Employment, Corporate Investment and Cash Flow Uncertainty

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Abstract

In this paper we make two contributions. First, we focus on the role of cash flow uncertainty on corporate employment and corporate investment policy and develop two cash flow risk measures. Our second major contribution is our consideration of both tangible and intangible corporate investments. We find that both our cash flow risk measures are significantly negatively correlated with corporate employment and corporate investments in tangible assets. Second, both these risk measures are also significantly negatively correlated with corporate investments in intangible assets. Furthermore, we document that both our risk measures have had a more negative impact on corporate employment and corporate investments in both tangible assets and intangible assets during the current economic recession of 2008-2009. These findings have significant policy implications. To wit, if policy makers would like corporations to increase their employment and investment, they should focus on policies that decrease corporate cash flow uncertainty.

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I. Introduction

Business observers and policymakers have repeatedly raised concerns about the decrease in corporate investment activity during the ongoing financial and economic crisis that started in the fall of 2007. Given the direct and indirect effects of corporate investment in increasing employment, corporate investment is understandably of critical policy importance.

Corporate investment policy has been studied by corporate finance scholars for the better part of the past century. The net present value investment decision rule is a well-accepted paradigm. Firms will invest in a new project if the expected cash flows are positive. As expected cash flows increase, businesses are more likely to invest. Equally important, as the uncertainty of these cash flows increases, businesses are less likely to invest. Policies that increase expected cash flows, and decrease the uncertainty of future cash flows will help increase corporate investment activity. Given the wide acceptance of the net present value paradigm, it is puzzling that the role of cash flow uncertainty on corporate investment has received such scant attention.

In this paper we make two contributions. First, we focus on the role of cash flow uncertainty on corporate investment policy. We consider a production economy with competitive firms. Production requires two types of inputs, namely, tangible and intangible capital. We develop two cash flow risk measures. The first risk measure captures the conditional variance of the elasticity of output with respect to tangible capital, while the second risk measure focuses on the conditional variance of the total factor of productivity. We construct these risk measures using the level of S&P 500 volatility index, VIX, and the one-year historical volatility of the equally-weighted risk-adjusted equity returns in the particular firms industry.

Our second major contribution is our emphasis on both tangible and intangible corporate investments. For at least the past decade, investments in intangible assets by U.S. corporations has been substantially greater than investments in tangible assets; for example, see Figure 1. Furthermore, the ratio of corporate investments in intangible assets to tangible assets has grown secularly over the past several decades. Given that U.S. corporations have been increasing their emphasis on intangible investments, it is surprising that the academic literature on corporate investment policy has continued to focus on tangible investments; for example see Kaplan and Zingales (1997), Fazzari, Hubbard, and Petersen (1998), Whited and Wu (2006), and Duchin, Ozbas, and Sensoy (2010). We cite these papers because of their significant contribution to our understanding of the determinants of corporate investments in tangible assets. A vast number of additional papers have also focused on corporate investments in tangible assets. The extant literature on corporate investments in intangible assets is comparatively quite modest: Bhagat and Welch (1995), and Fee, Hadlock, and Pierce (2009). However, even these papers consider but subsets of intangible assets; for example, Bhagat and Welch consider R&D investments, whereas Fee, Hadlock and Pierce focus on advertising expenditures. We consider several different measures of a more comprehensive set of corporate investments in intangible assets.

Corporate intangible investments include R&D, brand name, etc. More importantly, it includes investments in human capital, which, to a first degree of approximation is proxied by corporate employment. Many policy-makers consider corporate employment policy to be one of the most significant corporate policy decisions.

We find that both our risk measures, namely, the conditional variance of the elasticity of output with respect to tangible capital and the conditional variance of the total factor of productivity, are significantly negatively correlated with corporate investments in tangible assets. Second, both these risk measures are also significantly negatively correlated with corporate employment and corporate investments in intangible assets. These empirical findings are robust to a battery of specification tests.

Given the intense current interest among business observers and senior policy makers on corporate investment activity and its related impact on economic growth and employment, we next turn our attention to the impact of our risk measures on corporate employment and corporate investments in tangible and intangible assets during the recent and ongoing recession. We document that both our risk measures have had a more negative impact on corporate employment and corporate investments in both tangible assets and intangible assets during the current economic recession of 2008-2010.

These findings have significant policy implications; if policy makers would like corporations to increase their investment activity, they should focus on policies that decrease corporate cash flow uncertainty. Specifically, to the extent corporations are uncertain about the implementation and the implementation-timeline of the health reform act, and the impact of this act on their costs of hiring and retaining employees - a clarification of the implementation and the implementation-timeline of the health reform act would encourage corporations to invest more and hire more employees. Similarly, to the extent corporations are uncertain about the implementation and the implementation-timeline of the environmental cap-and-trade reform and corporate tax reforms - a clarification of the implementation and the implementation-timeline of these environmental and tax reforms would encourage corporations to invest more and hire more employees.

The relationship between investment and uncertainty has been the focus of many theoretical and empirical studies for the past 50 years. From a theoretical standpoint, the literature has reached the consensus that the sign of the investment-uncertainty relationship is positive if the marginal revenue product of capital is convex in productivity shocks - this is known in the literature as the Hartman-Abel-Caballero effect - and negative if investment is partially irreversible and the marginal revenue product of capital is concave in productivity shocks.[1] From an empirical standpoint, most of the evidence seems to support a

[1]For models that predict a positive investment-uncertainty relationship see Hartman (1972), Caballero (1991), Abel (1983), Abel (1984), and Abel (1985). For models that predict a negative investment-uncertainty relationship see Pindyck (1988), McDonald and Siegel (1985), McDonald and Siegel (1986), Dixit and Pindyck (1994), Saltari and Ticchi (2007).

negative investment-uncertainty relationship.[2]

Our model assumes a marginal revenue product of capital that is concave in productivity shocks and therefore it falls into the category of models that predict a negative investment-uncertainty relationship. However, unlike most of the models in this category, our model allows for tangible and intangible capital and it differentiates between the productivity of the two types of capital. Most importantly, our model is more general as it allows for both equity and debt financing, is more tractable - the investment-uncertainty relationship can be obtained analytically -, and delivers important restrictions which we exploit in the empirical part of the paper.

Our paper also differentiate from the extant empirical literature that study the relationship between investment and uncertainty. Unlike most empirical studies in this literature, our measures of uncertainty are not based on firm-level equity returns. Instead our uncertainty measures are extracted simultaneously with the productivity shocks and therefore are less prone to potential endogeneity issues that arise typically when using uncertainty measures based on the firm-level equity returns.[3]

The remainder of the paper is organized as follows. Section II develops our model of the production economy and motivates our two cash flow risk measures. Section III estimates the main parameters of our model and backs out the productivity shocks. Section IV constructs our two cash flow uncertainty measures. Section V investigates empirically the relationship between investment and cash flow uncertainty. Finally, Section VI concludes with a discussion of our results.

II. A Model of Investment under Uncertainty

We begin with a theoretical analysis of the relationship between corporate investment and cash flow uncertainty. The framework that we develop in this section will serve two purposes: First, it will allow us to sign the relationship between optimal investment in either tangible or intangible assets and the moments of the conditional distribution of cash flow uncertainty. Second, it will provide a natural framework for identifying sources of cash flow uncertainty in the data and guide us towards uncovering the conditional moments of these sources of risk.

Consider a production economy with competitive firms. Production requires two types of inputs namely tangible and intangible capital. Firms operate at full capacity and their

[2]See for instance Leahy and Whited (1996), Bulan (2005), Shaanan (2005), Bloom, Bond, and van Reenen (2007), Bloom (2009) and Panousi and Papanikolaou (2010). These studies also provide extensive literature review.

[3]There is an extensive literature documenting a strong link between investment post stock performance (including stock volatility). See for instance Anderson and Garcia-Feijoo (2006) and Cooper, Gulen, and Schill (2008).

output is characterized by the following Cobb-Douglas production function

$$y_t = F(k_t^T, k_t^I, \theta_t, \xi_t^1) = \theta_t^{1-\gamma} \left[\alpha(k_t^T)^\rho + (1-\alpha)(k_t^I \xi_t^1)^\rho\right]^{\frac{\gamma}{\rho}}. \tag{1}$$

Note that tangible and intangible capital enter the production function through a CES function. The production function depends on two productivity shocks. θ_t is the productivity shock capturing a firm's technological innovation and excess demand for its output. ξ_t^1 captures the productivity shock of the intangible capital and it helps drive a wedge between the productivity of two types of capital. We assume that $\xi_t^1 \geq 0$.

An important property of this productivity function, which will prove quite handy later on, is that elasticities of output with respect to either type of capital add up to a constant. That is

$$\frac{\partial F}{\partial k^T}\frac{k^T}{F} + \frac{\partial F}{\partial k^I}\frac{k^I}{F} = \gamma. \tag{2}$$

Let γ_t^T denote the instantaneous elasticity of output with respect to tangible capital. Using the definition of the productivity function we have that

$$\gamma_t^T = \frac{\partial F}{\partial k^T}\frac{k^T}{F} = \frac{\alpha\gamma}{\alpha + (1-\alpha)\left(\frac{k_t^I}{k_t^T}\right)^\rho \left(\xi_t^1\right)^\rho}. \tag{3}$$

In particular, notice that if γ_t^T is constant, then the output function does not depend on k_t^I and ξ_t^1. We now substitute the previous formula into the definition of output, and after taking logs we obtain that

$$\log y_t = \frac{\gamma}{\rho}\log(\alpha\gamma) + \gamma \log k_t^T - \frac{\gamma}{\rho}\log \gamma_t^T + (1-\gamma)\log\theta_t. \tag{4}$$

This equation offers an alternative description of output which does not depend directly on intangible capital stock k_t^I and relative productivity of intangible capital ξ_t^1. To the extent that γ_t^T is known, equation (4) can be used to estimate the main parameters of the productivity function. We will formalize this point in the next section.

Let B_t denote the outstanding amount of debt and $r_t B_t$ denote its coupon payment. Then the realized net worth of the representative firm can be defined by

$$\begin{aligned} w(k_t^T, k_t^I, B_t, \theta_t, \xi_t^1, \xi_t^2) = {} & F(k_t^T, k_t^I, \theta_t, \xi_t^1) - \xi_t^2 + (1-\delta^T)k_t^T + (1-\delta_t^I)k_t^I \\ & - \tau_C\left\{F(k_t^T, k_t^I, \theta_t, \xi_t^1) - \xi_t^2 - \delta^T k_t^T + (1-\delta_t^I)k_t^I\right\} \\ & - (1 + (1-\tau_C)r_t)B_t. \end{aligned} \tag{5}$$

δ^T and δ^I are depreciation rates for tangible and intangible capital, respectively. ξ_t^2 are the costs associated with production. We assume that these costs have the following form

$$\xi_t^2 = \alpha_0 + \alpha_1 k_t^T + \beta_1 y_t + u_t, \tag{6}$$

where the first two terms combined capture fixed costs of production, the third term captures variable costs of production and the last term captures uncertainty in production costs that is unrelated to either tangible assets k^T or output y. α_0, α_1, and β_1 are constants. We assume that $\beta_1 < 1$ to preclude negative marginal profits.

The equityholders' problem of the representative firm becomes

$$V\left(w_t, \theta_t, \xi_t^1, \xi_t^2\right) = \max_{k_{t+1}^T, k_{t+1}^I, B_{t+1}} \Big\{ w_t - k_{t+1}^T - (1-\tau_C)k_{t+1}^I + B_{t+1} + \beta E_t\left[V\left(w_{t+1}, \theta_{t+1}, \xi_{t+1}^1, \xi_{t+1}^2\right)\right] \Big\} \tag{7}$$

subject to the constraints

$$\begin{aligned} &k_{t+1}^T \geq \underline{k}^T \\ &k_{t+1}^I \geq 0 \\ &B_{t+1} \leq \min_{\theta, \xi^1, \xi^2} w(k_{t+1}^T, k_{t+1}^I, 0, \theta, \xi^1, \xi^2) = w^L(k_{t+1}^T, k_{t+1}^I) \end{aligned} \tag{8}$$

The last constraint in (8) ensures that corporate debt is riskless and therefore r_t is the default-free bond yield.[4]. To simplify the exposure, we denote with $w^L(k_{t+1}^T, k_{t+1}^I)$ the right-hand side of this constraint.

Let $\lambda_t^T \geq 0$, $\lambda_t^I \geq 0$ and $\lambda_t^B \geq 0$ denote the Lagrange multipliers of the three constraints. The first order conditions for k^T, k^I and B together with the envelope conditions yield

$$\begin{aligned} \frac{1 - \lambda_t^T - \lambda_t^B w_1^L(k_{t+1}^T, k_{t+1}^I)}{\beta} =& 1 - (1-\tau_C)[\alpha_1 + \delta^T] + \\ & (1-\tau_C)(1-\beta_1)E_t\left[F_1(k_{t+1}^T, k_{t+1}^I, \theta_{t+1}, \xi_{t+1}^1)\right] \\ \frac{1 - \lambda_t^I - \lambda_t^B w_2^L(k_{t+1}^T, k_{t+1}^I)}{\beta(1-\tau_C)} =& 1 - \delta^I + (1-\beta_1)E_t\left[F_2(k_{t+1}^T, k_{t+1}^I, \theta_{t+1}, \xi_{t+1}^1)\right] \\ \frac{1-\lambda_t^B}{\beta} =& 1 + (1-\tau_C)r_t, \end{aligned} \tag{9}$$

subject to the Kuhn-Tucker complementary slackness conditions $\lambda_t^T(k_{t+1}^T - \underline{k}^T) = 0$ and $\lambda_t^I k_{t+1}^I = 0$.

Our goal is to establish a link between investment decisions and conditional variances of the uncertainty shocks in our model. We focus on the derivation of this relationship for physical investment.[5]

[4]Since the time period in our model is 3 months (a quarter), r_t becomes the YTM of the 3-month U.S. Treasury Bills.

[5]The derivation for intangible investment are available upon request.

Suppose $\underline{\theta} > 0$ and $\bar{u} > 0$ are such that $\theta_t \geq \underline{\theta}$ and $u_t \leq \bar{u}$, for all t. Then, w^L can be computed explicitly as follows

$$\begin{aligned} w^L(k^T, k^I) =&(1-\tau_C)\left[(1-\beta_1)\underline{\theta}^{1-\gamma}\alpha^{\frac{\gamma}{\rho}}(k^T)^{\gamma} - \bar{u} - \alpha_0 - (\alpha_1+\delta^T)k^T\right] + \\ & k^T + (1-\tau_C)(1-\delta^I)k^I. \end{aligned} \tag{10}$$

It follows immediately that the partial derivatives of $w^L(k^T, k^I)$ can be computed with the following formulas

$$\begin{aligned} w^L_1(k^T, k^I) =&(1-\tau_C)\left[(1-\beta_1)\gamma\underline{\theta}^{1-\gamma}\alpha^{\frac{\gamma}{\rho}}(k^T)^{\gamma-1} - (\alpha_1+\delta^T)\right] + 1. \\ w^L_2(k^T, k^I) =&(1-\tau_C)(1-\delta^I) \end{aligned} \tag{11}$$

Going back to the definition of output and making use of the elasticity of output with respect to tangible capital, we obtain also that

$$F_1(k^T, k^I, \theta, \gamma^T) = (\gamma\alpha)^{\frac{\gamma}{\rho}}(k^T)^{\gamma-1}\theta^{1-\gamma}(\gamma^T)^{1-\frac{\gamma}{\rho}} \tag{12}$$

We now substitute the last two formulas in (9) and solve for k^T_{t+1} (away from the boundary value $\underline{k}^T$). We obtain

$$(k^T_{t+1})^{1-\gamma} = \frac{(1-\tau_C)(1-\beta_1)(\gamma\alpha)^{\frac{\gamma}{\rho}}\left\{\beta E_t[\theta^{1-\gamma}_{t+1}(\gamma^T_{t+1})^{1-\frac{\gamma}{\rho}}] + \lambda^B\underline{\theta}^{1-\gamma}\gamma^{1-\frac{\gamma}{\rho}}\right\}}{\beta(1-\tau_C)r_t + (\alpha_1+\delta^T)[\beta(1-\tau_C)+\lambda^B]}. \tag{13}$$

The previous equation shows that the determinants of investment are the interest rates r_t and the conditional joint distribution of productivity shock θ and elasticity γ^T. In particular, investment depends on the second moments of the marginal distributions of θ and γ^T.

Similarly, we can show that the optimal stock of intangible capital (away from the boundary value 0) is given by

$$(k^I_{t+1})^{1-\gamma} = \frac{(1-\tau_C)\beta(1-\beta_1)[(1-\alpha)\gamma]^{\frac{\gamma}{\rho}}}{1-(\lambda^B+\beta)(1-\tau_C)(1-\delta^I)} E_t[\theta^{1-\gamma}_{t+1}(\gamma-\gamma^T_{t+1})^{1-\frac{\gamma}{\rho}}(\xi^1)^{\gamma}]. \tag{14}$$

We notice that the determinants of investment in intangible capital are the interest rates r_t and the conditional joint distribution of productivity shock θ, elasticity $\gamma - \gamma^T$, and relative productivity shock of intangible capital ξ^1. In particular, investment depends on the second moments of the marginal distributions of θ and $\gamma - \gamma^T$.

In order to sign the relation between investment and the variance of either θ or γ^T, we approximate the conditional expectation in the previous two formulas using a bivariate Taylor polynomial. We focus on the investment in tangible capital, as the analysis for investment in intangible capital is quite similar. Specifically, we approximate the function

$g(\theta_{t+1}, \gamma^T_{t+1}) = \theta^{1-\gamma}_{t+1}(\gamma^T_{t+1})^{1-\frac{\gamma}{\rho}}$ around $(E_t[\theta_{t+1}], E_t[\gamma^T_{t+1}])$ using a quadratic Taylor polynomial. We obtain

$$\begin{aligned} E_t[g(\theta_{t+1}, \gamma^T_{t+1})] \approx &(E_t[\theta_{t+1}])^{1-\gamma}(E_t[\gamma^T_{t+1}])^{1-\frac{\gamma}{\rho}} \\ &- \frac{\gamma}{2}(1-\gamma)(E_t[\theta_{t+1}])^{-1-\gamma}(E_t[\gamma^T_{t+1}])^{1-\frac{\gamma}{\rho}} Var_t[\theta_{t+1}] \\ &- \frac{\gamma}{2\rho}(1-\frac{\gamma}{\rho})(E_t[\theta_{t+1}])^{1-\gamma}(E_t[\gamma^T_{t+1}])^{-1-\frac{\gamma}{\rho}} Var_t[\gamma^T_{t+1}] \\ &+ (1-\gamma)(1-\frac{\gamma}{\rho})(E_t[\theta_{t+1}])^{-\gamma}(E_t[\gamma^T_{t+1}])^{-\frac{\gamma}{\rho}} Cov_t[\theta_{t+1}, \gamma^T_{t+1}]. \end{aligned} \quad (15)$$

One can derive a similar approximation for the conditional expectation in equation (14). To sign the relationship between investment and and the conditional variance of either θ or η, we substitute the conditional expectations in (13) and (14) with their Taylor polynomial approximations. We obtain the following result:

Proposition 1 Suppose $\gamma > 0$. Then, investment in either tangible or intangible capital is inversely related to the conditional variance of θ. In addition, the relationship between investment and the conditional variance of γ^T is negative, if $\gamma < \min\{\rho, 1\}$ or $\gamma > \max\{\rho, 1\}$, and positive if $\min\{1, \rho\} < \gamma < \max\{1, \rho\}$.

Proposition 1 shows that in our model the relationship between investment and the conditional variance of either θ or γ^T is negative, as long as γ satisfies certain parameter constraints. For the case when $\gamma < 1$ this result is reminiscent of the negative investment-uncertainty relationship uncovered by Pindyck (1988), McDonald and Siegel (1985,86), and Dixit and Pyndick (1994) in a model where marginal product of revenue is a concave function of the productivity shock. Our result is slightly more general as it covers investment in both tangible and intangible capital and it relates these investments with the conditional variances of the productivity shocks of both types of capital.

We derive two testable implications from this result, namely

Hypothesis H1: Investment in either tangible or intangible capital is negatively related to the conditional variance of the productivity shock θ.

Hypothesis H2: Investment in either tangible or intangible capital is negatively related to the conditional variance of the productivity shock γ^T, as long as $\gamma < \min\{\rho, 1\}$ or $\gamma > \max\{\rho, 1\}$.

For the remainder of the paper we show how to approximate the conditional variance of the productivity shocks and then we test empirically H1 and H2. The next section shows how to back out the productivity shocks from the data and how to construct their conditional variances.

III. Measuring cash flow uncertainty

In order to test empirically hypotheses H1 and H2 we need to compute the conditional variances of the productivity shocks θ and γ^T. However, neither of these two shocks are observable. In this section we attempt to back out these productivity shocks from the data and approximate their conditional variances.

We start with γ^T. The definition in (16) suggests that γ^T depends on the productivity function parameters α, γ, and ρ as well as the stock and the relative productivity of intangible capital. This approach is problematic because neither these parameters nor the stock and relative productivity of intangible capital are straightforward to estimate.

Recall that γ^T is the elasticity of output with respect to tangible capital. One can estimate this elasticity at the firm level as the slope coefficient in the OLS regression of $\log y_t$ on $\log k_t^T$. The resulting elasticity coefficient is clearly firm-specific but also time-invariant. This approach is also problematic because in our analysis we interpret this elasticity coefficient as a proxy for the relative productivity shock of intangible capital ξ - which is time-varying.

Our approach to obtaining a time-varying estimate for the elasticity coefficient γ^T relies on a simple observation: If the elasticity of output with respect to tangible capital is identical for all firms within the same industry, one can estimate this elasticity as the slope coefficient in the cross-sectional regression of log output on log tangible capital. In other words, as long as the elasticity remains fixed within an industry we can estimate it using cross-sectional variation rather than time-series variation in output and tangible capital stock.

We now describe this approach in more detail. Let $\gamma_t^{T,i} = \gamma_t^{T,J}$, for all firms i in industry J. Then, $\gamma_t^{T,J}$ can be estimated as the slope coefficient in the following intra-industry cross-sectional regression

$$\log y_t^i = a_t + \gamma_t^{T,J} \log k_t^{T,i} + \epsilon_t^i, \tag{16}$$

where i is in industry J and ϵ_t^i are i.i.d. homoskedastic errors with cross-sectional mean $E_t[\epsilon_t^i] = 0$. To compute the conditional variance of $\gamma_t^{T,i}$ we assume that the time-series dynamics of $\gamma_t^{T,i}$ take the following form

$$\log \gamma_t^{T,i} = \mu_0^i + \mu^i t + \epsilon_t^i, \tag{17}$$

where the errors ϵ_t^i are serially uncorrelated but heteroskedastic, with conditional mean zero and conditional variance $E_{t-1}[(\epsilon_t^i)^2] = [\eta_{t-1}^i]^2$.

In order to estimate the model in (17), we have to specify the functional form of the conditional variances $[\eta_t^i]^2$. We assume the following linear specification

$$[\eta_t^i]^2 = \phi^{i,\prime} z_t, \tag{18}$$

where z_t is an exogenous vector of variables, universal across firms. We address below the issue about the choice of variables z. Suppose for now that z is known.

The model in (17) together with the specification (18) can be estimated via two-stage generalized least square (GLS).[6] In the first stage we estimate the ordinary least square (OLS) residuals $\hat{\epsilon}_t^i$ from (17). In the second stage we project $\hat{\epsilon}_t^i$ onto z_t to obtain estimates for the conditional variances $[\eta_t^i]^2$. The estimates for the conditional variances $[\eta_t^i]^2$ are then used to construct GLS estimates for μ_0^i and μ^i.

One important advantage of using the approach above to estimate the elasticity $\gamma_t^{T,i}$ and its conditional variance $[\eta_t^i]^2$ is that we obtain a readily available time-series for $\gamma_t^{T,i}$ that does not depend on the productivity shocks or parameters embedded in the productivity function. As a result, we can treat the elasticities $\gamma_t^{T,i}$ as observable and we can use equation (4) to extract information about the productivity shock θ.

In order to estimate the productivity shock θ and its conditional variance, we start by assuming that the time series dynamics for θ take the following form

$$(1-\gamma^i)\log\theta_t^i = \nu_0^i + \nu^i t + \epsilon_t^i, \tag{19}$$

where the errors ϵ_t^i are serially uncorrelated but heteroskedastic, with conditional mean zero and conditional variance $E_{t-1}[(\epsilon_t^i)^2] = [\sigma_{t-1}^i]^2$. For the functional form of the conditional variances $[\sigma_{t-1}^i]^2$ we assume a linear specification

$$[\sigma_t^i]^2 = \varphi^{i,\prime} w_t, \tag{20}$$

where w_t is an exogenous vector of variables, universal across firms. We address below the issue about the choice of variables w. Suppose for now that w is known.

Substituting the dynamics of θ in the original output equation (4) we obtain

$$\log y_t^i = \nu_0^i + \frac{\gamma^i}{\rho^i}\log(\alpha^i\gamma^i) + \nu^i t + \gamma^i \log k_t^{T,i} - \frac{\gamma^i}{\rho^i}\log\gamma_t^{T,i} + \epsilon_t^i. \tag{21}$$

In this specification we notice that ν_0^i and α_0^i cannot be simultaneously identified, and we have to normalize one of them. We choose to normalize $\nu_0^i = 0$, for all firms i.

The model in (21) together with the linear specification for $[\sigma_t^i]^2$ in (20) can be estimated using again two-stage GLS. The procedure is identical to the one used to estimate the model in (17), and we skip the details for brevity.

We now discuss the choice of exogenous variables z_t and w_t. The defining property of these sets of variables is that they have to contain information about the conditional variances of future cash flows $[\eta_t^i]^2$ and $[\sigma_t^i]^2$. Some of the variables likely to satisfy this property are aggregate measures of volatility such as market return volatility or industry equity return volatility. We choose w to be the level of S&P 500 volatility index, VIX. We

[6] See Greene (2008) or Harvey (1990) for a detailed description of this methodology.

choose the set of variables z used in the estimation of model (17) for firm i to be the one-year historical volatility of the equally-weighted risk-adjusted equity returns in industry in which firm i belongs.[7] Since variables z are historical volatility measured based on risk-adjusted industry returns, the informational content of variables z will not overlap much with that of w. Thus in order to proxy for cash flow uncertainty we can use either $[\eta_t^i]^2$ or $[\sigma_t^i]^2$ separately, or $[\eta_t^i]^2$ and $[\sigma_t^i]^2$ jointly. In the empirical tests in the next section we consider all these alternative measures of cash flow uncertainty.

We estimate the models in (17) and (21) firm by firm. Figure 2 plots annual cross-sectional aggregates (medians) of these cash flow uncertainty measures. Statistics tables for our parameter estimates are not reported but are available on demand.

The next section uses the estimated conditional variances $[\eta_t^i]^2$ and $[\sigma_t^i]^2$ to proxy for cash flow uncertainty and to explore the empirical relationship between corporate investment and cash flow uncertainty.

IV. Empirical relationship between investment and uncertainty

In this section we focus on testing our two hypotheses, namely H1 and H2.

We use the estimates of the conditional variances $[\eta_t^i]^2$ and $[\sigma_t^i]^2$ from the previous section, either separately or jointly, to proxy for corporate future cash flow uncertainty.

Unlike most empirical tests on the relationship between corporate investment and uncertainty, we expand the scope of the notion of corporate investment and include investment in both tangible and intangible assets. In addition, we provide separate investment measures for investment in intangible assets that are explicitly capitalized or expensed but not related to human capital and investment in human capital itself.

We measure investment in tangible assets as the ratio of capital expenditure to lagged net property, plant, and equipment. Our measures of investment in intangible assets are based on proxies for the stock of intangible capital and human capital. We defer our discussion about how we construct these proxies to subsections B. and C. below. Our sample consists of the intersection of firms in the CRSP and COMPUSTAT databases for the period 1972-2009 for which data are available.

Let Inv_{t+1}^i denote one of our corporate investment measures. In order to test for empirical investment-uncertainty relationships we employ panel regressions of the following form

$$\text{Inv}_{t+1}^i = d_0 + d_1 x_t^i + d_2 \log \bar{\theta}_t^i + d_3 \sigma_t^i + d_4 \log \gamma_t^{T,i} + d_5 \eta_t^i + \epsilon_t^i. \tag{22}$$

Variables x_t^i includes various firm characteristics known to impact investment - we address the firm characteristics below. Among the independent variables we also include $\log \bar{\theta}_t^i$

[7] Equity returns are risk-adjusted relative to equity market risk only.

and $\log \gamma_t^{T,i}$ to capture business cycle corporate investment effects. The former is the de-trended version of $\log \theta_t^i$.[8]

We consider various specifications of the regression (22) depending on whether we proxy for cash flow uncertainty with one of the conditional variances $[\eta_t^i]^2$ and $[\sigma_t^i]^2$ or with both. In all cases, we cannot reject H1 or H2 if $d_3 < 0$ and $d_5 < 0$.

As noted above, regression (22) includes among independent variables certain firm characteristics, x_t^i, that are known to impact corporate investment.[9] The vector of variables x_t^i includes four such firm characteristics, namely average Tobin's q - measured as the ratio of market assets (market equity plus long-term debt) to book assets - to proxy for the investment opportunity set, cash-to-assets and cash flow-to-capital ratios to proxy for financial slack, and book leverage to proxy for debt overhang. Since all variables suggested by our model are not perfectly observable but rather filtered-out from the data, we include x_t^i in all our specifications to ensure that our variables do not simply proxy for known investment determinants.

A. Tangibles investment and cash flow uncertainty

Our first pass at testing the validity of hypotheses H1 and H2 is to run (22) on the entire sample. Table II and Table III report the results for tangible and intangible investment, respectively. To better understand the marginal contribution of the variables suggested by our model, we run four specifications of regression (22) labeled I-IV.

We start by focusing on the results on tangible investment. The results in Table II provide overwhelming support for both hypotheses. Tangible investment is strongly positively related to the TFP shock θ_t and strongly inversely related to its conditional variance, σ_t. Tangible investment is also positively related to the elasticity γ^T - though not statistically significant in specification III - and strongly negatively related to its conditional variance η_t. We emphasize that these relationships are strong *after* controlling for the determinants z_t. In fact, relative to the specification I, any of the specifications II, III or IV in Table II reveal that the coefficients in front of z_t change only marginally once we include θ_t, σ_t, γ_t^T, and η_t. This result is also consistent with the small correlation coefficients between these two groups of variables documented in Table I.

Since variables σ_t and η_t proxy for cash flow uncertainty, the results of Table II reveal a strong negative relationship between corporate investment in tangible assets and cash flow uncertainty. This relationship is strong both statistically and economically. For instance, from specification IV, one unit increase in the conditional standard deviation of θ_t (i.e. σ_t doubles) reduces tangibles investment by 31%, while one unit increase in the conditional standard deviation of γ_t^T (i.e. η_t doubles) reduces tangibles investment by 28.4%.

[8] Specifically, $\log \bar{\theta}_t^i$ equals the residual ϵ_t^i from the model in equation (21).

[9] See for example Panousi and Papanikolaou (2010) for a more recent study that reviews these firm characteristics.

Next, we investigate whether the strong relationship between tangibles investment and uncertainty is driven by a particular time sub-period in our sample. To see this we run the regression (22) for four different sub-periods spanning the entire sample period 1972-2009. These sub-periods are 1972-1990, 1991-2000, 2001-2007, and 2008-2009, and they are delimited by the economic recessions of 1991, 2001, and 2008.[10] Table V reports the results.

We notice that in each of the four sub-periods the coefficients in front of either σ_t or η_t are all negative and almost all statistically significant (the exception is the coefficient of η_t for the sub-period 1972-1990). These results show that the strong negative relationship between tangibles investment and uncertainty is robust across different time periods.

Table V also shows the coefficients in front of σ_t do not vary much across the four sub-periods (they range between -0.282 and -0.210), and they are fairly close in magnitude to the coefficient in front of σ_t from Table II. However, the same cannot be said about the coefficients in front of η_t. These coefficients range from -0.794 to -0.114, and they can be quite far from the estimate of the coefficient in front of η_t from Table II. While these results are informative, one should exercise caution in interpreting them because the variability of both σ_t and η_t can change substantially from one sample to another.

The previous discussion about the variability of coefficients in front of σ_t and η_t suggests that the relationship between tangibles investment and uncertainty changes over time. The natural question in this context is whether the relationship between tangible investment and uncertainty changes in a predictable fashion as the economy transitions from an expansionary regime into a recessionary regime.

Our model can help with the predictable component. Equation (15) shows that the strength of the relationship between investment and uncertainty is inversely related to the conditional mean of either the TFP shock θ_t or the elasticity γ_t^T. Since these conditional means are smaller in economic recessions than in economic expansions, our model predicts that the investment-uncertainty relationship becomes stronger as the economy transitions from an expansion into a recession.

During our sample period there were three economic recessions, namely 1990, 2001, and 2008. In order to study the time variation in the investment-uncertainty relationship we focus on three-year periods prior to a recession year - which captures the expansionary regime - and three-year periods after a recession year - which captures the recessionary regime. Then, we compare the strength of the relationship over the three-year period prior to a recession year with the strength of the relationship over the three-year period after the recession year. To quantify the investment-uncertainty relationship over these three-year periods we interact the uncertainty measures (and the rest of the independent variables in the regression (22)) with dummy variables indicating whether firm-years belong to a three-year period prior to a recession year or the three-year period after a recession year. Finally, to document a more proper comparison (and avoid the issues raised when

[10] Date and duration of economic recessions come from NBER.

discussing the results in Table V), we standardize all variables of interest including σ_t and η_t.

Table VIII presents the results. First of all, we find that, once again, for each of the three-year periods prior or after a recession the relationship between tangibles investment and uncertainty is still negative. However, for every single one of the three recessions, the investment-uncertainty relationship *strengthens* as the economy transitions from an expansionary regime to a recessionary regime. In other words, a unit increase in uncertainty reduces tangibles investment by more during a recessionary regime than during an expansionary regime.

A more direct way to detect time-variation in the investment-uncertainty relationship is to simply plot the times series of investment, σ_t, and η_t. Figure 2 plots the annual cross-sectional median of both tangible and intangible investment as well as the annual cross-sectional median of σ_t and η_t. All time-series are normalized by their 1986-level, and the time-series of both tangibles and intangibles investments are shifted up to allow for an easier visual comparison. We postpone the discussion on intangible investment until the next section, and we focus on tangibles investment only.

A casual look at this figure reveals two interesting patterns. First, corporate tangibles investment and either σ_t or η_t almost always move in opposite directions. This pattern confirms the strong negative relationship between tangibles investment and cash flow uncertainty documented in Tables II, V, and VIII. Second, for the periods surrounding the economic recessions of 1991, 2001, and 2008, tangibles investment declines dramatically while, at the same time, σ_t and η_t increase. This pattern confirms the findings in Table VIII, namely that the investment-uncertainty relationship is stronger in periods of economic downturns than in other periods.

B. Intangibles investment and cash flow uncertainty

Many of the results of the previous section can be extended to intangibles investment as well. However, before we present our empirical findings, we discuss our measure of intangibles capital.

The lack of detailed data on investments in intangible assets complicates tremendously the task of measuring the stock of intangibles capital. Macroeconomist and financial economists alike recognize the severity of the problem, yet there are only a handful of studies focusing exclusively on the issue of measuring intangibles capital. Important contributions to the literature include Hall (2001), McGrattan and Prescott (2005b), McGrattan and Prescott (2005a) etc. Most of these studies estimate the U.S. aggregate stock of intangibles capital from real business cycle models constraint to fit aggregate moments of corporate activity from the NIPA tables. However, this approach is difficult to use at firm level because some of the aggregate quantities in the NIPA tables are not available at firm level.

From an accounting perspective, it is well known that certain investments in intangibles assets can be capitalize - such as goodwill from firm acquisitions, patents, rights, etc - while others can only be expensed - such as research and development. This means that the book value of intangibles assets acquired through capitalized investments should be on the balance sheet, while the book value of intangible assets acquired through expensed investments should not. Therefore, the challenge is to measure the book value of intangibles assets that are not on the balance sheet.

Our view is that a good measure of the stock of intangible capital should reflect the book value of both types of intangible assets, namely those that are acquired through capitalized investments and those that are acquired through expensed investments. Therefore, we propose the following measure of intangibles capital

$$k_t^I = (\text{TA}_t - \text{ CA}_t - \text{ PPENT}_t) + \sum_{s=t-T}^{t} (1-\delta^I)^{t-s}\text{R\&D}_s, \qquad (23)$$

where TA, CA, PPENT, and R&D stand for total book assets, total current assets, net property, plant, and equipment, and research and development, respectively. δ^I is the depreciation rate on R&D investments, and we discuss it below.

The first component captures the portion of the stock of intangibles capital that is the result of investment in intangibles assets that are capitalized. For a drug company (e.g. Merck) or a tech company (e.g. Cisco) this component will contain balance sheet items such as ”Goodwill” and/or ”Intangibles Assets”.

The second component is an attempt to capture the portion of the stock of intangibles capital that is the result of R&D investments. Our component is essentially a cumulative sum of all past R&D expenses, adjusted for depreciation. We assume a depreciation rate, δ^I, of 10%, which corresponds to an *amortizable life* - the length of time it takes research and development investments to be converted into commercial products - for R&D investments of 10 years. To put this number in perspective, it takes about 10 years for a drug company to get approval for a new drug from the Food and Drugs Administration.[11] We have experimented with various values for δ^I, ranging from 0% to 20%, and our results are qualitatively unchanged. These additional results are available upon request.

The change in k_t^I is our measure of intangibles investment. We choose to work with investment net of depreciation rather than simply investment to economize on the assumptions about depreciation rates for intangible assets. Recall that we had to make an assumption about the depreciation rate, δ^I, of intangible assets that are acquired with research and development expenses. However, it doesn't necessarily follow that intangible assets acquired with capitalized investments depreciate at the same rate. In fact, one would have to make an assumption about the depreciation rate of intangible assets acquired with capitalized investments, because we only observe the stock of these type of intangible assets.

[11] See Damodaran (2009) for more on the amortizable life of research and development.

Now that we have a good measure of intangibles investment, we are ready to replicate the empirical experiments of the previous section using intangibles investments instead of tangibles investment. Just as in the previous section, in order to investigate the relationship between intangibles investment and uncertainty we run regression (22) under several specifications. Table III reports the results for the entire sample, Tables VI-VII reports the results for several time periods in our sample, and Tables IX-X reports the results on the time-variation of the intangibles investment-uncertainty relationship around economic recessions.

We notice that the investment-uncertainty relationship extends to a large degree to intangibles investment as well. Table III documents that when σ_t or η_t are used separately to proxy for uncertainty (specification II or III), we obtain a strongly negative relationship between intangibles investment and uncertainty. However, when σ_t and η_t are used jointly to proxy for uncertainty (specification IV), only σ_t supports a strongly negative investment-uncertainty relationship.

Table VI-VII provides further proof that the intangibles investment - uncertainty relationship is strongly negative. On each of the four time periods 1972-1990, 1991-2000, 2001-2007, and 2008-2009 spanning our sample the relationship between intangibles investment and σ_t is strongly negative.

The time-series patterns in intangibles investment and either σ_t or η_t are also easy to spot in Figure 2. In this picture, we plot the annual cross-sectional median of both tangible and intangible investment as well as the annual cross-sectional median of σ_t and η_t. All time-series are normalized by their 1986-level, and the time-series of both tangibles and intangibles investments are shifted up to allow for an easier visual comparison.

We notice that intangibles and tangibles investments display similar patterns over time. In particular, just like tangibles investment, intangibles investment drops dramatically around the economic recessions of 1991, 2001, and 2008, and increases gradually after each of these recessions. The time series of either σ_t or η_t display exactly the opposite pattern. This observation supports further the negative relationship between intangible investment and uncertainty uncovered in Tables III and VI-VII.

Furthermore, Figure 2 also suggests that the intangible investment - uncertainty relationship is time varying. We study this possibility more formally by running an empirical experiment similar to the one described in Table VIII. In particular, variables $\log \theta_t$, σ_t, $\gamma - \gamma_t^T$, and η_t are standardized to allow for a proper comparison across time periods. Tables IX-X reports the results.

The sensitivities of intangibles investment to σ_t are negative and statistically significant in each of the three-year periods surrounding the recessions of 1991, 2001 and 2008. This result is consistent with the findings in Tables III and VI-VII and together support a strong negative relationship between intangibles investment and uncertainty.

Most interestingly, intangible investment - uncertainty sensitivities change as the economy leaves an expansionary state (three-year period leading to a recession) and enters a recessionary state (three-year period following a recession). Tables IX-X shows that intangibles investment - σ_t sensitivities increase in magnitude during the recessions of 2001 and 2008. The intangibles investment - σ_t is not statistically significant for the three-year period following the recession of 1991, and this might explain the decline in the magnitude of these sensitivities during the recession of 1991.

Overall the results of this section and the previous section support the conclusion that the relationship between corporate investment in either tangible or intangible assets and cash flow uncertainty is negative at all times, but more negative during economic recessions than during economic expansions.

C. Employment change and cash flow uncertainty

Our measure of intangible capital stock accounts for many types of intangible assets, but not all of them. One of the most important sources of intangible capital that our measure completely omits is human capital.

Capitalizing human capital is no easy task as investments in human capital are not only expensed but also commingled with other sources of cost of goods sold and operating expenses. While measuring the stock of human capital is of paramount importance in the typical macroeconomic paradigm, we do not attempt to back out such a measure in this paper. Rather, we are mostly interested in understanding how cash flow uncertainty affects the degree to which firms adjust their stock of human capital. Thus our focus is to construct a measure of investment in human capital that captures the sensitivity of changes in human capital stock to uncertainty.

One such measure that is likely to be highly correlated with the unobserved human capital investment is employment change. This measure is simply the annual rate of change in the number of employees in a firm (change in number of employees from past year divided by the past year number of employees). While this measure is arguably subject to potential problems (e.g. How accurately do firms report the current number of employees on payroll etc), the one clear advantage of using this measure is the fact that data on the number of employees is available at firm level. Most importantly for our goal, this measure is likely to capture one of the most important stylized facts around economic recessions/expansions: firms reduce labor investment during economic recessions and increase labor investment during economic expansion.[12] Figure 3 displays this behavior at the aggregate level as well as industry level.

In this section we use employment change to analyze the extend to which firms adjust investment in human capital in response to innovations in cash flow uncertainty. The empirical experiments follow the same format as with tangible and intangibles investment in the two subsections above. Results are reported in Tables IV and XI.

[12] See for instance Boileau and Normandin (2002), Reinhart and Rogoff (2009), IMF (2010), and Verick (2009).

Our findings are quite surprising. Both tables document a strong negative relationship between employment change and our measures of cash flow uncertainty. In fact this relationship seems somewhat stronger than the intangibles investment - uncertainty relationship as it is supported by both measures of uncertainty either separately or jointly. Economically, a unit standard deviation increase in η_t reduces the number of employees on average by 57.4%. Similarly, a unit standard deviation increase in σ_t reduces the number of employees on average by 24.6%. These are very large magnitudes, suggesting that firms adjust swiftly their use of labor to counteract the negative impact of large innovations in cash flow uncertainty. These results complement well the results for tangible and intangible investment in Tables II and III.

Table XI documents further that firms tend to accelerate layoffs during economic recessions. Indeed, during the recessions of 1991, 2001, and 2008, the sensitivity of employee turn over to σ_t is always larger post-recession (albeit not always statistically significant). This is also the case with η_t, especially when these sensitivities are estimated with precision.

Overall, our findings seem to suggest that firms react swiftly in response to positive innovations in cash flow uncertainty. Firms reduce tangibles investment, intangibles investment, and employ less labor in order to counteract an increase in cash flow uncertainty. This behavior becomes particularly acute during economic recessions.

V. Robustness

In the process of constructing our measures of uncertainty η_t^i and σ_t^i we typically exclude outlier observations (bottom 1% or top 99%). It is possible that these observations are themselves informative to some degree. To address this issue we construct an alternative measure of risk which is rank-based. We call this new measure π.

The rank-based risk measure π is obtained by obtained as follows. Each year, we rank firms separately with respect to σ_t or η_t. We keep all observations including outliers. Then we define π_t^i for firm i at time t as the average of firm is two ranks in year t.

We now rerun the empirical experiments of the previous section. Results are reported in Tables XII, XIII, XIV, and XV.

We notice that even when using this rank-based risk measure the main results presented in the previous sections still survive.

Our measures of cash flow uncertainty η_t^i and σ_t^i rely on important assumptions about the dynamics of the productivity shocks θ_t and $\gamma_t^{T,i}$, such as heteroskedasticity. The dynamics we consider in equations (19) and (17) are probably the simplest that we can consider while maintaining heteroskedasticity in errors. One, potentially unattractive assumption in these dynamics is the fact that while disturbances are heteroskedastic they are also serially uncorrelated. Dynamics that assume serially correlated disturbances usually assume homoskedasticity - which is not very useful given that we are interested in the time-series properties of the conditional variances of these disturbances.

We address this issue in two ways. First, for all our results we report the t-statisitics based on robust standard errors which adjust to some degree for potential serial correlation in errors. Second, we experimented with more complex dynamics for the productivity shocks. We were successful in implementing a hybrid structure on $\gamma_t^{T,i}$ which allows for both serial correlation and heteroskedasticity in errors.[13] Namely, equation (17) changes to

$$\log \gamma_t^{T,i} = \mu^i + \lambda^i \log \gamma_{t-1}^{T,i} + \epsilon_t^i, \tag{24}$$

where ϵ_t^i is serially uncorrelated with mean zero and conditional variance $E_{t-1}[(\epsilon_t^i)^2] = (\eta_t^i)^2$.

We find that even with this error structure the main results remain qualitatively the same. While not reported here, these additional results are available on demand.

Another important issue with using our cash flow uncertainty measures η_t^i and σ_t^i as independent variables in regressions is that of measurement error. Since both our uncertainty measures are not directly observable but rather backed out from the data, it is possible that due to measurement error our measures of cash flow uncertainty might still correlate with the disturbances in any version of the regression (22). In addition, all firm characteristics included in these regressions are clearly endogenous and therefore likely to correlate with regression disturbances.[14]

One way to address this possibility is to use dynamic panel data estimation methods proposed by Arellano and Bond (1992), Arellano and Bover (1995), and Ahn and Schmidt (1995). These methods estimate the regression model in differences rather than levels using general methods of moments with sets of moments that depend on whether the independent variables are exogenous relative to the disturbances or predetermined (up to some point in time).

We experiment with this approach using specifications that assume either perfect exogeneity or predetermination (up to $t-1$) and find that our results again remain qualitatively unchanged for our cash flow uncertainty measures. We do not report these results here, but they are available on demand.

Finally, when measuring investment in intangible assets we use proxy for the capitalized and expensed components of the stock of intangible capital. For instance, in (23) we proxy for the capitalized component with $\text{TA}_t - \text{CA}_t - \text{PPENT}_t$. This measure is certainly highly correlated with the stock of capitalized intangible assets, but it is also contaminated by other type of assets such as financial assets (e.g. commodity futures positions etc). To

[13]However, we were not successful in implementing this type of error structure with θ_t^i because, unlike $\gamma_t^{T,i}$, the time-series for θ_t^i are not available *prior* to estimating the conditional variance of the errors.

[14]The fact that firm characteristics such as average Tobin's q are endogenous and therefore might bias any investment regression is well known. See for instance Blundell, Bond, Devereux, and Schiantarelli (1992), Hayashi and Inoue (1991), and more recently Gilchrist and Himmelberg (1999).

address this potential issue, we consider also an alternative measure of capitalized tangible assets which picks up more carefully these type of intangible assets. This measure is the variable INTAN in Compustat. According to the Compustat definition this variable accounts for certain types of intangible assets which are capitalized when acquired. Some of these intangible assets include patents, client lists, etc. One problem with this variable is that it is available only from year 2000 onwards.

For the expensed component of intangible capital stock, in (23) we cumulate historical R&D expenses using a depreciation rate of 10%. While our R&D depreciation rate is somewhat justified by the amortizable life of R&D capital in industries such as drugs, this number is still ad-hoc. To address this issue we experiment with depreciation rates ranging from 0% to 20%.

We find that using these alternative measures for the capitalized and expensed components of intangible capital does not change our results much. Again these additional set of results are not in here but are available upon request.

VI. Discussion and Conclusions

An important stylized fact of the U.S. aggregate corporate activity is that corporate investment declines rapidly in the period leading to an economic recession, but rebounds equally rapidly in the period following a recession. For instance, Figure 2 shows that corporate investment reached pre-recession levels within 2-3 years following the recessions of 1991 and 2001.

However, the late economic recession of 2008 challenged this stylized empirical fact, as corporate investment post-recession grew painfully slow and failed to rebound to pre-recession levels. This observation has puzzled economist and policy makers alike because it is not immediately clear what causes the delay in corporate investment. For instance, a typical bottleneck known to preclude firms from pursuing growth opportunities is access to capital. However, in the aftermath of the 2008 financial crisis, the efforts of policy makers to resuscitate the credit channel failed to jump start corporate investment. Kahle and Stulz (2010) show that post-recession firms do not behave as if they face higher cost of capital. Quite the opposite in fact, as many firms hold on to significant amounts of cash on their balance sheet. This begs the obvious question: If firms face relatively unchanged or even lower costs of capital, why do we see so little corporate investment?

In this paper we argue that firms could chose to forego investment opportunities if firms assign larger conditional variances to future cash flows and perceive the net present values of their investment opportunities as being negative.

Our argument rests on the conjecture that the relationship between corporate investment and cash flow uncertainty is negative. This conjecture turns out to be true, theoretically, and supported by the data, empirically.

Our model is a neoclassical production economy with two production inputs and two productivity shocks. The two production inputs are tangible and intangible capital. The two productivity shocks capture the productivity of the two types of capital. Cobb-Douglas CES productivity functions transform inputs and productivity shocks into output.

In the context of our production economy, the marginal revenue product of capital is concave in productivity shocks. Consequently, uncertainty increases the waiting value of the option to invest an firms postpone investment. In particular, this leads to a negative relationship between corporate investment and conditional variances of both productivity shocks.

We use the conditional variances of the two shocks as our main measures of cash flow uncertainty. Thus, in our model, the relationship between investment and cash flow uncertainty is negative.

Next, we test empirically the relationship between investment and our measures of cash flow uncertainty. To this extent, we use our model as a guide to recover the two shocks from the data, and then, we employ a standard two-step procedure to back out the conditional variances of our two shocks. The two shocks we consider are the level of S&P 500 volatility index, VIX, and the one-year historical volatility of the equally-weighted risk-adjusted equity returns in the particular firms industry. These are our empirical measures of cash flow uncertainty. For the investment side of the investment-uncertainty relationship, tangibles investment is readily available in the data, but intangibles investment is not. Our measure of intangibles investment recognizes the fact that the stock of intangibles capital has two components: an observable component that captures capitalized investments in intangible assets and an unobserved component that captures expensed investments in intangible assets. Finally, we consider corporate employment as another, albeit partial, measure of corporate investment in intangibles. We place a special emphasis on corporate employment since many senior policy-makers consider the corporate employment policy as one of the more important corporate policy decisions.

Empirically, we detect a strong negative relationship between investment in either tangible or intangible assets and cash flow uncertainty. This relationship is robust to the usual determinants of corporate investments. Additionally, we find a strong negative relationship between corporate employment and cash flow uncertainty. Most interestingly, these relationships appear to be stronger during economic recessions than during any other time periods. These patterns are clearly apparent in Figure 2.

These empirical findings complement our theoretical investment-uncertainty relationship and together they suggest a compelling story for corporate investment behavior post 2008. Firms delay investment in the post-recession period because the relationship between investment and uncertainty is strongly negative during the 2008-2009 period and because cash flow uncertainty is exceptionally elevated during this time period (see for instance Figure 2).

Overall, our results suggest that the extent to which corporate investment rebounds after an economic recession depends on firms' perception about cash flow uncertainty. If firms perceive future cash flows as risky they will postpone investment and post-recession corporate investment will take longer to rebound. Our empirical findings show that not all recessions are alike. For instance, cash flow uncertainty during the post-recession periods 1991-1993 and 2001-2003 declines rapidly and, consequently, investment including employment bounces back rapidly. However, cash flow uncertainty during the post-recession period 2008-2009 has declined very slowly, and consequently corporate investment including corporate employment increases very modestly.

These findings have significant policy implications. To wit, if policy makers would like corporations to increase their investment activity, they should focus on policies that decrease corporate cash flow uncertainty. Specifically, to the extent corporations are uncertain about the implementation and the implementation-timeline of the health reform act, and the impact of this act on their costs of hiring and retaining employees - a clarification of the implementation and the implementation-timeline of the health reform act would encourage corporations to invest more and hire more employees. Similarly, to the extent corporations are uncertain about the implementation and the implementation-timeline of the environmental cap-and-trade reform and corporate tax reforms - a clarification of the implementation and the implementation-timeline of these environmental and tax reforms would encourage corporations to invest more and hire more employees.

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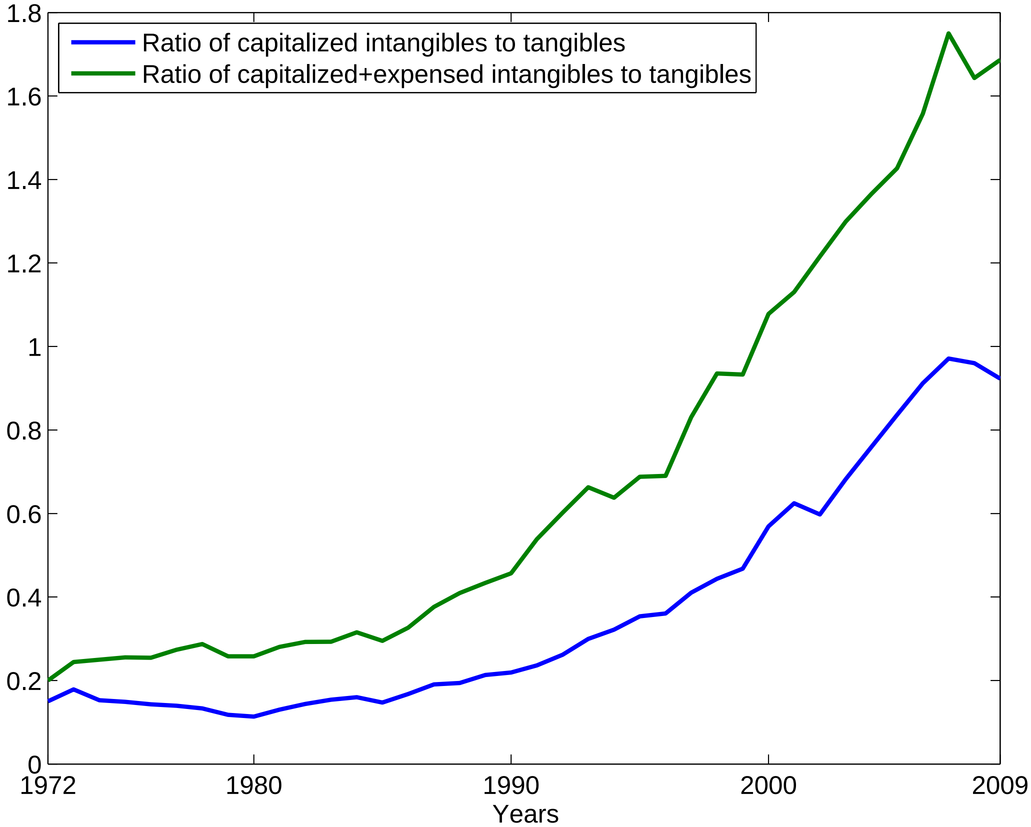

Figure 1: Stock of intangible capital: This figure plots the ratio of cross-sectional median of intangible capital stock and cross-sectional median of tangible capital stock. The stock of capitalized intangible capital is measured as book assets minus current assets, minus net property, plant and equipment. The stock of capitalized+expensed intangible capital is measured as book assets minus current assets, minus net property, plant and equipment, and plus the sum of current and past R&D expenses, $\sum_{s=t-T}^{t}(1-10\%)^{t-s}R\&D_s$, adjusted for a 10% annual depreciation. The stock of tangible capital is measured as net plant, property and equipment.

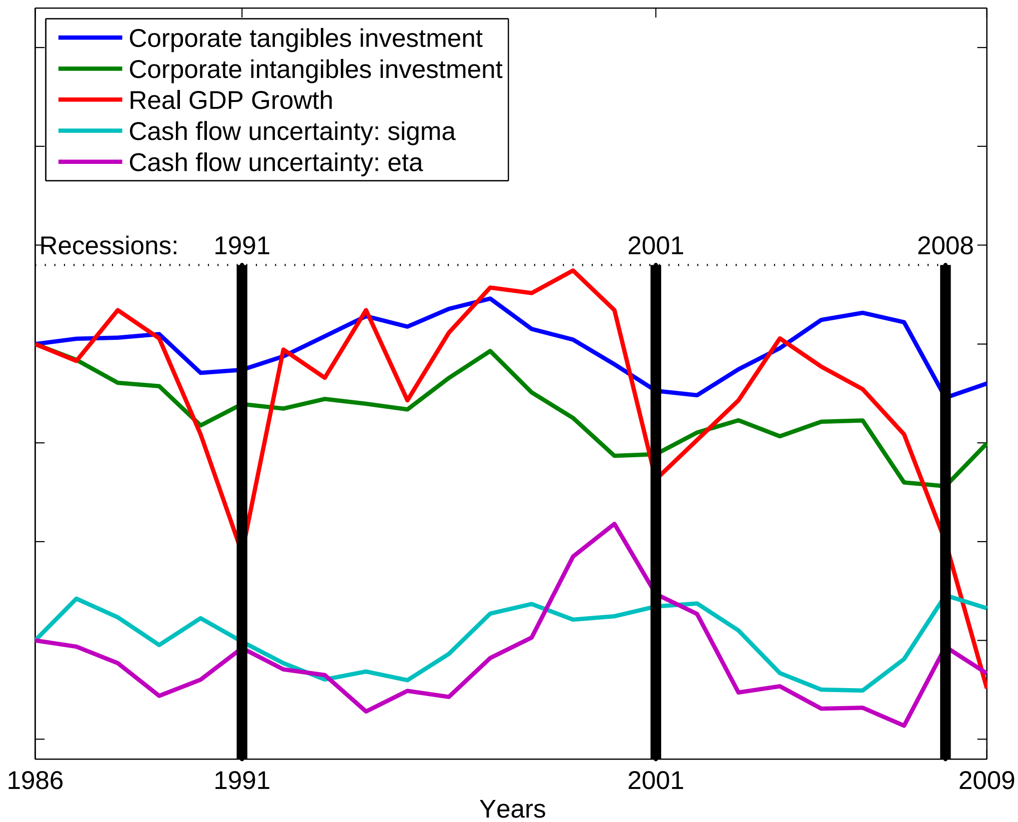

Figure 2: Corporate investment and cash flow uncertainty: This figure plots the cross-sectional medians of tangible and intangible investment over time. It also plots the cross-sectional medians of our two measures of cash flow uncertainty, namely σ_t^i and η_t^i. We refer to these later time series as "sigma" and "eta". Finally, the figure also plots the real GDP growth rate. All time-series are normalized to their 1986-levels. The normalized time series for tangibles and intangibles investment as well as real GDP growth are shifted up by the same amount to ease comparison with the time series "sigma" and "eta".

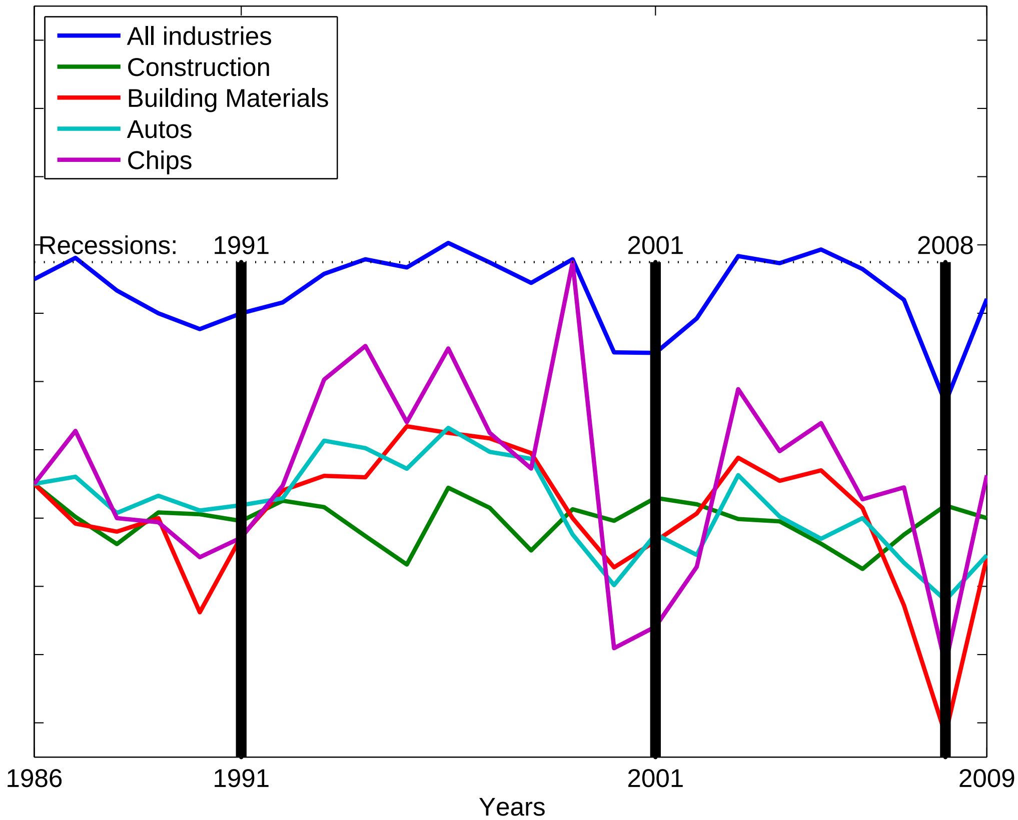

Figure 3: Employment change: This figure plots the cross-sectional medians of employment change over time. The top curve is a plot of the cross-sectional median across all industries. The bottom curves are plots of the cross-sectional median within a specific Fama-French industry. The industries included are Construction, Building Materials, Autos and Chips. All time-series are normalized to their 1986-levels. The normalized time series for the cross-sectional median across all industries is shifted up to ease comparison.

	$\frac{MA_t}{BA_t}$	$\frac{CF_t}{K_{t-1}}$	$\frac{Ca_t}{BA_t}$	$\frac{BD_t}{BA_t}$	$\log\theta_t$	σ_t	$\log\gamma_t^T$	η_t
MA_t/BA_t	100							
CF_t/K_{t-1}	1.23	100						
Ca_t/BA_t	21.34	-1.14	100					
BD_t/BA_t	-17.62	-3.54	-30.64	100				
$\log\theta_t$	-2.14	-3.27	5.63	-3.70	100			
σ_t	5.06	-20.93	10.43	-2.21	2.05	100		
$\log\gamma_t^T$	4.75	-1.59	-0.21	-5.42	-4.15	11.79	100	
η_t	1.41	-2.59	-1.06	-0.08	3.67	4.87	17.29	100

Table I: Correlation coefficients: This table reports the correlation coefficients of the regressors in Table II. All numbers are percentages (e.g., 1.23 means 1.23%). MA is market value of assets measured as market capitalization plus book debt. BA is book value of assets (COMPUSTAT Item 6). Ca is cash holding (COMPUSTAT Item 1). CF is cash flow (COMPUSTAT Item 14 + COMPUSTAT Item 18). K is book value of tangible capital (COMPUSTAT Item 8). BD is book value of debt (COMPUSTAT Item 6 - COMPUSTAT Item 216). η_t and σ_t are the two risk proxies. The former captures the conditional variance of the elasticity of output with respect to tangible capital, γ_t^T, while the latter captures the conditional variance of the total factor of productivity θ_t.

	I	II	III	IV
Const	0.214***	0.271***	0.234***	0.273***
	(37.35)	(22.74)	(39.63)	(23.62)
MA_t/BA_t	0.0273***	0.0293***	0.0272***	0.0292***
	(7.64)	(6.97)	(7.71)	(7.04)
$\text{CF}_t/\text{K}_{t-1}$	0.0122***	0.0123***	0.0121***	0.0122***
	(9.22)	(9.19)	(9.19)	(9.04)
Ca_t/BA_t	0.0135***	0.0147***	0.0135***	0.0146***
	(13.61)	(11.95)	(14.32)	(12.16)
BD_t/BA_t	-0.166***	-0.177***	-0.163***	-0.175***
	(-15.59)	(-9.81)	(-15.03)	(-9.66)
$\log\theta_t$		0.0136***		0.0136***
		(4.01)		(4.05)
σ_t		-0.339***		-0.310***
		(-5.54)		(-4.91)
$\log\gamma_t^T$			0.0479	0.0789*
			(1.05)	(2.23)
η_t			-0.812***	-0.284*
			(-6.67)	(-2.08)
N	32633	12761	32633	12761

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table II: The relationship between **tangible investment** and risk - entire sample: This table reports the results of panel-data regression of tangible investment on two risk proxies, namely η_t and σ_t. The former captures the conditional variance of the elasticity of output with respect to tangible capital, γ_t^T, while the latter captures the conditional variance of the total factor of productivity θ_t. In addition, we also include several well-known determinants of investment, namely Tobin's Q, MA/BA, cash-to-assets ratio, Ca/BA, cash-flows-to-capital ratio, CF/K, and book leverage ratio, BD/BA. Tangible investment is measured as the ratio of capital expenditures to net property, plant and equipment. All regressions are run with fixed effects and have errors clusters by industry. Robust t-statistics are reported in parentheses.

	I	II	III	IV
Const	0.120***	0.197***	0.153***	0.214***
	(13.34)	(6.84)	(6.84)	(6.44)
MA_t/BA_t	0.0299***	0.0322***	0.0299***	0.0323***
	(5.95)	(8.16)	(5.99)	(8.14)
$\text{CF}_t/\text{K}_{t-1}$	0.0125***	0.00915**	0.0123***	0.00912**
	(5.82)	(3.15)	(5.90)	(3.11)
Ca_t/BA_t	0.0103***	0.0118***	0.0103***	0.0119***
	(4.67)	(5.01)	(4.75)	(5.01)
BD_t/BA_t	-0.209***	-0.209***	-0.205***	-0.208***
	(-9.35)	(-6.11)	(-9.25)	(-6.06)
$\log\theta_t$		0.0326***		0.0325***
		(5.49)		(5.41)
σ_t		-0.364**		-0.342*
		(-2.79)		(-2.44)
$\gamma - \gamma_t^T$			0.0315	0.0351
			(0.69)	(0.62)
η_t			-0.973**	-0.221
			(-2.81)	(-0.79)
N	30528	11961	30528	11961

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table III: The relationship between **intangible investment** and risk - entire sample: This table reports the results of panel-data regression of tangible investment on two risk proxies, namely η_t and σ_t. The former captures the conditional variance of the elasticity of output with respect to intangible capital, $\gamma - \gamma_t^T$, while the latter captures the conditional variance of the total factor of productivity θ_t. In addition, we also include several well-known determinants of investment, namely Tobin's Q, MA/BA, cash-to-assets ratio, Ca/BA, cash-flows-to-capital ratio, CF/K, and book leverage ratio, BD/BA. Intangible investment is measured as the annual net rate of return in the 'stock' of intangible capital defined as book assets minus current assets, minus net property, plant and equipment, and plus the sum of current and past R&D expenses, $\sum_{s=t-T}^{t}(1-10\%)^{t-s}R\&D_s$, adjusted for a 10% annual depreciation. All regressions are run with fixed effects and have errors clusters by industry. Robust t-statistics are reported in parentheses.

	I	II	III	IV
Const	-0.00437	0.0680***	0.0189**	0.0725***
	(-0.80)	(5.02)	(2.99)	(5.32)
MA_t/BA_t	0.0216***	0.0224***	0.0216***	0.0224***
	(7.21)	(6.97)	(7.27)	(7.12)
$\text{CF}_t/\text{K}_{t-1}$	0.0109***	0.00944***	0.0108***	0.00946***
	(8.51)	(3.90)	(8.43)	(3.93)
Ca_t/BA_t	0.00566***	0.00581***	0.00567***	0.00576***
	(6.88)	(4.78)	(7.12)	(4.76)
BD_t/BA_t	-0.0789***	-0.120***	-0.0742***	-0.117***
	(-5.51)	(-6.07)	(-5.11)	(-5.91)
$\log\theta_t$		0.0186***		0.0184***
		(5.67)		(5.59)
σ_t		-0.308***		-0.246**
		(-3.59)		(-2.94)
$\log\gamma_t^T$			-0.0116	0.0616
			(-0.32)	(1.50)
η_t			-0.950***	-0.574**
			(-5.13)	(-3.11)
N	30533	11915	30533	11915

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table IV: The relationship between **employment change** and risk - entire sample: This table reports the results of panel-data regression of employment change on two risk proxies, namely η_t and σ_t. The former captures the conditional variance of the elasticity of output with respect to tangible capital, γ_t^T, while the latter captures the conditional variance of the total factor of productivity θ_t. In addition, we also include several well-known determinants of investment, namely Tobin's Q, MA/BA, cash-to-assets ratio, Ca/BA, cash-flows-to-capital ratio, CF/K, and book leverage ratio, BD/BA. Employment change is measured as the annual percentage change in the number of employees. All regressions are run with fixed effects and have errors clusters by industry. Robust t-statistics are reported in parentheses.

	1972-1990	1991-2000	2001-2007	2008-2009
MA_t/BA_t	0.0310***	0.0317***	0.0163*	0.0059
	(4.80)	(6.04)	(2.51)	(0.76)
CF_t/K_{t-1}	0.0278***	0.0156***	0.0065*	0.0069**
	(4.95)	(7.41)	(2.51)	(2.71)
Ca_t/BA_t	0.0099**	0.0178***	0.0147***	0.0095**
	(3.34)	(10.10)	(10.86)	(2.81)
BD_t/BA_t	-0.173***	-0.172***	-0.204***	-0.262***
	(-5.72)	(-6.51)	(-7.61)	(-6.66)
$\log \theta_t$	0.0089*	0.0076*	0.0017	0.0021
	(2.30)	(2.33)	(0.65)	(0.59)
σ_t	-0.237**	-0.242**	-0.282***	-0.210**
	(-2.93)	(-3.28)	(-4.54)	(-3.08)
$\log \gamma_t^T$	-0.113*	0.0313	0.139**	0.212***
	(-2.02)	(0.90)	(2.90)	(3.67)
η_t	-0.114	-0.318*	-0.736**	-0.794**
	(-0.42)	(-2.64)	(-3.02)	(-3.53)

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table V: The relationship between **tangible investment** and risk - subsamples: This table reports the results of panel-data regression of tangible investment on two risk proxies, namely η_t and σ_t. The former captures the conditional variance of the elasticity of output with respect to tangible capital, γ_t^T, while the latter captures the conditional variance of the total factor of productivity θ_t. In addition, we also include several well-known determinants of investment, namely Tobin's Q, MA/BA, cash-to-assets ratio, Ca/BA, cash-flows-to-capital ratio, CF/K, and book leverage ratio, BD/BA. Tangible investment is measured as the ratio of capital expenditures to net property, plant and equipment. The regressions are run over three different sub-samples, namely 1972-1990, 1991-2000, 2001-2007, and 2008-2009. These time-periods are delimited by the economic recessions of 1991, 2001, and 2008, as defined by NBER. All regressions are run with fixed effects and have errors clusters by industry. Robust t-statistics are reported in parentheses.

	1972-1990	1991-2000	2001-2007	2008-2009
MA_t/BA_t	0.0352***	0.0317***	0.0250**	0.0250
	(5.65)	(6.29)	(3.15)	(1.91)
CF_t/K_{t-1}	0.0268*	0.0093*	0.0061	0.0012
	(2.18)	(2.66)	(1.21)	(0.22)
Ca_t/BA_t	0.0162**	0.0182***	0.0079**	0.0058
	(2.78)	(5.22)	(3.42)	(0.90)
BD_t/BA_t	-0.1850***	-0.1950***	-0.2680***	-0.3840***
	(-3.96)	(-4.26)	(-6.60)	(-4.27)
$\log\theta_t$	0.0387**	0.0456**	0.0458*	0.0406
	(2.84)	(3.06)	(2.64)	(1.84)
σ_t	-0.0633*	-0.0776***	-0.0814**	-0.0813**
	(-2.33)	(-3.63)	(-3.53)	(-2.83)

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table VI: The relationship between **intangible investment** and risk - subsamples: This table reports the results of panel-data regression of intangible investment on two risk proxies, namely η_t and σ_t. The former captures the conditional variance of the elasticity of output with respect to intangible capital, $\gamma - \gamma_t^T$, while the latter captures the conditional variance of the total factor of productivity θ_t. In addition, we also include several well-known determinants of investment, namely Tobin's Q, MA/BA, cash-to-assets ratio, Ca/BA, cash-flows-to-capital ratio, CF/K, and book leverage ratio, BD/BA. Intangible investment is measured as the annual net rate of return in the 'stock' of intangible capital defined as book assets minus current assets, minus net property, plant and equipment, and plus the sum of current and past R&D expenses, $\sum_{s=t-T}^{t}(1-10\%)^{t-s}R\&D_s$, adjusted for a 10% annual depreciation. The regressions are run over three different sub-samples, namely 1972-1990, 1991-2000, 2001-2007, and 2008-2009. These time-periods are delimited by the economic recessions of 1991, 2001, and 2008, as defined by NBER. All regressions are run with fixed effects and have errors clusters by industry. Robust t-statistics are reported in parentheses.

	1972-1990	1991-2000	2001-2007	2008-2009
$\mathrm{MA}_t/\mathrm{BA}_t$	0.0459***	0.0270***	0.0203***	0.0137
	(4.86)	(4.66)	(4.02)	(0.95)
$\mathrm{CF}_t/\mathrm{K}_{t-1}$	0.0289***	0.0130***	0.0081***	0.0030
	(4.06)	(5.35)	(3.56)	(0.79)
$\mathrm{Ca}_t/\mathrm{BA}_t$	0.0141**	0.0164***	0.0079***	0.0010
	(3.52)	(7.39)	(4.48)	(0.26)
$\mathrm{BD}_t/\mathrm{BA}_t$	-0.1770***	-0.1940***	-0.2640***	-0.4030***
	(-6.25)	(-7.00)	(-6.26)	(-7.36)
$\gamma - \gamma_t^T$	0.0132	0.0124	0.0303*	0.0107
	(0.91)	(0.71)	(2.03)	(0.61)
η_t	0.0003	-0.0194***	-0.0222***	-0.0284***
	(0.04)	(-3.68)	(-4.19)	(-4.10)

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table VII: The relationship between **intangible investment** and risk - subsamples: This table reports the results of panel-data regression of intangible investment on two risk proxies, namely η_t and σ_t. The former captures the conditional variance of the elasticity of output with respect to intangible capital, $\gamma - \gamma_t^T$, while the latter captures the conditional variance of the total factor of productivity θ_t. In addition, we also include several well-known determinants of investment, namely Tobin's Q, MA/BA, cash-to-assets ratio, Ca/BA, cash-flows-to-capital ratio, CF/K, and book leverage ratio, BD/BA. Intangible investment is measured as the annual net rate of return in the 'stock' of intangible capital defined as book assets minus current assets, minus net property, plant and equipment, and plus the sum of current and past R&D expenses, $\sum_{s=t-T}^{t}(1-10\%)^{t-s}R\&D_s$, adjusted for a 10% annual depreciation. The regressions are run over three different sub-samples, namely 1972-1990, 1991-2000, 2001-2007, and 2008-2009. These time-periods are delimited by the economic recessions of 1991, 2001, and 2008, as defined by NBER. All regressions are run with fixed effects and have errors clusters by industry. Robust t-statistics are reported in parentheses.

	1991		2001		2008	
	88-90	91-93	98-00	01-03	05-07	08-10
MA_t/BA_t	0.0215**	0.0179***	0.0240***	-0.0002	0.0082	-0.0018
	(2.73)	(3.79)	(4.86)	(-0.03)	(1.33)	(-0.29)
$\text{CF}_t/\text{K}_{t-1}$	0.0248***	0.0204***	0.0104***	0.0063*	0.0096	0.0064***
	(5.22)	(4.43)	(5.01)	(2.31)	(1.69)	(3.61)
Ca_t/BA_t	0.0048	0.0099***	0.0110**	0.0085***	0.0078***	0.0018
	(1.74)	(3.63)	(3.03)	(4.73)	(5.11)	(0.60)
BD_t/BA_t	-0.176***	-0.124***	-0.165***	-0.159***	-0.134***	-0.224***
	(-5.35)	(-3.85)	(-5.16)	(-5.63)	(-4.48)	(-5.38)
$\log \theta_t$	0.0074	0.0156**	0.0142***	0.0106*	0.0041	0.0092
	(1.71)	(3.12)	(3.73)	(2.53)	(0.96)	(1.12)
σ_t	-0.0183	-0.0202*	-0.0217**	-0.0289***	-0.0165	-0.0176*
	(-1.74)	(-2.07)	(-3.23)	(-5.85)	(-1.88)	(-2.54)
$\log \gamma_t^T$	-0.0049	0.0018	-0.0051	0.0112*	0.0117	0.0204***
	(-0.77)	(0.45)	(-1.16)	(2.55)	(1.25)	(3.98)
η_t	-0.0027	-0.0054	-0.0104**	-0.0169**	-0.0132	-0.0216***
	(-0.40)	(-1.53)	(-3.07)	(-2.94)	(-1.85)	(-3.66)

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table VIII: The relationship between **tangible investment** and risk - economic recessions: This table reports the results of panel-data regression of tangible investment on two risk proxies, namely η_t and σ_t. The former captures the conditional variance of the elasticity of output with respect to tangible capital, γ_t^T, while the latter captures the conditional variance of the total factor of productivity θ_t. In addition, we also include several well-known determinants of investment, namely Tobin's Q, MA/BA, cash-to-assets ratio, Ca/BA, cash-flows-to-capital ratio, CF/K, and book leverage ratio, BD/BA. Tangible investment is measured as the ratio of capital expenditures to net property, plant and equipment. The regressions are run for sub-samples surrounding the economic recessions of 1991, 2001, and 2008, as defined by NBER. To capture the change in coefficients from before an economic recession to after we multiply our variables with time dummies. We report the coefficients in front of these time-interacted variables. All regressions are run with fixed effects and have errors clusters by industry. Robust t-statistics are reported in parentheses.

	1991		2001		2008	
	88-90	91-93	98-00	01-03	05-07	08-10
MA_t/BA_t	0.0188*	0.0119**	0.0187***	0.0145*	0.0075	0.0107
	(2.42)	(3.25)	(4.65)	(2.23)	(0.89)	(0.93)
CF_t/K_{t-1}	0.0247*	0.0146	0.0072	0.0067	0.0089	0.0007
	(2.63)	(1.87)	(1.87)	(0.96)	(1.75)	(0.12)
Ca_t/BA_t	0.0139*	0.0187***	0.0086**	0.0053*	-0.0023	-0.0014
	(2.17)	(3.80)	(2.74)	(2.05)	(-0.59)	(-0.20)
BD_t/BA_t	-0.173**	-0.0841	-0.235***	-0.166**	-0.362***	-0.353***
	(-3.24)	(-1.50)	(-4.18)	(-3.09)	(-5.33)	(-3.64)
$\log\theta_t$	0.0170**	0.0180*	0.0058	0.0180	0.0239	0.0174
	(3.01)	(2.69)	(0.46)	(1.79)	(1.69)	(1.03)
σ_t	-0.0107	-0.0069	-0.0348**	-0.0499***	-0.0275	-0.0395*
	(-0.70)	(-0.69)	(-3.50)	(-3.59)	(-1.80)	(-2.27)

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table IX: The relationship between **intangible investment** and risk - economic recessions: This table reports the results of panel-data regression of intangible investment on two risk proxies, namely η_t and σ_t. The former captures the conditional variance of the elasticity of output with respect to intangible capital, $\gamma - \gamma_t^T$, while the latter captures the conditional variance of the total factor of productivity θ_t. In addition, we also include several well-known determinants of investment, namely Tobin's Q, MA/BA, cash-to-assets ratio, Ca/BA, cash-flows-to-capital ratio, CF/K, and book leverage ratio, BD/BA. Intangible investment is measured as the annual net rate of return in the 'stock' of intangible capital defined as book assets minus current assets, minus net property, plant and equipment, and plus the sum of current and past R&D expenses, $\sum_{s=t-T}^{t}(1-10\%)^{t-s}R\&D_s$, adjusted for a 10% annual depreciation. The regressions are run for sub-samples surrounding the economic recessions of 1991, 2001, and 2008, as defined by NBER. To capture the change in coefficients from before an economic recession to after we multiply our variables with time dummies. We report the coefficients in front of these time-interacted variables. All regressions are run with fixed effects and have errors clusters by industry. Robust t-statistics are reported in parentheses.

	1991		2001		2008	
	88-90	91-93	98-00	01-03	05-07	08-10
MA_t/BA_t	0.0139**	0.0129**	0.0159***	0.0093*	0.0118	-0.0003
	(3.34)	(3.24)	(3.88)	(2.12)	(1.33)	(-0.02)
CF_t/K_{t-1}	0.0218**	0.0137*	0.0118***	0.0101**	0.0086**	0.0032
	(2.91)	(2.40)	(3.86)	(3.45)	(3.14)	(0.90)
Ca_t/BA_t	0.0192**	0.0199***	0.0084**	0.0069***	-0.0015	-0.0041
	(3.18)	(4.70)	(2.95)	(4.26)	(-0.46)	(-1.00)
BD_t/BA_t	-0.193***	-0.134***	-0.233***	-0.180***	-0.380***	-0.390***
	(-5.71)	(-4.10)	(-5.95)	(-4.52)	(-5.76)	(-8.00)
$\gamma - \gamma_t^T$	-0.0026	-0.0062	-0.0023	0.0103	0.0209*	-0.0047
	(-0.34)	(-0.74)	(-0.18)	(1.64)	(2.46)	(-0.48)
η_t	-0.0263**	-0.0304***	-0.0281***	-0.0376***	-0.0253**	-0.0338***
	(-3.29)	(-5.39)	(-4.79)	(-5.76)	(-3.18)	(-5.07)

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table X: The relationship between **intangible investment** and risk - economic recessions: This table reports the results of panel-data regression of intangible investment on two risk proxies, namely η_t and σ_t. The former captures the conditional variance of the elasticity of output with respect to intangible capital, $\gamma - \gamma_t^T$, while the latter captures the conditional variance of the total factor of productivity θ_t. In addition, we also include several well-known determinants of investment, namely Tobin's Q, MA/BA, cash-to-assets ratio, Ca/BA, cash-flows-to-capital ratio, CF/K, and book leverage ratio, BD/BA. Intangible investment is measured as the annual net rate of return in the 'stock' of intangible capital defined as book assets minus current assets, minus net property, plant and equipment, and plus the sum of current and past R&D expenses, $\sum_{s=t-T}^{t}(1-10\%)^{t-s}R\&D_s$, adjusted for a 10% annual depreciation. The regressions are run for sub-samples surrounding the economic recessions of 1991, 2001, and 2008, as defined by NBER. To capture the change in coefficients from before an economic recession to after we multiply our variables with time dummies. We report the coefficients in front of these time-interacted variables. All regressions are run with fixed effects and have errors clusters by industry. Robust t-statistics are reported in parentheses.

	1991		2001		2008	
	88-90	91-93	98-00	01-03	05-07	08-10
MA_t/BA_t	0.0118*	0.0135***	0.0190***	0.00672	0.0189*	0.00725
	(2.19)	(4.28)	(5.34)	(1.79)	(2.39)	(1.10)
$\text{CF}_t/\text{K}_{t-1}$	-0.00363	0.0102	0.00884***	0.00795*	0.00860*	0.00249
	(-0.32)	(1.42)	(4.29)	(2.04)	(2.41)	(0.83)
Ca_t/BA_t	0.00477	0.00716	0.00163	0.00277	0.00112	-0.00457
	(1.24)	(1.94)	(0.68)	(1.29)	(0.62)	(-1.60)
BD_t/BA_t	-0.0571	-0.0663	-0.183***	-0.147***	-0.178***	-0.355***
	(-1.31)	(-1.69)	(-3.81)	(-4.52)	(-3.86)	(-5.23)
$\log\theta_t$	0.00916	0.0168**	0.0148	0.00903	0.0173*	0.0213
	(1.51)	(3.24)	(1.80)	(1.32)	(2.61)	(1.49)
σ_t	-0.0170	-0.0209	-0.0138	-0.0143	-0.0263**	-0.0307*
	(-1.31)	(-1.39)	(-1.51)	(-0.92)	(-2.97)	(-2.07)
$\log\gamma_t^T$	-0.00187	-0.00447	-0.00660	0.00843	0.0241**	-0.00336
	(-0.26)	(-0.84)	(-0.69)	(1.72)	(3.03)	(-0.50)
η_t	-0.00120	-0.00374	-0.0117*	-0.0172*	-0.0218*	-0.00879
	(-0.15)	(-0.73)	(-2.19)	(-2.63)	(-2.23)	(-1.10)

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table XI: The relationship between **employment change** and risk - economic recessions: This table reports the results of panel-data regression of employment change on two risk proxies, namely η_t and σ_t. The former captures the conditional variance of the elasticity of output with respect to tangible capital, γ_t^T, while the latter captures the conditional variance of the total factor of productivity θ_t. In addition, we also include several well-known determinants of investment, namely Tobin's Q, MA/BA, cash-to-assets ratio, Ca/BA, cash-flows-to-capital ratio, CF/K, and book leverage ratio, BD/BA. Employment change is measured as the annual percentage change in the number of employees. The regressions are run for sub-samples surrounding the economic recessions of 1991, 2001, and 2008, as defined by NBER. To capture the change in coefficients from before an economic recession to after we multiply our variables with time dummies. We report the coefficients in front of these time-interacted variables. All regressions are run with fixed effects and have errors clusters by industry. Robust t-statistics are reported in parentheses.

Dependent	Tang Inv$_{t+1}$	Intang Inv$_{t+1}$	Empl. Change$_{t+1}$
Const	0.246***	0.199***	0.0836***
	(15.38)	(6.57)	(4.16)
MA$_t$/BA$_t$	0.0302***	0.0335***	0.0234***
	(7.14)	(8.38)	(7.22)
CF$_t$/K$_{t-1}$	0.0127***	0.00950**	0.00976***
	(9.34)	(3.19)	(3.98)
Ca$_t$/BA$_t$	0.0145***	0.0117***	0.00571***
	(11.31)	(4.97)	(4.74)
BD$_t$/BA$_t$	-0.181***	-0.214***	-0.124***
	(-9.97)	(-6.27)	(-6.31)
$\log \gamma_t^T$	0.0761	-0.00105	0.0581
	(2.01)	(-0.02)	(1.39)
$\log \theta_t$	0.0135***	0.0320***	0.0179***
	(4.05)	(5.27)	(5.10)
π_t	-0.0551*	-0.118*	-0.127*
	(-2.03)	(-2.09)	(-2.63)
N	12764	11961	11915

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table XII: The relationship between investment and risk - entire sample: This table reports the results of panel-data regression of investment in tangible, intangible and human capital on the rank-based risk measure π. The rank-based risk measure π is obtained as follows. Each year, we rank firms separately using η_t or σ_t. Then we define π_t^i for firm i at time t as the average of firm i's two ranks in year t. We include among other explanatory variables the levels of the productivity shocks $\log \gamma_t^{T,i}$ and $\log \theta_t^i$ to capture business cycle effects. In addition, we also include among explanatory variables several well-known determinants of investment, namely Tobin's Q, MA/BA, cash-to-assets ratio, Ca/BA, cash-flows-to-capital ratio, CF/K, and book leverage ratio, BD/BA. Tangible investment is measured as the ratio of capital expenditures to net property, plant and equipment. Intangible investment is measured as the annual net rate of return in the 'stock' of intangible capital defined as book assets minus current assets, minus net property, plant and equipment, and plus the sum of current and past R&D expenses, $\sum_{s=t-T}^{t}(1-10\%)^{t-s}R\&D_s$, adjusted for a 10% annual depreciation. Employment change is measured as the annual percentage change in the number of employees. All regressions are run with fixed effects and have errors clusters by industry. Robust t-statistics are reported in parentheses.

	1991		2001		2008	
	88-90	91-93	98-00	01-03	05-07	08-10
MA_t/BA_t	0.0264**	0.0191***	0.0245***	0.00295	0.00942	0.00111
	(3.25)	(3.96)	(5.16)	(0.56)	(1.48)	(0.17)
CF_t/K_{t-1}	0.0263***	0.0217***	0.0111***	0.00719**	0.00986	0.00678***
	(5.58)	(4.31)	(5.17)	(2.71)	(1.71)	(3.92)
Ca_t/BA_t	0.00528*	0.0100***	0.0107**	0.00891***	0.00786***	0.00297
	(2.06)	(3.63)	(2.98)	(5.35)	(5.42)	(1.03)
BD_t/BA_t	-0.154***	-0.110**	-0.158***	-0.133***	-0.119**	-0.186***
	(-4.18)	(-3.41)	(-4.22)	(-4.49)	(-3.42)	(-4.02)
$\log \gamma_t^T$	-0.00400	0.00225	-0.00640	0.0102*	0.0111	0.0190**
	(-0.54)	(0.55)	(-1.35)	(2.50)	(1.18)	(3.37)
$\log \theta_t$	0.00532	0.0132*	0.0119**	0.00678	0.00212	0.00375
	(1.27)	(2.51)	(3.03)	(1.76)	(0.48)	(0.50)
π_t	-0.0141*	-0.0127*	-0.0147***	-0.0244***	-0.0143**	-0.0243***
	(-2.50)	(-2.61)	(-3.94)	(-6.70)	(-2.87)	(-5.87)

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table XIII: The relationship between intangible investment and risk - economic recessions: This table reports the results of panel-data regression of investment in tangible capital on the rank-based risk measure π. The rank-based risk measure π is obtained as follows. Each year, we rank firms separately using η_t or σ_t. Then we define π_t^i for firm i at time t as the average of firm i's two ranks in year t. We include among other explanatory variables the levels of the productivity shocks $\log \gamma_t^{T,i}$ and $\log \theta_t^i$ to capture business cycle effects. In addition, we also include among explanatory variables several well-known determinants of investment, namely Tobin's Q, MA/BA, cash-to-assets ratio, Ca/BA, cash-flows-to-capital ratio, CF/K, and book leverage ratio, BD/BA. Tangible investment is measured as the ratio of capital expenditures to net property, plant and equipment. All regressions are run with fixed effects and have errors clusters by industry. Robust t-statistics are reported in parentheses.

	1991		2001		2008	
	88-90	91-93	98-00	01-03	05-07	08-10
MA_t/BA_t	0.0230**	0.0119*	0.0217***	0.0179**	0.0143	0.0193
	(2.73)	(2.54)	(5.59)	(2.91)	(1.47)	(1.60)
CF_t/K_{t-1}	0.0147*	0.0130	0.00812*	0.00916	0.00939	0.00174
	(2.24)	(1.68)	(2.18)	(1.30)	(2.00)	(0.31)
Ca_t/BA_t	0.0192**	0.0189***	0.00950*	0.00521	-0.00139	-0.000395
	(3.18)	(3.84)	(2.67)	(1.94)	(-0.38)	(-0.07)
BD_t/BA_t	-0.160**	-0.0846	-0.194**	-0.132*	-0.303***	-0.282*
	(-3.00)	(-1.80)	(-2.83)	(-2.32)	(-4.04)	(-2.65)
$\log \theta_t$	0.0153*	0.0169*	0.00168	0.0147	0.0181	0.0121
	(2.47)	(2.28)	(0.14)	(1.36)	(1.34)	(0.69)
π_t	-0.00859	-0.00301	-0.0206***	-0.0243***	-0.0230**	-0.0291**
	(-1.28)	(-0.58)	(-3.82)	(-3.56)	(-2.88)	(-3.28)

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table XIV: The relationship between **intangible investment** and risk - economic recessions: This table reports the results of panel-data regression of investment in intangible capital on the rank-based risk measure π. The rank-based risk measure π is obtained as follows. Each year, we rank firms separately using η_t or σ_t. Then we define π_t^i for firm i at time t as the average of firm i's two ranks in year t. We include among other explanatory variables the level of productivity shock $\log \theta_t^i$ to capture business cycle effects. In addition, we also include among explanatory variables several well-known determinants of investment, namely Tobin's Q, MA/BA, cash-to-assets ratio, Ca/BA, cash-flows-to-capital ratio, CF/K, and book leverage ratio, BD/BA. Intangible investment is measured as the annual net rate of return in the 'stock' of intangible capital defined as book assets minus current assets, minus net property, plant and equipment, and plus the sum of current and past R&D expenses, $\sum_{s=t-T}^{t}(1-10\%)^{t-s} R\&D_s$, adjusted for a 10% annual depreciation. All regressions are run with fixed effects and have errors clusters by industry. Robust t-statistics are reported in parentheses.

	1991		2001		2008	
	88-90	91-93	98-00	01-03	05-07	08-10
$\mathrm{MA}_t/\mathrm{BA}_t$	0.0142**	0.0129***	0.0190***	0.00877*	0.0179**	0.0127
	(2.81)	(4.21)	(4.94)	(2.41)	(2.92)	(1.86)
$\mathrm{CF}_t/\mathrm{K}_{t-1}$	-0.000247	0.00959	0.00694**	0.0113***	0.00997**	0.00348
	(-0.02)	(1.35)	(2.71)	(4.31)	(2.84)	(1.13)
$\mathrm{Ca}_t/\mathrm{BA}_t$	0.00711	0.00779*	0.00140	0.00260	0.00263	-0.00268
	(1.69)	(2.27)	(0.63)	(1.24)	(1.43)	(-0.91)
$\mathrm{BD}_t/\mathrm{BA}_t$	-0.0276	-0.0310	-0.145**	-0.123***	-0.124*	-0.271***
	(-0.69)	(-0.89)	(-2.77)	(-3.88)	(-2.46)	(-3.88)
$\log\theta_t$	0.00881	0.0153**	0.00911	0.00581	0.0123*	0.0176
	(1.48)	(3.18)	(1.14)	(0.91)	(2.08)	(1.33)
π_t	-0.0115*	-0.0106*	-0.0160**	-0.0168***	-0.0227***	-0.0258***
	(-2.09)	(-2.58)	(-3.27)	(-3.66)	(-4.08)	(-3.64)

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table XV: The relationship between **employment change** and risk - economic recessions: This table reports the results of panel-data regression of investment in human capital on the rank-based risk measure π. The rank-based risk measure π is obtained as follows. Each year, we rank firms separately using η_t or σ_t. Then we define π_t^i for firm i at time t as the average of firm i's two ranks in year t. We include among other explanatory variables the level of productivity shock $\log\theta_t^i$ to capture business cycle effects. In addition, we also include among explanatory variables several well-known determinants of investment, namely Tobin's Q, MA/BA, cash-to-assets ratio, Ca/BA, cash-flows-to-capital ratio, CF/K, and book leverage ratio, BD/BA. Employment change is measured as the annual percentage change in the number of employees. All regressions are run with fixed effects and have errors clusters by industry. Robust t-statistics are reported in parentheses.