# Productivity Gaps and Global Systematic Risk Exposure: Pricing Country-Industry Portfolios *

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**Abstract**

Shocks transmitted from productivity leaders to lagging economies are systematic sources of risk. Global technology and knowledge diffusion leads to predictable patterns in productivity dynamics across countries and industries. Technology gaps determine the level of exposure to the systematic productivity shocks. Firms in a country-industry with larger technology gaps relative to the world leader are more dependent on the leader's innovations compared to their own productivity improvements. They thus have higher loadings on the leader productivity shocks and higher average stock returns. For OECD panel data, a country-industry's technology gap significantly predicts the stock returns of the country-industry: holding the quintile of country-industry portfolios with the largest gaps and shorting the quintile with the smallest gaps generates annual returns of 9.8% (6.7% after risk adjustment with standard factors). A factor representing the technological productivity gap explains country-industry portfolio returns substantially better than standard factor models. Loadings on leader-country productivity shocks have substantial correlation with technology gaps, and leader productivity shocks are more important for stock returns than idiosyncratic productivity shocks. These findings support that the technology gaps and associated higher average returns are indeed linked to systematic risk.

***Keywords*** Production-Based Asset Pricing, Productivity Gap, Total Factor Productivity, OECD Countries, International Equity Returns, Technology Diffusion

## 1 Introduction

We attempt to explain country-wide and industry-wide differences in mean stock returns as originating from differences in exposure to systematic risk. From the production-based asset pricing (PBAP) perspective a true global

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systematic risk must have an important, pervasive, unpredictable, and highly variable impact on business conditions. We consider productivity shocks with a global impact. Specifically, the technology or knowledge shocks that originate with productivity leaders and eventually spill over to all countries and industries. Even though such shocks do not instantly impact the production levels and net income of trailing producers, their anticipated impact should be capitalized in stock prices rapidly. We develop a simple model which accounts for gradual diffusion of productivity shocks from industry or country technology leaders across the countries and industries trailing in productivity.

The model implies that the technology gap for any particular industry in a particular country (for short a "country-industry") relative to the technology of the currently most advanced country-industry has important explanatory power for the country-industry's equity returns. We empirically test the model using calculated productivity gaps, and stock return data for firms in OECD countries and demonstrate that these productivity gaps explain a significant fraction of the cross-sectional variation in average returns.

Previous studies have proposed plausible theoretical explanations for global differences in equity returns. Solnik (1974) develops an international intertemporal equilibrium model (the ICAPM) that incorporates exchange rate risk to explain the differences in returns across countries. Grauer et al. (1976) use a version of Breeden's consumption-based asset pricing model (Breeden, 1979), the CCAPM, employing the marginal utility of consumption as the pricing kernel to explain cross-country differences in mean returns. Both the ICAPM and CCAPM explanations have been difficult to support empirically. Empirical analysis instead documents the relevance of alternative global (Fama and French, 1998, 2017) and/or local (Hou et al., 2011, and Chaieb, Langlois, and Scaillet, 2020) risk factors for explaining mean returns across countries. Moreover, mean stock returns at the country level show persistence in the short run (Chan et al., 2000, Asness et al., 2013) which reverses in the long run (Balvers et al., 2000, Zaremba et al., 2020). These empirical results cannot easily be explained by consumption-based (i.e., marginal-utility-based) asset pricing models. The discouraging empirical results may be a consequence of time variation in return covariances with global wealth or with consumption or, more generally, indicate a problem in identifying and measuring the appropriate marginal utility components. The recent contribution of Gavazzoni and Santacreu (2020) produces encouraging results in a fully-developed consumption-based general equilibrium model with a non-expected-utility recursive preference formulation (Epstein-Zin). Endogenously developing the international diffusion of technologies, Gavazzoni and Santacreu explain quantitatively the level of the equity premia across countries and predict the correlation in stock returns across country pairs from their shared research and development. They do not address the difference in average returns by country and industry that is our focus.

Production-based asset pricing (PBAP) without frictions along the lines of Brock (1982), Lucas (1978), and Balvers et al. (1990) reasons that aggregate output is proportional to consumption, and that output growth, presumably measured more precisely, may substitute for consumption growth as the pricing kernel. Incorporating the friction of convex adjustment costs to investment, Cochrane (1991, 1996) shows that alternatively investment returns may be used as a pricing kernel. Since productivity affects output as well as investment returns both the approaches with and without frictions imply that productivity shocks are important for the pricing kernel (in particular, Zhang 2005, Balvers and Huang 2007, Papanikolaou 2011, Lin 2012, Garleanu, Panageas, and Yu 2012, Kogan and Papanikolaou 2013, Hou, Xue, and Zhang 2014, and Balvers, Gu, and Huang 2017). To this point in time, PBAP has scarcely been applied in the international asset pricing context to examine and explain stock return differences.[1]

Productivity in a particular country has more potential for improvement when the country's productivity gap relative to the world's productivity leader (the United States in some instances) is larger. This is the "catch-up" view by which existing advanced technology provides a target for reverse engineering, mimicking, or development that lowers the cost of productivity improvement, making it cheaper to catch up than to invent (see e.g. Comin and Hobijn, 2010 and Wolff, 2014). Hence future investment returns are expected to be higher in countries with lower current levels of productivity. From PBAP, higher investment returns imply higher stock returns, so it is possible to explain and predict future return differences arising from variation in risk exposure between international stock markets (at least within the OECD countries, i.e. developed economies with integrated financial and non-financial markets) by current country-wide "gaps" (e.g. Coe et al., 2009) in the levels of productivity.

A large literature on productivity elaborates on the dynamics of technology diffusion. The prevailing view of the dynamics of global technological innovation is that technology trickles down from the most advanced economy to less advanced economies (Parente and Prescott, 1994, Comin and Hobijn, 2004, 2010, and Comin and Mestieri, 2018). According to Keller (2004), 90 percent of the productivity growth for most countries can be explained from foreign sources of technology which diffuse through the channels of trade (mainly imports) and foreign direct investment (FDI), and possibly also through foreign aid or corporate espionage. The diffusion is slow as a result of the embodiment effect (Fisher, 2006) which argues that adoption of a new technology requires a series of investments to replace existing vintages of capital. The technology diffusion may well occur in important measure at the industry or firm level but its most important systematic component is likely to be at the country level because the timing of adaptation of new technologies and the associated risk exposure depend crucially on country-wide absorptive capacity which determines how well information about new technology is assimilated to improve productivity and efficiency, and depends on country-wide factors such as human capital, protection of intellectual property rights, R&D history, and government policies (Hall and Jones 1999, Keller 2004, Mancusi 2008).

[1] Empirical exceptions are Cooper and Priestley (2013), Watanabe et al. (2013), and Titman, Wei, and Xie (2013) who tie returns across countries to local investment-capital ratios and global capital-output ratios. Our explanation for differences in expected returns is complementary to that based on asset growth or investment in these papers. Projected increases in productivity increase investment returns, leading to higher stock returns, but may also lead to positive net investment and capital deepening (asset growth as considered by Titman et al., 2013, and Watanabe et al., 2013) which, all else equal, will have a negative impact on investment returns, offsetting part of the increase in investment returns due to the productivity increase.

Howitt (2000), Griffith et al. (2004), and Coe et al. (2009) argue that country-wide productivity increases are directly related to the technology gap between a country and the technological leader country. The productivity advantage of the leading economy spills over to other economies. The main reason is that mimicking or reverse engineering an existing technology is cheaper than creating it. Thus, lagging economies should ultimately catch up to the leading economy (all else equal) implying, in the process, higher productivity and higher investment returns for the lagging economy.[2] How do productivity differences between individual countries and the leading productivity economy, which we refer to as "technology gaps", explain cross-sectional variation in global stock returns? If a country has a large productivity gap compared to the leading-technology-producing country's productivity, then that country has more potential for improvement in productivity from any channels, such as trade, espionage, foreign investment, and foreign aid. The transmission from each of these channels is positively related to the technology gap. Since enhanced productivity at little extra cost raises investment returns, stock returns rise as well and must be linked to productivity in the PBAP framework.

This paper utilizes the dynamics of technology diffusion in a PBAP framework to explain the cross-sectional variation in stock returns. Variation in systematic risk exposure is linked to productivity gaps which in turn affects mean returns. The implications will be tested using historical data of stock returns by country and industry, productivity levels across industries and countries, and other mediating variables for the group of OECD countries.

## 2 A Simple Model of Capital and R&D Investment with Productivity Spillovers

We present a stylized equilibrium model from the production perspective following Brock (1982), Cox et al. (1985), and Berk et al. (1999). These models determine the impact on expected returns of firm-level investment decisions. In the model we avoid market frictions thus deviating from the approach of Cochrane (1991, 1996), Zhang (2005) and others, but following Balvers and Huang (2007), Papanikolaou (2011), Kogan and Papanikolaou (2013), and others. Our model adds two elements to a typical PBAP framework: heterogeneity by country and industry in the technology available to firms; and gradual technology diffusion commensurate with the productivity gap between a particular firm and the leader in its industry.

[2] Because new productivity shocks continue to occur, the process of diffusion will in principle continue indefinitely even if particular gaps are closed over time, with just the composition of the group of leading and lagging economies changing over time. Empirically, it is well known that convergence, although extensively documented for advanced economies, is not apparent between advanced and emerging economies (Galor, 2005). We limit our sample to a group of OECD countries which are advanced economies. Inklaar and Diewert (2016) find empirically that country industries on average did not get closer to the technology frontier over the 1995-2011 period in a sample containing both advanced economies and major emerging economies.

Industries in different countries have access to varying levels of technology and knowledge affecting productivity. We treat industries by country as separate units referred to as "country-industries" whose investment choices and average stock returns we attempt to explain. The model examines the actions of an individual firm representing a particular country-industry. The firm (i.e., the country-industry) is either the "leader" or one of the "laggards" for its industry worldwide (using the terminology of Bena and Garlappi, 2020).[3] The leading firm has access to superior technology and is the most advanced of all countries within the same industry. Any other firm in this industry worldwide is lagging, trailing the leading country-industry in terms of technology access. The leaders in the various industries may be likely to operate in the same country, but this is in part an empirical issue. Technology from the leader spills over to lagging producers by various mechanisms (such as trade, direct investment, corporate espionage, information technology, or unilateral aid) which we capture as positively related to the size of the technology gap between the recipient lagging firm and the leading firm. Unlike Bena and Garlappi (2020) we de-emphasize strategic interactions between the firms. For simplicity we assume that the laggards do not expect to take the lead, and that the leader does not expect to lose the lead in its industry worldwide.

Production incentives and the general business climate are characterized by two productivity indicators. First, the fundamental production infrastructure within a country which is not controllable by individual firms. It depends on human capital, physical and organizational infrastructure, regulation, government influence, etc. which affect a firm's total factor productivity without requiring firm inputs. This productivity component is not transferable across country-industries (or, if so, very slowly as is human capital via migration). We refer to it as Total Factor Productivity ($TFP$) or simply as productivity, denoted at time $t$ as $\theta_t$. The level of productivity $\theta_t$ available imparts a comparative advantage in a particular country-industry. It is affected by i.i.d. productivity shocks $\varepsilon_{t+1}$ and follows either a random walk or a mean-reverting exogenous process.

Second, the technology available to a country-industry. The technology level is controllable by the firm through R&D investment, which contributes to the R&D stock from which a random level of technology is produced. The technology concept is interpreted broadly to include patents, copyright, and trademarks, as well as knowledge and experience components involving management practices, production processes, etc. The level of technology is viewed as an input in the production function (or technically as a quality enhancement to the labor inputs that contribute to production). It is transferred to other country-industries through spillovers from leading firms to lagging firms worldwide. We refer to this productivity indicator as technological productivity or the technology level, denoted as $z_t$ for the country-industry. The technology level at a particular time, $z_t$, equals the chosen level of the R&D stock,

[3] Bena and Garlappi (2020) provide a specific analysis of the game-theoretical interactions of firms in a market where the ultimate technology leader gains a dominant market share. In this scenario, interestingly, laggard firms face higher systematic risk, as in our model, implying higher average stock returns. Unlike the productivity risk in our model, the systematic risk in Bena and Garlappi derives from a standard market risk factor. Laggard firms have higher market betas because their trailing market position makes them more susceptible to aggregate fluctuations.

$\bar{z}_t$, times a random return $\eta_{t+1}$ on R&D. The return is i.i.d. in each period, capturing the intrinsically stochastic character of the research and development process.

## 2.1 Investment, Stock Valuation, and Stock Returns of Lagging Firms

A representative firm in a specific country-industry chooses the future capital stock to maximize shareholder value. The firm operates in a "laggard" environment, meaning that its country-industry is not operating at the leading edge of technological productivity. We assume in the optimization formulation for simplicity that a laggard firm does not take into account that it may become the leader at some point in the future. The firm's decision problem then is expressed by the following Bellman equation:

$$V(k_t, z_t, z_t^*, \theta_t, \theta_t^*) = \underset{i_t, h_t}{max} \left\{ (y_t - i_t - h_t) + E_t \left[ m_{t+1} V(k_{t+1}, z_{t+1}, z_{t+1}^*, \theta_{t+1}, \theta_{t+1}^*) \right] \right\}. \tag{1}$$

The value function $V$ represents the maximum value of the firm that depends on a vector of state variables. Namely: the firm's current capital stock ($k_t$), the technology level ($z_t$), the leading country-industry technology level ($z_t^*$), and Total Factor Productivity ($TFP$) in the individual laggard country-industry and in the leader country-industry ($\theta_t$ and $\theta_t^*$). The "*" superscript indicates everywhere that the variable is associated with the leader country-industry. The control variables are $i_t$, $h_t$, which represent the current gross investment and R&D levels, respectively. The stochastic discount factor $m_{t+1}$ rules out the existence of arbitrage. Firm revenue is captured by output $y_t$. We assume that the production function $y(\ )$ exhibits decreasing returns to scale in capital and labor. The production function is of the Cobb-Douglas variety. Labor inputs $l$ are assumed fixed for simplicity, and technological productivity $z_t$ is labor-saving:

$$y_t = y(k_t, z_t l) = \theta_t A k_t^{\alpha} (z_t l)^{\beta} = \theta_t k_t^{\alpha} z_t^{\beta} \ ; \quad \theta_{t+1} = \varepsilon_{t+1} \theta_t^{\rho} \theta^{1-\rho}, \tag{2}$$

with $\alpha + \beta < 1$, $E(\varepsilon_{t+1}) = 1$ and $\theta > 0$. The level of productivity $\theta_t$ ($TFP$) follows a mean-reverting process with $0 < \rho \leq 1$. It represents the collection of human capital, infrastructure, and regulation that impacts production but is not measured as an input, is not controllable by the firm, and cannot be exported. The equations of motion for the inputs are as follows. For the capital stock:

$$k_{t+1} = (1 - \delta) k_t + i_t. \tag{3}$$

The depreciation rate of capital is a constant $\delta$ in equation 3 . Employing a stochastic version of the original formulation in Nelson and Phelps (1966) and based on the dynamics of technology diffusion illustrated by Comin and Hobijn (2004, 2010), we model the technological productivity as follows. The own country-industry and the lead-country-industry productivity shocks $\eta_{t+1}$ and $\eta_{t+1}^*$ are uncorrelated accross country-industries. Moreover $\eta_t$ (as well as $\eta_t^*$) is i.i.d. The spillover of leader country productivity is captured by $\gamma$ which is greater than zero, indicating the existence of positive spillovers, and less than one so that spillovers develop gradually: $0 < \gamma < 1$. Technological productivity at both the firm's country-industry and at the leading country-industry are state variables and its equations of motion are:

$$z_{t+1} = \eta_{t+1}\bar{z}_{t+1} \equiv \eta_{t+1}\left[z_t + \gamma(z_t^* - z_t) + h_t\right], \tag{4}$$

$$z_{t+1}^* = \eta_{t+1}^*\bar{z}_{t+1}^* \equiv \eta_{t+1}^*(z + h_t^*), \tag{5}$$

with $\eta_{t+1}$,$\eta_{t+1}^*$ reflecting the randomness in the outcomes of R&D, and $E(\eta_{t+1}) = 1$ and $E(\eta_{t+1}^*) = 1$. Total technology for lagging and leading country-industry, indicated by $z_t$ and $z_t^*$, is viewed as an input in the production process. For simplicity (to save on the number of parameters) we assume that technology does not depreciate. The technological productivity in equation 4 evolves stochastically given the current state which depends partially on own technical productivity and partly on technology spilling over from the leading foreign producer. It implies that the leading country-industry technology level $z_t^*$ is a state variable positively affecting the value of the firm since it benefits future technology of the firm, $z_{t+1}$, which, in turn, positively affects future profitability from equation 3.[4]

Following Berk et al. (1999) the stochastic discount factor (sdf) is specified exogenously based on productivity shocks. In our formulation systematic risk is exclusively related to the productivity shocks of the leading economy: $\varepsilon_{t+1}^*, \eta_{t+1}^*$. The stochastic discount factor need not be specified explicitly (although we consider in Appendix A a multiplicative form together with the assumption of logarithmic distributions of the shocks for concreteness). No exogenous correlations are present between the various shocks variables in each country-industry. All correlations in the model are endogenous. Maintaining the "small-country" assumption often made in international finance models, no country-industry or country is large enough to influence world prices. Together these assumptions mean that the maximum set of systematic shock variables consists of the shocks occurring in the leader country-industries.[5] Thus, the sdf is specified as

$$m_{t+1} = m(\varepsilon_{t+1}^*, \eta_{t+1}^*). \tag{6}$$

The sdf formulation omits state variables (such as $z_t^*$) for simplicity. There is no time variation in the functional form of the sdf and consequently in the prices of systematic risk of $\varepsilon_{t+1}^*$ and $\eta_{t+1}^*$. Furthermore, $E_t\left[m_{t+1}\right]$ then is

[4]Acemoglu et al. (2006), Benhabib et al. (2019), Buera and Oberfield (2020) and Lind and Ramondo (2019) provide a more nuanced view of endogenous productivity growth, considering innovation as well as imitation incentives. Firms closer to the frontier (firms in leader industries or countries in our terminology) have incentives to innovate, whereas firms further from the frontier benefit more from imitation. Given the state of conditioning factors, firms in a particular country end up at an equilibrium distance from the frontier in which, at the margin, imitation and innovation efforts are equally rewarding. Nevertheless, the equilibrium investment returns from either choice are higher when further from the frontier, as follows also from our simpler formulation. Another sophisticated formulation of productivity spillovers, Bloom et al. (2013), considers negative externalities as well as positive emerging from a technology gap: increased knowledge and a business-stealing effect. However, they find that the positive spillover dominates, as is maintained in our formulation.

[5]We do not yet presume that leader shocks are systematic since the leaders could be different for each industry, in which case the leader shocks would not be pervasive. Then the prices of risk consistent with the sdf would be zero.

constant and we can define $E_t[m_{t+1}] = \frac{1}{1+r}$, with $r > 0$. The shocks $\varepsilon_{t+1}$ and $\eta_{t+1}$ in each laggard country-industry are not pervasive and are thus unpriced idiosyncratic risks. Only the shocks in a leader country-industry are candidates for systematic risks (priced at a time-invariant rate) if they are pervasive, affecting all other countries. Define: $E_t\left[\eta_{t+1}^{*\beta}\right] = E_t\left[\eta_{t+1}^{\beta}\right] \equiv \bar{\eta}_\beta$ (the leading and lagging country-industry shock distributions are identical). Discounting systematic shocks $\eta_{t+1}^{*\beta}$ (for instance) gives, by definition, $E_t\left[\eta_{t+1}^{*\beta} m_{t+1}\right] = \frac{\bar{\eta}_\beta}{1+\kappa_\beta^\eta}$. The notational convention for required returns (such as) $\kappa_\beta^\eta$ is that the superscript denotes the risk factor(s) and the subscript denotes the exponent(s) working on the risk factor(s), allowing for the risk premium to be different for every exponent.[6]

The first-order condition for equation 1 generates (the time argument $t$ represents the set of state variables $\{k_t, z_t, z_t^*, \theta_t, \theta_t^*\}$, so that $V(t) \equiv V(k_t, z_t, z_t^*, \theta_t, \theta_t^*)$):

$$E_t[m_{t+1}V_k(t+1)] = 1, \qquad E_t[\eta_{t+1}m_{t+1}V_{\boldsymbol{z}}(t+1)] = 1. \tag{7}$$

The envelope conditions for the state variables controlled by the firm are

$$V_k(t) = \alpha\theta_t k_t^{\alpha-1} z_t^{\beta} + (1-\delta), \qquad V_z(t) = \beta\theta_t k_t^{\alpha} z_t^{\beta-1} + (1-\gamma). \tag{8}$$

Moving equations 8 one time period ahead, using the FOCs 7 and, finally, equation 4, yields

$$k_{t+1}^{1-\alpha} = \left(\frac{\alpha\theta_t^{\rho}\theta^{1-\rho}\bar{\eta}_\beta}{r+\delta}\right)\bar{z}_{t+1}^{\beta}, \qquad k_{t+1}^{\alpha} = \left(\frac{r+\gamma}{\beta\theta_t^{\rho}\theta^{1-\rho}\bar{\eta}_\beta}\right)\bar{z}_{t+1}^{1-\beta}. \tag{9}$$

Multiply the two equations above by each other to obtain:

$$\frac{k_{t+1}}{\bar{z}_{t+1}} = \left(\frac{\alpha}{\beta}\right)\left(\frac{r+\gamma}{r+\delta}\right). \tag{10}$$

Define $\omega = 1/(1-\alpha-\beta)$. The optimal $\bar{z}_{t+1}$ (the target level for the stock of R&D capital) then is:

$$\bar{z}_{t+1} = C\left(\frac{\theta_t}{\theta}\right)^{\rho\omega}, \quad C \equiv (\theta\,\bar{\eta}_\beta)^{\omega}\left(\frac{\alpha}{r+\delta}\right)^{\alpha\omega}\left(\frac{\beta}{r+\gamma}\right)^{(1-\alpha)\omega}. \tag{11}$$

Note that, in equilibrium, the target level of technological productivity and $TFP$, both in log terms, are perfectly linearly related. The fundamental underlying productivity provides incentives for R&D accumulation that lead to technology levels concordant with the comparative advantage.

The ex-dividend stock price is given by $P_t = E_t[m_{t+1}V(t+1)]$. The value function, equal to the stock-market

[6] If we specified lognormal distributions for the factor realizations and an exponential functional form for the sdf (as presented in parts of Appendix A), then the factor risk premium for the exponential risk $\kappa_\beta^\eta$ can be related systematically to that of the underlying risk factor, $\kappa^\eta$ : $1+\kappa_\beta^\eta = (1+\kappa^\eta)^\beta(1+r)^{1-\beta}$.

value of the firm with dividend included, requires first solving for the optimal actions of the leader firm and is derived in Appendix A. The solution for the ex-dividend stock price is

$$P_t = \left(1 + \frac{\beta(1-\gamma)}{r+\gamma} + \frac{\alpha(1-\delta)}{r+\delta}\right)\left(\frac{r+\gamma}{\beta\,(1+r)}\right)\bar{z}_{t+1} + \left(\frac{\gamma}{1+\kappa^{\eta}}\right)\bar{z}^*_{t+1} + g(\theta_t) + g^*(\theta^*_t), \tag{12}$$

with

$$g(\theta_t) = \sum_{\tau=2}^{\infty} W_\tau \left(\frac{\theta_t}{\theta}\right)^{\rho^\tau \omega}, \quad W_\tau = C\left(\frac{r+\gamma}{\beta\,\omega\,(1+r)}\right)\prod_{i=1}^{\tau-1}\frac{\bar{\varepsilon}_{\rho^i\omega}}{1+r},$$

$$g^*(\theta^*_t) = \sum_{\tau=2}^{\infty} W^*_\tau \left(\frac{\theta^*_t}{\theta}\right)^{\rho^\tau \omega}, \quad W^*_\tau = C^*\left(\frac{\gamma}{1+\kappa^{\eta}}\right)\prod_{i=1}^{\tau-1}\frac{\bar{\varepsilon}_{\rho^i\omega}}{1+\kappa^{\varepsilon}_{\rho^i\omega}}.$$

To guarantee that the stock price is finite the parameter condition that $\bar{\varepsilon}_\omega < 1+r$ is imposed, which is sufficient to guarantee that $g(\theta_t)$ and $g^*(\theta^*_t)$ are finite even when $\rho = 1$.

$V(t+1)$ is the value of the stock including dividends. Hence, the gross stock returns equals $1 + r^s_{t+1} = \frac{V(t+1)}{E_t[m_{t+1}V(t+1)]}$. And, therefore: $r^s_{t+1} - r = \frac{V(t+1)-(1+r)E_t[m_{t+1}V(t+1)]}{E_t[m_{t+1}V(t+1)]}$. From the solved value function updated by one period we obtain (as detailed in Appendix A),[7]

$$E_t(r^s_{t+1}) - r = \frac{\gamma\left(\frac{\kappa^\eta - r}{1+\kappa^\eta}\right)\bar{z}^*_{t+1} + (1+r)\left(g^*[(\frac{1+\kappa^\varepsilon}{1+r})^{1/\rho}\theta^*_t] - g^*(\theta^*_t)\right)}{\left(1+\frac{\beta(1-\gamma)}{r+\gamma}+\frac{\alpha(1-\delta)}{r+\delta}\right)\left(\frac{r+\gamma}{\beta\,(1+r)}\right)\bar{z}_{t+1} + \left(\frac{\gamma}{1+\kappa^\eta}\right)\bar{z}^*_{t+1} + g(\theta_t) + g^*(\theta^*_t)}. \tag{13}$$

If $TFP$ follows a random walk, $\rho = 1$, the expected return expression simplifies because the predictable contraction in future periods of productivity relative to its trend value no longer occurs. Then

$$g(\theta_t) = \left(\frac{r+\gamma}{\beta\,\omega\,(1+r)}\right)\left(\frac{\bar{\varepsilon}_\omega}{1+r-\bar{\varepsilon}_\omega}\right)\bar{z}_{t+1}, \quad g^*(\theta^*_t) = \left(\frac{\gamma}{1+\kappa^\eta}\right)\left(\frac{\bar{\varepsilon}_\omega}{1+\kappa^\varepsilon_\omega - \bar{\varepsilon}_\omega}\right)\bar{z}^*_{t+1}.$$

The expected excess returns for lagging country-industries then are given by:

$$E_t(r^s_{t+1}) - r = \frac{[w_1(\kappa^\eta - r) + w_2(\kappa^\varepsilon_\omega - r)]\,\bar{z}^*_{t+1}}{w_0\bar{z}_{t+1} + (w_1+w_2)\,\bar{z}^*_{t+1}}, \tag{14}$$

$$w_0 \equiv (1+\kappa^\eta)\left(1+\frac{\beta(1-\gamma-\bar{\varepsilon}_\omega)}{r+\gamma} + \frac{\alpha(1-\delta-\bar{\varepsilon}_\omega)}{r+\delta}\right)\left(\frac{r+\gamma}{\beta\,(1+r-\bar{\varepsilon}_\omega)}\right), \quad w_1 \equiv \gamma, \quad w_2 \equiv \frac{\gamma\bar{\varepsilon}_\omega}{1+\kappa^\varepsilon_\omega - \bar{\varepsilon}_\omega}$$

[7] The displayed equation for the expected return makes the additional assumption of an exponential sdf and lognormal factor shocks. The more general expression is in Appendix A. The derivation is relatively complicated because investment returns no longer exactly equal stock returns due to the assumption of decreasing returns to scale, as in Balvers et al. (2017). The stock returns stochastically exceed investment returns because under decreasing returns to scale the average productivity of capital exceeds the marginal productivity of capital. The gross investment return $1+r^I_{t+1} = V_k(t+1) = \alpha\theta_{t+1}\,(z_{t+1}/k_{t+1})^\beta\,k_{t+1}^{-1/\omega} + (1-\delta) = \varepsilon_{t+1}(\eta^\beta_{t+1}/\bar{\eta}_\beta)(r+\delta)+(1-\delta)$. The investment return increases in research intensity $z_t/k_t$ and decreases in size $k_t$, but in expected value is equal to $1+r$ (from equations 10 and 11) since it involves no systematic risk, $E_t(r^I_{t+1}) = r$. It differs here from the stock return for two reasons: decreasing returns to scale, and not including the spillover benefits.

The expected excess return is a weighted average of three risk premia related to: (1) the exposure to the leader R&D investment risk, with risk premium $\kappa^{\eta} - r > 0$ and loading $w_1\, \bar{z}^*_{t+1}/[w_0\bar{z}_{t+1} + (w_1 + w_2)\, \bar{z}^*_{t+1}]$; (2) the exposure to the leader productivity risk, with risk premium $\kappa^{\varepsilon}_{\omega} - r > 0$ and loading $w_2\, \bar{z}^*_{t+1}/[w_0\bar{z}_{t+1} + (w_1 + w_2)\, \bar{z}^*_{t+1}]$; and exposure to own production, technology, and productivity risk, which is idiosyncratic and has risk premium of zero with loading $w_0\bar{z}_{t+1}/[w_0\bar{z}_{t+1} + (w_1 + w_2)\, \bar{z}^*_{t+1}]$. Note that $w_0$ is positive (as are $w_1$ and $w_2$) because $\bar{\varepsilon}_{\omega} < 1 + r$. The exposures to both leader risks are proportional to the spillover fraction $\gamma$ as well as the technology productivity gap, which is defined as $gap_t = \bar{z}^*_{t+1}/\bar{z}_{t+1}$. The higher the planned technology stock of the leader relative to that of the laggard, the larger the gap. Equation 14 indicates that a greater technology gap increases the expected excess return for the laggard firm. The reason is that a larger gap means the firm is more dependent on the technological productivity of the leader which eventually spills over worldwide and represents a systematic risk. The risk arises from two sources. First, it stems from how successful the leader's R&D is in improving technology, measured by $\eta^*_{t+1}$. Second, it ensues from shocks to the overall productivity specific to the leader country-industry, measured by $\varepsilon^*_{t+1}$. The level of productivity, which may be mean reverting, is the general backdrop that provides the incentives and comparative advantage in the leader country-industry for technology investment. It thus signals future changes in the leading-edge level of technology.

## 2.2 Investment, Stock Valuation, and Stock Returns of Leading Firms

The stock prices and returns for the leader are determined differently from those of the lagging firms for two reasons. First, the leader experiences no spillovers so $\gamma^* = 0$. Second, the production, technology, and productivity shocks for the leader are systematic since they affect the ultimate realization of technology created which spills over to all countries. We assume for simplicity that the leader firm does not consider losing its leadership position. Appendix A derives the optimal choice of the R&D stock of capital for the leader firm:

$$\bar{z}^*_{t+1} = C^* \left(\frac{\theta^*_t}{\theta}\right)^{\rho\omega}, \quad C^* \equiv \left(\frac{(1+r)\theta\bar{\eta}_{\beta}}{1+\kappa^{\varepsilon\eta}_{1\beta}}\right)^{\omega} \left(\frac{\alpha}{r+\delta}\right)^{\alpha\omega} \left(\frac{\beta(1+\kappa^{\eta})}{\kappa^{\eta}(1+r)}\right)^{(1-\alpha)\omega}. \tag{15}$$

Here $\kappa^{\varepsilon\eta}_{1\beta}$ is the risk premium related to the risk factor $\varepsilon^1_{t+1}\eta^{\beta}_{t+1}$ associated with production $y_{t+1}$. The choice of the R&D stock of the leader country in equation 15 will change over time relative to the choice of the R&D stock of a lagging firm in equation 11. The leader country is in the leadership position fundamentally due to a comparative advantage measured by $\theta^*_t/\theta_t$. This advantage erodes exogenously due to mean reversion in the level of $TFP$, if $\rho < 1$. However, additional endogeous factors are at work. First, the spillover fraction $\gamma$ causes a free-rider effect, lowering the R&D accumulation incentives for the laggard firms. As a result, the leader country is likely to remain ahead. However, second, the higher cost of capital for the leader firms provides a disincentive for R&D investment. If $TFP$ follows a random walk there is no mechanism that implies convergence in technology levels across countries. However, if $TFP$ is mean reverting, $\rho < 1$, then technology levels must converge, with leader-laggard positions switching over time. Excess stock return differences then necessarily revert also.

The ex-dividend stock market value of the leader firm, $P_t^* = E_t\left[m_{t+1} V^*(t+1)\right]$, derived in Appendix A, equals

$$P_t^* = \left(1 + \frac{\alpha(1-\delta)}{r+\delta} + \frac{\beta}{\kappa^\eta}\right)\left(\frac{\kappa^\eta}{\beta\,(1+\kappa^\eta)}\right)\bar{z}_{t+1}^* + G^*(\theta_t^*),$$

with

$$G^*(\theta_t^*) = \sum_{\tau=2}^{\infty} W_\tau^* \left(\frac{\theta_t^*}{\theta}\right)^{\rho^\tau \omega}, \quad W_\tau^* = C^* \left(\frac{\kappa^\eta}{\beta\,\omega\,(1+\kappa^\eta)}\right) \prod_{i=1}^{\tau-1} \frac{\bar{\varepsilon}_{\rho^i\omega}}{1+\kappa^\varepsilon_{\rho^i\omega}}.$$

The leading-firm expected excess stock return is [8]

$$E_t(r_{t+1}^{s*}) - r = \frac{\frac{1}{\beta(1+\kappa^\eta)}\left(\kappa^\eta(\kappa^{\varepsilon\eta}_{1\beta} - r) + \beta(\kappa^\eta - r)\right)\bar{z}_{t+1}^* + (1+r)\left(G^*[(\frac{1+\kappa^\varepsilon}{1+r})^{1/\rho}\theta_t^*] - G^*(\theta_t^*)\right)}{\left(1 + \frac{\alpha(1-\delta)}{r+\delta} + \frac{\beta}{\kappa^\eta}\right)\left(\frac{\kappa^\eta}{\beta\,(1+\kappa^\eta)}\right)\bar{z}_{t+1}^* + G^*(\theta_t^*)}.$$

For the case in which $TFP$ follows a random walk, $\rho = 1$, anticipated future risk premia are constant, yielding:

$$G^*(\theta_t^*) = \left(\frac{\kappa^\eta}{\beta\,\omega\,(1+\kappa^\eta)}\right)\left(\frac{\bar{\varepsilon}_\omega}{1+\kappa^\varepsilon_\omega - \bar{\varepsilon}_\omega}\right)\bar{z}_{t+1}^*.$$

Hence,

$$E_t(r_{t+1}^{s*}) - r = \frac{w_1^*(\kappa^\eta - r) + w_2^*(\kappa^\varepsilon_\omega - r) + w_3^*(\kappa^{\varepsilon\eta}_{1\beta} - r)}{w_0^* + w_1^* + w_2^* + w_3^*}. \tag{16}$$

$$w_0^* \equiv \frac{\alpha(1-\delta)}{r+\delta}, \quad w_1^* \equiv \frac{\beta}{\kappa^\eta}, \quad w_2^* \equiv \frac{\bar{\varepsilon}_\omega(1-\alpha-\beta)}{1+\kappa^\varepsilon_\omega - \bar{\varepsilon}_\omega}, \quad w_3^* \equiv 1.$$

Equation 16 presents the expected excess return for the leader firm as the weighted average of four different production-based risks. First, the production risk, captured by the risk premium $\kappa^{\varepsilon\eta}_{1\beta} - r$ and loading $1/(w_0^* + w_1^* + w_2^* + w_3^*)$. It relates to a combination of the technology shocks and $TFP$ shocks, both impacting current realized output. Second, the uncertainty in the technology realization from the R&D stock, has risk premium, $\kappa^\eta - r$ with loading $\beta/\kappa^\eta(w_0^* + w_1^* + w_2^* + w_3^*)$. Third, the shocks to its $TFP$ that provide incentives for future technology buildup, with risk premium $\kappa^\varepsilon_\omega - r$, and loading $w_2^*/(w_0^* + w_1^* + w_2^* + w_3^*)$. Last, the changes to tangible investment which bring about a deterministic increase in the capital stock (unlike the R&D investment), thus carrying a risk premium equal to the risk free rate; the loading is $w_0^*/(w_0^*+w_1^*+w_2^*+w_3^*)$. Note that $w_2^* > 0$ because $\bar{\varepsilon}_\omega < 1+r$.

Thus, the expected stock return for the leader firm lies between the risk-free rate, $r$, and the expected factor

[8] The expression presented makes the additional assumption of an exponential sdf and lognormal factor shocks. The more general expression is shown in Appendix A.

return of the most risky production aspect, $\kappa_{\omega}^{\varepsilon}$ (which accounts for multiplied productivity risk due to operational leverage). The production shock is a combination of both productivity shocks, $\eta_{t+1}^{*}$ and $\varepsilon_{t+1}^{*}$(with the risk premium a geometric average of both, if the shocks are lognormal and the sdf exponential). Clearly, the gap is not relevant for the returns of the leader firms. Interestingly, the average returns for the leader firms need not be higher than those of the lagging firms. The reason is that only the part of revenue going to profits, $1-\alpha-\beta$, is impacted by productivity shocks, and that $\gamma = 0$, implying no risk related to spillovers for the leading firms. Thus, while only the profitability part $1-\alpha-\beta$ of technology gains affects stock returns of the leaders, it is the full gain of $\gamma$, the technology spillover fraction, that affects the lagging firms since there is no direct cost to the spillover adoption in the model (and a low cost in reality). Hence, the lagging firms may, in fact, be riskier with a higher operational impact from the leader productivity shocks.

When a firm/country-industry lags further in technology then it has more potential to catch up. From the productivity shock point of view, a positive shock lowers the gap for a firm/country which, as a result, becomes less dependent on technology diffusion from the leading firm/country. This in turn reduces the systematic risk, i.e. the exposure to the productivity shocks of the leading economy, and accordingly reduces the expected future return. A productivity gap has a positive effect on the firm's (country-industry's) loading on the aggregate productivity factor, with the latter naturally being represented by the productivity shocks of the leading country-industry. Idiosyncratic productivity shocks may quantitatively be more important in affecting production for individual country-industries than the leader country-industry shocks. However, they are not systematic and are uncorrelated with the leader country-industry shocks; hence sensitivity to these shocks does not affect mean stock returns.

# 3 Implications of the Model

The theoretical results for both laggard and leader firms imply, by equations 15 and 11, that the R&D stock and the level of $TFP$ become perfectly correlated in loglinear levels. We can thus refer to the "productivity gap" as representing either the technology gap or the $TFP$ gap. For empirical purposes, the productivity gap may be measured either by the technology gap, $\ln(\bar{z}_{t+1}^{*}/\bar{z}_{t+1})$, or the $TFP$ gap, $\ln(\theta_{t}^{*}/\theta_{t})$. The former measure may be obtained as the capitalized value of R&D measures. However, this has several shortcomings. First, depreciation rates are difficult to obtain and vary greatly by industry. Second, R&D observations by industry and country have short time series. Third, the spillovers that are central to our analysis should be included in a technology proxy but cannot be observed from R&D data. Accordingly, for empirical purposes we adopt the latter measure, the $TFP$ gap, using OECD country-industry observations of $TFP$.

The productivity gap as proxied by the $TFP$ gap is the gap in $TFP$ (at some point in time) of any country-industry compared to that of the leader, $TFP^*$. Empirically, for each industry we may take $TFP^*$ as either the productivity of the leader country or as the productivity of the country-industry that is in the country which is the most productive only in this industry. Empirically we consider both measures. The former is reasonable if a comparative advantage in terms of strong infrastructure, high human-capital levels, etc. that determines $TFP$ is highly geographically oriented and therefore should reasonably be expected to extend to all industries in a given country. Then the leader country for each industry should be the same. In this case, the leader productivity shocks are truly systematic since they do not only affect all countries, but do so in all industries. The latter is reasonable if $TFP$ is very industry specific, when human capital, for instance, is highly targeted to a single industry. In this case the leader productivity shocks are generally not systematic since they may diffuse worldwide but only in one industry.

## 3.1 Testable hypotheses

The model finds the expected return to be monotonically related to the productivity gap. As the gap increases, the expected return increases. This increase in expected return may be viewed from the PBAP perspective as due to higher average returns on capital, or, from the dual consumption-based perspective as due to the increase in systematic risk: A country with a larger gap stands to gain more from innovations by the leader country and is accordingly more exposed to these foreign productivity shocks, compared to a country with a smaller gap. The consequence of the determination of expected returns as given in equation 14 is that the productivity gap should explain the cross-sectional disparity of stock returns among country-industries. Separately, considering the dynamic process of return differences over time, a relatively large productivity gap must be the result of a past accrual of relatively poor realizations of productivity enhancements, generally accompanied by low stock returns. However, on average, the low returns will be reversed in the future as the larger productivity gap requires higher future stock returns. Since the productivity gap is persistent and disappears only slowly over time, exposure to the productivity in the leader country remains similar for extended periods, inducing a momentum effect. Lastly, the theory also implies that disparities in average stock returns arise from differences in exposure to systematic risk, and that the main source of systematic risk is aggregate shocks to leader productivity.

We propose three hypotheses namely:

*Hypothesis 1*: Technology gaps explain country- and industry-wide cross-sectional disparities in mean returns.

*Hypothesis 2*: Persistence and reversion in technology gaps generates momentum and mean reversion in equity returns.

*Hypothesis 3*: Technology and productivity gaps are positively associated with systematic risk exposure.

Hypothesis 1 results directly from equation14 in the model for the laggard firms where $\partial[E_t(r^{ic}_{t+1} - r)/\partial gap^{ic}_t > 0$. This is straightforward for the case of $\rho = 1$, but holds more generally also in equation 13. This is easiest to see by lowering $\theta_t$ for given $\theta^*_t$ which implies a larger productivity gap. Then the numerator in the expected return expression of equation 13 does not change, but the denominator (being proportional to the ex-dividend market value of the firm) falls, implying a higher expected excess return. Note that the hypothesis does not hold for leader firms. The model implies that the leading firm returns are not generally the highest, associated with a maximum gap, nor are they the lowest, associated with a zero gap. The leader returns are based on different fundamentals.

Hypothesis 2 follows because the productivity gap exhibits positive autocorrelation. Equation 13 shows that a relatively large return is associated with a large technology gap. This gap is persistent, implying that the subsequent-period returns remains relatively large, generating momentum on average. Additionally, a high productivity gap over time is systematically reduced, $\partial gap^{ic}_{t+1}/\partial gap^{ic}_t < 0$, as productivity levels revert to mean. Relatively high returns are eventually followed by relatively low returns, suggesting mean reversion.

Hypothesis 3 derives from the fact that $\partial[E_t(r^{ic}_{t+1} - r)/\partial z^*_t > 0$ given constant $\bar{z}_t$ for all $ic$. It follows from the duality between production-based and consumption-based approaches, implying that higher average productivity of capital must be associated with higher systematic risk. Note also that in equilibrium in the model both the log productivity gap $\ln(\theta^*_t/\theta_t)$ and the planned log technology gap $\ln(\bar{z}^*_{t+1}/\bar{z}_{t+1})$ are equivalent up to a linear transformation as follows from equations 15 and 11. Both measures accordingly have an identical impact on the systematic risk exposure of a given firm.

The remainder of the paper empirically considers Hypotheses 1-3 and additional related issues, examining a panel of OECD countries to determine if observed mean return differences are caused by productivity gaps and are consistent with a systematic risk explanation.

### 3.2 Specification of the productivity gap

Productivity spillovers may arise from various sources of discrepancies between firms. For any firm as presented in the above model we need to specify empirically what is meant by $\ln(z^*_t)$, the leading productivity level that serves as the benchmark from which technologies, approaches, and practices trickle down to individual firms. A particular firm in a particular industry and country may benefit by adopting the best practices of firms in more productive country-industries. These positive spillovers derive often from general "systematic" aspects of productivity that are pervasive at the country-wide level, related to such issues as transportation, infrastructure, or even human resource policies. But additionally a firm may benefit more specifically from observing the technological and managerial processes of firms in its own industry operating in a different country where this industry is currently more productive. In general, we distinguish systematic productivity differences that arise at the country level and, separately, more idiosyncratic differences that are specific to the industry level, between industries in different countries. Distinct productivity spillovers arise from both of these sources of productivity differentials. As the empirical proxy for the first component of the theoretical individual productivity gaps, $\ln(\frac{z_t^*}{z_t})$, we define the aggregate country-wide productivity gap facing an individual firm in industry $i$ and country $c$ at time $t$ as

$$CGAP_t^{ic} \equiv \ln(Z_t^{c*}/Z_t^c). \tag{17}$$

$CGAP$ is the *country-level* Productivity Gap across countries based on comparing the overall productivity of the leader country $c^*$ to the productivity of the specific country $c$ that is home to the industry grouping of firms $i$ we are considering. Here $ic$ indexes a particular industry in a particular country (a “country-industry”), and a portfolio of all stocks in this country-industry pairing will serve as an individual test asset. The country productivity level is the weighted average within the country, using industry size weights of the productivities of all industries within the country. $Z_t^{c*}$ represents the empirical measure of aggregate productivity level for the most productive country at time $t$ and $Z_t^c$ represents the empirical measure of aggregate productivity level in a specific country $c$.

As the empirical proxy for the second component of an individual productivity gap we define an industry-based measure. $IGAP$ is for each different industry the *industry-specific* Productivity Gap across countries: the difference between the log productivity of the country that has the highest productivity for industry $i$, $c^*(i)$, and that of any other country $c$ for the same industry $i$:

$$IGAP_t^{ic} \equiv \ln(Z_t^{ic*}/Z_t^{ic}) \tag{18}$$

$Z_t^{ic*}$ is the industry productivity for the country leading in this particular industry at time $t$, and $Z_t^{ic}$ is the productivity level in this same industry in some country $c$.

Thus, we can write as a proxy for the concept of the productivity gap, $\ln(\frac{z_t^*}{z_t})$, relevant for an individual firm in industry $i$ and country $c$, that:

$$GAP_t^{ic} = f(CGAP_t^{ic}, IGAP_t^{ic}) \tag{19}$$

where $f(\,)$ is a function that is monotonically increasing in both the country- and industry-specific components of the productivity gap measure. The components of the productivity gap considered separately may have different implications for average returns. If $CGAP$ is the dominant component then firms in all industries are subject to similar shocks, and these are then obviously systematic, affecting return fluctuations as well as average returns. If $IGAP$ is the dominant component determining spillovers then firms in different industries are affected by different leaders, which are subject to different shocks. The productivity gaps then represent a more idiosyncratic risk exposure. Accordingly, while the productivity gaps then still explain return fluctuations, they should not influence average returns.

# 4 Data

To test the hypotheses, we employ stock price data for firms in OECD countries as well as macroeconomic data to compute productivity at industry and country levels for OECD countries. We limit our analysis to OECD countries primarily because of the well-established results from the economic growth literature that the economies within the OECD converge over time, whereas this is not generally true for non-OECD countries (in particular not for developing economies). See for instance Dowrick and Nguyen (1989) or Johnson and Papageorgiou (2018).

## 4.1 Productivity Measures

The Structural Analysis database (STAN) available from the OECD contains macroeconomic data at the industry level. These data can be used to compute productivity at the industry level for OECD countries. STAN has an annual data frequency and uses the International Standard Industry Classification (ISIC) V4 to assign firms to industries, whereas Compustat uses the North American Industry Classification System (NAICS). Mapping of NAICS to ISIC is accomplished with an algorithm detailed in Appendix B. After the mapping only 16 mutually exclusive industry groups/sectors remain. From these we remove the Finance and Insurance and the Real Estate sectors for our analysis as is common practice in the finance literature. Appendix C presents further data particulars.

In comparing data across countries with different currencies and price levels, we adjust productivity for purchasing power parity (PPP) differences. We use the OECD Purchasing Power Parity exchange rate conversion to compute productivity for cross-country comparison. The PPP-adjusted exchange rate can be thought of as the price measure for an economy which is appropriate for comparing labor and capital costs as well as consumption and production value levels across countries in the same units.

Smaller countries tend to display more idiosyncratic variation. For example they may be specialized in just a few concentrated industries. These countries cannot play much of a role as leading economies on the world stage. As such they should be excluded from the group of potential productivity leaders at the aggregate level. To avoid assigning small countries as aggregate productivity leaders in the $CGAP$ measure we employ the criterion that a country should contribute at least 0.75% to world GDP to be included in the productivity-leading country group.[9] We use the World Bank (PPP-adjusted) GDP database of all countries to identify the potential productivity-leading

[9] When we change this criterion to consider alternatively 0.5, 1.0 or 2.0 percent our results do not change materially. When the threshold is reduced to 0.5%, Belgium sometimes shows up as productivity leader; when the threshold is increased to 1.0% or 2.0%, the Netherlands drops out as productivity leader and is replaced by either France or the US. In either case the gap numbers change very little and the overall results are not affected.

countries. The following OECD countries meet the criteria: USA, UK, Germany, France, Canada, Australia, Italy, Japan, South Korea, Netherlands, Spain, Poland, and Mexico. These constitute the group of potential technology-leading countries. The maximum productivity levels for an individual industry and averaged across industries from among this list of countries constitute the components of $z_t^*$ required to compute the $CGAP$ productivity gap in equation 17 and equation 19. Our measure for productivity $z_t$ at the country-industry level is total factor productivity ($TFP$). It adjusts production for the value of the capital inputs ("Net Capital Stock") used and the value of labor inputs ("Employee Hours") used, each in PPP-adjusted USD.[10] STAN does not allow us to compute the $TFP$ at the industry level for all OECD members between 1990 and 2015. In particular, the information to compute $TFP$ for individual industries in Mexico, Spain, and South Korea is not available so that the industry portfolios in these countries are omitted from analysis.

We compute Productivity Gaps at country and industry levels to account for the potential of various types of technology and knowledge spillovers depending on locality, economic activity, infrastructure, and regulatory environment and organization. At both the country and the industry level, the productivity levels are proxied on an annual basis by the $TFP$ measures relevant for each specific country-industry pairing, as calculated from the STAN data. Proxying the concept of productivity levels by the appropriate $TFP$ measures allows us to compute the two productivity gap component measures for each country-industry $ic$ given in equations 17 and 18.

At each time there are $C$ different values of $CGAP$, where $C$ represents the number of countries, and $C * I$ different values of $IGAP$, where $I$ represents the number of different industries. The two levels of the productivity gap refer to different spillover sources from which productivity improvements can occur. The between-country level "country productivity gap" ($CGAP$) represents an average productivity differential across countries. The within-industry gap "industry productivity gap" ($IGAP$) compares productivity for an industry in a given country among all countries in which this industry operates, to reflect the potential of industry-specific spillovers from highly productive countries to less productive ones. The pooled correlation between $CGAP$ and $IGAP$ is 0.670 (not tabulated). The reason for the relatively large correlation is that the $IGAP$ gap uses the country that is best for the industry as benchmark while the $CGAP$ gap uses the country that is best overall as benchmark. For many industries the most productive firms are in the most productive country.

The summary statistics of computed total factor productivity ($TFP$) at the country level, which is the basis for the $CGAP$ measure, are provided in Table 1. An important point to note is that a small country such as Luxembourg may have a very high $TFP$ but is ruled out from the technology-leader group since its productivity advantage is

[10] The labor input data categories in STAN are Employee Hours (hours worked by full-time employees) and Total Hours (hours worked), but the availability varies across countries and industries. Total Hours is available for the USA only from 1998, and for Japan not at all. To allow for inclusion of the USA and Japan as possible productivity leaders in the analysis, the $TFP$ measure we use is based on Employee Hours.

likely narrow (reflecting only a few industry segments) and is unlikely to lead to worldwide spillover effects. The information about the group of potential country leaders in $TFP$ based on the criterion that productivity leaders should at least contribute 0.75% of world economy GDP is listed in the table. Table 1 further contains the descriptive statistics of $Z_t^{c*}$. For country $c^*(t)$ (the productivity leader country at time $t$) the value of the productivity gap is by definition equal to zero for time $t$. The technology leaders vary from year to year.

### 4.2 Stock Return Data

Stock price data are obtained from Compustat Global. The database provides daily prices, and dividend information to compute total returns at the firm level. All returns are converted to USD using the nominal currency exchange rate that is available from Bloomberg. We use Fama-French global factor data from Kenneth French's website to control for world-wide risk factors. Since this data is available from 1991 onwards, the range of our data is from 1991 to 2015. (STAN updates its macroeconomic data on a lagged but continuous basis; in the most recent update, 2016 data were available for only a few of the countries). The stock price data are available for individual firms with particular industry designations in the various OECD countries.

Table 14 in the Data Appendix presents a summary of the stock returns of the available firms by OECD country and by year (from 1992 until 2015) as far as firm returns are available in a country for that year. The average return differences by country and industry are substantial. The monthly average of the mean excess returns for each country-industry portfolio over the 1992-2015 period is 0.144%, quite low in this period (the annualized risk premium is below 2%). The cross-sectional standard deviation of the mean monthly country-industry portfolio excess returns is a relatively high 0.735%. We focus on industries $i$ in countries $c$ and treat equal-weighted portfolios of all available firms for each country-industry with more than one firm as our test assets represented by index $ic$.[11] To deal with potential data errors, individual stock returns are winsorized at 5%. Table 15 in the Data Appendix C provides an overview of the firms available over the sample period for the set of industries and countries.

### 4.3 Countries and Industries Included

As the source of the test assets and productivity benchmarks we start with all stocks available from Compustat Global and productivity information of all countries and industries available from STAN, subject to the following criteria:

1. Only countries and industries are included for the periods that have data available to compute Total Factor Productivity ($TFP$) at the industry level, measuring labor inputs by Employee Hours and capital inputs by Net Capital Stock.

[11] The number of firms in a portfolio is quite variable across portfolios and across time. However, we find that our main results do not change significantly if we exclude all industry-country portfolios with five or fewer firms. We also find that the results are very similar if we use value-weighted industry portfolios instead of equal-weighted.

2. Test assets are portfolios of the firms for each country-industry, as long as data for more than one firm are available for a country-industry portfolio during a given month.

Table 13 in the Data Appendix gives a detailed analysis of the countries that are included in the productivity gap computation and the test assets. The following 26 countries are the OECD countries used to compute the various productivity gaps: Austria, Belgium, Canada, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Latvia, Lithuania, Luxembourg, Netherlands, Norway, Poland, Portugal, Slovak Republic, Slovenia, Sweden, United Kingdom, and United States.

The remaining 10 OECD countries (Australia, Chile, Iceland, Israel, Mexico, New Zealand, South Korea, Spain, Switzerland, Turkey) are excluded following criterion (1). Based on the Compustat Global data, Table 15 in the Data Appendix contains the number of firms in each country-industry portfolio. The following 14 industries are represented: Manufacturing; Electricity, Gas, Steam, and Air Conditioning; Water Supply, Sewage, Waste Management and Remediation Activities; Construction; Wholesale Retail Trade, Repair of Motor Vehicles and Motorcycles; Transportation and Storage; Accommodation and Food Services; Information and Communication; Professional Scientific and Technical Activities; Employment Activities; Education; Human Health Activities; Arts, Entertainment and Recreation; and Other Services. As is typical in the literature we do not include the Finance and Insurance, and the Real Estate industries. Compustat Global does not include U.S. and Canadian stocks so there are no test assets from these countries, even though these countries, in particular the U.S., do show up as leader countries and accordingly affect the productivity gaps for the test assets. It follows that there are test country-industry portfolios from 24 OECD countries ($C = 24$) and 14 Industry groupings ($I = 14$), generating a maximum of 336 test assets at any given time. However, some industries do not occur at all in each of the 24 countries, and many do not have data for all time periods. On average there are around 200 test assets in a given month.

# 5 Some Ancillary and Illustrative Results

## 5.1 Spillover Effects Predicting Productivity Growth

The STAN data allow us to identify potential sources of productivity spillovers. We first examine if indeed the productivity gap measures explain future growth in productivity, $\ln(Z^{ic}_{t+d}/Z^{ic}_t)$, for specific industries $i$ in specific countries $c$, where $d$ is the forecast horizon:

$$\ln(Z^{ic}_{t+d}/Z^{ic}_t) = c_0 + c_1 CGAP + c_2 IGAP + e^{ic}_{t+d}. \tag{20}$$

As a validation of the reasonability of the model assumptions we check to see if, indeed, it is true that productivity gaps predict future increases in productivity. Table 3 shows that each of the two gap measures have a highly significant positive sign in forecasting future productivity. A 1% larger gap implies an additional predicted increase in the growth of the productivity level of roughly 2 basis points (1.6 bps to 2.4 bps for CGAP and 1.6 bps to 2.0 bps for IGAP as the horizon increases from one to five years). It is equivalent to the 2 percent rate of convergence obtained for total factor productivity of OECD countries by Bernard and Jones (1996) for the 1970-87 period. The result suggests that technology and knowledge spillovers are important and trickle down to technologically less developed economies as previously argued by Comin and Hobijn (2004, 2010) and others.

When we consider both gap measures jointly in Panel C, each contributes positively and significantly to the productivity forecasts, with the idiosyncratic gap measure, $IGAP$, quantitatively more than twice as important (1.7 bps per year based on the five year horizon) as the aggregate gap measure, $CGAP$ (0.7 bps per year based on the five year horizon). We confirm the growth-literature results for our proxies and data, that the productivity gaps as we measure them are useful predictors for future productivity. Our aim in the following is to examine if the productivity gaps also have the explanatory power for future stock returns that the model suggests.

Whereas both types of spillover effects are expected to forecast and indeed do forecast productivity growth, certain spillovers may have a more significant impact on expected stock returns, namely those that relate to systematic risk exposure. The non-systematic industry gap measure ($IGAP$) may matter because it proxies for sensitivity to risk factors. The systematic country gap measure ($CGAP$) is more clearly relevant in that it directly measures exposure to a presumed systematic risk. We view the $CGAP$ gap measure as exposure to systematic risk as it is pervasive; whereas the $IGAP$ gap measure is industry specific and not directly tied to a systematic source of risk.

## 5.2 Productivity Shocks and Realized Returns

The prediction is not that all changes in productivity affect asset returns. They are likely important determinants of profitability and net cash flows, but they may be neither unexpected nor systematic. We examine if there is a direct connection between the excess returns of each country-industry portfolio and the systematic risk measured by the productivity shocks of the leader countries or industries. In doing so we control for idiosyncratic productivity risk which is represented by the (equal-weighted) productivity shock of each country-industry's own portfolio of firms. It is important to include this control because (notwithstanding our simplifying theoretical assumption of zero correlation between $z_t^*$ and $z_t$), leader country-industry productivity shocks may be positively correlated with the productivity changes attributed to shocks of trailing country-industries with, in that case, the latter spuriously reflecting the importance of the former. Table 4 presents the result of a pooled regression of the cross-section and annual time series of all country-industry returns explained by the contemporaneous change in the leader country productivity level, $\Delta \ln Z_t^{c*}$, and the change in the industry-specific leader country productivity level, $\Delta \ln Z_t^{ic*}$, over the same period as each annual return, and controlling also for the specific country-industry's own productivity shock over that period, $\Delta \ln Z_t^{ic}$ :

$$r_t^{ic} - r_t^f = \alpha_0 + \alpha_{ic}\Delta \ln\left(Z_t^{ic}\right) + \alpha_{ic}^*\Delta \ln\left(Z_t^{ic*}\right) + \alpha_c^*\Delta \ln\left(Z_t^{c*}\right) + \epsilon_t^{ic}. \tag{21}$$

We find in Table 4 that the idiosyncratic own productivity shocks ($\Delta \ln Z_t^{ic}$), by themselves, positively and significantly explain the individual returns contemporaneously. The industry-specific leading country shocks ($\Delta \ln Z_t^{ic*}$), also positively and significantly impact excess returns, either in isolation or together with the idiosyncratic productivity shocks. However, when the leader country productivity shocks are included ($\Delta \ln Z_t^{c*}$), the own productivity shock loadings are no longer significant. The leader country productivity shocks are by far the most important and have a significant positive contemporaneous effect on all stock returns. The leading country productivity shocks also dominate industry-specific leading country shocks ($\Delta \ln Z_t^{ic*}$) in their impact on contemporaneous stock returns, even though the industry-leading shocks predict future productivity better (as shown in Table 3). The results in Table 4 thus suggest strongly that it is systematic productivity shocks rather than idiosyncratic and predictable industry-specific productivity shocks that affect returns. It supports our view that leading-country productivity shocks, rather than just any productivity changes, are good candidates for systematic risk factors.

### 5.3 Productivity Gaps and Average Returns

It is necessary for a systematic risk factor to explain common time-series variation in realized returns but it is also necessary for it to explain cross-sectional variation in mean returns. We take an initial time for which most countries have productivity data available in our sample, 2000, as year zero and then obtain the average subsequent country returns, for the 15 years from then until the end of our sample, 2001-2015. Estimating the link between the country productivity gap measure and average returns at the country level yields

$$\underset{}{\hat{\mu}^c_{2001-2015} = 0.069 + \underset{(4.328)}{0.637}\, CGAP} \tag{22}$$

with t-stat in parentheses and $R^2 = 0.50$. The slope coefficient is positive and significant so that a larger productivity gap implies higher future average stock returns. This holds in addition to the result, familiar from the growth literature, in equation 20 that a larger gap implies higher future productivity growth. Figure 1 shows the results for the mean returns predicted by the initial productivity gap. Adding the industry productivity gap $IGAP$ as an explanatory variable makes virtually no difference: the variable is insignificant and the R-squared and predicted mean returns do not change (result not shown). This is consistent with $CGAP$ representing systematic risk exposure and $IGAP$ representing idiosyncratic risk exposure. The data involve a single cross-sectional regression for 22 of the 24 countries in the sample (Portugal and Slovakia still drop out for the year 2000 productivity data, and 2001-2015 period return, providing sufficient productivity data only later in the sample). Given the cross-sectional standard deviation of $CGAP$ equal to 0.470 and the slope coefficient equal to 0.637, a one-standard deviation difference in a country's country productivity gap increases the average country-index stock return by 0.30% monthly, about 3.66% annualized. We provide more reliable and comprehensive results in the following by predicting country-industry as well as country returns based on the productivity gaps one month at a time, which allows us to use considerably more data.

# 6 Empirical Results

## 6.1 Productivity Gaps and Stock Returns

To test Hypothesis 1 with our panel data set we perform a standard Fama-MacBeth two-stage regression procedure on the industry portfolios in each of the different countries, at a monthly frequency. Equally-weighted industry portfolio are constructed from the Compustat data, where the portfolios consist of all firms in a particular industry of a particular country.

In the first stage, a time series regression is performed for each country-industry portfolio (denoted by $ic$, representing the industry index $i$ and country index $c$) as in equation 23 to obtain the loadings of the portfolio returns on a set of standard systematic risk factors:

$$r_t^{ic} - r_t^f = \alpha^{ic} + \boldsymbol{\beta_t^{ic}}(\boldsymbol{F_t}) + \epsilon_t^{ic} \tag{23}$$

Here $\boldsymbol{F_t}$ is the vector of risk factors $\begin{bmatrix} F_{1t} \\ F_{2t} \\ \vdots \\ F_{nt} \end{bmatrix}$, and $\boldsymbol{\beta_t^{ic}}$ is the vector of estimated factor loadings $\begin{bmatrix} \beta_{1t}^{ic} \\ \beta_{2t}^{ic} \\ \vdots \\ \beta_{nt}^{ic} \end{bmatrix}$.

The risk factors represent those of the standard models: CAPM, Fama-French global three-factor (FF3), Fama-French global four-factor, including also the global Carhart momentum factor (FF3+MOM), Fama-French global five-factor (FF5), and Fama-French global five-factor including the global momentum factor (FF5+MOM). The excess annual returns of the industry portfolio are regressed on the different sets of factors. These factors act as controls for known factor risk.

In the second stage cross-sectional regressions are performed for each (monthly) time period in which the excess monthly returns for every country-industry portfolio are regressed on the productivity gap and the beta coefficients of the risk factors determined in the first stage:

$$r^{ic}_{t+1} - r^{f}_{t+1} = a_{t+1} + \boldsymbol{b_{t+1}}(\boldsymbol{\beta^{ic}_{t}}) + \boldsymbol{c_{t+1}}(\boldsymbol{GAP}) + \eta^{ic}_{t+1} \tag{24}$$

In equation 24 $\boldsymbol{GAP}$ is the vector of productivity gaps $[CGAP\ IGAP]'$ associated with each individual country-industry portfolio $ic$, $\boldsymbol{\beta^{ic}_{t}}$ is the vector of factor loadings for each country-industry portfolio obtained from the first stage. In the first stage a rolling regression is used to determine the set of betas for each model, with a window of at least 24 months expanding to a maximum of 60 months (following Fama and MacBeth, 1973). The coefficient (row) vectors $a_t, \boldsymbol{b_t}$, and $\boldsymbol{c_t}$ are estimated separately for each time period based on betas determined purely from prior data. Our productivity data start in January 1970 (for some countries). However, we use the global Fama-French risk factors which start in July 1990. Losing a minimum of 24 months for beta estimation, our effective sample period starts in July 1992. Thus, we employ monthly data from July 1992 until December 2015. This amounts to 282 monthly sample observations.

Since there are two productivity gap measures in equation 24, there are two $\boldsymbol{c_t}$ coefficients in the second stage of standard Fama-MacBeth regressions. The mean of 282 monthly cross-sectional regressions, $[c_1\ c_2] = \frac{1}{282} \sum_{t=1992,7}^{2015,12} \boldsymbol{c_t}$, represents the estimated mean of the cross-sectional coefficients and the standard deviation of each element of $\boldsymbol{c}$ represents its standard error. The null hypothesis is that coefficients are 0, and a standard t-test is performed separately for each coefficient to check for statistical significance. Rejecting the null hypothesis in favor of the alternative hypothesis that $c_1 > 0$ and $c_2 = 0$ confirms Hypothesis 1.

The cross-sectional mean coefficients and its standard error for equation 24 are presented for the augmented versions of the CAPM, the FF3+Mom (Carhart), and the FF5+Mom versions (for brevity and because the differences are inconsequential the results for the FF3 and FF5 models are omitted) in Tables 5, 6, and 7. We observe that in each model the coefficient on the aggregate country productivity gap $CGAP$ is positive and significant, for most specifications at the 1% level, after controlling for market, Carhart, and FF5+Mom factors. The result clearly suggests that in a panel of OECD countries, the country productivity gap as an indicator of systematic productivity risk explains important variation in cross-sectional returns. The coefficient on the country productivity gap $CGAP$ across the different risk models varies within the range 0.577-0.917 (and larger in the formulations that also include the industry productivity gap $IGAP$). Given the $CGAP$ average time-series standard deviation of 0.53, a country productivity gap that is larger by one standard deviation implies a monthly return that is between 0.306 percent and 0.486 percent higher, or, annualized, between 3.7% and 6.0% higher, a quantitatively significant result. These results support Hypothesis 1. Moreover, as expected when only systematic risk is priced, the idiosyncratic industry productivity gap measure $IGAP$ is insignificant when it is included, without also including $CGAP$. When both $IGAP$ and $CGAP$ are included, the marginal impact of $IGAP$ is negative, whereas the impact of $CGAP$ becomes larger. The net impact of both is very similar to when only the $CGAP$ measure is included, suggesting a collinearity issue. Thus, the idiosyncratic gap measure, while forecasting future productivity changes, does not on net affect average future stock returns.

**Sorting results**

To present the above results alternatively in a non-parametric way we sort all country-industry portfolios by prior $CGAP$ gap into quintiles. Quintile 1 includes the country-industries with the 20% smallest gaps at each time and Quintile 5 includes the country-industries with the 20% largest gaps at each time. The subsequent monthly returns are recorded for each quintile. In Table 8, Panel A the difference between the fifth quintile and first quintile mean returns is 7.92% annually (monthly return difference equal 0.637%) and significant at the 1% level. In Panel B we sort in the same way but now measure returns by the alphas from the Fama-French five-factor model plus momentum. In this case the difference is 5.07% annually (monthly difference is 0.413%) and significant at the 1% level. If we instead sort by the $IGAP$ gap the returns still increase with the quintiles but the difference is smaller and not statistically significant. In addition, for an independent double sort into quintiles based on both gaps, the mean return difference attributable to the $IGAP$ gap is negligible. These $IGAP$-sorting results are consistent with the parametric results in Tables 5, 6, and 7 and are not reported.

## 6.2 Connection to Momentum and Mean Reversion in International Stock Returns

To test the momentum part of Hypothesis 2 and see if the model can explain the results of international momentum in Chan et al., 2000, Asness et al., 2013, we concentrate on the factor sensitivities for each country-industry portfolio, $\beta^{ic}_{WML}$, obtained in the first stage for the systematic momentum factor. The WML factor loadings for each country-industry averaged over the sample period are regressed cross-sectionally on the average productivity gap values pertaining to each country-industry, $\boldsymbol{GAP} = \frac{\mathbf{1}}{\mathbf{282}} \sum_{\boldsymbol{t=1992,7}}^{\mathbf{2015,12}} \boldsymbol{GAP}$ in a cross-sectional regression as in equation 25 below. The momentum part of Hypothesis 2 is supported if the null hypothesis that a slope coefficient $h = 0$ can be rejected in favor of the alternative hypothesis that a slope coefficient is significantly positive, $h > 0$, (in which case the momentum effect, at least in part, aliases for the actual productivity gap effect on risk loadings):

$$\beta^{ic}_{WML} = g + \boldsymbol{h}\, \boldsymbol{GAP} + \omega^{ic}. \tag{25}$$

In addition, we check directly how much the risk premium on $\beta^{ic}_{WML}$ is attenuated when $\boldsymbol{GAP}$ is added in the cross-sectional regressions, equation 24.

Table 9 presents the mean coefficients of the 282 monthly cross-sectional regressions between the factor loadings of the systematic momentum factor and the productivity gaps. Results are similar when the momentum betas are those of the Carhart model (in Panel A) or the momentum betas of the Fama-French five-factor model plus momentum (in Panel B). We clearly see that the cross-sectional variation of the factor loadings on the systematic momentum factor can be explained by either one of the productivity gaps. Similar to what we find for the explanatory power of productivity gaps for the portfolio returns tested in Hypothesis 1, we also find in testing Hypothesis 2 that the aggregate country productivity gap is the most important gap measure (although the standard deviation of the industry gap is slightly higher than that of the country gap, 0.70 versus 0.53, the country gap coefficient is up to six times as large as the industry gap coefficient, 0.217 versus 0.037). Dummy variables for the leader country and industry momentum betas are significantly negative, indicating that, all else equal, a leader country or industry has a smaller momentum beta. The reason is that the productivity levels of the leading countries and industries depend on their own discoveries and improvements which are more likely to follow a random pattern. We further discuss the importance of the dummy variables for leader countries or industries in Section 6.5.

Additional evidence concerning the momentum explanation in Hypothesis 2 may be obtained from Tables 6 and 7 by comparing the estimated momentum risk premium with and without the aggregated country gap measure. In both cases the momentum risk premium decreases, by around one-third (from 0.24 to 0.16 in Table 6) for the Carhart model, and by almost half (from 0.24 to 0.13 in Table 7) for the FF5+Mom model. While the decrease in the momentum risk premium is as predicted when the aggregate productivity gap is included, the effect is partial. The momentum risk premium is not significant when the aggregate productivity gap is incorporated in the regression, but, in our sample, it is not significant even before the country productivity gap is added to the regression.

Because the length of our sample is limited to less than 25 years we do not look to directly confirm the finding of mean reversion in international country-wide returns (Balvers et al., 2000, Zaremba et al., 2020). However, we can test the mechanism responsible for mean reversion in the model. It requires that initial low country-wide productivity levels indicative of low previous returns are followed by relatively high country-wide returns. Currently-large productivity gaps suggest a previous series of low productivity realizations and low returns. Mean reversion would imply subsequent high returns. If the mechanism implied by the model is feasible we predict that the size of the productivity gap at the beginning of the sample is directly related to the subsequent average returns:

$$\mu_T^c = a + \boldsymbol{b}\,\boldsymbol{GAP} + \upsilon_T^c, \tag{26}$$

where we would expect to find $\boldsymbol{b} > \boldsymbol{0}$ for the country gap $CGAP$ but not for the country average industry gap $IGAP$ to confirm the mechanism leading to mean reversion. We already showed the results for this regression in equation 22 which confirm the hypothesis regarding the mechanism for mean reversion.

The evidence we provide here that productivity gaps and systematic productivity risk are responsible for the momentum and mean reversion patterns observed in international stock returns should be termed "circumstantial". We do not provide direct evidence and can only conclude that, as far as we can tell, the momentum and mean reversion observations are consistent with the systematic productivity risk perspective.

### 6.3 Systematic Risk and Productivity Gaps

Even though Hypothesis 1 may tell us if the productivity gaps contribute to average returns, it is not clear in how far the return premia may be viewed as compensation for systematic risk. We have shown theoretically from the perspective of production-based asset pricing that a larger productivity gap leads to a higher average return on capital which must imply higher stock returns. From the dual consumption-based perspective, the higher stock returns must be tied to increased exposure to systematic risk. Hypothesis 3 relates the return premia directly to systematic risk measures. To evaluate the hypothesis we check whether the productivity gaps relate to direct measures of loadings on systematic productivity risk, $\gamma_t^{ic}$:

$$GAP = c + d\,\gamma_t^{ic} \tag{27}$$

Hypothesis 3 is confirmed if the null hypothesis that a slope coefficient $d = 0$ can be rejected in favor of the alternative hypothesis that a slope coefficient is significantly positive, $d > 0$.

While we find that both the potential for aggregate and for industry-specific spillover effects increase future productivity, only the potential for aggregate spillover effects theoretically increases average stock returns. The industries in countries with larger aggregate productivity gaps subsequently generate persistently higher stock returns. Our model suggests as the reason that firms in lagging countries will be more affected by the productivity shocks in the leading economy. These lead-country productivity shocks represent a systematic risk factor because they disperse widely across all lagging-country firms. The firms with the larger productivity gaps will be more sensitive to these shocks and, accordingly, have higher loadings on this systematic risk (the leading economy productivity shocks). These firms should have higher mean returns on average as compensation for the systematic risk.

To confirm explicitly the key element in our systematic risk explanation, that systematic risk exposure of firms in a country-industry is directly linked to its productivity gap, we first generate standard empirical estimates for the systematic risk exposure by running time-series regressions for the returns of all country-industry portfolios against both of the leader country productivity measures: the aggregate leader country productivity shocks $\Delta \ln Z_t^{c*}$ and the industry-specific leader country productivity shocks $\Delta \ln Z_t^{ic*}$. Second, we then examine (with standard Fama-

MacBeth regressions) if the obtained exposures $\beta_{ic}^{c*}$ and $\beta_{ic}^{ic*}$ are indeed related to the country productivity gap measure (a special case of equation 27):

$$CGAP = a_{0t} + a_t^{c*}(\beta_{ic}^{c*}) + a_t^{ic*}(\beta_{ic}^{ic*}) + \epsilon_t^{ic}.$$

Using the full-sample leader productivity betas for each country-industry portfolio, we find from the Fama-MacBeth regressions in Table 11, showing the time-averages of $a_t^{c*}$ and $a_t^{ic*}$, that the leader-country-productivity beta $\beta_{ic}^{c*}$ for the country-industries is positively and significantly correlated with the aggregate country productivity gaps for the country-industries, either by itself or when the industry-specific beta $\beta_{ic}^{ic*}$ is included. The industry-specific beta $\beta_{ic}^{ic*}$ by itself is statistically significant, but quantitatively small. When added to $\beta_{ic}^{c*}$ it has significant marginal explanatory power for the $CGAP$, although the effect of the leader-country productivity beta, 0.12, is quantitatively larger than the effect of the leading-industry beta, 0.07. The link between leader-country-productivity betas and country productivity gaps explicitly support the supposed mechanism by which returns are affected by productivity gaps, providing support for the systematic risk explanation.

## 6.4 Behavioral or Systematic Risk Explanation

A straightforward alternative explanation for the importance of productivity gaps on future returns similarly rests on the idea of productivity spillovers.[12] However, it presumes a very different mechanism: spillovers arising from larger gaps generate higher future productivity and profitability. Cash flows to stockholders are expected to increase and directly lead to higher returns. While a straightforward explanation, it rests on investor behavioral biases: observable larger productivity gaps generate higher future windfall profits due to spillovers, but this potential is ignored at least in part by current investors who do not bid up stock prices until the anticipated windfall profits become fully discounted in the stock prices. The information about productivity gaps is disseminated slowly, as in Hong and Stein (1999), for instance. If investors would fully bid up stock prices earlier, and in absence of a systematic risk explanation, stock returns would not be higher when the anticipated windfall spillovers from the productivity gap are realized. Thus, the cashflow-based explanation relies on an underreaction perspective.

The earlier regression results presented in Table 3 allow us to distinguish the systematic risk explanation from the cashflow explanation with underreaction. Here systematic shocks in the form of leader country productivity shocks, $\Delta \ln (Z_t^{c*})$, have an important impact on returns. This by itself does not rule out the behavioral expla-

[12] Previous literature (Hsu 2011, Chen et al. 2013 and Jiang et al. 2015) has developed a similar idea in the context of US firms benefitting from R&D spillovers: firms that receive more positive technology spillovers from the inventions of other firms have higher future returns. The explanation is that, while clearly free external benefits raise stock valuations, the fact that the returns are predictable means that the market underreacts initially, only partially pricing in these spillovers. Tseng 2020 obtains a comparable empirical result but his explanation is that firms more sensitive to spillovers benefit from them mostly when the economy is strong. It follows that their stock pays off most (least) when the economy is strong (weak), implying more systematic risk so that the investors require a higher average return.

nation. However, the fact that the idiosyncratic shocks, $\Delta \ln Z_t^{ic}$, are unimportant for stock returns, in spite of representing presumably similar windfall gains for cashflows as the leader-country shocks, argues against the cash flow explanation.

### 6.5 Systematic Risk of the Leader Countries

So far we have failed to consider a specific additional implication of the theory concerning the source of systematic risk. As the productivity gap decreases, industries becomes less dependent on the worldwide advances originating in the leading country, and their exposure to systematic risk diminishes. However, at the extreme, when the productivity gap decreases to zero, the country-industry becomes the leader and may be in the new leader country. At that point, risk exposure actually increases rather than decreases because the country-industry is by definition fully exposed to its own productivity shocks which are to a large extent country-wide and thus, in the leader country, are systematic. I.e., as the industry is no longer catching up it increasingly sets the standard for worldwide productivity improvements and its idiosyncratic productivity shocks are now worldwide systematic productivity shocks. In practice, the transition is probably not as stark as presented here, mostly because the "leader" country position is really a continuous concept which, in spite of our discrete proxy for it, may be shared to different degrees by several economies. Nevertheless, relying on the imperfect proxy, the systematic risk measure for the leader country industries should be determined differently from that of the other industries. To deal with this empirically we distinguish the industries in the leader country from the other test assets, using dummy variables.

In the parametric tests shown in Tables 5, 6, and 7 we insert dummy variables $CGAP0_t^{ic}$ and $IGAP0_t^{ic}$ equal to 1 at times when the (country or industry, respectively) productivity gap is equal to 0. In these cases, the country-industry is located in the leader country or in the leader country for its industry, respectively. Rather than facing no systematic risk because it cannot mimic the innovations in the leader country, it operates in the leader country itself and its innovations actually become systematic. Their returns therefore should be substantially higher than the productivity gap predicts – we expect the coefficient on the dummy variable to be positive. As shown in Tables 5, 6, and 7 the dummy coefficients representing the subsample with $CGAP = 0$, indeed are everywhere positive. However, they are not statistically significant and quantitatively quite small, varying from 0.090 (expanded CAPM) to 0.263 (expanded Carhart). This amounts to between 1.1% to 3.2% annualized difference between the mean return for a leader country compared to that of a non-leader country exhibiting an (almost) zero productivity gap. These numbers are lower than anticipated. Possible explanations are: First, that the zero-one leadership assignation is not a very accurate representation of the transmission of productivity innovations. Second, that the insignificance of the results is a data problem resulting from the number of leaders being only a small fraction (four to five percent) of the data, together maybe with the risk premium in actuality being quite small. Third, the theory predicts that average returns for the leader are determined on a different basis, but not that they must be higher.

For the non-parametric sorting case we cannot use dummy variables. Rather, we exclude all country industries in months when they are in the leader country (when they have a productivity gap of zero, $CGAP = 0$). We then sort the remaining country industries into quintiles. The results are in Table 8, Panels C and D. As predicted, the difference between the returns of Quintile 5 (large productivity gaps) and Quintile 1 (small productivity gaps) is now larger, equal to 9.82% annualized (0.784% monthly). When we include the risk correction based on the FF5+momentum factor model the annualized return is 6.65% as shown in Panel D (0.583% monthly), again larger than when we include the country-industries with zero gaps. Both are significantly positive at the 1% level. The reason that excluding the industries with zero gaps makes a difference is that these industries are included in Quintile 1 (or Quintile 2 since there are industries from productive small countries with negative gap values) because they have small (zero) gaps. However, they should have high systematic risk and, accordingly, high expected returns and are now rightly excluded from Quintile 1 (or Quintile 2) which is the quintile shorted in the sorting strategy and, in this case, ends up with comparatively lower returns (compare in particular Panels B and D). The difference compared to the case where we included the mis-assigned assets with zero gaps is 1.90% percent for raw return differences and 1.58% for differences in alphas. Since only a small fraction of the assets is mis-assigned (only a small fraction, about four to five percent, of the country-industries are in the leader country), the return difference here is quite substantial.

## 6.6 Productivity Gap Mimicking Factor

The connection to systematic risk of the productivity gap measured by $CGAP$ suggests that a mimicking factor may be generated that contributes to pricing assets. We utilize the method of Balvers and Luo (2018) and Balduzzi and Robotti (2008) to generate a "characteristic mimicking factor" with the property that the loadings of each test asset $ic$ on this factor equals the asset characteristic – in this case, the country-specific productivity gap, $CGAP$, at each time $t$. For monthly return data, the loading estimate on this factor for a particular month therefore is at the same time an estimate of the productivity gap ( observable only at the annual frequency) for the month. The mimicking factor allows a more comprehensive look at the systematic risk represented by the productivity gap.

The mimicking factor is obtained as

$$r_t^{GAP} = (\boldsymbol{r_t^{ic}})' \left( \boldsymbol{\hat{\Sigma}_{t-1}^{ic}} \right)^{-1} \boldsymbol{CGAP_{t-1}},$$

where $\boldsymbol{r_t^{ic}}$ is the vector of returns in month $t$ for the country-industries. $\boldsymbol{\hat{\Sigma}_{t-1}^{ic}}$is the estimated covariance matrix for the country-industry returns using information prior to month $t$. We use 24 prior months to estimate this covariance matrix on a rolling basis. $\boldsymbol{CGAP_{t-1}}$ is the vector of the aggregate country production gaps for each country-industry using the most recent annual observation preceding month $t$. In view of the difficulty of pricing leader country-industries (zero-gap country-industries) based on the productivity gaps discussed in section 6.5, we exclude all periods in which a country-industry is in the leader country (has a gap of zero) from both the determination of the mimicking factor and from the test assets.

To see how well the productivity gap factor explains the country-industry portfolios, given that the factor loadings evolve as the production gaps change over time, we perform again a standard Fama-MacBeth procedure. The loadings on the production gap factor (as well as on the other factors we consider) of all country industry portfolios are estimated on a rolling basis using up to 60 prior monthly observations with a minimum of 24 observations (as in Fama and MacBeth, 1973). The predicted return is the loading for each factor times the realized factor return for the month. For each country-industry portfolio we then compare the predicted return against the realized monthly return, and average over all sample months. The result is show in Figure 2(a). The country and industry are identified by the first three letters and last three letters, respectively, of the labels in Figure 2. See Appendix C, Table 15 for the legend. The solid line indicates the regression of realized mean returns on predicted mean returns. The R-squared for this regression is 27.1 percent. The dotted line is the 45-degree line, indicating that the estimated risk premium approximately tracks the true risk premium. The slope of the regression line is not significantly different from one.

The absolute value of the alphas (the differences between the average realized and the average predicted returns) for the country-industry assets is a relatively large 0.466%. This is typical for models explaining industry portfolios. It is exacerbated by the relatively short sample size which causes realized mean returns to deviate stochastically by more from true mean returns.[13] Figure 2(a) illustrates that our model works less well for explaining the country-industry portfolios with negative mean returns. However, it is for these assets that the misestimation error of portfolio mean returns resulting from the relatively short time series of the sample may be most prominent, as negative risk premia for primary assets are generally not observed in samples with long time series. Generally, the country industries deviating most from their predicted values are smaller industries in smaller countries. The misestimation error is more severe for less diversified portfolios. More diversified portfolios should have reduced measurement error of the mean returns and hence should provide a better fit. To check this we aggregate all industries within a country and consider the model fit at the national level (for all countries with on average by

[13]To appreciate the numerical importance of the relatively short sample consider that the standard deviation of an industry portfolio return, averaged across all country-industries we use as test assets, is 7.29 percent for monthly returns. With 282 monthly returns this implies an average standard deviation of 0.43 percent for estimated monthly return means. This number is already close to the absolute alpha values generated by the model. When we consider country average returns as the test assets, the average standard deviation for these more diversified portfolios is 4.87 percent for monthly returns. With 282 monthly returns this generates an average standard deviation of 0.29 percent for the estimated monthly country-index return means. Our model applied to the country-index portfolios (as displayed in Figure 2a) generates accordingly a larger R-squared and smaller alphas: the average absolute alpha for the country-index portfolios is 0.22. Another indication of the imprecision of monthly mean return estimates is that, among the country-industry test assets for our sample period, 75 of 182 have a negative estimated equity premium. For mainstream asset pricing views the majority of these negative mean excess return estimates cannot reflect actual risk premia.

industry at least 24 months of data). Figure 3(a) shows indeed a closer fit for the 21 countries that meet the data criteria, with an R-squared of 56.5 percent.

The remaining results in Table 10 and in Figures 2 and 3 display the model fit for the competing models. Each of these models perform substantially worse than the productivity gap factor model. The figures show the CAPM (panel b), the Carhart model (panel c), and the Fama-French 5-factor model with momentum (panel d). The FF3 and FF5 model performances are listed in Table 10 but are not displayed in the figures. The fit for the 187 country-industries in Figure 2 is conveyed by R-squares of 0.7%, 8.4%, 12.0%, 8.3%, and 7.0%, for CAPM, FF3, Carhart, FF5, and FF5Mom, respectively. For the 21 countries in Figure 3, the R-squares for CAPM, FF3, Carhart, FF5, and FF5Mom are, respectively, 33.8%, 8.0%, 1.0%, 17.7%, and 9.8%. The absolute alphas for these same models are 0.553%, 0.577%, 0.543%, 0.604%, and 0.574%, respectively. The relatively good fit for the CAPM in explaining country returns is misleading since the "tracking" coefficient is negative, meaning that higher predicted returns are associated with lower realized returns. Of the competing models the Carhart model performs best. Its tracking coefficient is 0.879 which is not significantly different from 1.0 and it explains 12.0% of the variation in mean country-industry asset returns.[14]

**Barillas-Shanken Tests**

The above model comparison is relevant for the country industry portfolios as test assets and for the conditional model versions when factor loadings vary over time. Based on Barillas and Shanken (2017) we can make a nested unconditional (assuming constant factor loadings over the full sample) model comparison that is valid for any group of test assets. Essentially, any group of factors that has a larger maximum Sharpe ratio than a competing group of factors, will explain any group of test assets better (as long as this group of test assets includes both groups of factors). A model that consists of the union of the factors from two contesting models is the "large" model. We can test if the large model explains assets significantly better than either one of the "small" component models. The test is equivalent to the GRS test but with the small model serving as the factor model and the large model serving as the test assets. The test finds whether the maximum Sharpe Ratio of the large model is significantly larger than the Sharpe Ratio of the small model; or, equivalently, whether the factors excluded from the small model have significantly positive alphas as a group when explained by the factors from the small model. If they have significantly larger alphas, it follows that the large model when set to explain any group of test assets will have smaller alphas than the small model (when weighted by the inverse return covariance matrix).

The results of the Barillas-Shanken tests are shown in Table 12. As summary statistics for all factors considered,

[14]Part of the better fit for the Production-Gap Factor model is due to a few outliers, mostly industries from the Czech Republic (which have relatively few time series data points). When we remove all Czech data points, the R-squared for the Production-Gap based model decreases somewhat to 20.8% (not tabulated), but still remains substantially higher than for the other models in Table 10.

note that the Sharpe ratios vary from 0.070 (for the size factor) to 0.289 (for the productivity-gap factor). Only the profit factor has a Sharpe ratio of 0.239 close to the productivity-gap factor. This is interesting because both factors may be related conceptually in the sense that high productivity gaps may be associated with high profitability (due to the ability to cheaply mimic existing technology and knowledge). However, a large productivity gap also implies a low level of current productivity which is detrimental to profitability. As it is, the correlation between the two factors in our data is equal to -0.007 which is not significantly different from zero.

Applying the Barillas-Shanken test to compare one-factor models we find that, for all FF5 model factors plus the momentum factor, viewed individually as a factor model, the productivity gap factor has a significantly positive alpha, meaning that it contributes significantly to the explanation of any group of asset returns when added to one of the six factors. On the other hand, when the market factor or the size factor is added to the productivity gap factor either factor does not contribute to the explanation of any group of asset returns – the alpha of either factor is not significantly positive at the 5% level – meaning that the productivity gap factor explains this factor and that this factor is not marginally useful in explaining other asset returns. The alphas of the value and investment growth factors also are not significantly positive at the 1% level. The remaining FF5 factors, the profitability factor as well as the momentum factor, have significantly positive alphas (even at the 1% level) so that they are not subsumed by the productivity gap factor. The profit and momentum factors, thus, neither subsume nor are subsumed by the productivity gap factor.

The multi-factor models (FF3, Carhart, FF5, and FF5+Momentum) also cannot outperform the productivity gap factor model. The three FF3 factors jointly do not subsume the productivity gap factor, but the productivity gap factor subsumes the FF3 factors in the sense that the alphas of these three factors jointly are not significantly positive at the 1% level. Similarly, the Carhart, FF5, and FF5+Mom models do not subsume the productivity gap factor at any reasonable level of significance. On the other hand, the productivity gap factor by itself also does not subsume the Carhart, FF5, and FF5+Mom models at any reasonable level of significance. A further positive indication of the importance of the productivity gap factor is that its factor alphas generate higher GRS statistics than do the factor alphas of the multi-factor models the other way around (which is, of course, not a statistically significant difference). Furthermore, likely the factor model comparison results are affected by the unconditional nature of the test which (in this form) does not allow for time variation in factor loadings, an essential element of the productivity gap factor model. Lastly, the Barillas-Shanken results require that the test assets include all of the factors under consideration. This is automatically the case for the productivity gap factor for our test assets, but not for the FF5+Momentum factors (with the exception of the market factor). Thus, these factors should be expected to perform less well for the country-industry test assets we consider than would be expected based on the Barillas-Shanken tests.

# 7 Conclusion

There is broad consensus in the finance field that systematic risk is the suitable concept of risk for explaining average asset returns. But, curiously, there are few specific theories of what determines systematic risk. The APT and Merton Model merely provide a structure of how we can process systematic risk once it has been identified. With well-developed and integrated international markets, a systematic risk must be pervasive worldwide, as well as fundamentally important and persistent. In the current paper we propose that a strong candidate for a systematic risk is the fundamental uncertainty in how well resources may be combined to generate desired products. The uncertainty is a result of fundamental randomness in how technology and know-how develop to stimulate production. Discoveries (managerial, technological, procedural, etc.) are the random realizations that, when useful, spread worldwide. These realizations are the risk that generally originates with productivity leaders and spreads globally. The cause of systematic risk thus is the variation in productivity of leading producers that are in the best position to develop and discover new techniques and practices.

We develop a simple international production-based asset pricing model that accounts for technology spillover effects across countries and across industries. Firms, in countries and industries that lag behind the leading technology country or industry, face what we call "technology gaps" and which we capture empirically as productivity gaps calculated from discrepancies in $TFP$. Systematic productivity risks are driven mostly by the stochastic progress made in the leading-technology countries or industries, which spills over gradually to lagging-technology countries or industries. Larger productivity gaps in particular countries and industries mean that the firms in these country-industries stand to gain more from technology spillovers over time and, accordingly, are more exposed to the productivity shocks that occur in the leading-technology economies and industries. The latter factor is responsible for higher average stock returns for firms in the countries and industries with larger productivity gaps; these firms depend more on leader-country productivity gains and thus have higher loadings on the global systematic productivity risk. Because of the dynamics of the technology spillovers, productivity levels in lagging economies and industries are likely to catch up over time, but do so slowly. The high systematic productivity risk exposure of lagging firms, therefore, only diminishes slowly over time. In the overall picture, low returns accompanying a slide to a large productivity gap, are eventually reversed through subsequent persistently higher average returns, a process that shows aspects of both mean reversion and momentum in international returns.

The implications of the theory that technologically lagging firms (1) have higher average returns, that (2) display momentum and eventual mean reversion, and (3) display higher systematic risk, are examined here using detailed annual industry- and country-specific productivity data for OECD countries, and monthly stock return data for firms in these countries. The technology spillovers may occur through a multitude of different channels. We empirically examine two measures of productivity gaps that capture spillovers relevant to individual firms. In particular, we assess two contributory components to the productivity deficit, and the potential spillovers, faced by a particular firm: (a) gaps in the firm's country productivity relative to the most productive country; and (b) gaps at the industry level in the firm's country relative to the country which is the most productive for this particular industry. The total spillovers that benefit a firm may be a combination of these two different (but correlated) sources.

Both the aggregate country productivity gap and the industry-specific country productivity gap have significant explanatory power for future productivity in individual country-industries. Nevertheless, only the aggregate country productivity gap has forecast power for future stock returns. Firms in countries with a larger aggregate country productivity gap have significantly higher average returns, irrespective of the set of global risk factor exposures we use as controls. The reason is that a larger country productivity gap generates more exposure for the country's firms (industries) to the leader country productivity shocks, which by nature have a pervasive global impact and are indicators of systematic risk. The higher loadings on systematic risk emanating from the country productivity gaps imply higher average returns for the firms in countries with larger productivity gaps. In contrast, larger industry productivity gaps present a risk that is not systematic and has no detectable impact on average returns. As the country productivity gaps are persistent, the higher mean returns in countries with larger productivity gaps are also persistent. We find that a firm's exposure to systematic productivity risk is positively linked to the firm's exposure to the Carhart momentum factor, so that the model is consistent with the (systematic) momentum effect across countries. Further, after experiencing periods of relative decline which manifest in low returns and increasing country productivity gaps, the increased exposure to systematic risk generates a subsequent period of higher returns (with momentum) that reverses the negative earlier returns and resembles mean reversion.

A straightforward alternative explanation for our empirical result of a positive link between country productivity gaps and subsequent stock returns for the country's firms is that larger positive spillovers simply generate windfall gains in productivity and profit for these firms, which are responsible for higher stock returns. This explanation is inherently different from what our model suggests, especially because it requires the stock market to be inefficient in that the anticipated benefits of future productivity spillovers are at best partially incorporated in current stock prices, a scenario referred to as underreaction in the behavioral finance literature. In juxtaposition, our explanation assumes that anticipated positive spillovers are fully incorporated in stock prices but tie a firm more strongly to the systematic productivity risk emanating from the productivity-leading country, generating higher average returns as compensation for the increased systematic risk exposure.

Our results convey that a larger country productivity gap implies that firms in the lagging country exhibit higher future productivity growth. However, while these findings support our basic model, they are consistent also with the behavioral explanation. To decide among the competing explanations we check specifically if we can tie productivity gaps to systematic risk exposure. We investigate if it is possible to identify the positive link between productivity gaps and productivity betas as required for the systematic risk explanation. Estimating full-sample leader productivity betas for each country-industry portfolio, we find in Fama-MacBeth regressions that leader-country-productivity betas are positively and significantly correlated with country-industry productivity gaps. Indeed, changes in the stock prices of firms in countries with larger productivity gaps are significantly more positively correlated with the productivity shocks measured for the productivity leader country. Further, own-country-industry productivity shocks are far less important which argues against the cash flow explanation because, in this view, any productivity windfall (including in particular own-country-industry productivity shocks) should increase cash flows and, accordingly, given the inefficient markets perspective, increase stock returns.

It appears that productivity spillover effects are important on a global scale and generate significant predictability in stock returns as well as important differences in mean stock returns across countries and industries and over time, that are related to time-varying loadings on systematic productivity risk. We find some support for the view that the dynamics across countries between productivity shocks, productivity gaps, and stock returns may be partly responsible for empirical findings of momentum and mean reversion in international returns.

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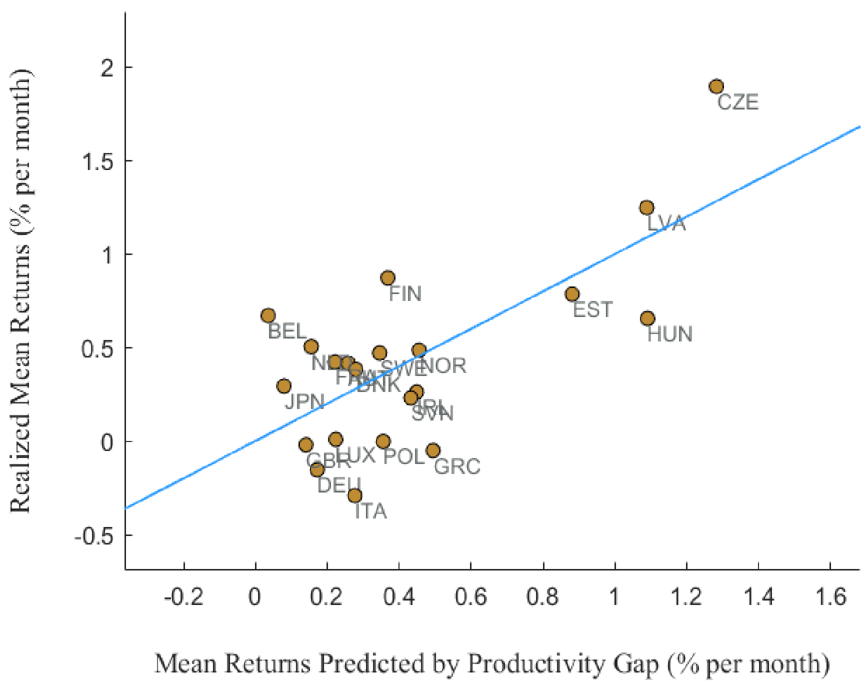
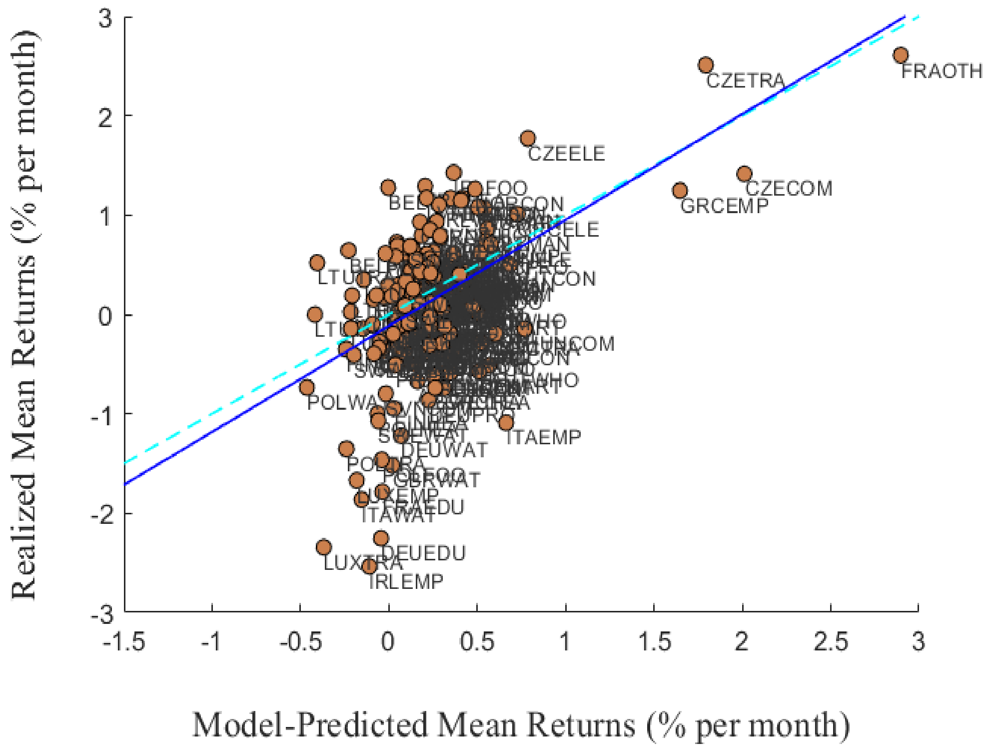
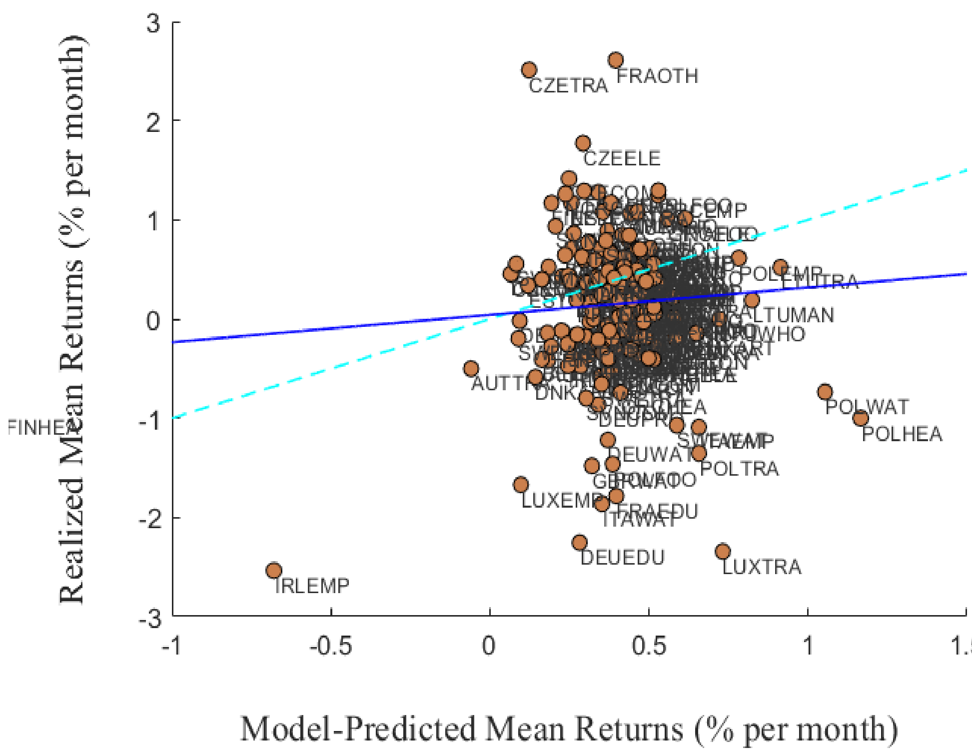


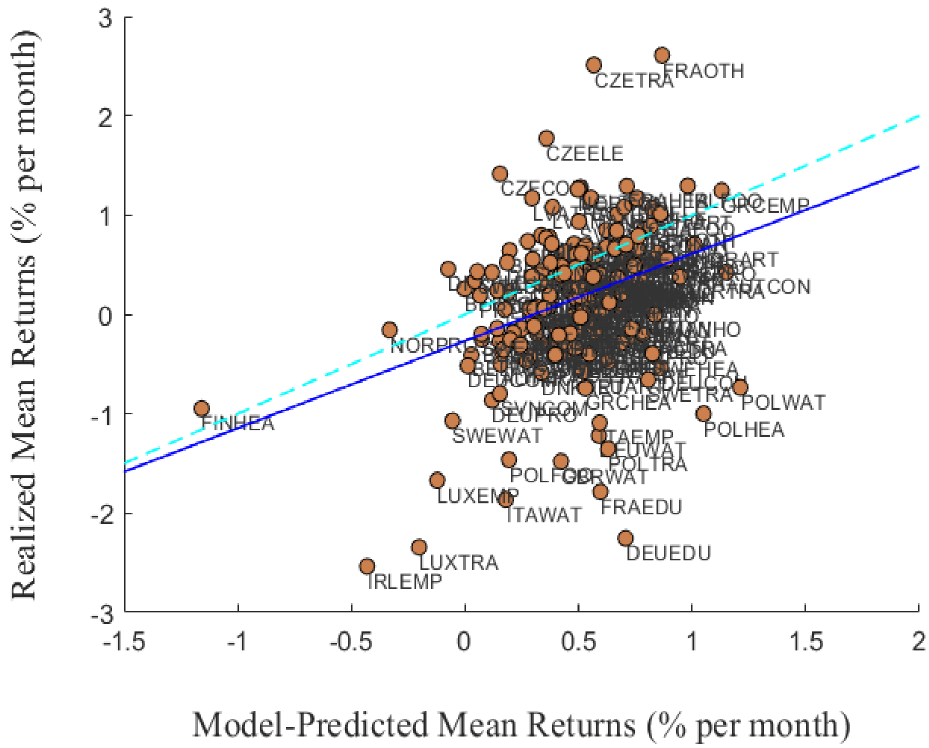

**Figure 1: Initial Productivity Gaps and Average Country Returns**



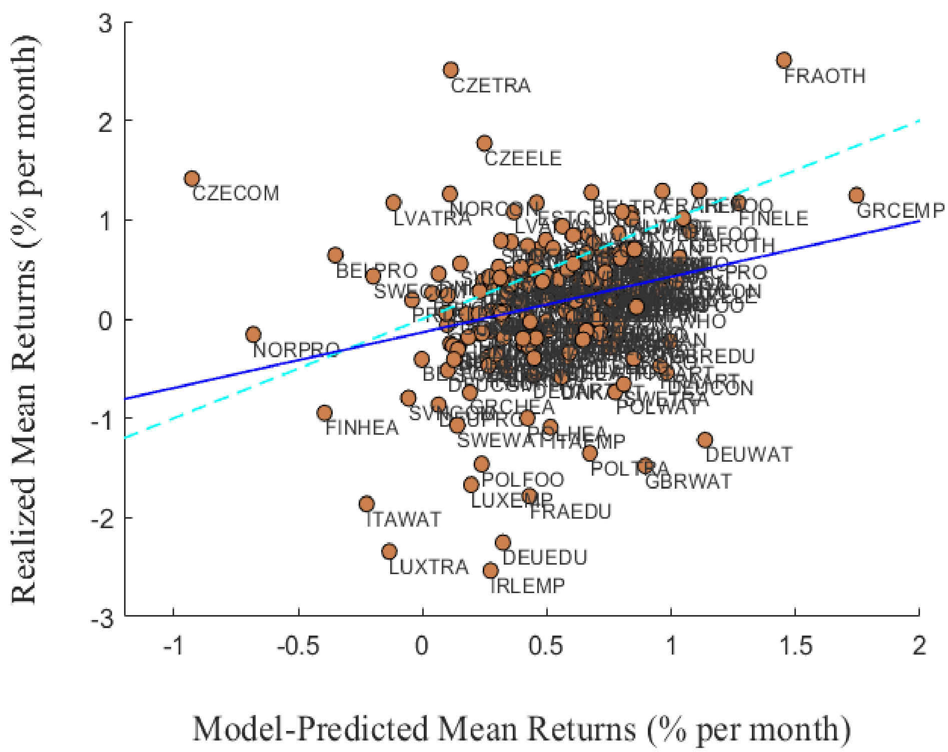

(a) Production-Gap Mimicking Factor Model




(b) CAPM

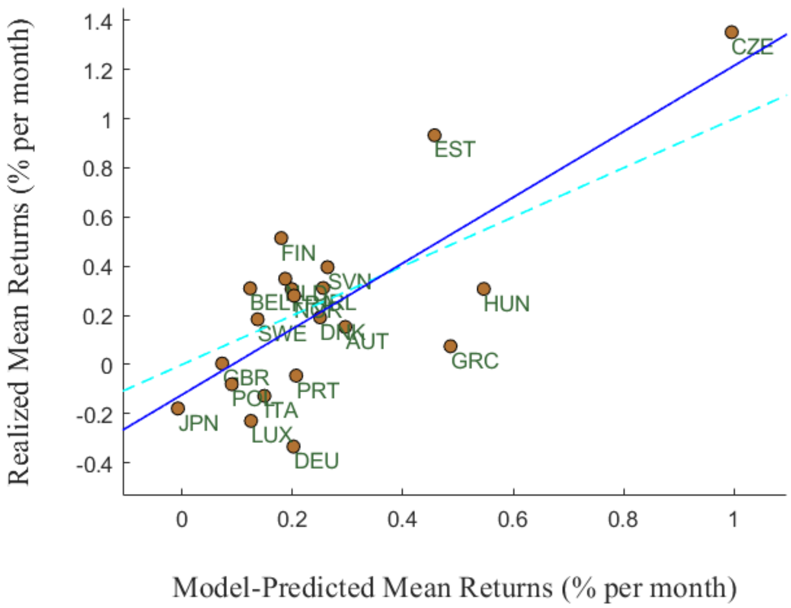



(c) Fama-French 3-Factor Model

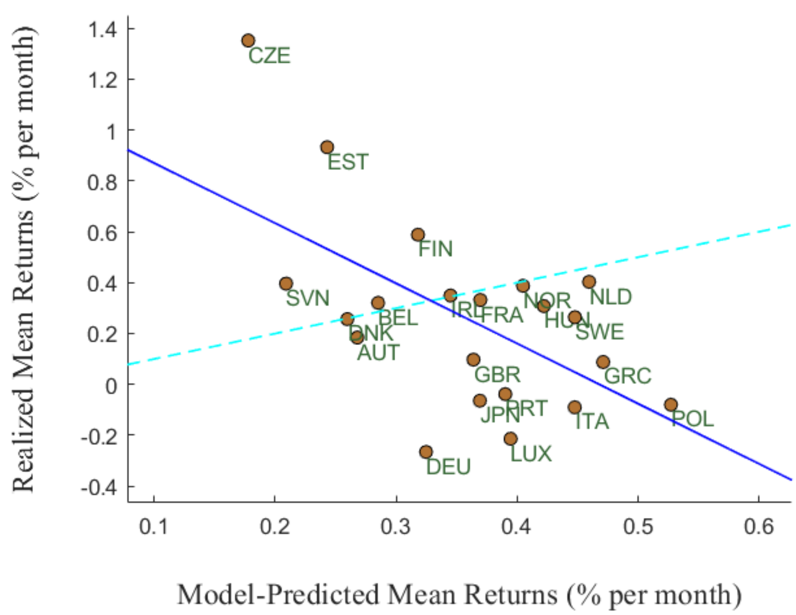



(d) Fama-French 5-Factor Model

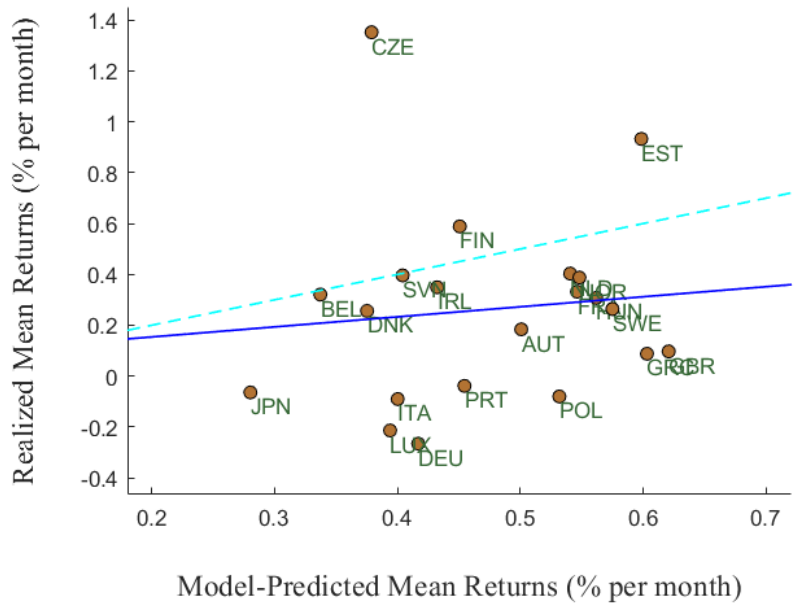
**Figure 2: Performance of Factor Models in Explaining Country-Industry Portfolio Returns**



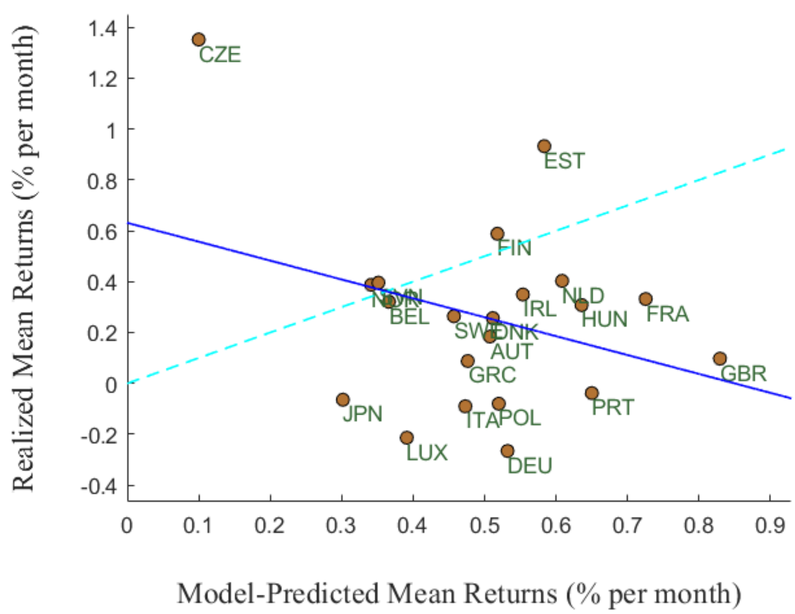

(a) Production-Gap Mimicking Factor Model




(b) CAPM




(c) Fama-French 3-Factor Model




(d) Fama-French 5-Factor Model

**Figure 3: Performance of Factor Models in Explaining Country Portfolio Returns**

Table 1: Country Level Total Factor Productivity

This Table presents the Mean, Standard Deviation (SD), Maximum, and Minimum of the Total Factor Productivity measure ($TFP$) for each country. In calculating $TFP$, capital is measured as the Net Capital Stock in PPP-adjusted USD and labor is measured in Employee Hours (hours worked by full time employees). Count is the number of years for which the country has the appropriate data in the 1990-2015 sample period. The countries are Austria (AUT), Belgium (BEL), Canada (CAN), the Czech Republic (CZE), Germany (DEU), Denmark (DMK), Estonia (EST), Finland (FIN), France (FRA), Great Britain (GBR), Greece (GRC), Hungary (HUN), Ireland (IRL), Italy (ITA), Japan (JPN), Lithuania (LTU), Luxemburg (LUX), Latvia (LVA), the Netherlands (NLD), Norway (NOR), Poland (POL), Portugal (PRT), the Slovak Republic (SVK), Slovenia (SVN), Sweden (SWE), and the United States of America (USA).

| **Country Level Total Factor Productivity** | | | | | |
|---|---|---|---|---|---|
| **Country** | **Mean** | **SD** | **Max** | **Min** | **Count** |
| AUT | 6.77 | 0.61 | 8.12 | 6.14 | 21 |
| BEL | 11.53 | 1.60 | 14.38 | 8.96 | 20 |
| CAN | 8.33 | 0.27 | 8.65 | 7.91 | 7 |
| CZE | 1.94 | 0.63 | 2.75 | 1.11 | 21 |
| DEU | 7.20 | 0.81 | 8.82 | 6.03 | 24 |
| DNK | 7.03 | 1.49 | 9.66 | 5.38 | 26 |
| EST | 3.41 | 0.78 | 4.56 | 2.38 | 15 |
| FIN | 6.23 | 1.09 | 8.34 | 5.14 | 26 |
| FRA | 8.85 | 1.41 | 11.78 | 6.70 | 26 |
| GBR | 8.12 | 1.67 | 10.03 | 5.31 | 21 |
| GRC | 5.00 | 0.76 | 6.10 | 3.64 | 19 |
| HUN | 2.33 | 0.57 | 2.99 | 1.46 | 19 |
| IRL | 5.42 | 0.89 | 7.32 | 4.12 | 20 |
| ITA | 6.78 | 0.67 | 8.04 | 5.96 | 26 |
| JPN | 8.31 | 1.26 | 11.14 | 6.49 | 22 |
| LTU | 2.23 | 0.50 | 2.99 | 1.36 | 16 |
| LUX | 8.00 | 1.31 | 10.06 | 5.99 | 20 |
| LVA | 2.17 | 0.51 | 3.02 | 1.38 | 15 |
| NLD | 9.58 | 1.35 | 12.27 | 7.43 | 26 |
| NOR | 5.98 | 0.86 | 7.55 | 4.64 | 26 |
| POL | 5.21 | 0.37 | 5.77 | 4.59 | 15 |
| PRT | 4.64 | 0.04 | 4.67 | 4.61 | 2 |
| SVK | 2.36 | 0.39 | 2.86 | 1.78 | 12 |
| SVN | 7.01 | 1.42 | 8.96 | 4.57 | 16 |
| SWE | 7.05 | 1.29 | 9.63 | 5.48 | 21 |
| USA | 7.88 | 0.74 | 8.73 | 6.31 | 26 |

Table 2: Country Level $TFP$ Leaders

Total Factor Productivity ($TFP$) leader countries by year among the countries that contribute morer than 0.75% of world GDP and have $TFP$ data available at the industry level: USA, UK, Germany, France, Canada, Australia, Italy, Japan, South Korea, Netherlands, Spain, Poland, and Mexico. $TFP$ is calculated based on Employee Hours (hours worked by full time employees) and Net Capital Stock. The leader countries include France (FRA), the Netherlands (NLD), Japan (JPN), and the United States (USA).

| **Year** | **Maximum $TFP$** | **Max $TFP$ Country** |
|---|---|---|
| 1990 | 7.811 | FRA |
| 1991 | 8.676 | NLD |
| 1992 | 8.711 | NLD |
| 1993 | 8.834 | NLD |
| 1994 | 10.350 | JPN |
| 1995 | 11.140 | JPN |
| 1996 | 9.881 | JPN |
| 1997 | 9.256 | JPN |
| 1998 | 8.912 | JPN |
| 1999 | 9.601 | JPN |
| 2000 | 9.526 | JPN |
| 2001 | 8.506 | USA |
| 2002 | 8.544 | NLD |
| 2003 | 9.980 | NLD |
| 2004 | 10.495 | NLD |
| 2005 | 9.309 | NLD |
| 2006 | 9.610 | NLD |
| 2007 | 10.196 | NLD |
| 2008 | 10.142 | NLD |
| 2009 | 11.091 | NLD |
| 2010 | 11.146 | NLD |
| 2011 | 10.667 | NLD |
| 2012 | 11.383 | NLD |
| 2013 | 12.271 | NLD |
| 2014 | 11.073 | FRA |
| 2015 | 10.183 | FRA |

Table 3: Forecastability of Productivity Changes from Productivity Gaps

Future changes in empirical measures of the productivity levels $Z_t^{ic}$ for country-industry portfolios $ic$ are regressed on current values of the relevant productivity gaps for the country-industry portfolio. We consider five different intervals $d$ for the period of the future changes:

$$\ln(Z_{t+d}^{ic}) - \ln(Z_t^{ic}) = \alpha_0^d + \boldsymbol{\alpha_{GAP}^d GAP} + \epsilon^d,$$

where $GAP = [CGAP^{ic}, IGAP]$. Panel A presents the results with the relevant country level gap $CGAP$ as the forecast variable; Panel B presents the results with the relevant industry gap $IGAP$ as the independent variable; Panel C presents the results with both country level gap $CGAP$ and industry gap $IGAP$ as the independent variables. The coefficients and standard errors are for the pooled regression with White standard errors.

| | $\ln Z_{t+1}^{ic} - \ln Z_t^{ic}$ | $\ln Z_{t+2}^{ic} - \ln Z_t^{ic}$ | $\ln Z_{t+3}^{ic} - \ln Z_t^{ic}$ | $\ln Z_{t+4}^{ic} - \ln Z_t^{ic}$ | $\ln Z_{t+5}^{ic} - \ln Z_t^{ic}$ |
|---|---|---|---|---|---|
| Panel A: $CGAP$ | | | | | |
| $\alpha_{CGAP}$ | 0.016 | 0.037 | 0.066 | 0.090 | 0.118 |
| t-stat | (5.75)*** | (8.64)*** | (11.88)*** | (13.65)*** | (16.03)*** |
| p-value | [0.00] | [0.00] | [0.00] | [0.00] | [0.00] |
| $R^2$ | 0.01 | 0.01 | 0.03 | 0.04 | 0.05 |
| N | 7,221 | 6,792 | 6,379 | 5,983 | 5,588 |
| Panel B: $IGAP$ | | | | | |
| $\alpha_{IGAP}$ | 0.016 | 0.037 | 0.059 | 0.079 | 0.099 |
| t-stat | (7.76)*** | (11.36)*** | (14.11)*** | (15.77)*** | (17.41)*** |
| p-value | [0.00] | [0.00] | [0.00] | [0.00] | [0.00] |
| $R^2$ | 0.01 | 0.03 | 0.04 | 0.06 | 0.07 |
| N | 7,413 | 6,984 | 6,571 | 6,159 | 5,748 |
| Panel C: $CGAP$ and $IGAP$ | | | | | |
| $\alpha_{CGAP}$ | 0.000 | 0.002 | 0.014 | 0.022 | 0.036 |
| t-stat | (0.08) | (0.28) | (1.82)* | (2.45)** | (3.45)*** |
| p-value | [0.94] | [0.78] | [0.07] | [0.01] | [0.00] |
| $\alpha_{IGAP}$ | 0.017 | 0.037 | 0.054 | 0.071 | 0.086 |
| t-stat | (5.73)*** | (8.00)*** | (9.22)*** | (10.16)*** | (10.54)*** |
| p-value | [0.00] | [0.00] | [0.00] | [0.00] | [0.00] |
| $R^2$ | 0.01 | 0.03 | 0.05 | 0.06 | 0.08 |
| N | 7,221 | 6,792 | 6,379 | 5,983 | 5,588 |

* p<0.10; ** p<0.05; *** p<0.01

Table 4: Returns with respect to Leading Productivity Shocks

Excess Returns of country-industry portfolio $r_t^{ic}$ are regressed on its own productivity level shock, the productivity shock of the leader country for the industry, and the productivity shock of the leader country, in a pooled regression across time periods and country-industry portfolios. For the firm's own productivity level shock we use the change in $\Delta \ln(Z_t^{ic})$ which is industry productivity at the country-industry portfolio level; for the productivity shock of the industry leader country we use the change in leader industry productivity $\Delta \ln \left(Z_t^{ic*}\right)$; and for the productivity shock of the leader country we take leader country productivity $\Delta \ln \left(Z_t^{c*}\right)$.

$$r_t^{ic} - r_t^f = \alpha^0 + \alpha^{ic} \Delta \ln \left(Z_t^{ic}\right) + \alpha^{ic*} \Delta \ln \left(Z_t^{ic*}\right) + \alpha^{c*} \Delta \ln \left(Z_t^{c*}\right) + \epsilon_t^{ic}.$$

where $\Delta \ln \left(Z_t^{ic}\right) = \ln \left(Z_t^{ic}\right) - \ln \left(Z_{t-1}^{ic}\right)$, $\Delta \ln \left(Z_t^{ic*}\right) = \ln \left(Z_t^{ic*}\right) - \ln \left(Z_{t-1}^{ic*}\right)$, $\Delta \ln \left(Z_t^{c*}\right) = \ln \left(Z_t^{c*}\right) - \ln \left(Z_{t-1}^{c*}\right)$.

| **Coefficients** | | | | $r_t^{ic} - r_t^f$ | | | |
|---|---|---|---|---|---|---|---|
| $\alpha_{ic}$ | 0.219 | | | 0.183 | -0.086 | | -0.067 |
| t-stat | (3.57)*** | | | (2.94)*** | (-1.46) | | (-1.14) |
| p-value | [0.00] | | | [0.00] | [0.14] | | [0.26] |
| $\alpha_{ic}^*$ | | 0.194 | | 0.169 | | -0.168 | -0.163 |
| t-stat | | (3.95)*** | | (3.39)*** | | (-3.47)*** | (-3.34)*** |
| p-value | | [0.00] | | [0.00] | | [0.00] | [0.00] |
| $\alpha_c^*$ | | | 1.535 | | 1.561 | 1.627 | 1.645 |
| t-stat | | | (21.40)*** | | (21.11)*** | (21.30)*** | (21.10)*** |
| p-value | | | [0.00] | | [0.00] | [0.00] | [0.00] |
| $R^2$ | 0.00 | 0.01 | 0.14 | 0.01 | 0.14 | 0.15 | 0.15 |
| N | 2,730 | 2,730 | 2,730 | 2,730 | 2,730 | 2,730 | 2,730 |

* p<0.10; ** p<0.05; *** p<0.01

Table 5: Second Stage Fama-MacBeth Regressions with Productivity Gaps and the Global CAPM Risk Factor

The returns of the equal-weighted country-industry portfolios are regressed at a monthly frequency for the period July 1992-December 2015 on the various productivity gaps relevant for each country-industry portfolio and controlling for the global CAPM beta of the country-industry portfolio. The computation of the productivity gap measures uses $TFP$ based on capital measured as the Net Capital Stock in current PPP terms and labor measured in Employee Hours. The global market factor is taken from Kenneth French's website. The cross-sectional regression is a specific case of equation 24:

$$r_{t+1}^{ic} - r_{t+1}^{f} = a_t + b_t^{MKT}\beta_{MKT}^{ic} + \boldsymbol{c_t}\left(\boldsymbol{GAP}\right) + \eta_t^{ic}$$

Here $\boldsymbol{GAP} = [CGAP\, CGAP0_t^{ic}\, IGAP\, IPC0_t^{ic}]'$,with $CGAP$and $IGAP$the country and the industry productivity gap, respectively, and $CGAP0_t^{ic}$ ($IPC0_t^{ic}$) a dummy variable that is equal to one when $CGAP = 0$ ($IGAP = 0$), the productivity gap equals zero. The coefficients and the standard errors in this table are the means and standard deviations of $a_t$, $b_t^{MKT}$and elements of $\boldsymbol{c_t} = [c_t^{CGAP}, c_t^{CGAP0}, c_t^{IGAP}, c_t^{IGAP0}]$ based on the 282 monthly regression from July 1992 until December 2015.

| **Coef** | GAP | | | | | | CAPM | CAPM + GAP | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $c^{CGAP}$ | 0.902 | | 1.167 | 0.892 | | 1.350 | | 0.917 | | 1.166 | 0.916 | | 1.386 |
| T-STAT | (3.23)*** | | (4.35)*** | (3.09)*** | | (4.09)*** | | (3.31)*** | | (4.40)*** | (3.19)*** | | (4.20)*** |
| P-VALUE | [0.00] | | [0.00] | [0.00] | | [0.00] | | [0.00] | | [0.00] | [0.00] | | [0.00] |
| $c^{IGAP}$ | | 0.073 | -0.252 | | 0.107 | -0.197 | | | 0.074 | -0.244 | | 0.113 | -0.190 |
| T-STAT | | (0.77) | (-3.00)*** | | (1.13) | (-2.31)** | | | (0.80) | (-2.93)*** | | (1.24) | (-2.27)** |
| P-VALUE | | [0.44] | [0.00] | | [0.26] | [0.02] | | | [0.43] | [0.00] | | [0.22] | [0.02] |
| $c^{CGAP0}$ | | | | 0.149 | | 0.158 | | | | | 0.090 | | 0.107 |
| T-STAT | | | | (0.68) | | (0.72) | | | | | (0.38) | | (0.45) |
| P-VALUE | | | | [0.49] | | [0.47] | | | | | [0.71] | | [0.65] |
| $c^{IGAP0}$ | | | | | 0.137 | 0.162 | | | | | | 0.120 | 0.141 |
| T-STAT | | | | | (1.29) | (1.44) | | | | | | (1.17) | (1.28) |
| P-VALUE | | | | | [0.20] | [0.15] | | | | | | [0.24] | [0.20] |
| $b^{MKT}$ | | | | | | | -0.510 | -0.458 | -0.476 | -0.435 | -0.417 | -0.512 | -0.444 |
| T-STAT | | | | | | | (-1.74) | (-1.57) | (-1.63) | (-1.49) | (-1.42) | (-1.77)* | (-1.53) |
| P-VALUE | | | | | | | [0.08] | [0.12] | [0.10] | [0.14] | [0.71] | [0.08] | [0.13] |
| $R^2$ | | | | | | | 0.06 | 0.10 | 0.08 | 0.11 | 0.12 | 0.09 | 0.14 |
| N | 34,321 | 34,321 | 34,321 | 34,321 | 34,321 | 34,321 | 34,321 | 34,321 | 34,321 | 34,321 | 34,321 | 34,321 | 34,321 |

* p<0.10; ** p<0.05; *** p<0.01

Table 6: Second Stage Fama-MacBeth Regressions with Productivity Gaps and the Global Carhart Model

The returns of the equal-weighted country-industry portfolios are regressed at a monthly frequency for the period July 1992-December 2015 on the various productivity gaps relevant for each country-industry portfolio and controlling for exposure to systematic risk factors. The computation of the productivity gap measures uses $TFP$ based on capital measured as the Net Capital Stock in current PPP terms and labor measured in Employee Hours. The global risk factors are from Kenneth French's website. The cross-sectional regression is a specific case of 24:

$$r_{t+1}^{ic} - r_{t+1}^{f} = a_t + b_t^{MKT}\beta_{MKT}^{ic} + b_t^{SMB}\beta_{SMB}^{ic} + b_t^{HML}\beta_{HML}^{ic} + b_t^{WML}\beta_{WML}^{ic} \boldsymbol{+c_t}\left(\boldsymbol{GAP}\right) + \eta_t^{ic}$$

Here $\boldsymbol{GAP} = [CGAP\, CGAP0_t^{ic}\, IGAP\, IPC0_t^{ic}]'$,with $CGAP$and $IGAP$the country and the industry productivity gap, respectively, and $CGAP0_t^{ic}$ $(IPC0_t^{ic})$ a dummy variable that is equal to one when $CGAP = 0$ $(IGAP = 0)$, the productivity gap equals zero. The coefficients and the standard errors in this table are the means and standard deviations of $a_t$, $b_t^{MKT}, b_t^{SMB}, b_t^{HML}, b_t^{WML}$and elements of $\boldsymbol{c_t} = [c_t^{CGAP}, c_t^{CGAP0}, c_t^{IGAP}, c_t^{IGAP0}]$ based on the 282 monthly regression from July 1992 until December 2015.

| **Coef** | Carhart | Carhart + GAP | | | | | |
|---|---|---|---|---|---|---|---|
| $c^{CGAP}$ | | 0.830 | | 1.061 | 0.821 | | 1.326 |
| T-STAT | | (2.96)*** | | (3.64)*** | (2.83)*** | | (4.17)*** |
| P-VALUE | | [0.00] | | [0.00] | [0.00] | | [0.00] |
| $c^{IGAP}$ | | | 0.035 | -0.240 | | 0.052 | -0.196 |
| T-STAT | | | (0.45) | (-3.48)*** | | (0.66) | (-2.60)*** |
| P-VALUE | | | [0.65] | [0.00] | | [0.51] | [0.01] |
| $c^{CGAP0}$ | | | | | 0.237 | | 0.263 |
| T-STAT | | | | | (0.87) | | (0.94) |
| P-VALUE | | | | | [0.39] | | [0.35] |
| $c^{IGAP0}$ | | | | | | 0.061 | 0.074 |
| T-STAT | | | | | | (0.61) | (0.76) |
| P-VALUE | | | | | | [0.54] | [0.45] |
| $b^{MKT}$ | -0.244 | -0.245 | -0.240 | -0.228 | -0.232 | -0.262 | -0.255 |
| T-STAT | (-0.93) | (-0.93) | (-0.92) | (-0.87) | (-0.85) | (-1.00) | (-0.94) |
| P-VALUE | [0.36] | [0.35] | [0.36] | [0.39] | [0.39] | [0.32] | [0.35] |
| $b^{SMB}$ | -0.064 | -0.137 | -0.074 | -0.142 | -0.116 | -0.074 | -0.115 |
| T-STAT | (-0.57) | (-1.27) | (-.68) | (-1.32) | (-1.09) | (-0.69) | (-1.07) |
| P-VALUE | [0.57] | [0.20] | [0.50] | [0.19] | [0.28] | [0.50] | [0.29] |
| $b^{HML}$ | 0.315 | 0.304 | 0.339 | 0.311 | 0.295 | 0.341 | 0.309 |
| T-STAT | (2.39)** | (2.30)** | (2.56)** | (2.35)** | (2.21)** | (2.55)** | (2.31)** |
| P-VALUE | [0.02] | [0.02] | [0.01] | [0.02] | [0.03] | [0.01] | [0.02] |
| $b^{WML}$ | 0.236 | 0.161 | 0.193 | 0.146 | 0.218 | 0.196 | 0.175 |
| T-STAT | (1.17) | (0.79) | (0.95) | (0.71) | (1.05) | (0.97) | (0.85) |
| P-VALUE | [0.24] | [0.43] | [0.34] | [0.48] | [0.29] | [0.33] | [0.40] |
| $R^2$ | 0.14 | 0.17 | 0.16 | 0.18 | 0.20 | 0.17 | 0.21 |
| N | 34,218 | 34,218 | 34,218 | 34,218 | 34,218 | 34,218 | 34,218 |

* p<0.10; ** p<0.05; *** p<0.01

Table 7: Second Stage Fama-MacBeth Regressions with Productivity Gaps and the Global Fama-French Five-Factor Model plus Momentum

The returns of the equal-weighted and value-weighted country-industry portfolios are regressed at a monthly frequency for the period July 1992-December 2015 on the various productivity gaps relevant for each country-industry portfolio and controlling for exposure to systematic risk factors. The computation of the productivity gap measures uses $TFP$ based on capital measured as the Net Capital Stock in current PPP terms and labor measured in Employee Hours. The global risk factors are from Kenneth French's website. The cross-section regression is a specific case of equation (24):

$$r_{t+1}^{ic} - r_{t+1}^{f} = a_t + b_t^{MKT}\beta_{MKT}^{ic} + b_t^{SMB}\beta_{SMB}^{ic} + b_t^{HML}\beta_{HML}^{ic} + b_t^{RMW}\beta_{RMW}^{ic} + b_t^{CMA}\beta_{CMA}^{ic} + b_t^{WML}\beta_{WML}^{ic} \boldsymbol{+ c_t(GAP)} + \eta_t^{ic}$$

Here $\boldsymbol{GAP} = [CGAP\, CGAP0_t^{ic}\, IGAP\, IPC0_t^{ic}]'$,with $CGAP$and $IGAP$the country and the industry productivity gap, respectively, and $CGAP0_t^{ic}$ ($IPC0_t^{ic}$) a dummy variable that is equal to one when $CGAP = 0$ ($IGAP = 0$), the productivity gap equals zero. The coefficients and the standard errors in this table are the means and standard deviations of $a_t$, $b_t^{MKT}$, $b_t^{SMB}$, $b_t^{HML}$, $b_t^{RMW}$, $b_t^{CMA}$, $b_t^{WML}$and subsets of $\boldsymbol{c_t} = [c_t^{CGAP}, c_t^{CGAP0}, c_t^{IGAP}, c_t^{IGAP0}]$ based on the 282 monthly regression from July 1992 until December 2015. We eliminate the finance and insurance, and real estate industry groups.

| **Coef** | FF5 + Mom | | | FF5 + Mom+GAP | | | |
|---|---|---|---|---|---|---|---|
| $c^{CGAP}$ | | 0.577 | | 0.808 | 0.610 | | 1.122 |
| T-STAT | | (2.30)** | | (3.20)*** | (2.34)** | | (4.06)*** |
| P-VALUE | | [0.02] | | [0.00] | [0.02] | | [0.00] |
| $c^{IGAP}$ | | | -0.048 | -0.243 | | -0.028 | -0.207 |
| T-STAT | | | (-0.61) | (-3.30)*** | | (-0.33) | (2.60)*** |
| P-VALUE | | | [0.54] | [0.00] | | [0.74] | [0.01] |
| $c^{CGAP0}$ | | | | | 0.160 | | 0.177 |
| T-STAT | | | | | (0.56) | | (0.60) |
| P-VALUE | | | | | [0.57] | | [0.55] |
| $c^{IGAP0}$ | | | | | | 0.063 | 0.094 |
| T-STAT | | | | | | (0.64) | (0.94) |
| P-VALUE | | | | | | [0.52] | [0.35] |
| $b^{MKT}$ | -0.283 | -0.214 | -0.247 | -0.215 | -0.211 | -0.289 | -0.249 |
| T-STAT | (-1.06) | (-0.80) | (-0.92) | (-0.80) | (-0.77) | (-1.08) | (-0.90 |
| P-VALUE | [0.29] | [0.42] | [0.36] | [0.42] | [0.44] | [0.28] | [0.37] |
| $b^{SMB}$ | 0.006 | -0.072 | -0.007 | -0.081 | -0.061 | -0.004 | -0.062 |
| T-STAT | (0.06) | (-0.65) | (-0.07) | (-0.74) | (-0.56) | (-0.04) | (-0.55) |
| P-VALUE | [0.96] | [0.51] | [0.95] | [0.46] | [0.57] | [0.97] | [0.58] |
| $b^{HML}$ | 0.340 | 0.325 | 0.364 | 0.337 | 0.309 | 0.371 | 0.328 |
| T-STAT | (2.56)** | (2.43)** | (2.73)*** | (2.52)** | (2.30)** | (2.74)*** | (2.41)** |
| P-VALUE | [0.01] | [0.02] | [0.01] | [0.01] | [0.02] | [0.01] | [0.02] |
| $b^{RMW}$ | -0.025 | 0.050 | -0.013 | 0.039 | 0.035 | -0.000 | 0.032 |
| T-STAT | (-0.30) | (0.61) | (-0.16) | (0.48) | (0.41) | (-0.00 | (0.37) |
| P-VALUE | [0.76] | [0.54] | [0.87] | [0.63] | [0.68] | [1.00] | [0.71] |
| $b^{CMA}$ | 0.105 | 0.127 | 0.117 | 0.131 | 0.177 | 0.110 | 0.176 |
| T-STAT | (0.83) | (1.02) | (0.92) | (1.03) | (1.43) | (0.86) | (1.40) |
| P-VALUE | [0.11] | [0.31] | [0.36] | [0.30] | [0.15] | [0.39] | [0.16] |
| $b^{WML}$ | 0.244 | 0.131 | 0.205 | 0.133 | 0.198 | 0.205 | 0.169 |
| T-STAT | (1.22) | (0.65) | (1.02) | (0.65) | (0.97) | (1.02) | (0.83) |
| P-VALUE | [0.22] | [0.52] | [0.31] | [0.52] | [0.33] | [0.31] | [0.41] |
| $R^2$ | 0.20 | 0.22 | 0.21 | 0.23 | 0.24 | 0.23 | 0.25 |
| N | 34,126 | 34,126 | 34,126 | 34,126 | 34,126 | 34,126 | 34,126 |

* p<0.10; ** p<0.05; *** p<0.01

Table 8: Portfolio Sort: unisort on CGAP

The equally weighted country industry portfolios are sorted into quintiles using the previous year $CGAP$ value. The portfolios are formed in June and are held for a year without rebalancing. Quintile 1 holds the country-industry portfolios with the smallest productivity gaps and, Quintile 5 holds the portfolios with the largest productivity gaps. Panels A and C present the excess return for the quintiles and the difference between the fifth and first quintile.

Panels B and D presents the alpha for the quintiles based on Fama French five-factor model with the systematic momentum factor. In Panels C and D we present the results only for country industries with $CGAP \neq 0$ so that the leader country industries at each time are excluded because the leader country has high systematic risk even though it has a zero productivity gap.

| | | | | | | |
|---|---|---|---|---|---|---|
| Panel A (mean returns and includes $CGAP = 0$) | | | | | | |
| | **1** | **2** | **3** | **4** | **5** | **5-1** |
| $\mu^{ic} - r^f$ | 0.204 | -0.181 | 0.063 | 0.494 | 0.841 | 0.637 |
| T-STAT | (0.886) | (-0.697) | (0.259) | (1.818)* | (2.522)** | (2.966)*** |
| P-VALUE | [0.376] | [0.486] | [0.796] | [0.070] | [0.012] | [0.003] |
| Panel B (alphas and includes $CGAP = 0$) | | | | | | |
| $\alpha^{ic}$ | -0.506 | -0.598 | -0.357 | -0.103 | -0.092 | 0.413 |
| T-STAT | (-4.931)*** | (-3.982)*** | (-3.204)*** | (-0.723) | (-0.484) | (2.397)** |
| P-VALUE | [0.000] | [0.000] | [0.002] | [0.470] | [0.629] | [0.017] |
| Panel C (mean returns and includes only $CGAP \neq 0$) | | | | | | |
| $\mu^{ic} - r^f$ | 0.209 | -0.330 | 0.151 | 0.400 | 0.939 | 0.784 |
| T-STAT | (0.918) | (-1.319) | (0.595) | (1.409) | (2.756)*** | (3.548)*** |
| P-VALUE | [0.359] | [0.188] | [0.552] | [0.160] | [0.006] | [0.000] |
| Panel D (alphas and includes only $CGAP \neq 0$) | | | | | | |
| $\alpha^{ic}$ | -0.576 | -0.529 | -0.248 | -0.130 | -0.038 | 0.538 |
| T-STAT | (-5.223)*** | (-3.836)*** | (-2.207)** | (-0.836) | (-0.193) | (2.996)*** |
| P-VALUE | [0.000] | [0.000] | [0.028] | [0.404] | [0.847] | [0.003] |

* p<0.10; ** p<0.05; *** p<0.01

Table 9: Cross-Sectional Regression of Momentum Factor Loadings from the Five-Factor plus Momentum Model on the Productivity Gap Measures

The momentum betas based on the Fama-French Three-Factor Model plus Momentum (Panel A) and the largest risk model we used, the Fama-French Five-Factor Model plus Momentum (Panel B) of each country-industry portfolio are regressed at a monthly frequency for the period July 1992-December 2015 on the various productivity gaps relevant for each country-industry portfolio. The computation of the productivity gap measures uses $TFP$ based on capital measured as the Net Capital Stock in current PPP terms and labor measured in Employee Hours. The global risk factors are from Kenneth French's website.

$$\beta^{ic}_{WML_t} = a_t + \boldsymbol{c_t}(\boldsymbol{GAP}) + \eta^{ic}_t$$

Here $\boldsymbol{GAP} = \begin{bmatrix} CGAP \\ IGAP \end{bmatrix}$. The coefficients and the standard errors in this table are the means and standard deviations of the elements of $\boldsymbol{c_t} = [c_t^{CGAP}, c_t^{IGAP}]$ based on the 282 monthly regressions from July 1992 until December 2015.

| **Coefficients** | | | **BetaWML** | | | |
|---|---|---|---|---|---|---|
| | | | Panel A: Carhart Model Momentum Betas | | | |
| $c^{CGAP}$ | 0.250 | | 0.217 | 0.203 | | 0.202 |
| t-stat | (8.07)*** | | (6.59)*** | (6.53)*** | | (4.40)*** |
| p-value | [0.00] | | [0.00] | [0.00] | | [0.00] |
| $c^{IGAP}$ | | 0.093 | 0.037 | | 0.093 | 0.055 |
| t-stat | | (11.68)*** | (4.96)*** | | (9.91)*** | (6.77)*** |
| p-value | | [0.00] | [0.00] | | [0.00] | [0.00] |
| $c^{CGAP0}$ | | | | -0.227 | | -0.239 |
| t-stat | | | | (-7.80)*** | | (-8.12)*** |
| p-value | | | | [0.00] | | [0.00] |
| $c^{IGAP0}$ | | | | | -0.024 | 0.016 |
| t-stat | | | | | (-3.54)*** | (1.75)* |
| p-value | | | | | [0.00] | [0.08] |
| $R^2$ | 0.05 | 0.03 | 0.06 | 0.12 | 0.03 | 0.14 |
| N | 34,343 | 34,343 | 34,343 | 34,343 | 34,343 | 34,343 |
| | | | Panel B: FF5+Mom Model Momentum Betas | | | |
| $c^{CGAP}$ | 0.255 | | 0.197 | 0.215 | | 0.183 |
| t-stat | (8.33)*** | | (6.11)*** | (6.88)*** | | (4.01)*** |
| p-value | [0.00] | | [0.00] | [0.00] | | [0.00] |
| $c^{IGAP}$ | | 0.106 | 0.062 | | 0.106 | 0.079 |
| t-stat | | (13.03)*** | (7.82)*** | | (11.16)*** | (8.75)*** |
| p-value | | [0.00] | [0.00] | | [0.00] | [0.00] |
| $c^{CGAP0}$ | | | | -0.172 | | -0.190 |
| t-stat | | | | (-8.04)*** | | (-8.51)*** |
| p-value | | | | [0.00] | | [0.00] |
| $c^{IGAP0}$ | | | | | -0.103 | 0.016 |
| t-stat | | | | | (-12.29)*** | (1.68)* |
| p-value | | | | | [0.00] | [0.09] |
| $R^2$ | 0.04 | 0.03 | 0.06 | 0.08 | 0.04 | 0.11 |
| N | 34,343 | 34,343 | 34,343 | 34,343 | 34,343 | 34,343 |

* p<0.10; ** p<0.05; *** p<0.01

Table 10: Model Comparisons for Explaining the Mean Country-Industry Portfolio Returns

The returns of the country-industry portfolios (all permutations from 24 countries and 14 industries included if data for more than one firm are available for at least 24 months) are regressed at a monthly frequency for the period July 1992-December 2015 on the risk factors of various models to estimate factor loadings based on 60 months with at least 24 months being available. The factor loadings estimated from past data are used to predict returns of a months later:

$$\hat{E}_{t-1}(r_t^{ic} - r_t^f) = (\boldsymbol{\hat{\beta}_{t-1}^{ic}})' \boldsymbol{F_t}$$

$$Avg(r_t^{ic} - r_t^f) = \hat{a} + \hat{b} Avg[\hat{E}_{t-1}(r_t^{ic} - r_t^f)] + \hat{\varepsilon}^{ic}$$

The productivity gap model (GAPM) consists of the productivity gap characteristic mimicking portfolio, $r_t^{GAP}$: The global risk factors are from Kenneth French's website: the market factor $r_t^{MMF}$,the size factor $r_t^{SMB}$,the value factor $r_t^{HML}$,the profitability factor $r_t^{RMW}$,the investment growth factor $r_t^{CMA}$,and the momentum factor $r_t^{WML}$. The alternative models are the Fama-French 3-factor (FF3) model ($r_t^{MMF}$,$r_t^{SMB}$, $r_t^{HML}$), the Carhart model ($r_t^{MMF}$,$r_t^{SMB}$, $r_t^{HML}$,$r_t^{WML}$), the Fama-French 5-factor (FF5) model ($r_t^{MMF}$,$r_t^{SMB}$,$r_t^{HML}$,$r_t^{RMW}$,$r_t^{CMA}$) and the FF5Mom (FF5+momentum) model ($r_t^{MMF}$,$r_t^{SMB}$,$r_t^{HML}$,$r_t^{RMW}$,$r_t^{CMA}$,$r_t^{WML}$).

| | GAP | CAPM | FF3 | Carhart | FF5 | FF5+Mom |
|---|---|---|---|---|---|---|
| $\hat{a}$ | -0.115 | 1.106 | -0.207 | -0.266 | -0.206 | -0.134 |
| T-STAT | (-2.157)** | (3.960)*** | (-2.078)** | (-2.766)** | (-2.063)* | (-1.475) |
| $\hat{b}$ | 1.066 | -2.365 | 0.698 | 0.879 | 0.633 | 0.561 |
| T-STAT | (8.282)*** | (-3.117)*** | (4.123)*** | (5.012)*** | (4.097)*** | (3.732)*** |
| $R^2$ | 0.271 | 0.007 | 0.084 | 0.120 | 0.083 | 0.070 |
| $\|\alpha\|$ | 0.466 | 0.553 | 0.577 | 0.543 | 0.604 | 0.574 |
| N | 46,996 | 46,996 | 46,996 | 46,996 | 46,996 | 46,996 |

* p<0.10; ** p<0.05; *** p<0.01

Table 11: Productivity Gaps and Systematic Risk Exposure

Employing the Black-Jensen-Scholes Procedure (estimating betas for the full sample period) we first obtain full-sample betas for each country-industry portfolio. The time series of annual excess returns of each country-industry portfolio is regressed against the productivity shocks of the leader country and the productivity shocks of the specific industry's leader country to compute risk exposures (betas).

$$r_t^{ic} - r_t^f = \beta_0 + \beta^{c*} \Delta \ln \left(Z_t^{c*}\right) + \beta^{ic*} \Delta \ln \left(Z_t^{ic*}\right) + \epsilon_t^{ic},$$

where $\Delta \ln \left(Z_t^{c*}\right) = \ln \left(Z_t^{c*}\right) - \ln \left(Z_{t-1}^{c*}\right)$, and $\Delta \ln \left(Z_t^{ic*}\right) = \ln \left(Z_t^{ic*}\right) - \ln \left(Z_{t-1}^{ic*}\right)$. Second, cross-sectional regressions of the Country Productivity Gap for each country-industry at each time period against the estimated betas:

$$CGAP = a_t^0 + a_t^{c*}(\beta^{c*}) + a_t^{ic*}(\beta^{ic*}) + \eta_t^{ic}.$$

The mean coefficients and t-stats of the time series for the 24 annual regressions ($a^{c*} = \sum_{t=1}^{24} a_t^{c*}/24$ and $a^{ic*} = \sum_{t=1}^{24} a_t^{ic*}/24$) are presented below.

| **Coefficients** | | *CGAP* | |
|---|---|---|---|
| $a^{c*}$ | 0.153 | | 0.119 |
| t-stat | (10.08)*** | | (10.55)*** |
| p-value | [0.00] | | [0.00] |
| $a^{ic*}$ | | 0.041 | 0.074 |
| t-stat | | (7.61)*** | (9.05)*** |
| p-value | | [0.00] | [0.00] |
| $R^2$ | 0.13 | 0.02 | 0.11 |
| N | 3,104 | 3,104 | 3,104 |

* p<0.10; ** p<0.05; *** p<0.01

Table 12: Model Comparisons for Explaining any Group of Test Assets

The productivity gap model (GAPF) consists of the productivity gap characteristic mimicking portfolio, $r_t^{GAP}$: The global risk factors are from Kenneth French's website: the market factor $r_t^{MMF}$,the size factor $r_t^{SMB}$,the value factor $r_t^{HML}$,the profitability factor $r_t^{RMW}$,the investment growth factor $r_t^{CMA}$,and the momentum factor $r_t^{WML}$. The alternative models are the Fama-French 3-factor (FF3) model ($r_t^{MMF}$,$r_t^{SMB}$, $r_t^{HML}$), the Carhart model ($r_t^{MMF}$,$r_t^{SMB}$, $r_t^{HML}$, $r_t^{WML}$), the Fama-French 5-factor (FF5) model ($r_t^{MMF}$, $r_t^{SMB}$, $r_t^{HML}$, $r_t^{RMW}$,$r_t^{CMA}$) and the FF5Mom (FF5+momentum) model ($r_t^{MMF}$, $r_t^{SMB}$, $r_t^{HML}$, $r_t^{RMW}$,$r_t^{CMA}$, $r_t^{WML}$).

Panel A: Test whether GAPF is a significant addition to alternative factor models

| | GAP $\Longrightarrow$ | MMF | SMB | HML | RMW | CMA | WML | FF3 | Carhart | FF5 | FF5Mom |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *SR* | 0.289 | 0.110 | 0.070 | 0.142 | 0.239 | 0.121 | 0.163 | 0.209 | 0.319 | 0.435 | 0.466 |
| *GRS* | N.A. | 22.99 | 24.30 | 23.81 | 15.14 | 25.57 | 24.66 | 20.23 | 18.16 | 14.073 | 13.22 |
| F-crit | N.A. | 3.873 | 3.873 | 3.873 | 3.873 | 3.873 | 3.873 | 3.873 | 3.873 | 3.873 | 3.873 |
| p-value | N.A. | [0.00] | [0.00] | [0.00] | [0.00] | [0.00] | [0.00] | [0.00] | [0.00] | [0.00] | [0.00] |

Panel B: Test whether the alternative factors are a significant addition to GAPF

| | GAP $\Longleftarrow$ | MMF | SMB | HML | RMW | CMA | WML | FF3 | Carhart | FF5 | FF5Mom |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *GRS* | N.A. | 1.750 | 0.798 | 4.885 | 22.96 | 4.899 | 7.625 | 2.859 | 5.863 | 8.878 | 8.550 |
| F-crit | N.A. | 3.873 | 3.873 | 3.873 | 3.873 | 3.873 | 3.873 | 2.635 | 2.402 | 2.245 | 2.129 |
| p-value | N.A. | [0.19] | [0.37] | [0.03] | [0.00] | [0.03] | [0.01] | [0.04] | [0.00] | [0.00] | [0.00] |

* $p<0.10$; ** $p<0.05$; *** $p<0.01$

# Appendix A: Derivations

**Leader Country-Industry Firm Investment Decisions and Market Valuation**

A representative firm in a specific country-industry chooses capital investment $i_t^*$ and R&D investment $h_t^*$ to maximize shareholder value. An asterisk "*" indicates a leading country-industry. The model parameters and random variable distributions for the leader country-industry are equal to those of the lagging country-industries. The random realizations for the productivity and technology shocks are different, leading to different values for the state variables and investment choices. By nature, the spillovers to the leader country are zero, so $\gamma^* = 0$. To simplify the model, the leader country does not take into consideration losing its leadership position. The decision problem is expressed in the following Bellman equation:

$$V^*(k_t^*, z_t^*, \theta_t^*) = \max_{i_t^*, h_t^*} \left\{ (y_t^* - i_t^* - h_t^*) + E_t \left[ m_{t+1} V^*(k_{t+1}^*, z_{t+1}^*, \theta_{t+1}^*) \right] \right\}. \tag{A.1}$$

The value function $V^*$ represents the maximum value of the firm that depends on a vector of state variables, namely: the current capital stock ($k_t^*$), the country-industry intangible capital stock given by the productivity of the stock of R&D ($z_t^*$), and total factor productivity in the country industry, $\theta_t^*$. The control variables are capital investment $i_t^*$ and R&D investment $h_t^*$. Output $y_t^*$ is determined by a Cobb-Douglas production function. The stochastic discount factor is specified as in the text, $m_{t+1} = m(\varepsilon_{t+1}^*, \eta_{t+1}^*)$. The specific constraints are

$$k_{t+1}^* = (1-\delta)k_t^* + i_t^*, \quad z_{t+1}^* = \eta_{t+1}^* \bar{z}_{t+1}^* \equiv \eta_{t+1}^*(z_t^* + h_t^*). \tag{A.2}$$

Capital $k_t^*$ accumulates with a constrant depreciation rate $\delta$ and without adjustment costs. The available intangible capital is given by the cumulative stock of the random productivity realizations of R&D, $z_t^*$. The random realization of the efficacy of R&D is given by an i.i.d. random variable $\eta_{t+1}^*$,with mean equal to 1. To avoid introducing too many parameters we assume no deprecations of the R&D stock. Output is determined by a Cobb-Douglas production function of the tangible and intangible capital stocks as variable inputs, with decreasing returns to scale so $\alpha + \beta < 1$. We view the R&D stock as providing labor-saving technology, with labor inputs $l^*$ here assumed constant for simplicity. Other random productivity factors, such as weather, regulatory considerations, and raw materials prices cannot be controlled and are captured by the productivity level $\theta_t^*$ which is taken as mean reverting with a random walk as special case, where the innovation $\varepsilon_{t+1}^*$ is i.i.d with $E(\varepsilon_{t+1}) = 1$ and $\theta > 0$:

$$y_t^* = y(k_t^*, z_t^* l^*) = \theta_t^* A^* k_t^{*\alpha} (z_t^* l^*)^\beta = \theta_t^* k_t^{*\alpha} z_t^{*\beta} \;;\;\; \theta_{t+1}^* = \varepsilon_{t+1}^* \theta_t^{*\rho} \theta^{1-\rho}. \tag{A.3}$$

The first-order conditions for the investment choices are:

$$E_t \left[ m_{t+1} V_{k^*}^*(t+1) \right] = 1, \quad E_t \left[ \eta_{t+1}^* m_{t+1} V_{\boldsymbol{z}^*}^*(t+1) \right] = 1, \tag{A.4}$$

where the function argument $t$ is shorthand for the set of state variables $\{k_t^*, z_t^*, \theta_t^*\}$. The envelope conditions are

$$V_{k^*}^*(t) = \alpha\theta_t^* k_t^{*\alpha-1} z_t^{*\beta} + (1-\delta), \quad V_{z^*}^*(t) = \beta\theta_t^* k_t^{*\alpha} z_t^{*\beta-1} + 1. \tag{A.5}$$

Updating equations A.5 by one period and substituting into the first-order conditions, A.4, considering that the shocks here are systematic, yields:

$$k_{t+1}^{*1-\alpha} = \left( \frac{(1+r)\alpha\theta_t^{*\rho}\theta^{1-\rho}\bar{\eta}_\beta}{(1+\kappa_{1\beta}^{\varepsilon\eta})(r+\delta)} \right) \bar{z}_{t+1}^{*\beta}, \quad k_{t+1}^{*\alpha} = \left( \frac{(1+\kappa_{1\beta}^{\varepsilon\eta})\kappa^\eta}{\beta\theta_t^{*\rho}\theta^{1-\rho}(1+\kappa^\eta)\bar{\eta}_\beta} \right) \bar{z}_{t+1}^{*1-\beta}. \tag{A.6}$$

Multiply the two equations above by each other to obtain:

$$\frac{k_{t+1}^*}{\bar{z}_{t+1}^*} = \left(\frac{\alpha}{\beta}\right) \left(\frac{1+r}{r+\delta}\right) \left(\frac{\kappa^\eta}{1+\kappa^\eta}\right) \equiv B^*. \tag{A.7}$$

Compared to laggard firms, it is unclear if the R&D intensity is higher or lower. While the lack of spillover benefits provide less of a disincentive to invest in R&D, the systematic risk of R&D investment increases its cost. Define $\omega = 1/(1-\alpha-\beta)$. Substituting equation A.7 into the first part of A.6, the optimal choice for the expected level of the R&D stock productivity $\bar{z}_{t+1}^*$ is found to be

$$\bar{z}_{t+1}^* = C^* \left(\frac{\theta_t^*}{\theta}\right)^{\rho\omega}, \quad C^* \equiv \left( \frac{(1+r)\theta\bar{\eta}_\beta}{1+\kappa_{1\beta}^{\varepsilon\eta}} \right)^\omega \left(\frac{\alpha}{r+\delta}\right)^{\alpha\omega} \left(\frac{\beta(1+\kappa^\eta)}{\kappa^\eta(1+r)}\right)^{(1-\alpha)\omega}. \tag{A.8}$$

The value function solution can be identified partially by integrating the envelope conditions. This yield

$$V^*(t) = y_t^* + (1-\delta)k_t^* + z_t^* + F^*(\theta_t^*). \tag{A.9}$$

Substituting the optimal input choices

$$V^*(t) = y_t^* + (1-\delta)k_t^* + z_t^* - \bar{z}_{t+1}^* - k_{t+1}^* + E_t\left[m_{t+1}V^*(t+1)\right]. \tag{A.10}$$

Equate the two above equations for the value function:

$$F^*(\theta_t^*) = -\bar{z}_{t+1}^* - k_{t+1}^* + E_t\left[m_{t+1}V^*(t+1)\right]. \tag{A.11}$$

To obtain $E_t\left[m_{t+1}V^*(t+1)\right]$ use equation A.9 updated by one period and keep in mind that for a leading country all risks are systematic. Hence,

$$E_t\left[m_{t+1}V^*(t+1)\right] = \frac{E_t(y_{t+1}^*)}{1+\kappa_{1\beta}^{\varepsilon\eta}} + \frac{(1-\delta)k_{t+1}^{*opt}}{1+r} + \frac{\bar{z}_{t+1}^{*opt}}{1+\kappa^\eta} + E_t\left[m_{t+1}F^*(\theta_{t+1}^*)\right]. \tag{A.12}$$

The optimally chosen capital stock $k_{t+1}^*$ can be inferred by substituting equation A.7 into equation A.8.

Next substitute the optimal values for $k^*_{t+1}$ and $E_t(y^*_{t+1})$, using $E_t(y^*_{t+1}) = \bar{z}^*_{t+1}\frac{\kappa^\eta(1+\kappa^{\varepsilon\eta}_{1\beta})}{\beta(1+\kappa^\eta)}$, in terms of $\bar{z}^*_{t+1}$ to obtain that

$$E_t\left[m_{t+1}V^*(t+1)\right] = \left(1+B^*+D^*\right)\bar{z}^*_{t+1} + E_t\left[m_{t+1}F^*(\theta^*_{t+1})\right], \quad D^* \equiv \frac{\kappa^\eta}{\beta\,\omega\,(1+\kappa^\eta)}. \tag{A.13}$$

Thus:

$$F^*(\theta^*_t) = E_t\left[m_{t+1}F^*(\theta^*_{t+1})\right] + D^*\bar{z}^{*opt}_{t+1}. \tag{A.14}$$

Solving forward generates

$$F^*(\theta^*_t) = \sum_{\tau=1}^{\infty} W^*_\tau(\theta^*_t/\theta)^{\rho^\tau\omega}, \quad W^*_\tau = \left(\frac{1+\kappa^\varepsilon_\omega}{\bar{\varepsilon}_\omega}\right)C^*D^*\prod_{i=0}^{\tau-1}\frac{\bar{\varepsilon}_{\rho^i\omega}}{1+\kappa^\varepsilon_{\rho^i\omega}}. \tag{A.15}$$

Substitute equation A.15 into equation A.9 to find the solution for the market value of a leader firm. The expression may be simplified when we consider a specific sdf to relate the various risk premia to eachother, which we do later in this Appendix.

**Laggard Country-Industry Firms**

The model provided in the text is solved as follows. The value function can be identified in part by integrating the envelope conditions of equations (8) and a similar envelope condition for $z^*_t$. This yields

$$V(t) = y_t + (1-\delta)k_t + (1-\gamma)z_t + \gamma z^*_t + F(\theta_t, \theta^*_t), \tag{A.16}$$

The functional form of the term concerning the state of the productivity levels $F(\theta_t, \theta^*_t)$, is not yet determined. From equation (1), substituting the optimal input choices (using equations 3 and 4),

$$V(t) = y_t + (1-\delta)k_t + (1-\gamma)z_t + \gamma z^*_t - \bar{z}_{t+1} - k_{t+1} + E_t\left[m_{t+1}V(t+1)\right] \tag{A.17}$$

Equating the two above equations for the value function yields

$$F(\theta_t, \theta^*_t) = -\bar{z}_{t+1} - k_{t+1} + E_t\left[m_{t+1}V(t+1)\right] \tag{A.18}$$

To obtain $E_t\left[m_{t+1}V(t+1)\right]$ use equation A.16 updated by one period and keep in mind that for a lagging country all risks except that associated with $z^*_{t+1}$ are idiosyncratic. Hence,

$$E_t\left[m_{t+1}V(t+1)\right] = \frac{E_t(y_{t+1}) + (1-\delta)k_{t+1} + (1-\gamma)\bar{z}_{t+1}}{1+r} + \frac{\gamma\bar{z}^*_{t+1}}{1+\kappa^\eta} + E_t\left[m_{t+1}F(\theta_{t+1}, \theta^*_{t+1})\right]$$

Next substitute the optimal values for $k_{t+1}$(using equations 10 and 11) and $E_t(y_{t+1})$, using $E_t(y_{t+1}) = E_t\left[\theta_{t+1}k_{t+1}^{\alpha}z_{t+1}^{\beta}\right] = \bar{z}_{t+1}\frac{(r+\gamma)}{\beta}$, in terms of $\bar{z}_{t+1}$ to obtain that

$$E_t\left[m_{t+1}V(t+1)\right] = (1+B+D)\,\bar{z}_{t+1} + \frac{\gamma}{1+\kappa^{\eta}}\bar{z}_{t+1}^{*} + E_t\left[m_{t+1}F(\theta_{t+1},\theta_{t+1}^{*})\right] \ , \tag{A.19}$$

$$B \equiv \left(\frac{\alpha}{\beta}\right)\left(\frac{r+\gamma}{r+\delta}\right), \quad D \equiv \frac{r+\gamma}{\beta\,\omega\,(1+r)}.$$

Substitute equation A.19 into equation A.18 and substitute the optimal value for $k_{t+1}$ in terms of$\bar{z}_{t+1}$ from equation (10) to find:

$$F(\theta_t,\theta_t^{*}) = E_t\left[m_{t+1}F(\theta_{t+1},\theta_{t+1}^{*})\right] + D\bar{z}_{t+1} + \left(\frac{\gamma}{1+\kappa^{\eta}}\right)\bar{z}_{t+1}^{*} \tag{A.20}$$

Equation A.20 is a first-order difference equation which can be solved forward straightforwardly. We obtain that $F(\theta_t,\theta_t^{*}) = f(\theta_t) + f^{*}(\theta_t^{*})$. Here , using equation (11),

$$f(\theta_t) = \sum_{\tau=1}^{\infty} W_{\tau}\left(\frac{\theta_t}{\theta}\right)^{\rho^{\tau}\omega}, \quad W_{\tau} = C\,D\left(\frac{1+r}{\bar{\varepsilon}_{\omega}}\right)\prod_{i=0}^{\tau-1}\frac{\bar{\varepsilon}_{\rho^{i}\omega}}{1+r}, \tag{A.21}$$

$$f^{*}(\theta_t^{*}) = \sum_{\tau=1}^{\infty} W_{\tau}^{*}\left(\frac{\theta_t^{*}}{\theta}\right)^{\rho^{\tau}\omega}, \quad W_{\tau}^{*} = C^{*}\left(\frac{1+\kappa_{\omega}^{\varepsilon}}{\bar{\varepsilon}_{\omega}}\right)\left(\frac{\gamma}{1+\kappa^{\eta}}\right)\prod_{i=0}^{\tau-1}\frac{\bar{\varepsilon}_{\rho^{i}\omega}}{1+\kappa_{\rho^{i}\omega}^{\varepsilon}}. \tag{A.22}$$

$$f(\theta_t) = D\bar{z}_{t+1} + g(\theta_t) \ , \quad g(\theta_t) = \sum_{\tau=2}^{\infty} W_{\tau}\left(\frac{\theta_t}{\theta}\right)^{\rho^{\tau}\omega}, \quad W_{\tau} = C\,D\prod_{i=1}^{\tau-1}\frac{\bar{\varepsilon}_{\rho^{i}\omega}}{1+r},$$

$$f^{*}(\theta_t^{*}) = \left(\frac{\gamma}{1+\kappa^{\eta}}\right)\bar{z}_{t+1}^{*} + g^{*}(\theta_t^{*}) \ , \quad g^{*}(\theta_t^{*}) = \sum_{\tau=2}^{\infty} W_{\tau}^{*}\left(\frac{\theta_t^{*}}{\theta}\right)^{\rho^{\tau}\omega}, \quad W_{\tau}^{*} = C^{*}\left(\frac{\gamma}{1+\kappa^{\eta}}\right)\prod_{i=1}^{\tau-1}\frac{\bar{\varepsilon}_{\rho^{i}\omega}}{1+\kappa_{\rho^{i}\omega}^{\varepsilon}}$$

Substitute equations A.21 and A.22 into equation A.16 to obtain the expression for the market value of the firm.

### Stock Returns and Risk Premia

Thus, the value function for a firm in a lagging country is given as

$$V(t) = \theta_t k_t^{\alpha} z_t^{\beta} + (1-\delta)k_t + (1-\gamma)z_t + \gamma z_t^{*} + f(\theta_t) + f^{*}(\theta_t^{*}). \tag{A.23}$$

The stock returns for any firm may be determined by noting that the ex-dividend stock price is given by $P_t = E_t\left[m_{t+1}V(t+1)\right]$. Further, $V(t+1)$ is the value of the stock including dividends. Hence, the gross stock returns equals $1 + r_{t+1}^{s} = V(t+1)/E_t\left[m_{t+1}V(t+1)\right]$. And, therefore:

$$r_{t+1}^{s} - r = \frac{V(t+1) - (1+r)E_t\left[m_{t+1}V(t+1)\right]}{E_t\left[m_{t+1}V(t+1)\right]} \tag{A.24}$$

From the solved value function updated by one period we obtain, by repeatedly applying equation A.20

$$E_t(r^s_{t+1}) - r = \frac{\gamma \bar{z}^*_{t+1} + E_t\left[f^*(\theta^*_{t+1})\right] - (1+r)f^*(\theta^*_t)}{(1+B)\bar{z}_{t+1} + f(\theta_t) + f^*(\theta^*_t)} \tag{A.25}$$

The specific expression for the expected excess return can be written as

$$E_t(r^s_{t+1}) - r = \frac{\gamma\left(\frac{\kappa^\eta - r}{1+\kappa^\eta}\right)\bar{z}^*_{t+1} + \sum_{\tau=2}^{\infty}\left[W^*_\tau\left(\bar{z}^*_{t+1}/C^*\right)^{\rho^{\tau-1}}\left(\frac{\kappa^\varepsilon_{\rho^\tau\omega} - r}{1+\kappa^\varepsilon_{\rho^\tau\omega}}\right)\right]}{(1+B+D)\bar{z}_{t+1} + \sum_{\tau=2}^{\infty}\left[W_\tau\left(\bar{z}_{t+1}/C\right)^{\rho^{\tau-1}}\right] + \left(\frac{\gamma}{1+\kappa^\eta}\right)\bar{z}^*_{t+1} + \sum_{\tau=2}^{\infty}\left[W^*_\tau\left(\bar{z}^*_{t+1}/C^*\right)^{\rho^\tau\omega}\right]} \tag{A.26}$$

which becomes, under the exponential sdf, the equation shown in the text:

$$E_t(r^s_{t+1}) - r = \frac{\gamma\left(\frac{\kappa^\eta - r}{1+\kappa^\eta}\right)\bar{z}^*_{t+1} + (1+r)\left(g^*[(\frac{1+\kappa^\varepsilon}{1+r})^{1/\rho}\theta^*_t] - g^*(\theta^*_t)\right)}{(1+B+D)\bar{z}_{t+1} + \left(\frac{\gamma}{1+\kappa^\eta}\right)\bar{z}^*_{t+1} + g(\theta_t) + g^*(\theta^*_t)}$$

For the leading-economy firms, the expected returns incorporate all risk as systematic:

$$V^*(t+1) = y^*_{t+1} + (1-\delta)k^*_{t+1} + z^*_{t+1} + F^*(\theta^*_{t+1}). \tag{A.27}$$

$$F^*(\theta^*_t) = E_t\left[m_{t+1}F^*(\theta^*_{t+1})\right] + D^*\bar{z}^*_{t+1}. \tag{A.28}$$

$$F^*(\theta^*_t) = \sum_{\tau=1}^{\infty} W^*_\tau(\theta^*_t/\theta)^{\rho^\tau\omega}, \quad W^*_\tau = \left(\frac{1+\kappa^\varepsilon_\omega}{\bar{\varepsilon}_\omega}\right)C^*D^*\prod_{i=0}^{\tau-1}\frac{\bar{\varepsilon}_{\rho^i\omega}}{1+\kappa^\varepsilon_{\rho^i\omega}}. \tag{A.29}$$

$$F^*(\theta^*_t) = D^*\bar{z}^*_{t+1} + G^*(\theta^*_t)\ , \quad G^*(\theta^*_t) = \sum_{\tau=2}^{\infty} W^*_\tau\left(\frac{\theta^*_t}{\theta}\right)^{\rho^\tau\omega}\ , \quad W^*_\tau = C^*D^*\prod_{i=1}^{\tau-1}\frac{\bar{\varepsilon}_{\rho^i\omega}}{1+\kappa^\varepsilon_{\rho^i\omega}}$$

$$E_t(r^{s*}_{t+1}) - r = \frac{\left(\frac{(\kappa^{\varepsilon\eta}_\beta - r)\kappa^\eta}{\beta(1+\kappa^\eta)} + \frac{\kappa^\eta - r}{1+\kappa^\eta}\right)\bar{z}^*_{t+1} + E_t\left[F^*(\theta^*_{t+1})\right] - (1+r)G^*(\theta^*_t)}{(1+B^*+D^*)\bar{z}^*_{t+1} + G^*(\theta^*_t)}$$

The expected excess return for the leading firm in the text is

$$E_t(r^{s*}_{t+1}) - r = \frac{\frac{1}{\beta(1+\kappa^\eta)}\left(\kappa^\eta(\kappa^{\varepsilon\eta}_{1\beta} - r) + \beta(\kappa^\eta - r)\right)\bar{z}^*_{t+1} + (1+r)\left(G^*[(\frac{1+\kappa^\varepsilon}{1+r})^{1/\rho}\theta^*_t] - G^*(\theta^*_t)\right)}{(1+B^*+D^*)\bar{z}^*_{t+1} + G^*(\theta^*_t)}$$

**Specific SDF**

To compare the various risk premia and discount rates we assume a specific form for the stochastic discount factor and concordingly specific assumptions for the random variables. First, the random variables, $\varepsilon$ and $\eta$,both for the leading and lagging country-industries, already assumed to be i.i.d. and have means equal to 1, now are also assumed to have lognormal distributions: $\varepsilon_t, \varepsilon^*_t \sim LN(\mu_\varepsilon, \sigma^2_\varepsilon)$,where $\mu_\varepsilon, \sigma^2_\varepsilon$ are the mean and variance, respectively, of a normally distributed variable $X$, for which the exponent $e^X$ has the above lognormal distribution. Requiring that $E_{t-1}(\varepsilon_t) = 1$ implies that $\mu_\varepsilon = -\frac{1}{2}\sigma^2_\varepsilon$ so that

$$\varepsilon_t, \varepsilon_t^* \sim LN(-\frac{1}{2}\sigma_\varepsilon^2, \sigma_\varepsilon^2) \ , \quad \eta_t, \eta_t^* \sim LN(-\frac{1}{2}\sigma_\eta^2, \sigma_\eta^2). \tag{A.30}$$

Second, we specify the sdf as

$$m_{t+1} = m\,(\varepsilon_{t+1}^*)^{-a}(\eta_{t+1}^*)^{-b}. \tag{A.31}$$

For a lognormal variable $\varepsilon_t$, the expected value of an exponentional function $\varepsilon_t^c$ is $E(\varepsilon_t^c) = e^{c\mu_\varepsilon + c^2\sigma_\varepsilon^2/2}$. If $E(\varepsilon_t) = 1$ then $E(\varepsilon_t^c) = e^{(c^2-c)\sigma_\varepsilon^2/2}$. Since we know that $E_t(m_{t+1}) = \frac{1}{1+r}$ it must be from the above and independence of the two random variables that $\frac{1}{1+r} = m(E\varepsilon_{t+1}^{-a})(E\eta_{t+1}^{-b})$, so

$$m = \frac{e^{-(a^2+a)\sigma_\varepsilon^2/2-(b^2+b)\sigma_\eta^2/2}}{1+r}. \tag{A.32}$$

The present value of the realization of the systematic risk $\eta_{t+1}^*$ is

$$E_t(m_{t+1}\eta_{t+1}^*) = \frac{E_t(\eta_{t+1}^*)}{1+\kappa^\eta} = \frac{1}{1+\kappa^\eta} = mE_t[(\varepsilon_{t+1}^*)^{-a}(\eta_{t+1}^*)^{1-b}] = me^{(a^2+a)\sigma_\varepsilon^2/2+[(1-b)^2-(1-b)]\sigma_\eta^2/2} = \frac{e^{-b\sigma_\eta^2}}{1+r}. \tag{A.33}$$

Hence,

$$\frac{1+\kappa^\eta}{1+r} = e^{b\sigma_\eta^2} > 1. \tag{A.34}$$

The (log ) risk premium is the product of the price of risk $b$ and the quantity of risk measured by variance $\sigma_\eta^2$.

The R&D investment risk for the leader is related to $\eta_{t+1}^{*\beta}$. The risk-adjusted expected value per unit is

$$E_t(m_{t+1}\eta_{t+1}^{*\beta}) \equiv \frac{E_t[(\eta_{t+1}^*)^\beta]}{1+\kappa_\beta^\eta} \equiv \frac{\bar{\eta}_\beta}{1+\kappa_\beta^\eta} = mE_t[(\varepsilon_{t+1}^*)^{-a}(\eta_{t+1}^*)^{\beta-b}] \tag{A.35}$$

$$= me^{(a^2+a)\sigma_\varepsilon^2/2+[(\beta-b)^2-(\beta-b)]\sigma_\eta^2/2} = \frac{\bar{\eta}_\beta\, e^{-\beta b\sigma_\eta^2}}{1+r}.$$

It follows that

$$\frac{1+\kappa_\beta^\eta}{1+r} = e^{\beta\, b\sigma_\eta^2} = \left(\frac{1+\kappa^\eta}{1+r}\right)^\beta. \tag{A.36}$$

As a result we also have that $1+\kappa_\beta^\eta = (1+\kappa^\eta)^\beta(1+r)^{1-\beta}$. Lastly, calculate the discount factor for production risk. The proportional random component of production $y_{t+1}$is $\varepsilon_{t+1}^*\eta_{t+1}^{*\beta}$. The discount rate for production risk, $\kappa_{1\beta}^{\varepsilon\eta}$ can be inferred from

$$E_t(m_{t+1}\varepsilon^*_{t+1}\eta^{*\beta}_{t+1}) \equiv \frac{E_t[(\varepsilon^*_{t+1}\eta^*_{t+1})^\beta]}{1+\kappa^{\varepsilon\eta}_{1\beta}} = \frac{\bar{\eta}_\beta}{1+\kappa^{\varepsilon\eta}_{1\beta}} = mE_t[(\varepsilon^*_{t+1})^{1-a}(\eta^*_{t+1})^{\beta-b}] \tag{A.37}$$

$$= me^{[(1-a)^2-(1-a)]\sigma^2_\varepsilon/2+[(\beta-b)^2-(\beta-b)]\sigma^2_\eta/2} = \frac{\bar{\eta}_\beta\, e^{-a\sigma^2_\varepsilon-\beta b\sigma^2_\eta}}{1+r}.$$

This implies that $\frac{1+\kappa^{\varepsilon\eta}_{1\beta}}{1+r} = \left(\frac{1+\kappa^\eta_\beta}{1+r}\right)\left(\frac{1+\kappa^\varepsilon}{1+r}\right)$ and

$$1+\kappa^{\varepsilon\eta}_{1\beta} = (1+\kappa^\varepsilon)\left(\frac{1+\kappa^\eta}{1+r}\right)^\beta \tag{A.38}$$

Rewriting, using the specific sdf and logarithmic distribution of the shock terms,

$$F^*(\theta^*_t) = \sum_{\tau=1}^{\infty} W^*_\tau\left(\frac{\theta_t}{\theta}\right)^{\rho^\tau\omega},\ W^*_\tau = \bar{C}^*\frac{e^{\frac{\sigma^2_\varepsilon}{2}\left[\omega^2\left(\frac{1-\rho^{2\tau}}{1-\rho^2}\right)-\omega(1+2a)\left(\frac{1-\rho^\tau}{1-\rho}\right)\right]}}{(1+r)^\tau},\ \bar{C}^* = \frac{1}{\omega\bar{\varepsilon}_\omega}(\theta\bar{\eta}_\beta)^\omega\left(\frac{\alpha}{r+\delta}\right)^{\alpha\omega}\left(\frac{\beta}{\kappa^\eta}\right)^{\beta\omega} \tag{A.39}$$

$$f(\theta_t) = \sum_{\tau=1}^{\infty}\bar{W}_\tau\left(\frac{\theta_t}{\theta}\right)^{\rho^\tau\omega},\ \bar{W}_\tau = \bar{H}\frac{e^{\frac{\sigma^2_\varepsilon}{2}\left[\omega^2\left(\frac{1-\rho^{2\tau}}{1-\rho^2}\right)-\omega\left(\frac{1-\rho^\tau}{1-\rho}\right)\right]}}{(1+r)^\tau},\ \bar{H} = \frac{1}{\omega\bar{\varepsilon}_\omega}(\theta\bar{\eta}_\beta)^\omega\left(\frac{\alpha}{r+\delta}\right)^{\alpha\omega}\left(\frac{\beta}{r+\gamma}\right)^{\beta\omega} \tag{A.40}$$

and

$$f^*(\theta^*_t) = \sum_{\tau=1}^{\infty} W^*_\tau\left(\frac{\theta_t}{\theta}\right)^{\rho^\tau\omega},\ W^*_\tau = \bar{H}^*\frac{e^{\frac{\sigma^2_\varepsilon}{2}\left[\omega^2\left(\frac{1-\rho^{2\tau}}{1-\rho^2}\right)-\omega(1+2a)\left(\frac{1-\rho^\tau}{1-\rho}\right)\right]}}{(1+r)^\tau},\ \bar{H}^* = \frac{\gamma}{\bar{\varepsilon}_\omega}(\theta\bar{\eta}_\beta)^\omega\left(\frac{\alpha}{r+\delta}\right)^{\alpha\omega}\left(\frac{\beta}{\kappa^\eta}\right)^{(1-\alpha)\omega} \tag{A.41}$$

# Appendix B: Productivity Measures

## Compustat Global Database

Return are computed in local currency using the following Compustat fields: prccd, trfd and ajexdi. The returns are computed as $prccd * trfd/ajexdi$ and converted to USD using exchange rates from Bloomberg.

## STAN

The following STAN's fields are used to compute $TFP$: Hours worked-total engaged (HRSN), Hours worked employee (HRSE), Net Capital Stock at current replacement cost (CAPN), Value added at current price (VALU), Labor cost (LABR), Total Employment (EMPN), Self-employed (SELF), Number of Employees (EMPE), Full time equivalents – total engaged (FTEN), Full time equivalents – employees (FTEE), Other taxes less subsidy in production (OTXS) and Gross Operating Surplus and mixed income (GOPS). The OECD Productivity OECD (2001, pp

112-114) elaborates on the procedure for computing $TFP$. Labor inputs are in hours. The capital input $CAPN_{PPP}$ is CAPN (Net Capital Stock at current replacement cost) adjusted for PPP by converting to USD using the OECD PPP exchange rate. The value-added $TFP$ measure is used where the $VALU_{PPP}$is VALU adjusted for PPP by converting to USD using OECD PPP exchange rate. The VALU field is analogous to GDP per industry/country.

$$log(TFP) = log(VALU_{PPP}) - ((labshare * log(HRSE)) + (capshare * log(CAPN_{PPP})) \tag{B.1}$$

OECD assumes $labshare + capshare = 1$, then the definitions of $TFP$ given in equation B.1 are the same as the weighted average of labor and capital productivity and are given by equation B.2:

$$log(TFP) = \left(labshare * log(\frac{VALU_{PPP}}{HRSE})\right) + \left(capshare * log(\frac{VALU_{PPP}}{CAPN_{PPP}})\right) \tag{B.2}$$

The Labor share (labshare) and capital share (capshare) are determined by estimating the proportion of value-add to labor and capital factors. Intuitively, the value added has contributions from labor and capital factors that determines the labor share and capital share. This disaggregation is not simple because there is a mixed income part which is combined with the Gross operating surplus of firms (GOPS). STAN database expresses Value added (at current price) relationship as in equation B.3

$$VALU = LABR + GOPS + OTXS \tag{B.3}$$

If mixed income were not included in GOPS, then it would have been part of capital income. The proportion of mixed-income attributed to labor is extrapolated with the assumption that self-employed have the same compensation as full-time employees. The self-employment is measured in hours (HRSE-HRSN) or numbers (EMPN-EMPE, FTEN-FTEE) depending upon the availability of data. The labor component of mixed-income $LABR_{MIXED}$ is given by equation B.4

$$LABR_{MIXED} = \frac{LABR}{HRSN} * (HRSE - HRSN) = \frac{LABR}{EMPN} * (EMPN - EMPE) = \frac{LABR}{FTEN} * (FTEN - FTEE) \tag{B.4}$$

Once we disaggregate the labor income component from the mixed income part, we can determine the tax share of the labor factor

$$TAX\_Share_{Labor} = \frac{LABR + LABR_{MIXED}}{VALK} \tag{B.5}$$

Finally, $labshare$ is given by:

$$labshare = \frac{LABR + LABR_{MIXED} + (TAX\_Share_{Labor} * OTXS)}{VALK} \tag{B.6}$$

The capital share is determined residually and given by:

$$capshare = 1 - labshare \tag{B.7}$$

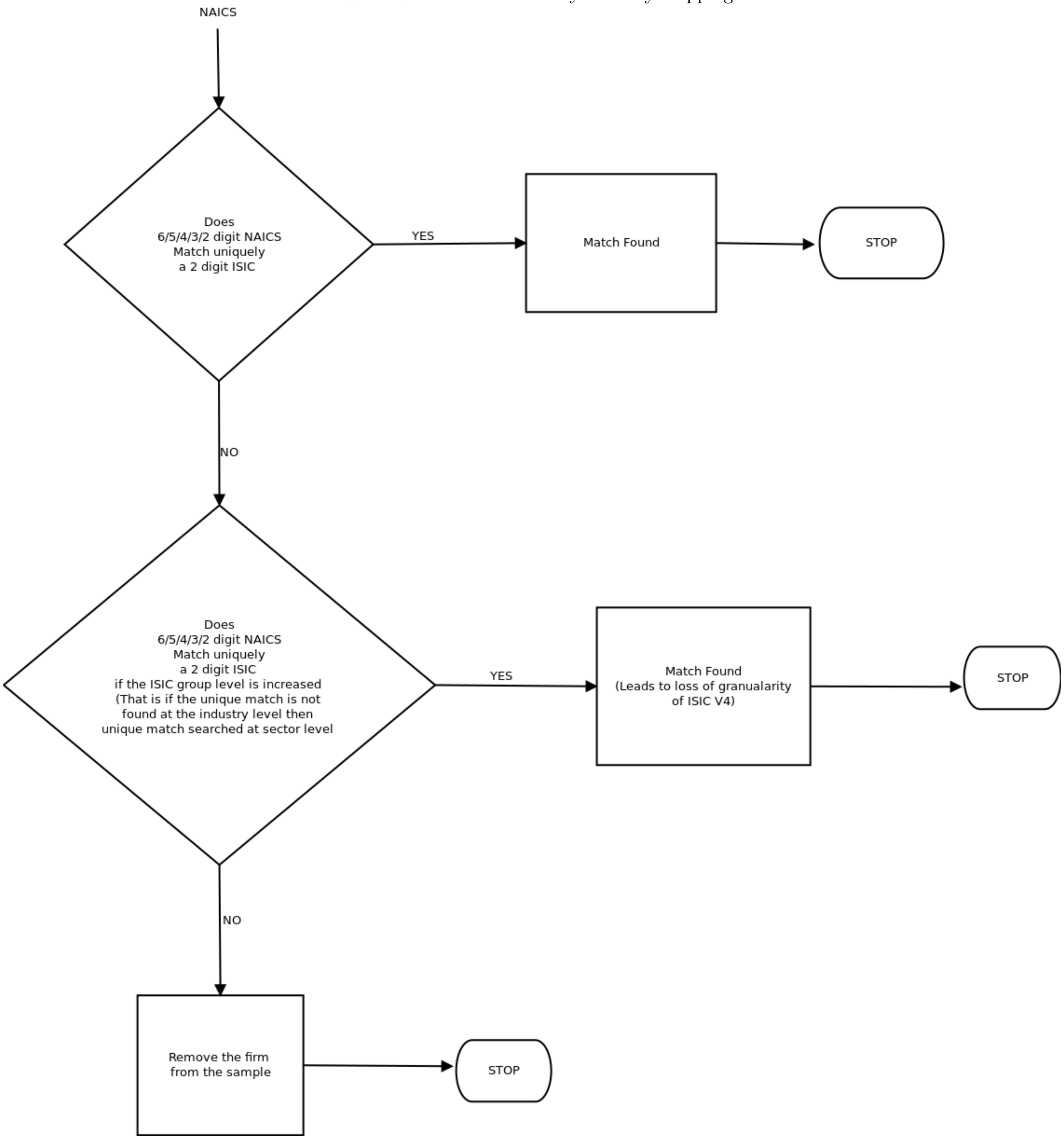
In keeping with the OECD convention *labshare* and *capshare* are averaged across two time periods ($t$ & $t-1$).

## Mapping NAICS with ISICV4.0

One important point to note is that Compustat uses North American Industry classification system (NAICS) whereas STAN uses the version 4.0 of the International Standard Industrial Classification (ISIC). The standard correspondence table is utilized to map NAICS into ISIC V4. In the Compustat data, we observe that classification of all firms is not available in 6 digits of NAICS. There are firms with 2,3,4,5 or 6-digit NAICS which implies that classification is available at the sector, subsector, industry groups or industry level. We use a simple algorithm to map NAICS (2,3,4,5 or 6 digits) code to ISIC V4.0. Since the mapping of NACIS to ISICV4.0 is many to many mapping, we keep on expanding the ISIC matching industry so that the NAICS can map into a logical unit.

The flowchart of the algorithm used to map NAICS to ISICV4 is in figure 4. In the process of mapping we loose 10% of the firms as they map to multiple sectors.

Figure 4: Mapping NAICS To ISICV4
NAICS to ISICV4 involves many to many mapping



# Appendix C: Details of Included Data

Table 13 gives a detailed analysis of countries that are included in the productivity gap computation and the test assets. Table 15 contains details of the test assets which are the country industry portfolios. Table 14 presents a summary of the stock returns of the available firms by OECD country and by year (from 1992 until 2015) as far as firm returns are available in a country for that year.

Table 13: Intersection of STAN and the Compustat Global Database to compute $TFP$ based on Employee Hours

| | OECD - STAN | | | COMPUSTAT GLOBAL |
|---|---|---|---|---|
| **Country** | **Name** | $TFP$ **using EH** | **Used in computing Productivity Gap** | **Country Industry Test Assets** |
| AUS | Australia | NO HRSE | | |
| AUT | Austria | | ✓ | ✓ |
| BEL | Belgium | | ✓ | ✓ |
| CAN | Canada | | ✓ | |
| CHL | Chile | NO CAPN HRSE | | |
| CRI | Costa Rica | NO HRSE | | |
| CHE | Switzerland | NO CAPN HRSE | | |
| CZE | Czech Republic | | ✓ | ✓ |
| DEU | Germany | | ✓ | ✓ |
| DNK | Denmark | | ✓ | ✓ |
| ESP | Spain | NO CAPN | | |
| EST | Estonia | | ✓ | ✓ |
| FIN | Finland | | ✓ | ✓ |
| FRA | France | | ✓ | ✓ |
| GBR | United Kingdom | | ✓ | ✓ |
| GRC | Greece | | ✓ | ✓ |
| HUN | Hungary | | ✓ | ✓ |
| ISL | Iceland | NO CAPN HRSE | | |
| IRL | Ireland | | ✓ | ✓ |
| ISR | Israel | No $\alpha$ | | |
| ITA | Italy | | ✓ | ✓ |
| JPN | Japan | | ✓ | ✓ |
| KOR | Korea | NO HRSE | | |
| LTU | Lithuania | | ✓ | ✓ |
| LUX | Luxembourg | | ✓ | ✓ |
| LVA | Latvia | | ✓ | ✓ |
| MEX | Mexico | NO HRSE | | |
| NLD | Netherlands | | ✓ | ✓ |
| NOR | Norway | | ✓ | ✓ |
| POL | Poland | | ✓ | ✓ |
| PRT | Portugal | | ✓ | ✓ |
| SVK | Slovak Republic | | ✓ | ✓ |
| SVN | Slovenia | | ✓ | ✓ |
| SWE | Sweden | | ✓ | ✓ |
| TUR | Turkey | NO HRSE | | |
| USA | United States | | ✓ | |

Table 14: Excess Returns of Equally Weighted Country Portfolios by Year

Equal-weighted portfolio returns for the OECD countries available in Compustat Global by Country and Year for the period 1992-2015. The excess returns are monthly means (aritmetic) and are in USD percentage terms obtained after local prices are converted to USD. The risk free rate used to compute the excess return is the USA risk free rate.The countries include Austria (AUT), Belgium (BEL), the Czech Republic (CZE), Germany (DEU), Denmark (DMK), Estonia (EST), Finland (FIN), France (FRA), Great Britain (GBR), Greece (GRC), Hungary (HUN), Ireland (IRL), Italy (ITA), Japan (JPN), Lithuania (LTU), Luxembourg (LUX), Latvia (LVA), Netherlands (NLD), Norway (NOR), Poland (POL), Portugal (PRT), Slovak Republic(SVK), Slovenia (SVN), Sweden (SWE), and the United States of America (USA).

| Year | AUT | BEL | CZE | DEU | DMK | EST | FIN | FRA | GBR | GRC | HUN | IRL | ITA | JPN | LTU | LUX | LVA | NLD | NOR | POL | PRT | SVK | SVN | SWE | USA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1992 | -2.24 | -0.61 | | -1.56 | -2.40 | | -0.75 | -0.94 | -1.58 | -2.77 | -11.99 | | -3.55 | -2.48 | | -2.93 | | -0.29 | -3.72 | | | | | -3.35 | 0.51 |
| 1993 | 1.25 | 1.53 | | 1.99 | 1.15 | | 3.12 | 1.86 | 2.33 | 3.71 | 1.63 | | -0.64 | 1.48 | | 2.73 | | 1.84 | 4.60 | | | | | 3.85 | 0.66 |
| 1994 | -0.05 | 0.47 | | 0.80 | 1.05 | | 0.77 | -0.02 | -0.08 | 0.53 | 0.89 | | 0.01 | 0.51 | | 2.06 | | 1.47 | 0.82 | | | | | 0.94 | -0.30 |
| 1995 | -1.07 | 0.82 | -0.29 | 0.01 | 0.25 | | -0.29 | -0.24 | 0.59 | -0.31 | -2.17 | -0.07 | -1.14 | -1.24 | | 0.11 | | 1.04 | 1.67 | 0.22 | -1.23 | -1.32 | 1.11 | 1.68 | 2.20 |
| 1996 | -1.60 | 0.31 | 2.57 | -1.32 | 1.71 | 7.62 | 3.12 | 0.62 | 1.51 | -0.90 | 2.08 | 2.36 | -0.41 | -1.68 | | 0.97 | | 2.17 | 2.36 | 3.09 | 1.24 | 5.46 | -0.01 | 2.22 | 1.24 |
| 1997 | -0.74 | 0.25 | -2.39 | 0.22 | -0.40 | 0.44 | 0.23 | -0.53 | 0.24 | 2.23 | 0.89 | 0.47 | 1.19 | -4.45 | | -0.55 | 1.70 | 0.28 | 0.22 | -0.18 | 0.60 | -3.69 | -0.03 | 0.28 | 1.95 |
| 1998 | 0.90 | 1.84 | 0.24 | 0.83 | -0.98 | -4.20 | 0.42 | 1.49 | -0.33 | 4.66 | -1.70 | -0.04 | 2.10 | 0.06 | | 0.09 | -3.36 | 0.76 | -3.25 | -0.05 | 1.55 | -2.84 | 1.61 | -0.20 | 1.65 |
| 1999 | -2.60 | -1.49 | 0.63 | -1.33 | -0.09 | 1.81 | 0.30 | 0.36 | 1.38 | 8.88 | -0.52 | -0.51 | 0.38 | 3.06 | | 1.96 | 0.47 | -0.93 | 2.21 | 0.96 | -1.02 | -1.92 | -0.69 | 1.39 | 1.59 |
| 2000 | -3.02 | -1.63 | -1.31 | -2.48 | -0.89 | 2.31 | -2.35 | -0.57 | -1.31 | -7.03 | -2.31 | -0.63 | -0.88 | -2.34 | | -1.39 | 1.17 | -0.89 | -2.21 | -0.57 | -1.14 | -2.83 | -0.80 | -0.92 | -1.37 |
| 2001 | -1.37 | -0.75 | 1.13 | -2.81 | -1.44 | -0.20 | -0.28 | -1.06 | -1.01 | -1.04 | -0.87 | -1.63 | -2.53 | -1.12 | | -1.30 | 0.27 | -1.50 | -1.67 | -2.29 | -1.75 | 3.28 | 0.64 | -1.34 | -1.14 |
| 2002 | 0.72 | 0.76 | 5.21 | -1.97 | 0.47 | 3.61 | 0.63 | 0.51 | -1.09 | -1.36 | 1.91 | 1.17 | -0.56 | -0.26 | | -1.87 | 0.31 | -0.73 | 0.02 | -1.62 | 0.31 | 1.33 | 4.78 | -0.20 | -1.94 |
| 2003 | 2.52 | 3.00 | 6.29 | 2.74 | 4.06 | 4.58 | 4.49 | 2.66 | 2.87 | 3.76 | 1.48 | 4.78 | 2.66 | 2.60 | | 4.57 | 7.41 | 3.23 | 3.42 | 3.47 | 2.52 | 5.83 | 2.97 | 4.16 | 2.29 |
| 2004 | 2.29 | 2.63 | 5.99 | 0.84 | 2.37 | 3.00 | 2.39 | 1.60 | 1.65 | -0.51 | 3.84 | 2.40 | 1.31 | 1.61 | | 3.32 | 3.68 | 2.31 | 3.18 | 3.82 | 2.09 | 4.34 | 2.62 | 3.09 | 0.87 |
| 2005 | 0.34 | 0.93 | 1.50 | 0.65 | 2.21 | 3.07 | 1.21 | 0.71 | -0.20 | 0.95 | 0.78 | 1.23 | 0.52 | 1.45 | | 1.52 | 5.68 | 1.84 | 2.52 | 0.92 | 0.00 | -1.03 | -1.92 | 1.44 | 0.28 |
| 2006 | 1.77 | 1.68 | 3.02 | 0.61 | 1.65 | 3.52 | 2.67 | 1.83 | 1.65 | 3.30 | 3.88 | 2.40 | 1.72 | -2.11 | | 2.42 | 0.81 | 2.68 | 2.86 | 5.15 | 2.41 | 3.05 | 2.18 | 1.62 | 0.83 |
| 2007 | 0.75 | 0.77 | 3.55 | -0.06 | 0.63 | -0.31 | 1.07 | 0.99 | -1.05 | 1.92 | 2.19 | -1.29 | -0.26 | -1.48 | | 0.17 | 0.67 | 0.47 | 1.36 | 1.24 | 1.24 | 0.86 | 4.64 | -0.51 | 0.12 |
| 2008 | -3.81 | -2.02 | -1.64 | -2.94 | -4.72 | -6.09 | -3.76 | -3.24 | -5.65 | -4.94 | -3.99 | -6.07 | -3.67 | -1.29 | | -4.04 | -4.93 | -4.25 | -6.54 | -5.34 | -2.72 | -3.20 | -5.92 | -5.12 | -3.68 |
| 2009 | 2.13 | 1.71 | 2.63 | 0.80 | 0.44 | 1.53 | 3.29 | 2.05 | 2.51 | 1.25 | 2.47 | 1.72 | 1.01 | 0.65 | | 1.95 | 3.05 | 2.91 | 3.36 | 3.04 | 1.92 | 0.57 | 0.10 | 3.72 | 2.28 |
| 2010 | 0.86 | 0.02 | 0.78 | 0.31 | -0.88 | 3.37 | 0.94 | -0.03 | 0.27 | -3.52 | -0.33 | -0.93 | -0.69 | 1.44 | 1.57 | -0.12 | 2.92 | 0.85 | 0.97 | 0.56 | -1.74 | -1.21 | -1.44 | 1.28 | 1.49 |
| 2011 | -2.09 | -0.99 | 0.50 | -0.93 | -1.73 | -2.66 | -2.36 | -1.47 | -1.38 | -3.62 | -2.39 | -1.96 | -2.43 | 0.26 | -2.41 | -2.08 | -0.91 | -1.97 | -1.55 | -4.78 | -2.67 | -1.11 | -3.88 | -2.19 | 0.14 |
| 2012 | 0.82 | 0.63 | 0.64 | 0.18 | 0.05 | 2.00 | 0.50 | 0.74 | 1.18 | 3.35 | 0.76 | 1.13 | -0.11 | 0.60 | 1.05 | -0.09 | 0.75 | 1.18 | 1.12 | -0.12 | -0.17 | 0.65 | 0.42 | 0.73 | 1.31 |
| 2013 | 1.30 | 1.57 | -0.27 | 0.99 | 1.54 | 0.96 | 1.96 | 1.51 | 1.58 | 1.86 | 0.93 | 2.83 | 2.07 | 1.33 | 1.21 | 0.02 | 0.23 | 1.98 | 0.21 | 0.63 | 2.40 | 1.17 | -0.36 | 1.30 | 2.57 |
| 2014 | -0.46 | -0.43 | -0.18 | -0.76 | -1.14 | -1.90 | -1.20 | -0.33 | -0.56 | -2.00 | -1.14 | -0.97 | -1.35 | -0.40 | -0.67 | -2.33 | 0.32 | -1.06 | -1.69 | -2.00 | -0.89 | -0.90 | 1.95 | -1.26 | 0.96 |
| 2015 | 0.09 | 0.51 | 0.97 | -0.46 | 0.19 | 0.76 | 1.31 | -0.11 | -0.29 | -1.00 | 0.93 | 0.75 | -0.61 | 0.66 | -0.56 | -1.25 | 0.14 | 0.03 | -1.00 | -0.64 | -0.80 | 0.69 | -2.02 | 0.49 | 0.07 |
| Mean | -0.14 | 0.48 | 1.41 | -0.24 | 0.13 | 1.16 | 0.73 | 0.35 | 0.13 | 0.31 | -0.12 | 0.34 | -0.24 | -0.13 | 0.03 | 0.16 | 1.07 | 0.56 | 0.39 | 0.26 | 0.10 | 0.34 | 0.28 | 0.55 | 0.61 |

Table 15: Country/Industry Portfolios (Test Assets) Time Series Description

This table provides information about the available firm-level data by industry for each country. *Months* is the number of months for which the country industry portfilio data is available between July 1992 to December 2015. *Start Year* and the *End Year* is the data availability in years. *Firms* is the mean number of firms in the country industry portfilio; *Min* is the minimum number of firms in the portfolio and *Max* is the maximum number of firms in the portfolio. The Industry Portfolios are represented by MAN for Manufacturing, ELE for Electricity, Gas, Steam, and Air Conditioning, WAT is Water Supply, Sewage, Waste Management and Remediation Activities, CON is Construction, WHO is Wholesale Retail Trade, Repair of Motor Vehicles and Motorcycles, TRA is Transportation and Storage, FOO is Accomodation and Food Services, COM is Information and Communication, PRO is Professional Scientific and Technical Activities, EMP is Employment Activities, EDU is Education, HEA is Human Health Activities, ART is Arts, Entertainment and Recreation, and OTH is Other Services. The countries include Austria (AUT), Belgium (BEL), the Czech Republic (CZE), Germany (DEU), Denmark (DMK), Estonia (EST), Finland (FIN), France (FRA), Great Britain (GBR), Greece (GRC), Hungary (HUN), Ireland (IRL), Italy (ITA), Japan (JPN), Lithuania (LTU), Luxembourg (LUX), Latvia (LVA), and Netherlands (NLD), Norway (NOR), Poland (POL), Portugal (PRT), Slovak Republic(SVK), Slovenia (SVN), and Sweden (SWE).

| | **Industry** | MAN | ELE | WAT | CON | WHO | TRA | FOO | COM | PRO | EMP | EDU | HEA | ART | OTH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Country** | | | | | | | | | | | | | | | |
| | Start Year | 1992 | 1992 | | 1992 | 1992 | 1992 | 1999 | 1998 | 2001 | 1994 | | | 2000 | |
| | End Year | 2015 | 2015 | | 2015 | 2015 | 2015 | 2015 | 2015 | 2007 | 2001 | | | 2015 | |
| | Months | 282 | 282 | | 277 | 269 | 272 | 193 | 205 | 62 | 51 | | | 179 | |
| AUT | Firms | 47.4 | 4.0 | | 2.8 | 2.1 | 1.5 | 2.3 | 8.7 | 1.0 | 1.0 | | | 2.2 | |
| | *Min* | 25 | 3 | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | 1 | |
| | *Max* | 57 | 5 | | 5 | 4 | 2 | 4 | 13 | 1 | 1 | | | 4 | |
| | Start Year | 1992 | 1992 | | 1992 | 1992 | 1992 | 1992 | 1995 | 2005 | 1992 | | | 1997 | |
| | End Year | 2015 | 2015 | | 2015 | 2015 | 2015 | 2007 | 2015 | 2015 | 2007 | | | 2015 | |
| | Months | 282 | 282 | | 282 | 282 | 281 | 175 | 241 | 108 | 175 | | | 205 | |
| BEL | Firms | 48.2 | 4.4 | | 3.4 | 11.8 | 3.0 | 2.4 | 15.0 | 1.5 | 1.0 | | | 1.6 | |
| | *Min* | 16 | 2 | | 2 | 8 | 2 | 1 | 1 | 1 | 1 | | | 1 | |
| | *Max* | 64 | 11 | | 4 | 15 | 4 | 3 | 23 | 3 | 1 | | | 2 | |
| | Start Year | 1995 | 1995 | 1997 | 1995 | | 1995 | 1997 | 1995 | | | | | 1997 | |
| | End Year | 2015 | 2015 | 2015 | 2001 | | 2013 | 2008 | 2015 | | | | | 2015 | |
| | Months | 251 | 251 | 94 | 78 | | 175 | 55 | 241 | | | | | 94 | |
| CZE | Firms | 8.7 | 6.5 | 1.0 | 1.0 | | 1.9 | 1.0 | 2.2 | | | | | 1.0 | |
| | *Min* | 4 | 2 | 1 | 1 | | 1 | 1 | 1 | | | | | 1 | |
| | *Max* | 18 | 12 | 1 | 1 | | 3 | 1 | 3 | | | | | 1 | |
| | Start Year | 1992 | 1992 | 1995 | 1992 | 1992 | 1992 | 1992 | 1992 | 1992 | 1992 | 2001 | 1992 | 1999 | 2001 |
| DEU | End Year | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2014 |
| | Months | 282 | 282 | 242 | 282 | 282 | 282 | 282 | 282 | 282 | 282 | 148 | 280 | 202 | 149 |
| | Firms | 270.1 | 22.3 | 3.4 | 14.7 | 39.5 | 9.1 | 1.8 | 116.0 | 15.0 | 12.8 | 1.3 | 8.2 | 7.4 | 1.4 |

| | Industry | MAN | ELE | WAT | CON | WHO | TRA | FOO | COM | PRO | EMP | EDU | HEA | ART | OTH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Min* | 113 | 16 | 1 | 8 | 12 | 2 | 1 | 4 | 1 | 4 | 1 | 1 | 1 | 1 |
| | *Max* | 337 | 30 | 5 | 19 | 50 | 14 | 2 | 183 | 27 | 22 | 2 | 12 | 11 | 2 |
| DNK | Start Year | 1992 | 1993 | 1993 | 1992 | 1992 | 1992 | | 1993 | 1992 | 1992 | | | 1995 | |
| | End Year | 2015 | 2015 | 2007 | 2015 | 2015 | 2015 | | 2015 | 2006 | 2005 | | | 2015 | |
| | Months | 282 | 239 | 130 | 281 | 282 | 282 | | 267 | 159 | 150 | | | 241 | |
| | Firms | 59.3 | 1.4 | 1.0 | 7.0 | 11.2 | 8.6 | | 13.2 | 1.0 | 1.6 | | | 5.4 | |
| | *Min* | 16 | 1 | 1 | 1 | 2 | 6 | | 1 | 1 | 1 | | | 1 | |
| | *Max* | 75 | 2 | 1 | 8 | 17 | 13 | | 25 | 1 | 2 | | | 8 | |
| EST | Start Year | 1997 | | | 1997 | 1997 | 2006 | | 1999 | | | | | 2006 | |
| | End Year | 2015 | | | 2015 | 2015 | 2015 | | 2015 | | | | | 2015 | |
| | Months | 227 | | | 218 | 211 | 111 | | 192 | | | | | 98 | |
| | Firms | 5.8 | | | 3.1 | 1.0 | 1.0 | | 1.4 | | | | | 1.2 | |
| | *Min* | 3 | | | 1 | 1 | 1 | | 1 | | | | | 1 | |
| | *Max* | 8 | | | 6 | 1 | 1 | | 3 | | | | | 2 | |
| FIN | Start Year | 1992 | 1994 | 1992 | 1992 | 1992 | 1993 | 2013 | 1992 | 1996 | 1996 | | 1999 | | |
| | End Year | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | | 2015 | | |
| | Months | 282 | 254 | 273 | 251 | 282 | 268 | 25 | 280 | 240 | 224 | | 163 | | |
| | Firms | 59.7 | 2.6 | 1.0 | 2.6 | 7.5 | 6.7 | 1.2 | 22.6 | 3.3 | 2.5 | | 1.1 | | |
| | *Min* | 26 | 1 | 1 | 1 | 3 | 5 | 1 | 1 | 1 | 1 | | 1 | | |
| | *Max* | 74 | 4 | 1 | 4 | 10 | 9 | 2 | 37 | 5 | 3 | | 2 | | |
| FRA | Start Year | 1992 | 1992 | 1992 | 1992 | 1992 | 1992 | 1992 | 1992 | 1992 | 1992 | 2000 | 1994 | 1992 | 2000 |
| | End Year | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 |
| | Months | 282 | 282 | 282 | 282 | 282 | 282 | 282 | 282 | 282 | 282 | 168 | 253 | 280 | 156 |
| | Firms | 247.7 | 9.3 | 4.6 | 16.3 | 45.3 | 8.9 | 11.7 | 101.4 | 29.9 | 11.3 | 1.5 | 4.1 | 6.8 | 2.0 |
| | *Min* | 82 | 3 | 1 | 6 | 19 | 5 | 4 | 12 | 5 | 2 | 1 | 1 | 1 | 1 |
| | *Max* | 313 | 19 | 8 | 24 | 64 | 16 | 18 | 160 | 46 | 18 | 2 | 6 | 10 | 3 |
| GBR | Start Year | 1992 | 1992 | 1992 | 1992 | 1992 | 1992 | 1992 | 1992 | 1992 | 1992 | 1992 | 1992 | 1992 | 1992 |
| | End Year | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 |
| | Months | 282 | 282 | 282 | 282 | 282 | 282 | 282 | 282 | 282 | 282 | 282 | 282 | 282 | 282 |
| | Firms | 403.3 | 13.0 | 6.2 | 47.8 | 117.4 | 31.9 | 37.5 | 197.6 | 94.2 | 47.1 | 4.7 | 7.9 | 35.1 | 3.2 |
| | *Min* | 329 | 10 | 3 | 33 | 67 | 14 | 19 | 69 | 39 | 31 | 2 | 3 | 11 | 2 |
| | *Max* | 503 | 22 | 9 | 64 | 187 | 41 | 56 | 290 | 151 | 64 | 9 | 12 | 51 | 4 |
| GRC | Start Year | 1992 | 1998 | 2013 | 1994 | 1992 | 1996 | 1992 | 1995 | 1996 | 1992 | | 1996 | 2000 | |

| | Industry | MAN | ELE | WAT | CON | WHO | TRA | FOO | COM | PRO | EMP | EDU | HEA | ART | OTH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | End Year | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | | 2015 | 2015 | |
| | Months | 282 | 204 | 32 | 257 | 281 | 229 | 278 | 243 | 232 | 272 | | 228 | 182 | |
| | Firms | 67.2 | 1.9 | 1.0 | 15.3 | 17.9 | 6.8 | 4.0 | 22.0 | 2.3 | 1.3 | | 4.2 | 3.5 | |
| | *Min* | 6 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | | 1 | 1 | |
| | *Max* | 98 | 3 | 1 | 21 | 31 | 9 | 6 | 32 | 3 | 2 | | 5 | 4 | |
| HUN | Start Year | 1993 | 1995 | | | 1992 | | 1993 | 1997 | 2012 | 1993 | | | | |
| | End Year | 2015 | 2015 | | | 2015 | | 2015 | 2015 | 2015 | 2015 | | | | |
| | Months | 269 | 239 | | | 269 | | 261 | 215 | 38 | 117 | | | | |
| | Firms | 16.4 | 2.7 | | | 2.4 | | 1.9 | 5.4 | 1.0 | 1.0 | | | | |
| | *Min* | 1 | 1 | | | 1 | | 1 | 1 | 1 | 1 | | | | |
| | *Max* | 24 | 4 | | | 3 | | 2 | 8 | 1 | 1 | | | | |
| IRL | Start Year | 1992 | 2008 | | 1992 | 1992 | 1992 | 1992 | 1992 | 1992 | 1998 | | | 1992 | |
| | End Year | 2015 | 2015 | | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | | | 2015 | |
| | Months | 282 | 64 | | 281 | 281 | 281 | 184 | 282 | 281 | 199 | | | 269 | |
| | Firms | 25.1 | 1.0 | | 3.9 | 6.4 | 4.2 | 3.8 | 7.1 | 5.6 | 2.3 | | | 3.5 | |
| | *Min* | 13 | 1 | | 1 | 4 | 2 | 1 | 1 | 1 | 1 | | | 1 | |
| | *Max* | 31 | 1 | | 6 | 9 | 7 | 6 | 15 | 9 | 4 | | | 6 | |
| ITA | Start Year | 1992 | 1992 | 1999 | 1992 | 1992 | 1992 | 1992 | 1992 | 1999 | 2001 | 1992 | 2006 | 1992 | 2007 |
| | End Year | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 |
| | Months | 282 | 282 | 187 | 282 | 282 | 282 | 272 | 282 | 193 | 179 | 245 | 87 | 282 | 99 |
| | Firms | 94.0 | 16.0 | 1.5 | 8.2 | 7.6 | 5.8 | 1.8 | 27.0 | 2.9 | 3.5 | 1.0 | 1.0 | 4.6 | 1.0 |
| | *Min* | 58 | 8 | 1 | 6 | 3 | 3 | 1 | 8 | 1 | 1 | 1 | 1 | 2 | 1 |
| | *Max* | 128 | 26 | 2 | 10 | 13 | 10 | 3 | 51 | 8 | 5 | 1 | 1 | 7 | 1 |
| JPN | Start Year | 1992 | 1992 | 1995 | 1992 | 1992 | 1992 | 1992 | 1992 | 1992 | 1992 | 1992 | 1992 | 1992 | 1992 |
| | End Year | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 |
| | Months | 282 | 282 | 236 | 282 | 282 | 282 | 282 | 282 | 282 | 282 | 274 | 280 | 282 | 282 |
| | Firms | 1480.9 | 22.2 | 3.6 | 208.0 | 492.7 | 99.0 | 86.5 | 244.9 | 82.0 | 55.7 | 22.4 | 10.5 | 13.6 | 7.9 |
| | *Min* | 961 | 16 | 1 | 126 | 158 | 61 | 20 | 27 | 17 | 5 | 1 | 1 | 2 | 1 |
| | *Max* | 1628 | 26 | 8 | 248 | 601 | 111 | 116 | 403 | 121 | 83 | 33 | 22 | 18 | 12 |
| LTU | Start Year | 2010 | 2010 | | 2010 | 2010 | 2010 | | 2010 | | 2013 | | | | |
| | End Year | 2015 | 2015 | | 2015 | 2015 | 2015 | | 2015 | | 2015 | | | | |
| | Months | 61 | 61 | | 56 | 61 | 60 | | 61 | | 29 | | | | |
| | Firms | 15.0 | 5.7 | | 1.0 | 2.0 | 3.1 | | 1.0 | | 1.0 | | | | |

| | Industry | MAN | ELE | WAT | CON | WHO | TRA | FOO | COM | PRO | EMP | EDU | HEA | ART | OTH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Min* | 14 | 4 | | 1 | 2 | 2 | | 1 | | 1 | | | | |
| | *Max* | 17 | 6 | | 1 | 2 | 4 | | 1 | | 1 | | | | |
| LUX | Start Year | 1992 | 1992 | | 1998 | 1992 | 2007 | | 1992 | 2000 | 2001 | | | 1992 | |
| | End Year | 2015 | 2015 | | 2015 | 2015 | 2015 | | 2015 | 2015 | 2015 | | | 2015 | |
| | Months | 282 | 248 | | 175 | 144 | 100 | | 282 | 146 | 158 | | | 216 | |
| | Firms | 14.8 | 1.3 | | 1.5 | 1.5 | 2.1 | | 4.8 | 1.0 | 2.6 | | | 1.3 | |
| | *Min* | 3 | 1 | | 1 | 1 | 1 | | 1 | 1 | 1 | | | 1 | |
| | *Max* | 31 | 2 | | 3 | 2 | 3 | | 7 | 1 | 4 | | | 3 | |
| LVA | Start Year | 1997 | | | 1998 | | 2000 | | | | | | 2007 | | |
| | End Year | 2015 | | | 2015 | | 2015 | | | | | | 2015 | | |
| | Months | 219 | | | 123 | | 185 | | | | | | 85 | | |
| | Firms | 11.7 | | | 1.0 | | 3.9 | | | | | | 1.0 | | |
| | *Min* | 1 | | | 1 | | 1 | | | | | | 1 | | |
| | *Max* | 18 | | | 1 | | 5 | | | | | | 1 | | |
| NLD | Start Year | 1992 | | | 1992 | 1992 | 1992 | 1992 | 1992 | 1992 | 1992 | | | 1992 | |
| | End Year | 2015 | | | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | | | 2015 | |
| | Months | 282 | | | 282 | 282 | 282 | 203 | 282 | 282 | 282 | | | 282 | |
| | Firms | 68.6 | | | 7.8 | 17.9 | 4.2 | 1.0 | 26.3 | 8.5 | 5.3 | | | 4.5 | |
| | *Min* | 48 | | | 6 | 6 | 3 | 1 | 10 | 6 | 3 | | | 1 | |
| | *Max* | 83 | | | 9 | 29 | 6 | 1 | 49 | 11 | 7 | | | 9 | |
| NOR | Start Year | 1992 | 1992 | 2014 | 1992 | 1992 | 1992 | 1998 | 1992 | 1992 | 1998 | | | 1992 | |
| | End Year | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2006 | 2015 | 2015 | 2015 | | | 2015 | |
| | Months | 282 | 282 | 20 | 282 | 277 | 282 | 100 | 282 | 282 | 202 | | | 282 | |
| | Firms | 49.1 | 4.3 | 1.6 | 4.5 | 3.3 | 18.3 | 1.6 | 18.5 | 7.3 | 1.0 | | | 14.3 | |
| | *Min* | 20 | 3 | 1 | 1 | 1 | 10 | 1 | 2 | 3 | 1 | | | 3 | |
| | *Max* | 76 | 7 | 2 | 7 | 5 | 24 | 2 | 31 | 12 | 1 | | | 33 | |
| POL | Start Year | 1995 | 1995 | 2008 | 1995 | 1995 | 2004 | 1998 | 1996 | 1995 | 2003 | 2010 | 2006 | 2012 | |
| | End Year | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | |
| | Months | 251 | 247 | 95 | 251 | 243 | 132 | 204 | 238 | 244 | 145 | 52 | 115 | 41 | |
| | Firms | 97.4 | 6.6 | 3.9 | 17.5 | 22.2 | 3.5 | 3.9 | 39.8 | 9.8 | 5.9 | 1.6 | 4.9 | 1.5 | |
| | *Min* | 9 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| | *Max* | 236 | 19 | 7 | 48 | 68 | 10 | 8 | 134 | 37 | 13 | 3 | 12 | 2 | |
| PRT | Start Year | 1992 | 1997 | | 1992 | 1992 | 1992 | 1992 | 1994 | 1998 | | | 2014 | 1992 | |

| | **Industry** | MAN | ELE | WAT | CON | WHO | TRA | FOO | COM | PRO | EMP | EDU | HEA | ART | OTH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | End Year | 2015 | 2015 | | 2015 | 2015 | 2015 | 2015 | 2015 | 2001 | | | 2015 | 2015 | |
| | Months | 282 | 222 | | 273 | 281 | 55 | 282 | 256 | 45 | | | 22 | 280 | |
| | Firms | 17.8 | 1.5 | | 3.2 | 5.5 | 1.0 | 2.7 | 8.3 | 1.0 | | | 1.0 | 2.9 | |
| | *Min* | 12 | 1 | | 1 | 2 | 1 | 2 | 1 | 1 | | | 1 | 1 | |
| | *Max* | 29 | 3 | | 5 | 8 | 1 | 5 | 12 | 1 | | | 1 | 5 | |
| SVK | Start Year | 1995 | | | 1995 | | 2005 | 2011 | 2007 | | | | | | |
| | End Year | 2015 | | | 2011 | | 2010 | 2015 | 2015 | | | | | | |
| | Months | 244 | | | 73 | | 42 | 54 | 104 | | | | | | |
| | Firms | 4.7 | | | 1.0 | | 1.8 | 1.0 | 1.0 | | | | | | |
| | *Min* | 2 | | | 1 | | 1 | 1 | 1 | | | | | | |
| | *Max* | 6 | | | 1 | | 2 | 1 | 1 | | | | | | |
| SVN | Start Year | 1995 | | | | 1995 | 1998 | 1995 | 2005 | 1999 | | | | | |
| | End Year | 2015 | | | | 2015 | 2015 | 2015 | 2015 | 2015 | | | | | |
| | Months | 241 | | | | 238 | 196 | 224 | 124 | 170 | | | | | |
| | Firms | 8.5 | | | | 2.9 | 1.0 | 1.0 | 2.1 | 1.0 | | | | | |
| | *Min* | 1 | | | | 1 | 1 | 1 | 1 | 1 | | | | | |
| | *Max* | 12 | | | | 4 | 1 | 1 | 3 | 1 | | | | | |
| SWE | Start Year | 1992 | 1992 | 2001 | 1992 | 1992 | 1992 | 1997 | 1992 | 1992 | 1993 | 2001 | 2000 | 2001 | |
| | End Year | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | 2015 | |
| | Months | 282 | 282 | 171 | 282 | 282 | 282 | 227 | 282 | 282 | 268 | 150 | 181 | 163 | |
| | Firms | 137.9 | 3.2 | 1.7 | 9.4 | 20.2 | 9.1 | 2.5 | 48.8 | 12.2 | 8.3 | 1.0 | 2.8 | 5.8 | |
| | *Min* | 40 | 1 | 1 | 6 | 7 | 5 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | |
| | *Max* | 281 | 6 | 5 | 16 | 34 | 15 | 4 | 81 | 23 | 17 | 1 | 5 | 10 | |