condition for dynamic optimisation) takes the form

$$C_t^{-\bar{\theta}} = \frac{1}{1+\rho} E_t\left[(1+r_{t+1}^j)C_{t+1}^{-\bar{\theta}}\right] \tag{4}$$

where $\bar{\rho}$ is the subjective time discount rate (which we assume can be aggregated in the same fashion as $\bar{\theta}$) and $E_t\left[(1+r_{t+1}^j)\right]$ is the expected pay-off from investing in asset $j$. If we divide both sides by $C_t^{-\bar{\theta}}$ and multiply both sides by $1+\bar{\rho}$, then (4) becomes

$$1+\bar{\rho} = E_t\left[(1+r_{t+1}^j)\frac{C_{t+1}^{-\bar{\theta}}}{C_t^{-\bar{\theta}}}\right] \tag{5}$$

Let $g_{t+1}^c$ denote the growth rate of consumption and omitting time subscripts yields

$$E\left[(1+r^j)(1+g^c)^{-\bar{\theta}}\right] = 1+\bar{\rho} \tag{6}$$

Taking a second-order Taylor approximation of the left-hand side of (6) provides

$$(1+r^j)(1+g^c)^{-\bar{\theta}} \approx 1+r^j-\bar{\theta}g^c-\bar{\theta}g^c r^j+\frac{1}{2}\bar{\theta}(\bar{\theta}+1)(g^c)^2 \tag{7}$$

(6) can therefore be re-written as

$$\begin{aligned} &E\left[r^j\right]-\bar{\theta}E\left[g^c\right]-\bar{\theta}\left\{E\left[r^j\right]E\left[g^c\right]+Cov(r^j,g^c)\right\} \\ &+\frac{1}{2}\bar{\theta}(\bar{\theta}+1)\left\{\left(E\left[g^c\right]\right)^2+Var(g^c)\right\}\approx\bar{\rho} \end{aligned} \tag{8}$$

When the time period is short, $E\left[r^j\right]E\left[g^c\right]$ and $\left(E\left[g^c\right]\right)^2$ are small relative to the other terms in (8), and can be omitted. Solving the resulting expression for $E\left[r^j\right]$, the expected return on asset $j$, provides

$$E[r^j] \approx \bar{\rho} + \bar{\theta}E[g^c] + \bar{\theta}Cov(r^j, g^c) - \frac{1}{2}\bar{\theta}(\bar{\theta}+1)Var(g^c) \quad (9)$$

For the risk free asset with return, $r^f$, (9) simplifies to

$$r^f \approx \bar{\rho} + \bar{\theta}E[g^c] - \frac{1}{2}\bar{\theta}(\bar{\theta}+1)Var(g^c) \quad (10)$$

Subtracting (10) from (9) yields

$$E[r^j] - r^f \approx \bar{\theta}Cov(r^j, g^c) \quad (11)$$

Defining $r^e$ as the real return on a broadly-diversified representative index of equities and substituting into (11) provides

$$E[r^e] - r^f \approx \bar{\theta}Cov(r^e, g^c) \quad (12)$$

(12) implies that the expected excess return of equities (the equity risk premium) is a linear function of $\bar{\theta}$, the aggregate coefficient of relative risk aversion. A high value of $\bar{\theta}$, which by definition implies a low elasticity of intertemporal substitution and a high level of precautionary saving, also implies a relatively large equity risk premium.

Now consider a situation where this model is initially populated only by the less risk-averse group of investors (i.e., $w_1 = 0, w_2 = 1$) but the weight attached to the more risk-averse group grows over time to the point where both groups have an equal weighting (i.e., $w_1 = 0.5, w_2 = 0.5$). In this scenario, the ERP is initially given by

$$E[r^e] - r^f \approx \theta_2 Cov(r^e, g^c) \quad (13)$$

However, as the weight of the more risk-averse investors grows, the ERP increases to

$$E[r^e] - r^f \approx \frac{\theta_1 + \theta_2}{2} Cov(r^e, g^c) \quad (14)$$

where $\theta_2 < \frac{\theta_1 + \theta_2}{2}$ by definition.

In other words, the increase in importance of the risk averse group of investors ('China') in this model results in a proportionate increase in global precautionary saving and in the global ERP.

The interpretation of the parameters in a representative-agent model as an aggregation across heterogeneous agents is key to this result. It is one that is implicit in all representative-agent models, including those that explicitly attempt to model the micro-foundations underlying aggregate consumption and asset price behaviour (such as Lucas's (1978) model of asset prices and the real business cycle models of Kydland and Prescott (1982)). Individual preferences differ, of course, but Constantinides (1982) and Lucas (2003) argue that such heterogeneity is important only to the extent that these differences cannot be diversified away. With full consumption insurance, Constantinides (1982) shows that heterogeneous models are isomorphic to representative-agent models in their implications for asset pricing. In the absence of complete markets, however, the existence of uninsurable idiosyncratic shocks implies that realised intertemporal marginal rates of substitution can differ across agents; while incomplete asset market participation implies that the Euler conditions for non-participants can hold as inequalities rather than equalities. There are different views within the theoretical literature as to how important such market failures are likely to prove (see, for example, Lucas (1991) and Mankiw (1986)). The question of how well representative-agent models perform in explaining security prices is also one that has been addressed empirically, although—once again—there are conflicting interpretations of the results.[16]

What are the implications of loosening the assumption that preferences can be aggregated in this way? One factor that has limited the use of explicitly heterogeneous models in asset pricing is that they are much less tractable than single-agent models. Where such models have been derived, they typically do not provide closed-form solutions (Constantinides and Duffie (1996)). However, Wang (1996) and Kogan, Makarov and Uppal (2007) have derived two-agent pure exchange models in which both agents have CRRA preferences but differing risk-aversion parameters. Under the limiting assumption that the risk-aversion parameters take

[16] Constantinides and Duffie (1996) suggest that the existence of the equity risk premium puzzle observed by Mehra and Prescott (1985) may be accounted for by the failure of representative-agent models adequately to account for heterogeneous preferences. However, this is only one of a large number of alternative explanations of the puzzle that have been proffered. Other explanations include the suggestion that the ERP is over-estimated (Dimson, Marsh and Staunton (2008)) or that genuine risk is under-estimated (Rietz (1988), Barro and Ursúa (2008)).

specific values, the authors obtain closed-form solutions. In both cases, the size of the equity risk premium is found to lie within the bounds set by the corresponding representative-agent model with the risk respective parameters of $\theta_1$ and $\theta_2$ although, under most conditions, the price of risky assets more closely (or entirely) reflects the preferences of the more risk-averse investor.[17] The techniques required to provide closed-form solutions to these models are reasonably complex but the intuition as to why asset pricing is more closely aligned with the relatively risk-averse agent is more straightforward: prices are set by the marginal investor rather than the average investor, so risk-averse agents (who save more) have a disproportionate influence on asset pricing.

Relative to the baseline scenario derived from the representative-agent model—in which the global ERP rises in proportion to the increasing income share of the relatively risk-averse group ('China')—the implication from explicitly heterogeneous models is that the pricing of risky assets more closely reflects the preferences of risk-averse agents. This suggests that the introduction of an important group of risk-averse investors ('China') will have a larger impact on the global ERP than their rising income share alone would suggest.

[17] Blume and Easley (2006) also find that the most patient agent in models with heterogeneous agents determines the aggregate preference at long horizons.

**Section 4: Methodology and Data Sources**

**4.a Calculating the return on physical capital**

Using national accounts data, we have derived a database of the return on physical capital, $r_t^K$. The database, which was set out in more detail in Chapter 1, has the following main attributes: (i) It is comparable across economies; (ii) it covers the 10 largest economies in the world and more than three-quarters of the world's economy; and (iii) it covers more than a quarter of a century in every case (with significantly earlier starting dates for some economies). The economies covered in decreasing order of size are: the United States, Japan, Germany, China, UK, France, Italy, Canada, Spain and South Korea.

Although previous studies have calculated the return on capital for individual countries or small groups of countries, there is little or no pre-existing work in deriving comparable rates of return for all of the major economies. Given a broad and comparable dataset, we can combine individual country ROC results into an estimate of the global ROC for the first time.

We have taken a number of steps to ensure comparability of the ROC measures across countries. For instance, we focus on non-financial corporations where the measurement of profits and capital stocks is most accurate and we have adjusted for differences in the treatment of imputed labour income of the self-employed across countries.

The ROC measures calculated are based on data sourced directly from the 10 national statistical agencies. Where official capital stock measures are not available, we have constructed our own estimates using data on investment flows, real investment prices and depreciation.

The return on capital measure, $r_t^K$, that we estimate is composed of yield on capital (net of depreciation) and the capital gain, and it takes the following structure:

$$r_t^K = \frac{\Pi_t}{P_{t-1}^K K_{t-1}} + \left( \frac{P_t^K P_{t-1}^C}{P_{t-1}^K P_t^C} - 1 \right) \qquad (15)$$

where $r_t^K$ is the return on capital in period *t*, $\frac{\Pi_t}{P_{t-1}^K K_{t-1}}$ is the operating surplus net of depreciation in period *t* expressed as a ratio of the nominal net capital stock at the end of period t-1, $P_{t-1}^K K_{t-1}$, which is given by the product of the real capital stock, $K_{t-1}$, and the capital stock (at replacement cost) deflator, $P_{t-1}^K$. $P_t^C$ is the household consumption deflator at time *t*. The first term in the RHS of equation (15) represents the net yield on capital, while the second term represents the real capital gain (loss) from holding a representative piece of capital from the start to the end of period *t*. $r_t^K$ is expressed in percentage terms.

To understand why the calculation takes this form, consider a representative household in period *t-1* facing the choice of consuming $P_{t-1}^K K_{t-1}$ or investing it in period *t*. If the household chooses to invest, it forgoes the consumption of $P_{t-1}^K K_{t-1}$. But the ex post, additional return from doing so is given by $\frac{\Pi_t}{P_{t-1}^K K_{t-1}}$, the profits in period *t* as a fraction of the capital invested in period *t-1*, plus $\frac{P_t^K P_{t-1}^C}{P_{t-1}^K P_t^C} - 1$, the fractional change in real capital prices during the period *t* (as measured by the capital stock deflator deflated by the household consumption deflator). Moving the decision on by one period, the sum that the representative household can choose to invest or consume at the end of period *t* is then given by $\left(1 + r_t^K\right) P_{t-1}^K K_{t-1}$, while the sum at the end of period *t+1* is given by $1 + r_{t+1}^K \left(\left(1 + r_t^K\right) P_{t-1}^K K_{t-1}\right)$, and so forth.

Previous studies that have compared the return on capital across countries have typically ignored the capital gain element of the return on capital calculation, reporting instead the yield on capital as being the 'return on capital'. One important innovation of this database is that we have combined the yield and the capital gain (loss) to report correctly the national-accounts-based return on capital data.

The national accounts inputs are inserted into this structure broadly as follows. The net yield on capital is given by:

$$\frac{\Pi_t}{P_{t-1}^K K_{t-1}} = \frac{NetOperatingSurplus_t^{PNFC}}{NomCapital_{t-1}^{PNFC}}$$

$$= \frac{(GVA_t^{PNFC} - L_t^{PNFC} - TP_t^{PNFC} - Kcons_t^{PNFC})}{NomCapital_{t-1}^{PNFC}} \quad (16)$$

Where $GVA$ = Gross Value Added or total resources, $L$ = total compensation of employees, $TP$ = taxes (less subsidies) on production, and $Kcons$ = capital consumption. The capital stock measure includes all physical, reproducible capital. The measure is net of past depreciation and is calculated at replacement cost. The real capital gain (loss) is calculated using the deflators for the capital stock and household consumption deflator, as discussed previously.

**4.b Estimating the equity risk premium**

The ERP is the expected excess return, or the additional return, that investors expect over the risk-free rate of return for the additional risk of investing in a market portfolio of common stocks

$$E_t[er_t] = E_t[r_t^e] - r_t^f \quad (17)$$

where $E_t[]$ indicates the expectation of a variable in time $t$, $r_t^e$ is the real rate of return on equities and $r_t^f$ is the risk-free rate. The ERP is defined relative to some theoretical risk-free rate but, in the absence of any wholly risk-free investment, the widespread convention in finance literature is to use the return on government bonds (Mehra and Prescott (1985)).

The ERP is a forward-looking concept, intrinsically linked to the uncertainty of future returns. But a simple means of estimating the ERP is to compare long-run historical equity and bond returns to measure an *ex-post* ERP—a method used by Mehra and Prescott (1985) in their seminal paper on the equity risk premium puzzle.[18] However, the use of *ex-post* returns data provides an estimate of the unconditional expectation of returns, rather than the expectation of the excess return conditional on the current available information. Campbell and Shiller (1998), among others, argue against the use of realised returns data to calculate the ERP because what investors expect and what they receive can be very different, even over long investment horizons. Campbell and Shiller (1988, 1998), Shiller (2000), and Fama and French (2002) each hold that the ERP should be estimated on the basis of what investors might

[18] Mehra and Prescott (1985) found that the average real return on the US S&P 500 index was 6.2% greater than that obtained by holding US T-Bills over a 90-year period from 1889 to 1978. The authors argued that the size of this excess return was too large to reconcile with any reasonable assessment of investors' risk aversion.

reasonably have expected to get (the expectation of the excess return conditional on the current available information), rather than on the basis of what they actually received. This is a practice that we follow in this paper.

The *ex-ante* ERP is not directly observable—it needs to be derived by making assumptions, in particular about investors' expectations regarding future dividend growth. Our estimation procedure is derived from a standard Gordon (1962) growth model, a one-stage dividend discount model describing the level of the dividend:price ratio in a steady state with a constant discount rate and growth rate. Using upper-case letters to denote levels of variables and lower-case letters to denote growth rates, the Gordon (1962) growth model implies

$$P_t^e N_t = \frac{D_t}{E_t[r_t^e] - E_t[g]} \tag{18}$$

where $P_t^e$ is the price of a broadly-diversified representative index of equities in time $t$ and the product, $P_t^e N_t$, represents the total market value of the equity index, $D_t$ is the dividend flow paid to the owners of the equity index in period $t$, $g$ represents the growth rate of dividends, and $r_t^e$ and $r_t^f$ are as previously defined.[19]

(18) can be re-arranged to provide a value for $E[r_t^e]$, the *ex-ante* expected real return on equities

$$E_t[r_t^e] = \frac{D_t}{P_t^E N_t} + E_t[g] \tag{19}$$

In this standard version of the Gordon growth equation, the expected dividend growth rate is constant. Campbell and Shiller (1988) provide a dynamic version of the model that allows for variation in dividend growth rates but which requires a recursive solution and provides a result that is much less tractable. Using this dynamic model, Campbell and Shiller (1988) show that short-run changes in dividend growth have a much more limited impact on prices than persistent changes, and that the key driver of expected equity returns is, therefore, the

[19] The standard version of the Gordon equation is referenced to a single share, in which case the right-hand side of (14) is simply $P_t^e$ and $D_t$ is equal to the dividend per share rather than the sum of dividends paid on the stock market index. Scaling the equation up to the total index does not alter the fundamental relation and makes the exposition more comparable to the previous discussion.

assumed long-run (or steady-state) growth rate. In other words, the simplification in the standard Gordon growth model—that dividends grow at a constant, steady-state growth rate—does not imply a significant loss of accuracy.

Combining (17) and (19) provides a relation between the (*ex-ante*) equity risk premium, the dividend yield, dividend growth and the riskless rate:

$$E_t[er_t] = E_t\left[r_t^e\right] - r_t^f = \frac{D_t}{P_t^e N_t} + E_t[g] - r_t^f \qquad (20)$$

We substitute the following inputs into (20):

- The current (trailing) dividend yield for the market portfolio of common stocks. This is directly observable for a broad range of countries and for the global equity market as a whole. The data we use is provided by Datastream.[20]

- We assume dividends per share grow at a constant rate in line with long-run GDP per capita growth. The assumption that dividends per share grow in line with GDP per capita rather than GDP growth reflects empirical evidence (Bernstein (2002)) and has a strong theoretical foundation (Baker, DeLong and Krugman (2005)).

- For the expected risk-free rate, we use the current real, ex-ante 10-year government bond yields, which we have estimated for the US, Euro-zone, UK and Japan from the early-1970s onwards. The development of inflation-linked government bond markets means that these rates are now directly observable but the duration of the historical data is varied: the UK authorities were the first to introduce index-linked bonds in the early-1980s, while Japan's market only got under way this decade. Where the data on index-linked rates are not directly observable, we have extended the historical series based on an estimated relation between real, *ex-ante* bond yields and variables that are available over a longer duration (nominal bond yields, current inflation and inflation lagged by one year and real, *ex-ante* bond yields for other economies). By construction, these series provide a discounted estimate of future short-term government bond rates. The results of these estimations are set out in Figure 4.

[20] We have made an upward adjustment to the US dividend ratio to reflect a high rate of dividend buy-backs in that economy. This adjustment reflects estimates discussed in Dimson, Marsh and Staunton (2008).

The estimated output of our calculation of the *ex-ante* ERP for the world, as a whole, and for the US, the Euro-zone and UK individually are discussed in the following section.

**Section 5: Results**

In the introduction to this paper we presented graphical evidence that, while real government bond yields declined in the years preceding the 2007/2008 financial crisis (Figure 4), the global return on physical capital and the global equity yield both increased (Figures 5 & 9), and that the global ERP also rose (Figure 10). In this section we provide a more formal analysis of the hypothesis put forward in this paper, namely that the 'savings glut' from the emerging world was accompanied by a rise in risk aversion, and that, in contrast to the predictions of the standard 'savings glut' hypothesis, this was accompanied by a higher global return on physical capital, a higher global equity yield and an increase in the global ERP.

The first challenge is to establish a set of statistical tests that would reasonably distinguish the hypothesis set out in this paper from the existing 'savings glut' literature. As discussed in the literature review in Section 2, a common strand that ties together the various branches of the 'savings glut' literature is the implication that yields across all major asset classes moved lower together in the years preceding the 2007/2008 financial crisis. The broad objective of the statistical analysis set out in this section is to consider whether global equity yields and the global return on capital did indeed move lower together with global real bond yields, or whether they diverged in the years leading up to the start of the crisis.

In the introduction to this paper, we discussed how the difference (or spread) between the earnings yield on equities and the real, *ex-ante* government bond yield is closely related to the equity risk premium, and that, under limiting conditions set out by Campbell (2008), they are in fact equivalent.[21] Thus, our findings as to whether equity and bond yields co-moved in the years preceding the crisis have direct implications for the global ERP. We also carry out a separate set of tests on the measure of the global ERP that we set out in Section 4, to determine whether there was a structural break in this series and, if so, when that break occurred.

We have taken August 2007 as the starting date of the crisis, as this is when credit spreads and interbank lending rates first widened sharply (see, for instance, Brunnermeier (2009)), and we use January 2000 as the start of the period preceding the crisis. The choice of 2000 as a starting point is more subjective but it broadly corresponds to the date in which emerging market economies, as a group, transitioned from being net recipients of capital inflows to net

[21] Because the difference between the equity and bond yield is closely related to the ERP, the literature modelling the relation between equity and bond yields and the literature discussing the ERP are essentially one and the same. We discussed a selection of the ERP literature in Section 3.

exporters of capital (Figure 2). Later in this section we test for different breakpoints in these relations. The series for global equity yields, the global return on capital and global real bond yields all extend back to 1981 and we use the data for the period 1981 to 1999 primarily for the purpose of a benchmark comparison with the 2000-2007 performance.[22]

In Table 1 we set out the results of a series of simple regressions that explore the relation between the global equity yield and the global real government bond yield using monthly data. In regressions of the equity yield on just bond yields and a constant (i.e., without the inclusion of the lagged dependent variable), the Durbin-Watson statistics imply significant positive serial correlation in the residuals for both the January 1981-December 1999 and January 2000-July 2007 periods (results not shown). With the lagged dependent variable included among the regressors, the Durbin-Watson statistic falls within acceptable bounds. Column 1 displays the results of the estimated relation between the global equity yield and the global bond yield for the period January 1981-December 1999. The estimated coefficient on the real bond yield is positive and highly significant. The estimated long-run response of global equity yields to a 1.0% change in the global real bond yield is +2.3%. Column 2 displays the results of the same regression estimated over the sample January 2000-July 2007—the estimated coefficient on the real bond yield is negative and significant over this sample, in marked contrast to their relation between January 1981 and December 1999. The estimated long-run response of global equity yields to a 1% change in the global real bond yield for this period is -1.0%. We formally test for a break in the relation between equity yields and bond yields between the first and second periods in Column 3, which displays the results of a single regression carried out over the entire sample (January 1981-July 2007) in which we include a dummy variable which takes the value of 1 from January 2000 until July 2007 (inclusive) and 0 in all other periods and also the product of the global real bond yield series and the dummy variable as independent explanatory variables.[23] The coefficients on both the global real bond yield and the product of the global real bond yield series and the dummy variable are both highly significant. The collective long-run coefficient on the real bond yield series is -0.9 between January 2000 and July 2007 and +2.3 otherwise, closely reflecting the results from Columns 1 and 2.

[22] The equity yield, bond yield and ERP series are available on a monthly frequency but the returns on capital data are available on an annual basis only. Where the analysis is restricted to an annual frequency, we use 2000-2007 (inclusive) as the pre-crisis period and 1981-1999 for the purposes of the benchmark comparison.

[23] The dummy is included as a separate regressor to account for the possibility of any changes in the intercept. Without the inclusion of the dummy as a separate variable, the estimated coefficient on the product variable (RBY*D1) would potentially be biased.

In Table 2 we present analysis based on annual rather than monthly data that can be applied across each of the variables, including the return on physical capital. For the purpose of comparability with the return on capital data, we re-run the regression set out in Column 3 of Table 1, using annual data and obtaining similar results. With a lag of a year rather than one month on the lagged dependent variable, the estimated coefficient on this series drops from 0.92 to 0.47. However, the estimated long-run response of global equity yields to changes in global bond yields is very similar: the collective long-run coefficient on the real bond yield series is -1.1 and highly significant between January 2000 and July 2007 but +2.0 and highly significant from 1981 to 1999. The Durbin-Watson statistic implies little evidence of serial correlation. We then consider the relation between the global return on physical capital and the global real government bond yield. In Column 2 we regress the global return on capital on real bond yields, the lagged dependent variable and a constant using annual data for the period 1981-2007. The estimated coefficient on the real bond yield is negative but not significant. With only 7 data points between 2000 and 2007, we do not carry out a separate regression for this period but, in Column 3, we report the results of a regression using the full sample in which we include as independent explanatory variables a dummy variable which takes the value of 1 from 2000 to 2007 (inclusive) and 0 in all other years and the product of the global real bond yield series and the dummy variable. The estimated coefficients on both real bond yield and the product of the global real bond yield series and the dummy variable are both negative but not significant.

To summarise the findings of Tables 1 and 2, we find strong evidence that global equity yields did not move lower together with global real bond yields in the years preceding the financial crisis, as the standard savings glut hypothesis would imply. While there was a strong positive relation between equity and bond yields in the 1980s and 1990s, this transformed into a strong negative relation in the 2000s. There is also no evidence to suggest that the return on capital moved lower together with real bond yields as the standard savings glut hypothesis would imply. We find a negative (but not significant) relation between these two variables but, in contrast with the relation between equity and bond yields, we do not find evidence of a significant structural break in the relation.

How should we interpret the structural breaks found in the regression of the global equity yield on the global bond yield? Our preferred interpretation is that these 'breaks' can be explained by fluctuations in the degree of risk aversion. In a statistical sense, the estimated

equation linking equity yields to bond yields is unstable because there is a relevant explanatory variable (the ERP) that is missing from the specification.[24]

In Table 3 we test for different breakpoints in the relation between global equity and bond yields, through the use of a Quandt-Andrews breakpoint test (Andrews (1993)). We also explore whether and when there was a break in the global ERP series that we set out in Section 4. The Quandt-Andrews test performs a series of Chow breakpoint tests at every observation between two dates and reports the date at which the Chow F-statistic is highest (i.e., the probability of the null hypothesis that there is no break in the relation being incorrectly rejected is lowest).[25] The Chow breakpoint test fits an equation separately for two subsamples on either side of a pre-specified breakpoint to determine whether there are significant differences in the estimated equations.[26] In performing a Chow breakpoint test across a range of dates, the Quandt-Andrews procedure tests for the occurrence of a structural break in a relation without imposing the restriction that the break occurred at a pre-specified point.

Column 1 of Table 3 sets out the results for a breakpoint test on the regression of equity yields, lagged equity yields, the real bond yields and a constant, based on monthly data from January 1981 to July 2007. The maximum individual Chow F-statistic is obtained in October 2000, at which point the null hypothesis that there is no break in the relation is just rejected at the 5% level. In Column 2 we test for the existence and timing of a structural break in the univariate time series of the global ERP (Figure 10). To do so, we carry out the Quandt-Andrews breakpoint test on a regression of the global ERP on a constant and the global ERP series lagged by one period, using monthly data from January 1981-July 2007.[27] The

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[24] One possibility that we do not consider is that equity yields and the return on capital might be endogenously influenced by bond yields. In principle one could examine this through the use of an instrumental variable approach (although we struggle to think on an appropriate instrument that is correlated with bond yields but does not itself affect equity yields and the return on capital). The reason why we do not pursue this route further is because we are not attempting to determine whether there is a causal relation between these variables—our statistical objective in this section is simply to determine whether the global equity yields and return on capital co-moved with global bond yields in the years preceding the crisis. We are simply observing conditional correlations.

[25] The first and last 7.5% of the observations from the testing procedure because the distribution of the F-statistic becomes degenerate at breakpoints close to the ends of the equation sample (Andrews (1993)).

[26] The Chow F-statistic is calculated as $F = \dfrac{(\bar{u}'\bar{u} - (u_1'u_2 + u_2'u_2))/k}{(u_1'u_1 + u_2'u_2)/(T-2k)}$ where $\bar{u}'\bar{u}$ is the restricted sum of the squared residuals, $u_i'u_i$ is the sum of the squared residuals from sub-sample $i$, $T$ is the total number of observations and $k$ is the number f parameters in the equation.

[27] Note that the residuals in the regressions of the Global ERP on a constant and the lagged ERP perform satisfactorily, implying that the Quandt-Andrews breakpoint test provides reliable results.

maximum individual Chow F-statistic is obtained at May 2002, at which point the null hypothesis that there is no break in the relation is rejected at the 5% level. In Column 3 we perform the same test using annual data. We find the most likely breakpoint to be 2001, at which point the null hypothesis that there is no break in the relation is just rejected at the 1% level.

The conclusion that there was a structural break result in the global ERP that occurred around the turn of the century is consistent with Campbell (2008), who found that the global ex-ante ERP had fallen sharply during the 1990s but had risen since the turn of the century.

One possibility that is difficult to preclude—at least on the basis of statistical analysis alone—is that the rise in the ERP reflected a genuine increase in the riskiness of corporate earnings, not just a higher degree of aversion to risk. Could the upward trend in the ERP from 2000 onwards have been accounted for by a genuine rise in risk? One possibility is that corporate earnings were viewed as more risky following the terrorist attacks of September 2001. But such an event-driven change in risk would be consistent with a step change in the ERP, rather than the upward trend that was witnessed. Moreover, it is difficult to reconcile this view with the cross-country performance of ERPs—in particular, evidence that the rise in the ERP has been more marked in Europe than in the US (Figure 13). Another possibility is that investors perceived future corporate earnings to be more risky in the years leading up to the start of the financial crisis. But, once again, the timing of the rise in the ERP is wrong—the series began to rise eight years before the crisis began—and this proposition is difficult to reconcile with the performance of other asset classes. More generally, Fama and French (2002) find that, while the *ex-ante* ERP does co-vary with genuine estimated risk, this does not explain the long-term predictability of returns. A more likely explanation for the rise in the global ERP, it seems to us, is a shift in global risk preference, directly related to the rise in the quantity of finance coming from the emerging world.

**Section 6: Conclusion**

This paper suggests that EM economies have been key drivers of developed country returns. Their low capital intensity and high growth rates pushed up underlying rates of return on capital; but the scale and composition of their saving kept *ex-ante* yields on bonds, although not equities, relatively low. If there is any truth to this account, it has implications for how we see the credit boom, and the crunch that has followed.

As far as the credit boom is concerned, the link is straightforward: if high EM saving drove bond yields lower, and low bond yields were an important driver of the credit boom that preceded the crunch, it follows that high EM saving was an important precursor of the financial crisis. According to this view, the supply of developed-country credit did not grow spontaneously from the financial system, but because increasing numbers of investors were willing to buy low-yielding fixed-income assets. The financial system merely intermediated between that demand and borrowers in the developed world keen to meet it.

If high saving in developing economies was instrumental in fuelling credit growth in the developed world, the skewness of EM saving that we have discussed in this paper was also reflected in the pattern of the asset boom that preceded the crisis. It was housing, the sector most dependent on fixed-income funding, that saw the biggest boom; corporate investment, more dependent on equity finance, was relatively subdued.

If the glut of emerging economy saving was a necessary precursor to the credit crunch and international finance did no more than match patient EM savers with impatient developed economy borrowers, what role does this leave for the excesses and regulatory laxness in the financial system in the formation of the crisis? Our own view is that both factors were important—that faults in the developed-country financial system and high EM saving were both necessary components of the credit boom, even if neither was sufficient on its own. The experience of many emerging economies is that capital inflows and financial distortions can be strong complements in the formation of a financial crisis (see, for instance, McKinnon and Pill (1997) and Wilson (2001)). We see no reason why developed economies should be different in this regard, with large inflows of capital and deficiencies in regulation combining to produce resource misallocation and accumulation of financial risk.

Table 1: Ordinary Least Squares Regression Results for Global Equity Yields on Global Real Bond Yields

| | (1) | (2) | (3) |
|---|---|---|---|
| Dependent variable | Global Equity Yield | Global Equity Yield | Global Equity Yield |
| Constant | -0.31<br>(3.72)*** | 1.03<br>(2.61)** | -0.32<br>(-4.00)*** |
| Global Equity Yield (-1) | 0.92<br>(64.25)*** | 0.87<br>(17.60)*** | 0.92<br>(68.55)*** |
| Global Real Bond Yield | 0.18<br>(5.22)*** | -0.14<br>(-2.05)** | 0.18<br>(5.75)*** |
| D1 | — | — | 0.94<br>(5.18)*** |
| RBY*D1 | — | — | -0.26<br>(-4.39)*** |
| Adj $R^2$ | 0.99 | 0.95 | 0.98 |
| Data frequency | Monthly | Monthly | Monthly |
| N | 228 | 91 | 319 |
| Sample | 81m1-99m12 | 00m1-07m07 | 81m1-07m07 |
| DW | 1.62 | 1.82 | 1.68 |

Notes: T-statistics in parentheses. ***, **, * denote significance at the 1, 5 and 10 percent levels respectively. DW stands for Durbin-Watson statistic. D1 is a dummy variable which takes the value of 1 from January 2000 until July 2007 (inclusive) and takes a value of 0 in all other periods. RBY*D1 is the product of the Global Real Bond Yield series and D1.

Table 2: Ordinary Least Squares Regression Results for Global Equity Yields and the Global Return on Capital on Global Real Bond Yields

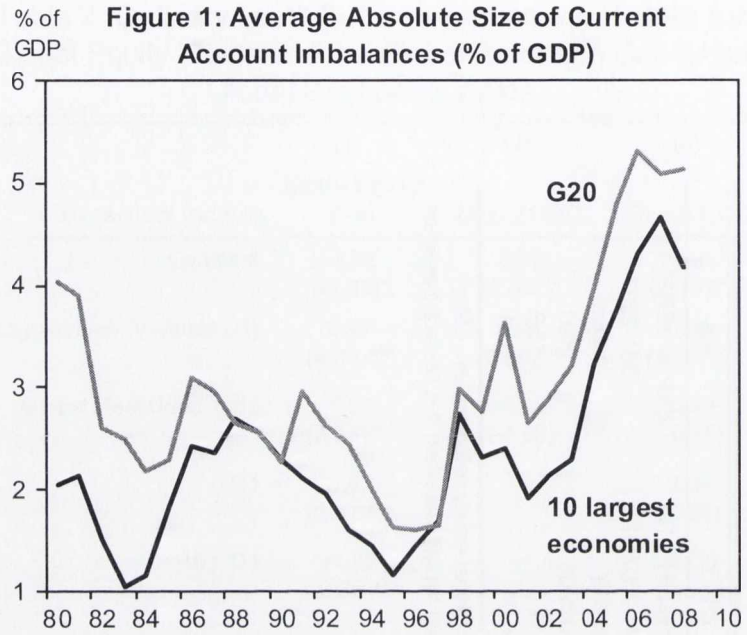
| | (1) | (2) | (3) |
|---|---|---|---|
| Dependent variable | Global Equity Yield | Global ROC | Global ROC |
| Constant | -1.62<br>(-1.92)* | 5.68<br>(2.58)** | 6.2<br>(2.10)** |
| Lagged Dep. Variable (-1) | 0.47<br>(4.01)*** | 0.61<br>(3.98)*** | 0.58<br>(3.68)*** |
| Global Real Bond Yield | 1.08<br>(3.34)*** | -0.40<br>(-1.58) | -0.36<br>(-0.86) |
| D1 | 5.92<br>(3.37)*** | — | 2.39<br>(0.98) |
| RBY*D1 | -1.69<br>(-2.89)*** | — | -1.08<br>(-1.26) |
| Adj $R^2$ | 0.88 | 0.54 | 0.54 |
| Data frequency | Annual | Annual | Annual |
| N | 27 | 26 | 26 |
| Sample | 1981-2007 | 1982-2007 | 1982-2007 |
| DW | 1.88 | 1.47 | 1.69 |

Notes: T-statistics in parentheses. ***, **, * denote significance at the 1, 5 and 10 percent levels respectively. DW stands for Durbin-Watson statistic. D1 is a dummy variable which takes the value of 1 from 2000 until 2007 (inclusive) and takes a value of 0 in all other periods. RBY*D1 is the product of the Global Real Bond Yield series and D1.

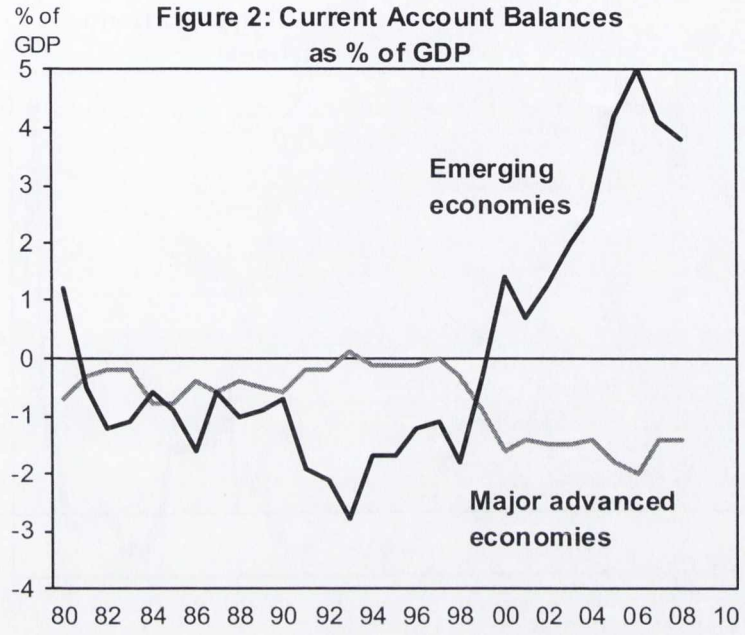
Table 3: Quandt-Andrews Breakpoint Test Results

| | (1) | (2) | (3) |
|---|---|---|---|
| Regression | EY=c+a*EY(-1)+b*BY | ERP=c+aERP(-1) | ERP=c+aERP(-1) |
| Equation sample | 1981M1-2007M7 | 1981M1-2007M7 | 1981-2007 |
| Frequency | Monthly | Monthly | Annual |
| Date Maximum LR F-stat | 2000M10 | 2002M05 | 2001 |
| Maximum LR F-stat | 13.4 | 12.0 | 15.9 |
| Prob | 0.05 | 0.04 | 0.01 |

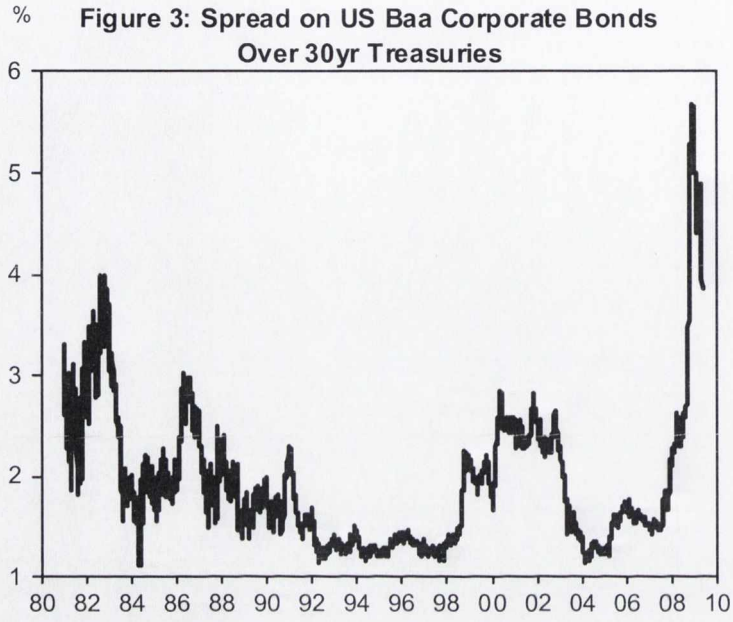
Notes: EY = global equity yield, BY = global real bond yield. ERP = Global equity risk premium. LR = Likelihood ratio. Prob = The estimated probability of rejecting the null hypothesis when it is correct, based on Hansen (1997) *p*-values.



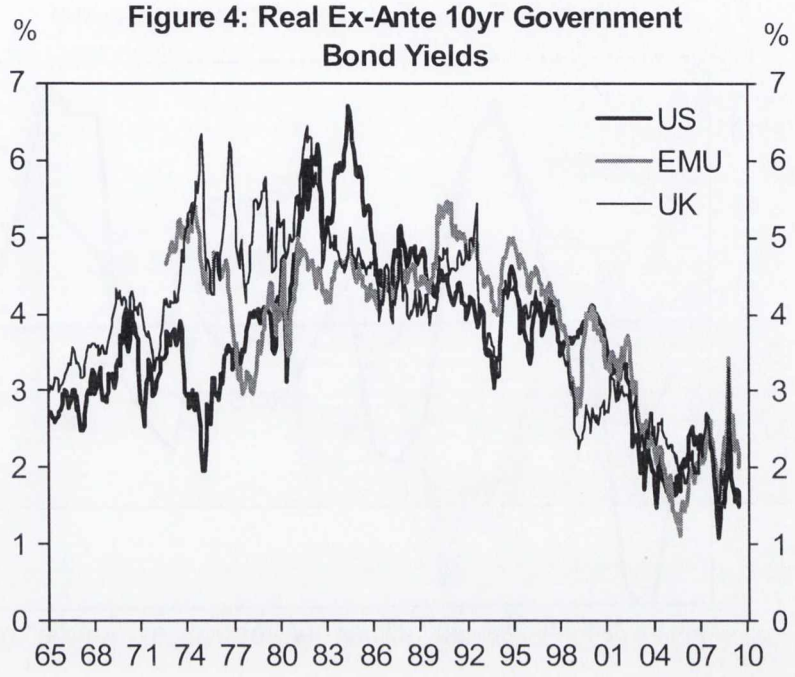

Notes: Source Author's calculation based on IMF data. The 10 largest economies in the world (based on 2008 GDP in market US$) are US, Japan, Germany, China, UK, France, Italy, Canada, Spain and South Korea. The G20 also includes Russia, Brazil, Argentina, Mexico, India, Indonesia, Saudi Arabia, South Africa and Turkey.



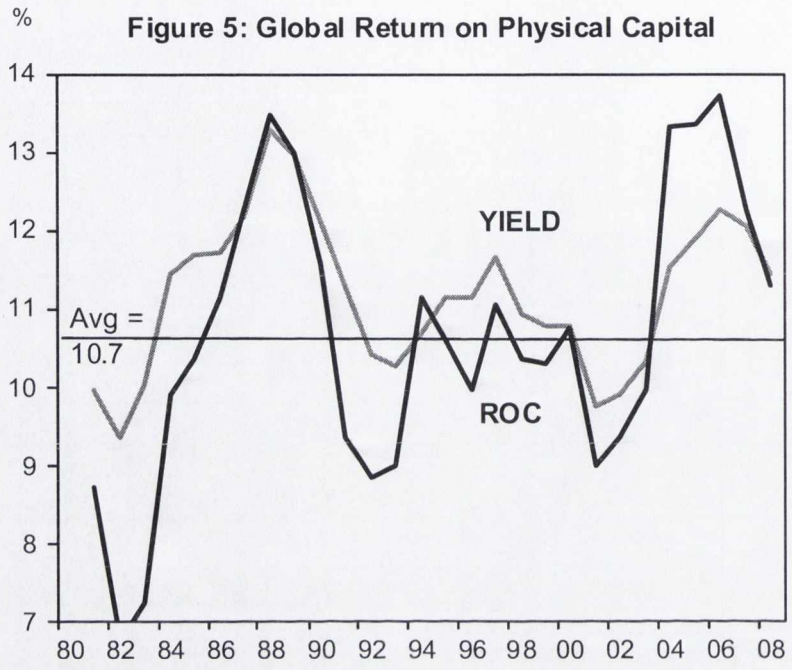

Notes: Source IMF. Major Advanced Economies are the G7 economies (US, Japan, Germany, UK, France, Italy and Canada).



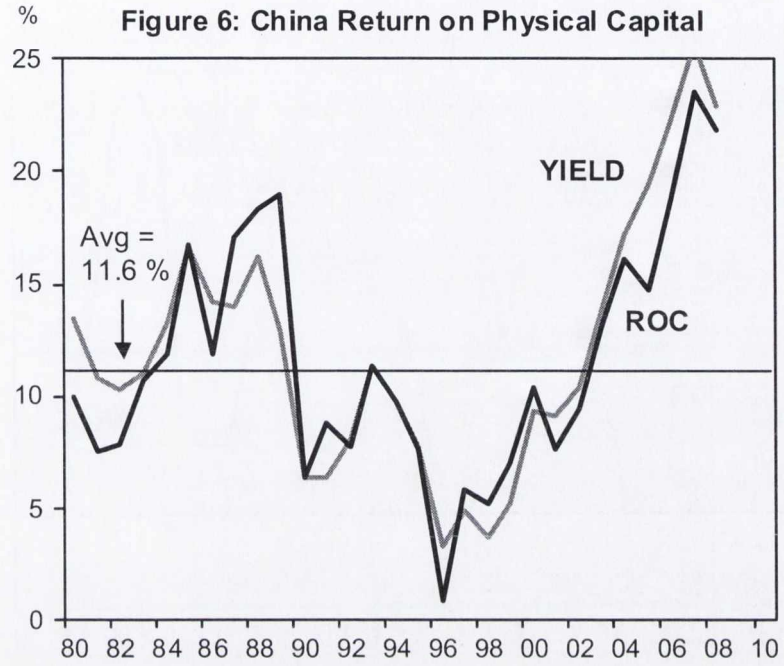

Notes: Source Moody's, Haver Analytics.




Notes: Source Author's calculations using national data from index-linked government bond markets and extending the historical series based on the estimated relation with observable variables (see Section 4 for more details).

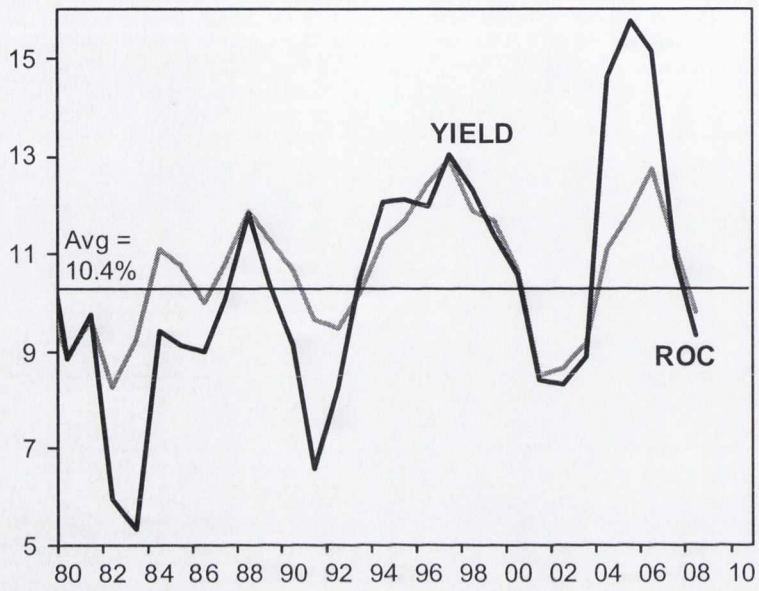



Notes: Author's calculations based on national accounts data. Global series based on a capital stock weighted average of country estimates. See Section 4 for more details.

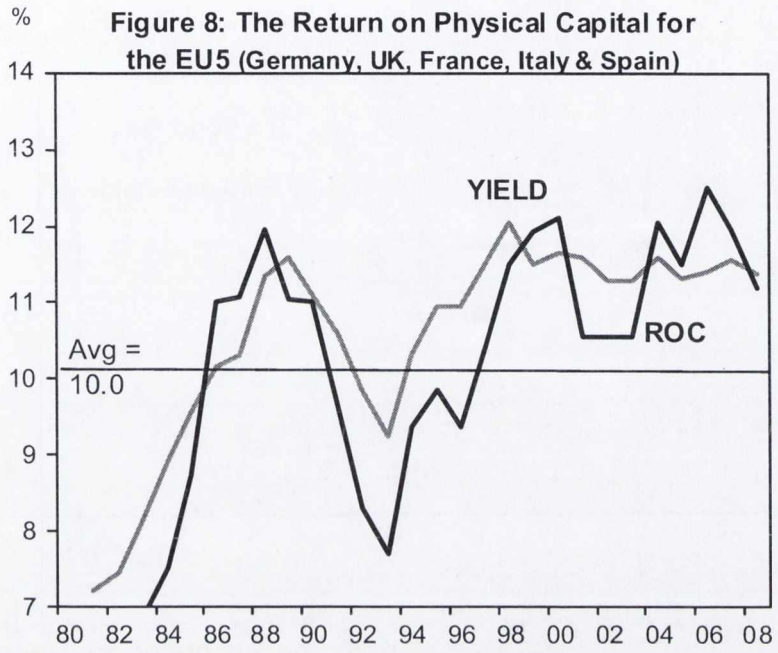



Notes: Author's calculations based on national accounts data. See Section 4 for more details.

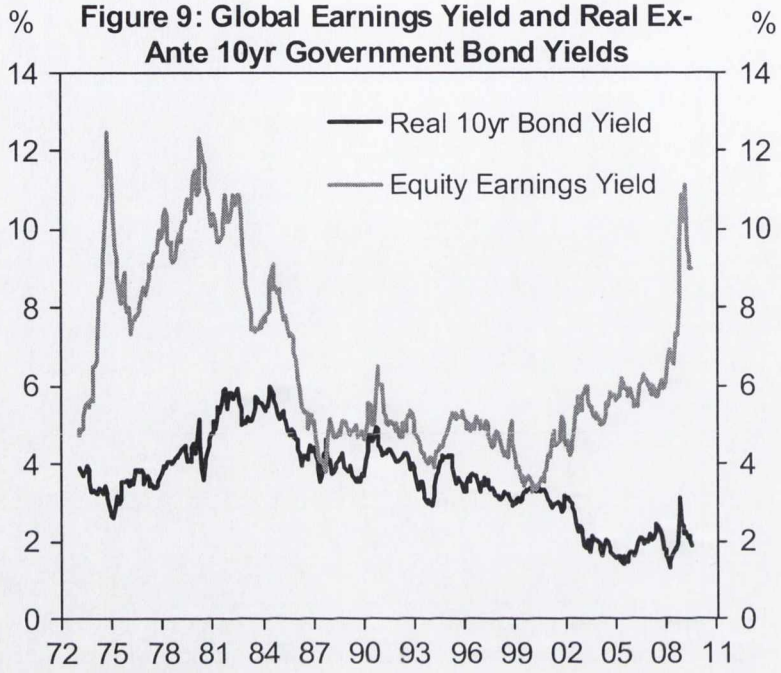
**Figure 7: US Return on Physical Capital**



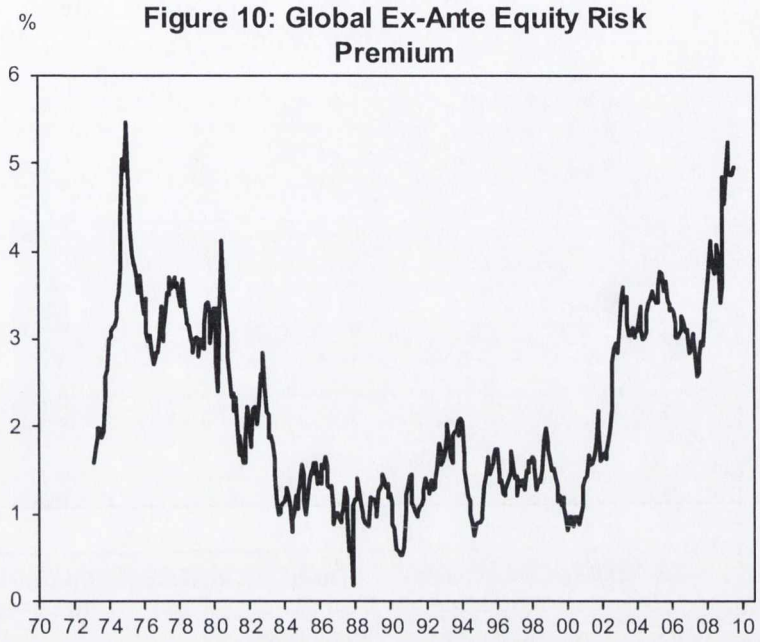

Notes: Author's calculations based on national accounts data. See Section 4 for more details.



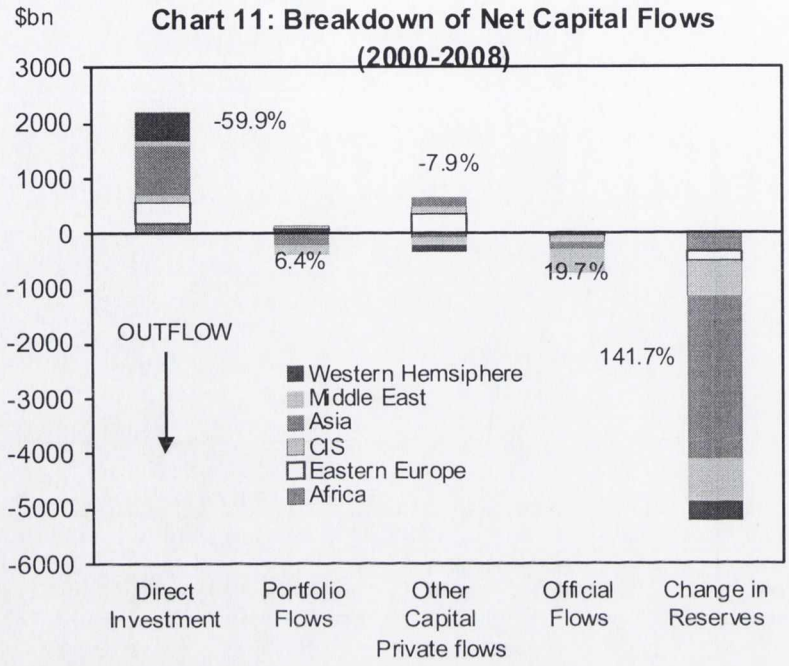

Notes: Author's calculations based on national accounts data. See Section 4 for more details.




Notes: Author's calculations. See Section 4 for more details.



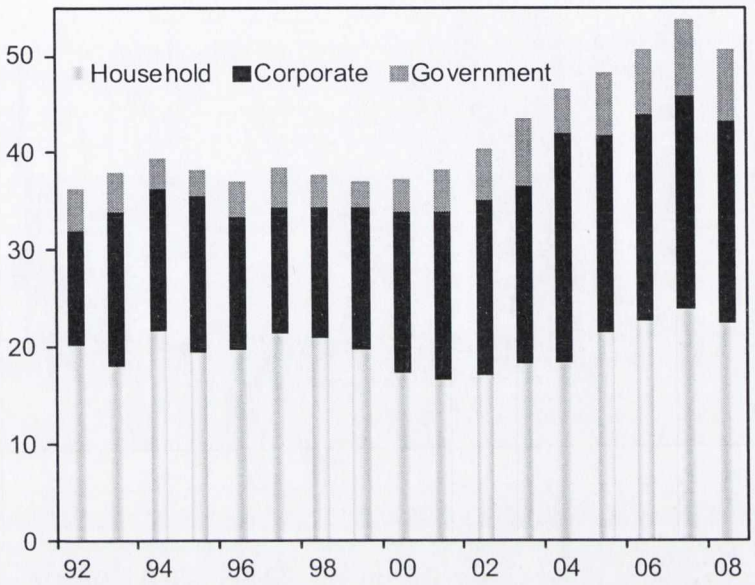

Notes: Author's calculations. See Section 4 for more details.




Notes: Author's calculations based on IMF data.

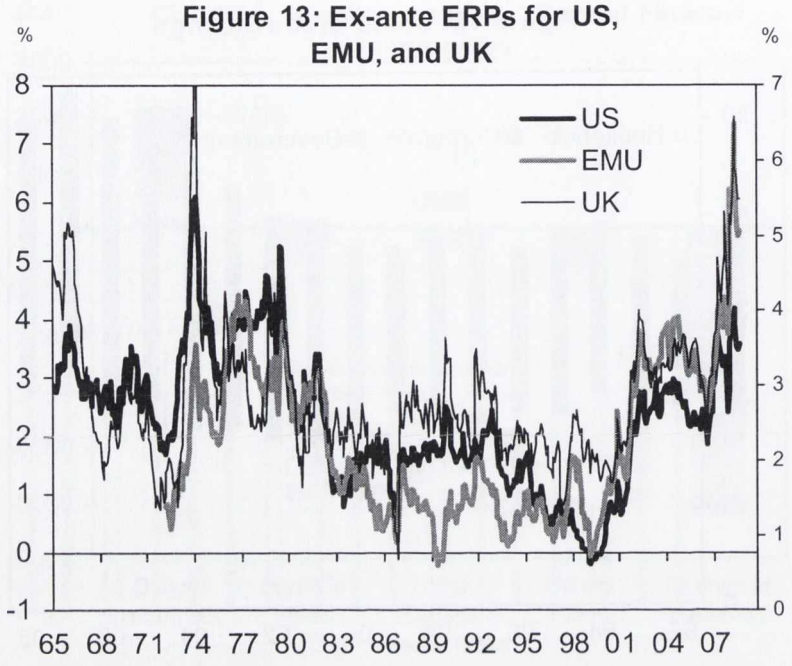
% of GDP

**Figure 12: China Gross Savings**




Notes: Source CEIC.

**Figure 13: Ex-ante ERPs for US, EMU, and UK**




Notes: Author's calculations. See Section 4 for more details.

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