The real effects of stock market mispricing at the aggregate: Theory and Empirical Evidence

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Abstract

In this paper we investigate whether stock market overpricing leads to aggregate (real) inefficiencies. We first investigate a standard dynamic contracting model of investment subject to financing constraints. We show that stock market mispricing will have two robust effects on welfare: on the one hand it will distort investment decisions and lead to inefficiencies. On the other hand it will alleviate underinvestment problems and allow some efficient projects to be undertaken. We then turn to the data and investigate which of the two effects dominates at the aggregate. By using proxies for investor sentiment within a vector autoregression (VAR) we find that positive shocks to sentiment boost (real) investment while reducing aggregate profits over the long run, all else equal. We interpret this as evidence that mispricing causes more inefficiencies than it corrects.

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1 Introduction

"We have a company that earlier this year was out trying to raise a second round of funding", says Atlas Venture's Michael Feinstein. "And it wasn't going too well because his valuation expectation was too high. He thinks the slumping equity markets don't apply to him because his company is so great. The thing he doesn't understand is when the water level in the ocean goes down, all boats sink."

Boston Business Forward, October 2001

The dramatic rise and fall of the stock market around the turn of the millennium raised a number of questions and concerns about both the rationality and the real effects of such rapid changes in stock valuations. Economists are still debating whether there was a "bubble" in the market or whether the behavior of prices was just a symptom of a well founded belief that the structure of the economy had fundamentally changed in that period. An equally important question concerns the real effects of this variation in stock prices. In most policy related discussion at the time, physical investment by corporations was commonly viewed as the thread that connected the financial sector with the real economy, and rightly so. There is little doubt that among all macroeconomic aggregates investment was the one that was most affected by the rise and drop in stock market valuations.

In a way this behavior of investment is hardly surprising in light of the neoclassical (Tobin's "q") theory of investment. As the left panel of figure 1 shows, both q and the investment/capital ratio rose and fell together during the boom and the collapse of the stock market. Indeed, under certain assumptions[1] standard q theory predicts that investment should be affected by potential overpricing in the stock market.

However, another quite pervasive observation is that investment by younger firms was affected by speculation much more than the investment behavior of older firms. The right panel of figure 1

[1] [Panageas 2003] develops a model where mispricing is endogenous (due to shorting constraints) and shows that "q" theory holds as long as a) investors are short termist and b) there is disagreement about the marginal product of capital. See also [Blanchard, Rhee, and Summers 1993], [Gilchrist, Himmelberg, and Huberman 2002], [Polk and Sapienza 2002], [Stein 1996] who make similar points.

plots first differences in log q, the log investment to capital ratio and log aggregate disbursements to portfolio companies by Venture capitalists (VC's). A pattern that emerges from this figure is that movements in VC disbursements are more volatile and more sensitive to a change in loq q compared to changes in the aggregate investment to capital ratio. This suggests that speculation in the markets might be operating through a second channel, namely by relaxing financing constraints which are likely to affect younger firms more than established companies.

This observation raises some important questions concerning the real effects of potential speculative mispricing. On the one hand one would expect mispricing to have distortionary effects on investment. Overly optimistic expectations might lead to investment in projects that ex-post turn out to be loss-making. On the other hand however, a certain degree of speculation might actually help overcome underinvestment problems and hence increase the number of efficient investments in the economy, if indeed mispricing has the effect of relaxing financing constraints.

The present paper develops a unified theory to study investment in the presence of both mispricing and financing constraints in a dynamic framework. We first develop a theoretical framework that examines the optimal dynamic contract between an entrepreneur and a financier in the presence of mispricing. The model addresses the question of why speculative mispricing in the stock market seems to be more important for young companies rather than established ones. The explanation that we propose in this paper is simple and intuitive: The stock market offers all parties involved in the creation of a new venture an attractive way of reaping benefits from the contractual relationship: speculative gains from flotation of shares. In this way, a severe increase in the speculative component of the stock market has similar effects to an increase in collateral: Collateral is an option to exchange the continuation value of a company with the value of the collateral. Similarly, an increase in the speculative component of shares provides initial investors and entrepreneurs with the option to exchange the continuation value of the company with the speculative gains from its flotation. This analogy explains why younger firms can benefit mostly from an increase in the speculative components of prices.

These intuitions are formalized in the context of an intertemporal dynamic contracting framework. We derive the dynamic optimal contract between an entrepreneur and a financier in a setup similar to [Albuquerque and Hopenhayn 2004] (for similar models see also [DeMarzo and Fischman 2003a], [DeMarzo and Fischman 2003b], [Clementi and Hopenhayn 2002], [Cooley and

Quadrini 2001], [Jermann and Quadrini 2002], [Cooley, Marimon, and Quadrini 2003] for example) The advantage of these frameworks is that they are explicitly dynamic and hence allow a clear modelling of magnitudes related to company age and size. Besides some of the standard assumptions of these models, we allow for the possibility of "exit" from the contract, broadly defined as the reselling of the company to potentially overoptimistic outside investors. The model makes a sequence of predictions about the data

- Mispricing should affect investment by younger companies more than investment by older companies. Actually, we discuss generic cases where speculative mispricing has *no real* effect on established companies, while it has real effects on younger companies only.

- Conditional on firm age, the time to "exit" is shortened by an increase in mispricing, and more so for younger rather than older companies.

- An increase in mispricing will increase the size of new business starts

- Increases in mispricing will increase the set of efficient (under the objective probability measure) projects that become financially feasible. At the same time it will increase the number of inefficient investments. The theoretical analysis that we conduct actually produces a generic result: Mispricing will *always* result in efficiency gains for projects that are *sufficiently* financially constrained, while it will *always* lead to inefficiencies when financing constraints cease to bind.

This last observation suggests that theory alone cannot produce a clear answer concerning the (in-)efficiency of mispricing at the aggregate. Whether mispricing will increase the number of inefficient investments more than the number of efficient ones will crucially depend on the relative importance of financing constraint relaxations to investment distortions. Hence, evaluating the aggregate real effects of mispricing becomes necessarily an empirical question.

The most important aspect of the efficiency criterion that we propose is that it reduces to a simple test: If the long run effect of a shock to the "average holding horizon" results in a decrease in aggregate profits, that strongly suggests that the distortionary effects outweigh the relaxation of financing constraints and vice versa.

We take up this question in the empirical part of the paper. We adopt a fairly atheoretical approach. In particular we start by estimating a vector autoregression of changes in real (log) aggregate profits and changes in (log) turnover[2] of trading in the NYSE from 1916 to 2003. We allow the first quantity to be subject to (contemporaneous) fundamental shocks, while the latter quantity is subject to both fundamental and shocks to "investor horizons". As we argue, there are a number of theoretical and empirical grounds to interpret increases in turnover and volume as indicators of an increase in speculative trading. Turnover is just a measure of investors' average holding horizons. In theoretical models (e.g. [Scheinkman and Xiong 2003]) this quantity is just a non-linear transformation of the extent of mispricing. Using a VAR methodology we show that the long run effect of a shock to investor horizons leads to statistically significant reductions in aggregate profits. We interpret this as being consistent with the view that increases in speculation are inefficient.

We then inspect the mechanism by which shorter average investment horizons affect the real economy, to verify that it conforms with the model. By using direct regressions of investment and new company creation on profits,q, and volume (or turnover) we confirm the basic predictions of the model: both aggregate investment and new company creation at the aggregate respond positively to investor short-termism. However, the magnitudes are strikingly different. The sensitivity of aggregate investment to shocks in average holding horizons is substantially lower than the sensitivity of new company creation, by an order of magnitude.

The joint finding that a) a shock to speculative trading increases new company creation and aggregate investment while b) reducing profits suggests that the average project undertaken is loss making. This finding seems inconsistent with either purely rational theories or with theories that accept the possibility of mispricing, but claim that the relaxation of financing constraints is relatively more important than the investment distortions that it creates. We perform various robustness checks by expanding the number of variables in the basic variable VAR and ordering the variables in alternative ways. The basic finding remains the same: In contrast to all other shocks, shocks to investor horizons increase investment, however they tend to decrease aggregate profits over the subsequent years. We are led to conclude that increased short termism and speculation will increase the investment distortions in the economy and lead to loss making projects.

[2] We also use changes in log volume and obtain similar results.

Finally, we investigate how well our VAR framework fits the data of the late nineties. We find that the model predicts the movements of investment and profits quite well from 1996-1999, but the subsequent drops in profits and investment from 2000-2002 are larger than what the model predicts. Hence, compared to the historical experience, the reaction of investment and aggregate profits was *even* larger than what the simple VAR framework predicts.

The paper is related to a literature in corporate finance and macroeconomics that investigates whether a) firms try to time the market with their financing decisions and b) whether bubbles affect investment. Some representative work is [Baker, Stein, and Wurgler 2003], [Baker and Wurgler 2000], [Blanchard, Rhee, and Summers 1993], [Morck, Shleifer, and Vishny 1990], [Polk and Sapienza 2002], [Gilchrist, Himmelberg, and Huberman 2002], [Chirinko and Schaller 1996], [Chirinko and Schaller 2001], [Panageas 2003], and [Stein 1996]. An important theme in this literature is that bubbles could potentially be beneficial for companies faced with financing constraints. However, most of the models do not explicitly model the source of the constraints, nor do they analyze the effects of the bubble in a "life cycle" model of firm investment and financing. By having an explicit dynamic model of the underinvestment problem we are able to show how the life cycle of a company's growth can be used in order to identify the effects of mispricing that are attributable to the financing channel. It also allows us to make joint predictions about a number of quantities, like the average time to "exit", the set and size of financially feasible projects. Most importantly, since the financing constraints are endogenous we can address efficiency questions.

A related strand of the literature models bubbles with OLG models. A partial listing of this voluminous literature would include [Abel, Mankiw, Summers, and Zeckhauser 1989], [Tirole 1985], [Olivier 2000], [Caballero, Farhi, and Hammour 2004], [Santos and Woodford 1997]. Bubbles in this literature arise sometimes in dynamically inefficient economies, and thus they help resolve an overaccumulation problem. The argument that we give in this paper is quite distinct: In our model, mispricing is efficient because it helps resolve an underinvestment problem. Moreover, we don't need to assume that agents have finite lives, nor do we need to provide conditions so that the bubble does not "overtake" the economy. Additionally, a bubble in the OLG literature has typically unambiguous efficiency effects, while in our framework both positive and negative effects coexist.

Papers that are also related to the present one are [Pastor and Veronesi 2004], [Jovanovic and Rousseau 2001]. The first of these papers uses variations in the risk aversion of the representative investor in order to derive properties of the optimal IPO time in partial equilibrium, whereas the latter provides a Q Theory of IPO's by effectively assuming that new business creation is subject to different types of adjustment costs than investment by existing firms. Both of these papers provide interesting rational alternatives to understand new business creation and investment. Even though rational models could attribute variations in turnover to rational relocation needs and also deliver the result that the aggregate profit rate (profits normalized by the capital stock) should be lowered by new company starts, they also imply an increase in the number of new business starts and hence it appears that *aggregate profits* in the economy should increase in expectation, as long as the new business starts are profit making instead of loss making. However, we find that increases in volume tend to increase investment and yet decrease aggregate profits, which suggests that the new investments are loss making.

Methodologically, the paper is closely related to a growing literature that uses continuous time methods to analyze properties of dynamic contracting problems. ([DeMarzo and Sannikov 2004], [Sannikov 2004], [Williams 2004] etc.). The methods that we develop allow a very close characterization of the properties of the optimal dynamic contract for arbitrary assumptions about the distribution of mispricing, the profit function etc. By reducing the optimal contracting problem to a simple ordinary differential equation we are able to analyze the properties of the optimal contract in a very tractable way. Finally, the paper is also related to a literature that models the life cycle behavior of financing and investment by firms.([DeMarzo and Fischman 2003a], [DeMarzo and Fischman 2003b], [Clementi and Hopenhayn 2002], [Albuquerque and Hopenhayn 2004], [Cooley and Quadrini 2001], [Jermann and Quadrini 2002], [Cooley, Marimon, and Quadrini 2003] for instance)

The structure of the paper is as follows. Section 2 contains the model setup. Section 3 contains a discussion of the properties of the solution. Section 4 discusses efficiency. Section 5 contains the empirical results of the paper and section 6 concludes. All proofs are contained in the appendix.

2 Model Setup

The basic model is a variant of [Albuquerque and Hopenhayn 2004], that allows for a) possibility of "exit" through reselling the company to outside investors and b) outside investors who have potentially overly optimistic beliefs that lead to distorted investment decisions. We set the model in continuous time, because thus we are able to provide a quite detailed characterization of the properties of the optimal contract[3].

2.1 The setup

An entrepreneur wants to obtain financing for a project that requires I_0 to start. The entrepreneur (E) is risk neutral as are the outside financiers (F) of the project. The project cannot be started without (E). However, the financier (F) is competitive. Moreover, there is one-sided commitment: (F) is bound by the terms of a contract, while (E) can walk away from the contract at any time. Throughout we shall assume that there is no difference in beliefs between E and F. Moreover they both discount the future at the rate r.

The second assumption is that once started a firm delivers a (net) profit stream of:

$$\pi(K_t)$$

per unit of time, where K_t should be understood as working capital. We shall assume that

Assumption 1 *π is continuous, smooth and concave and has a global maximum at $\overline{K}$.*

In other words there is an optimal scale of the firm, beyond which marginal returns turn negative. Notice that there is no uncertainty in $\pi(K_t)$, both for simplicity and in order to isolate the basic new intuitions provided by the model.[4][5]

[3] This is achieved by reducing the solution to the problem to a simple non-linear ordinary differential equation, whose properties can be analyzed by using ideas similar to so called "maximum principles" for ODE's.

[4] [Panageas 2003] considers a model where the marginal product of capital is stochastic, investors disagree about its long run mean and trading is subject to shorting constraints. In such a framework investment will be increased for purely neoclassical "q"-theoretic reasons. In this paper we are interested in showing the effects of financing constraint relaxations on investment. Hence, we abstract from "q" theoretic considerations and refer the interested reader to [Panageas 2003].

[5] An implication of assuming no uncertainty in $\pi(K_t)$ is that there can be no independent role for firm size and

2.1.1 The optimal dynamic contract

Financing constraints are going to be introduced in the following way. The entrepreneur can "steal" the working capital at any time that she chooses and run away unpunished. Hence the optimal contract between (E) and (F) must take into account that at all times:

$$K_t \leq V_t = E\left(\int_t^\tau e^{-r(s-t)} D_s ds + e^{-r(\tau-t)} V_\tau\right) \tag{1}$$

where D_t denotes transfers to (E), V_t is the net present value of the entrepreneur's share, and V_τ is a potential terminal payoff to (E) at a time τ. This constraint captures the limits of commitment between (E) and (F). (F) can commit to the contract whereas (E) cannot, and hence has to be appropriately incentivised. The promised payoffs to (E) must be enough to prevent her from "stealing" K_t and running away. This is exactly what constraint (1) captures. It is important to note that this modeling of the financing constraint is not critical to the conclusions. The important assumption is that K_t be somehow linked to the share of the entrepreneur.[6]

The optimal contract then is to determine a path of K_t, D_t and an optimal "exit" strategy τ along with a terminal payoff to (E), (denoted as V_τ) so as to maximize the joint surplus of (F) and (E) subject to the constraint (1). In mathematical terms:

$$\begin{aligned}
W(V_t) &= \sup_{K_t, D_t, \tau, V_\tau} E\left[\int_t^\tau e^{-r(s-t)} \pi(K_t) dt + e^{-r(\tau-t)} P_\tau\right] && \text{((P))} \\
& \quad s.t. \\
0 &\leq D_t \leq \pi(K_t) \text{ for all } 0 \leq t \leq \tau && (2) \\
V_t &\leq V_\tau \leq P_\tau && (3) \\
K_t &\leq V_t \qquad \text{for all } 0 \leq t \leq \tau && (4) \\
V_t &= E\left(\int_t^\tau e^{-r(s-t)} D_s ds + e^{-r(\tau-t)} V_\tau\right) && (5)
\end{aligned}$$

where P_τ is the (total) value of the firm upon "exit", which both (E) and (F) take as given. Exit is the only source of randomness and is introduced in the next subsection. Equations (2) and (3) capture feasibility constraints on how the running payoff $\pi(K_t)$ and the terminal payoff P_τ are

age, but the two are linked. See [Albuquerque and Hopenhayn 2004] for a model allowing a separate role for the two effects.

[6] As [DeMarzo and Fischman 2003a] show, there are many ways of introducing such a link (effort provision, costly state verification etc.)

going to be split. In particular (3) captures both the "promise keeping" constraint, namely that (E) should not receive less than what is promised, but also not more than the liquidating price. The last two equations just restate (1).

2.1.2 Exit

Even though (E) and (F) may share the same beliefs, there are some outside investors (I) that have different beliefs and who are willing to purchase the entire company at the price P_τ. (E) and (F) have the option to resell to these investors and will do so if $W_\tau < P_\tau$, i.e. if the price that they can obtain is larger than the value of the joint surplus under continuation.

We shall assume that the process of exit takes the following form. At some random times that arrive with Poisson intensity λ, investors (I) make a proposal to (E) and (F) to buy the company from them. If the proposal is accepted then the firm changes hands, else it remains under the ownership of (E) and (F) and they have the option to wait for a better offer at the next time τ.

To understand how (I) form their bid, assume that once bought by (I) the company gets reorganized and expanded and its payoffs are given by:

$$\pi(\overline{K})Z_t, \quad t \geq \tau$$

where Z_t follows a process of the form:

$$\frac{dZ_t}{Z_t} = \xi dB_t, \quad Z_\tau = 1$$

for a constant ξ and a standard Brownian motion dB_t. In other words the process Z_t always starts at 1 upon reorganization. Finally, reorganization involves an initial investment at a cost of $c > \frac{\pi(\overline{K})}{r}$. Notice that under these assumptions no rational agent would want to buy the company, and pay c in order to reorganize it since:

$$E\int_\tau^\infty e^{-r(t-\tau)}\pi(\overline{K})Z_t dt = \frac{\pi(\overline{K})}{r} < c$$

Assume however that investors (I) in the market believe that the stochastic process of Z_t is given by:

$$\frac{dZ_t}{Z_t} = \phi dt + \xi dB_t$$

where $0 < \phi < r$. Such investors would be willing to pay up to:

$$E^{(I)} \int_{\tau}^{\infty} e^{-r(t-\tau)} \pi(\overline{K}) Z_t dt = \frac{\pi(\overline{K})}{r - \phi} - c$$

in order to purchase the company. Assume now that (I) are competitive and thus the offer that they make to (E) and (F) in order to buy the company is given by:

$$P_{\tau} = \frac{\pi(\overline{K})}{r - \phi} - c \tag{6}$$

ϕ is a random variable that captures investor sentiment. Investors who arrive at different (Poisson) times will have $\phi's$ drawn from a (common) distribution Φ in an i.i.d. fashion. This will imply a distribution on P_{τ}. It will greatly simplify the exposition to make assumptions on the distribution of P_{τ} directly. We shall assume that P_{τ} has a distribution *with density* $H(x)$ where $x \in [\underline{P}, \overline{P}]$

2.2 Financially feasible projects

To close the model, one needs to determine V_0, i.e. the initial promise given to the (E) by (F). Since (E) is key to starting the project, while (F) is competitive, the allocation of the initial surplus will be such that:

$$V_0 = \sup\{V : s.t. W(V) - I_0 = V\} \tag{7}$$

In other words the total surplus is allocated so that the net present value of the payments to (F) in expectation equal I_0 while the rest is given to (E).

A first and very important remark about (7) is that it implies $W_V(V_0) \leq 1$ once the project is started. To see why this is so suppose otherwise. Then a marginal increase in V by 1 unit will increase the total surplus by more than 1, say $1 + \varepsilon$. Hence it will be in the interest of (F) and (E) to renegotiate because V can obtain one more unit and ε additional units can go to (F). The requirement that a contract satisfy $W_V \leq 1$ throughout is known as renegotiation proofness in the dynamic contracting literature and we shall impose it throughout. However, it turns out that in our setup renegotiation proofness will be automatically satisfied for all $t > 0$ once it is satisfied at $t = 0$.

Figure 2 gives a graphical depiction of the above discussion. The top panel depicts the total surplus $W(V)$ while the bottom panel depicts the share of the financier $B(V) = W(V) - V$. As the bottom panel shows, for a given I_0, we choose V_0 to be the maximal V such that: $I_0 = W(V_0) - V_0 = B(V_0)$. The largest point where $B(V_0) = I_0$ is given by point C' in that diagram. Note that C' is to the right of the point A' (i.e. the point where $B(V)$ is maximized). Alternatively put, point C in the top diagram is to the right of point A (i.e. the point where $W_V = 1$) .

A second and very important issue concerns *contract feasibility.* Assume for a moment that W is concave and differentiable. The maximum share that (F) can obtain is:

$$W(V) - V$$

which is maximized for a V^* such that $W_V(V^*) = 1$. Hence the condition for a project to be financially feasible is that:

$$W(V^*) - V^* \geq I_0 \tag{8}$$

Else, the maximum possible share that can be pledged to (F) will not be large enough in order to satisfy her participation constraint. In terms of figure 2 the maximal I_0 is given by $I_{\max}$ and is given by point A' in the bottom panel and point A in the top panel. Hence we have the following definition:

Definition 1 *A project will be called financially feasible if and only if:*

$$\max_V [W(V) - V] > I_0$$

It is particularly important to stress that sometimes projects with positive NPV (in the conventional sense) might fail to be financially feasible. To see this notice that the conventional NPV rule for financial feasibility is:

$$\frac{\pi(\overline{K})}{r} \geq I_0 \tag{9}$$

Notice that the left hand side of (9) is larger than the left hand side of (8) for two reasons. First $W(V^*)$ is the total surplus in the presence of the financing constraint which cannot be larger than the total surplus in its absence. And second, the NPV rule does not take into account that a minimum share must be given to (E) to prevent her from "stealing". Hence, a project that is feasible in the absence of financing constraints might become infeasible in their presence. This will be the source of efficiency gains that are analyzed in a subsequent section. We shall assume throughout that (9) holds for the project that we consider.

2.3 Comparative Statics and Location shifts

All of the results that we obtain will be statements about how the endogenous quantities of the contract change as one "shifts" the density of outside offers P_τ which we have denoted as $H(\cdot)$. By shifts we mean parallel location shifts of $H(\cdot)$ by κ. Mathematically, a location shift of H by κ means that P_τ is now distributed as:

$$H(x-\kappa)$$

where $x \in [\underline{P}+\kappa, \overline{P}+\kappa]$. Hence increasing κ implies rightward shifts of H so that the resulting distribution of P_τ first order stochastically dominates the preexisting one. Figure 3 illustrates a location shift by κ.

To perform comparative statics it will be useful to embed the model into a framework where initially the upper bound on P_τ, namely $\overline{P}$ is too low for mispricing to matter. This can be achieved by setting $\kappa = 0$, and $\overline{P}$ equal to the lowest possible W that (E) and (F) could achieve in the complete absence of offers from (I). Formally this lower bound can by computed by restricting $\tau = \infty$ in the program (P), determining V_0 from the solution to (7) and setting $\overline{P}$ equal to $W(V_0; \tau = \infty)$. As we shall show, an implication of the optimal contract is that $W_V > 0$ and $V_t > 0$. Hence $W(V_0)$ is a lower bound on the total surplus for all t. In summary, by setting the upper bound on offers to be equal to the *minimum total surplus* that (E) and (F) could achieve in a world without any offers, guarantees that even if offers arrive they will never be accepted.

Hence for $\kappa = 0$ and $\overline{P} = W(V_0; \tau = \infty)$ it is as if exit offers did not even exist. However, as we increase κ exit offers will start affecting the optimal contract. It is such variations that we study in the next section. The following assumption collects all of the requirements on $H(x-\kappa)$

Assumption 2 *For a fixed $\kappa \geq 0$ consider the density $H(x-\kappa)$ of P_τ on $x \in [\underline{P}+\kappa, \overline{P}+\kappa]$. We shall assume that:*

a) $\overline{P} = W(V_0; \tau = \infty)$

b) H is continuous, smooth and satisfies $H(\underline{P}) = H(\overline{P}) = 0$

The second assumption on the density is purely technical and could easily be relaxed at the cost of complicating the proofs.[7]

[7] It is used to guarnatee that the derivatives of W w.r.t. κ exist

3 The optimal contract: Analysis

The analysis is structured into four subsections. The first subsection discusses some basic properties of the optimal contract. The second subsection introduces variations in the location parameter $\kappa \geq 0$ (which controls the degree of mispricing) and examines the reaction of the total surplus to such variations as a function of the size of the company. It also studies the effects on the set of financially feasible projects. The third subsection addresses the issue of how variations in κ affect the time to "exit". The next section introduces the efficiency criterion that we shall use and examines how this criterion is affected when mispricing is increased.

3.1 Basic properties

The following proposition summarizes some of the properties of the optimal contract. These results are fairly standard in the literature on so called "limited enforcement".

Proposition 3 *For any $\kappa \geq 0$, $W(V)$ satisfies the following properties:*

i) if $V \geq \overline{K}$ then W is independent of V (i.e. $W_V = 0$).

ii) if $V < \overline{K}$:

$$\begin{aligned} D_t &= 0, V_\tau = V \\ W_V &> 0, W_{VV} < 0 \\ \dot{V} &= rV \end{aligned}$$

The basic message of the above proposition is simple and quite common in the literature on dynamic contracting. If $V \geq \overline{K}$ the Modigliani Miller theorem holds. How total surplus is allocated between (E) and (F) is irrelevant for the total size of the surplus. Hence W does not depend on the share of (E) and thus $W_V = 0$.

In terms of figure 2 this point is given by D in the top panel and D' in the bottom panel. To the right of D (D' in the bottom panel) the curve $W(V)$ becomes a constant (similarly the curve $B(V)$ becomes a line with slope -1). This is the sense in which the Modigliani Miller Theorem holds in this region. The total surplus does not depend on how it is split between (E) and (F).

However, if $V \leq \overline{K}$ the allocation of the shares to (E) and (F) affects the total size of W, because it affects the choice of capital K_t via the financing constraint (1). Hence there is an incentive to make V grow as fast as possible. This way the firm can avoid the financing constraints in the shortest amount of time. To attain this goal the optimal contract sets $V_\tau = V_t$ and $D_t = 0$. To see this formally, note that V satisfies by construction the ODE:

$$\dot{V} + D + \lambda(V_\tau - V) = rV$$

The left hand side is the expected total change in the share of (E) per unit of time. It is comprised of three components: First the regular deterministic time derivative which captures "capital gains". The second term captures any dividends that are paid out, while the third time captures the possibility that with probability λ per (infinitesimal) unit of time the value of the entrepreneur's share might exhibit a jump to V_τ. Since the discount rate is r, the right hand side captures just the requirement that the expected total "return" on V be equal to r. It is clear from this equation that $\dot{V}$ is maximized by setting D and V_τ to their lowest possible values.

3.2 Financially feasible projects and size of the project once started

In what follows, we take up two questions. The first concerns the increase in total surplus that results from a location shift in P. The second concerns the interaction between the magnitude of the entrepreneur's share V and κ.

Proposition 4 *The derivative of W w.r.t. κ is given as:*

$$0 \leq \frac{dW(\overline{K})}{d\kappa} \leq 1$$

This proposition shows that a location shift in the distribution of offers P_τ will result in an increase of the total surplus, even when the company faces no financing constraints. It is interesting to note that in this case one would observe an increase in the total surplus of the firm (W) without any change in its investment. Mathematically:

$$\frac{dK_t}{d\kappa} = \frac{d\overline{K}}{d\kappa} = 0$$

However:

$$\frac{dW(\overline{K})}{d\kappa} \geq 0$$

Since in this model both V_t and hence K_t grow deterministically with time, this implies that it will be older companies with $V \geq \overline{K}$. Combining the above results, it is easily seen that mature companies' investment might not be affected by increases in speculative mispricing, even though their total surplus is.

It is also interesting to observe that a location shift of $d\kappa$ will result in an increase of the total surplus by less than $d\kappa$. This effect will be key in establishing certain properties related to the average time to "exit". The next result examines the effect of location shifts for companies that are still in the region where financing constraints bind.

Proposition 5 *For any* $0 < V \leq \overline{K}$ *and any* $\kappa \geq 0$*:*

$$\begin{aligned} 0 &\leq W_{\kappa}(V) < 1 \qquad (10) \\ W_{\kappa V} &\leq 0 \qquad (11) \end{aligned}$$

The first part of this proposition extends the result of proposition 4 to companies that are "young" in the sense that (E)'s share has not yet increased enough. The major difference is that now the increase in the total surplus will affect investment. To see why, we focus on the opposite extreme of a company that has reached optimal scale $\overline{K}$ and study a firm that is just being created. Then its initial size will be determined by equation (7):

$$V_0 = \sup\{V : s.t. W(V) - I_0 = V\}$$

Using the above results one can study the derivative $V_{0\kappa}$ which is given by the implicit function theorem as

$$V_{0\kappa} = \frac{W_{\kappa}}{1 - W_V} > 0 \qquad (12)$$

Since in the constrained region $V = K_t$ it also follows that an increase in κ (i.e. a location shift) will result in an increase *in both* K_t *and* W_t. Alternatively put, for younger companies the relaxation of a financial constraint will both increase the "value" of the firm and its "size" as captured by K_t. This is the sense in which an increase in mispricing will affect younger companies more than older companies.

Figure 4 illustrates these effects. An increase in κ will shift the curves in both the top and the bottom panel upward. This will in turn imply that for a fixed I_0 the initial V_0 will now be given by $V_{0,new}$.

This result is due to a relaxation of the financing constraint. An increase in κ offers more attractive exit alternatives to (E) and (F). Since (F) is competitive, this increase in the surplus is effectively appropriated by (E), which implies that the financing constraint (1) is relaxed. This constraint in turn is more important for younger firms, and this shows why their investment is affected more.

The fact that $W_{\kappa V} \leq 0$ is another manifestation of these effects. As a firm grows, the effect of increases in a bubble on the total surplus is attenuated.

An alternative way to think about the above derivations is by considering the set of financially feasible projects. The maximum project cost $I^{\max}$ is defined as:

$$I^{\max} = \sup_{V}(W(V) - V) \tag{13}$$

since this is the maximum share that debt can obtain. The envelope theorem implies that:

$$\frac{dI^{\max}}{d\kappa} = W_{\kappa} \geq 0$$

or a location shift in the magnitude of mispricing will increase the set of financially feasible projects.

In terms of figure 4 this effect is illustrated in the bottom panel, which depicts the maximum of curve $B(V) = W(V) - V$ for κ, κ' with $\kappa' > \kappa$. As can be seen the maximum project cost is shifted upward from $I_{\max}$ to $I_{\max,new}$.

Summarizing, the above discussion suggests that the same increase in exit offers will have different effects on young and established firms. For established firms an increase in the magnitude of exit offers will increase surplus, but will not necessarily lead to increased investment. However, for younger companies the increase in outside offers will simultaneously affect the size of the company once started and the set of financially feasible projects, because it will mitigate the underinvestment problem.

3.3 Time to "Exit"

The time to exit is given by the first time that an offer will arrive such that $P_\tau > W(V)$. This section investigates the effects of a location shift in the distribution of the offers P_τ by κ on the mean time to exit.

The easiest way to proceed is to start with a company that is not subject to financing constraints, so that $\overline{W} = W(\overline{K})$ and compute the expected time until an offer gets accepted. Mathematically, this time is given by

$$\tau^{exit} = \inf\{t : P_{\tau} > \overline{W}\}$$

This expected time is distributed exponentially with hazard rate equal to

$$\lambda^* = \lambda \int_{\overline{W}}^{\overline{P}+\kappa} H(\zeta - \kappa) d\zeta = \lambda \int_{\overline{W}-\kappa}^{\overline{P}} H(x) dx$$

where λ was defined above as the intensity with which offers arrive per unit of time and $\int_{\overline{W}}^{\overline{P}+\kappa} H(\zeta - \kappa) d\zeta = \lambda \int_{\overline{W}-\kappa}^{\overline{P}} H(x) dx$ is the probability that an offer gets accepted. A closer examination of $\lambda \int_{\overline{W}-\kappa}^{\overline{P}} H(x) dx$ reveals that the only quantity that depends on κ is the lower limit of integration of the integral $\left(\overline{W} - \kappa\right)$. Since $\overline{W}_{\kappa} < 1$ by proposition 4 it is clear that an increase in κ will decrease the lower limit of integration and hence the probability that an offer gets accepted. Hence λ^* will increase and so the expected time to exit which is given by

$$E\left(\tau^{exit}\right) = \frac{1}{\lambda^*}$$

will decline.

We shall now generalize the results to $V < \overline{K}$. To simplify, we analyze the probability of accepting an offer directly, (since the intensity of offer arrival is not affected by κ). The probability of offer acceptance (for a given κ) is given as:

$$\omega(V, \kappa) = \int_{W(V)}^{\overline{P}+\kappa} H(\zeta - \kappa) d\zeta = \int_{W(V)-\kappa}^{\overline{P}} H(x) dx$$

Hence:

$$\begin{aligned} \frac{\partial \omega}{\partial \kappa} &= H(W(V) - \kappa) \cdot (1 - W_{\kappa}) \geq 0 \\ \frac{\partial \omega}{\partial V} &= -H(W(V) - \kappa) \cdot W_V \leq 0 \end{aligned}$$

since $W_{\kappa} < 1$, $W_V \geq 0$ and $H(\cdot) \geq 0$. In practical terms, these two equations imply the quite intuitive results that a) an increase in κ will increase the likelihood of offer acceptance irrespective of V and b) the same offer is more likely to be accepted by a younger firm rather than by an older firm. Hence "exit" (i.e. resale to outside investors) *will be more prevalent for younger firms rather than older firms.*

The model also suggests another effect by which an increase in mispricing will increase the mean time to exit at the *aggregate* level. As mispricing increases, projects that were not financially feasible before, will become financially feasible and hence the average "age" of companies will decline, as will the incidence of "exits" (given the increased number of younger firms).

4 Some efficiency implications

What are the implications of the model for efficiency? This question is of paramount importance but unfortunately ill defined. The reason is that it is not obvious what is an appropriate welfare criterion. We take a pragmatical view and define welfare in a "paternalistic" way. This means that efficiency gains are evaluated via an "objective" probability measure. The reason for this choice is threefold. First, this criterion inherently makes it most difficult for mispricing to be associated with welfare gains. As we show, in the absence of financing constraints mispricing is always inefficient under the proposed criterion. Second, this efficiency criterion has the very interesting property that it is potentially measurable because an econometrician can only observe data that were created under the objective measure. Third, from a theoretical perspective this criterion makes the trade-offs that are inherent in the model with financing constraints most transparent.

Mathematically, the welfare criterion will coincide with the expected net present value of profits from 0 to ∞, net of the investment cost c, i.e.:

$$\Omega \equiv E\left[\int_t^{\tau} e^{-r(s-t)}\pi(K_t)dt + e^{-r(\tau-t)}P_{\tau}^R\right]$$

where

$$P_{\tau}^R = \frac{\pi(\overline{K})}{r} - c < 0$$

where all expectations are taken under the *objective* probability measure. Moreover, this criterion takes into account that at τ a negative NPV project is undertaken. This tries to capture the idea that the "irrationality" of (I) presents a real cost to the economy since it results in negative NPV investments. Hence, even though to (E) and (F) the irrationality of (I) presents a net transfer, from an "aggregate" perspective this transfer results in distorted investment decisions.

4.1 Efficiency in the presence of financing constraints

The purpose of this section is to show that Ω will *always (weakly)* increase for companies that are just being created and whose I_0 is sufficiently close to $I^{\max}$ as defined in (13). Similarly Ω will *always (weakly)* decline for companies with $V = \overline{K}$. A crucial observation is that this result is robust to any assumption about π, H or the other parameters of the dynamic contract.

We show the latter result first. In mathematical terms:

Proposition 6 *If $V = \overline{K}$, then:*

$$\Omega_\kappa \leq 0$$

This result is hardly surprising. Neglecting any potential benefits of relaxing financing constraints, it is clear that mispricing will decrease efficiency, since it will just increase the instances where inefficient projects are undertaken. Hence, in the absence of underinvestment problems increases in mispricing will lead to efficiency losses.

However, in the presence of financing constraints one would expect mispricing to potentially increase efficiency. An intermediate step is to show that the result above generalizes to arbitrary V :

Proposition 7 *For any $V < \overline{K}$,*

$$\begin{aligned} \Omega_V &> 0 \\ \Omega_\kappa &\leq 0 \\ \Omega_{\kappa V} &\geq 0 \end{aligned}$$

This result should be interpreted with caution, since it is a statement about the partial derivative of Ω. It states that -*conditional* on V- efficiency is decreased by an increase in κ. However, it is more interesting to consider a company that is just being created and examine the total derivative:

$$\frac{d\Omega(V_0,\kappa)}{d\kappa} = \Omega_\kappa + \Omega_{V_0} V_{0\kappa} = \Omega_\kappa + \Omega_{V_0}\frac{W_\kappa}{1 - W_V}$$

where we have used expression (12). This term captures the two forces behind the efficiency gains. The first term is negative as established above and captures the distortion to investment.

However, V will not stay the same, because an increase in mispricing will also increase the starting value of V. This implies that the overall effect on welfare can be ambiguous. However, there is one case where an increase in κ will have unambiguous effects. Namely when $W_V \to 1$.[8] Hence it becomes interesting to examine when W_V will be close to 1. This will always be the case when I_0 is sufficiently close to $I_{\max}$ as one can see from figure 4. Hence, whenever a contract is sufficiently close to the feasibility limit, the positive part of $\frac{d\Omega}{d\kappa}$, (namely $\Omega_{V_0}\frac{W_\kappa}{1-W_V}$) will "overwhelm" the negative part and the effect on welfare will be unambiguously positive.

The above results have an intuitive interpretation: As long as financing constraints are irrelevant, mispricing will distort investment, since there is no friction to be corrected. If however mispricing helps alleviate a financing friction it will have unambiguously positive effects. The limit $W_V \to 1$ captures situations where the project is close to the feasibility limit and hence the financing constraint becomes extremely tight. Hence, an increase in mispricing will have unambiguously positive welfare effects in that region.

In summary, the effect of mispricing on the welfare criterion we adopted cannot be assessed a priori. Assuming that an economy is composed of a large number of projects, the total effect will critically depend on how tight financing constraints are for the average project, and how large the mispricing is. An important advantage of the criterion adopted in this section is that it is potentially measurable with data, since the expectation is taken w.r.t. to the objective measure. Hence one can in principle assess exactly how that criterion is affected if a "shock" to mispricing can be identified in the data.[9]

5 Empirical investigation

The major theoretical results obtained sofar can be summarized as follows:

First, mispricing will tend to relax financing constraints. Hence, an increase in mispricing is

[8] This is so because Ω_κ, Ω_V and W_κ are bounded. Moreover, Ω_V will be strictly larger than 0 whenever the financing constraint is binding, and W_κ will also be strictly larger than 0 whenever $\kappa > 0$. Finally, W_κ is bounded away from 0. To see this examine equation (24) in the appendix.

[9] We conclude with a remark about equation (9). We have assumed throughout that the project that we consider satisfies this condition. If however that were not true, then one could easily picture cases where mispricing would be undoubtedly inefficient, since it would lead to project starts even when $I_0 \leq \frac{\pi(\overline{K})}{r}$

likely to affect younger companies more than older ones.[10]

Second, an increase in mispricing will spawn new firm creation, since the relaxation of financing constraints will allow projects to get started that were previously infeasible.

Third, there should be an increase in the incidence of "exit" (defined as reselling companies to outside investors) while there should be a decrease in the mean time to exit.

Finally, the effects of mispricing on the expected net present value of future profits is ambiguous. On the one hand, the relaxation of financing constraints could allow efficient projects to get started. On the other hand, mispricing increases the investment distortions leading to the adoption of projects that are loss making in a net present value sense. The net effect will depend on the relative strength of the two effects.

In what follows we examine these implications of the model empirically. We start by examining the first two predictions by investigating how aggregate investment and new firm creation responds to various types of shocks. We first follow the approach in [Blanchard, Rhee, and Summers 1993] (henceforth BRS) to aggregate investment and new firm creation respectively. Second we investigate how aggregate profits respond to a shock to "short-termism" by investigating the cumulative impulse response functions of some simple vector autoregressions (VAR's).

The major new variable that we use throughout is turnover. Turnover captures the average holding horizon of investors. In models of speculation like [Scheinkman and Xiong 2003] (henceforth SX) turnover is a nonlinear transformation of the magnitude of the speculative component of stock prices. Hence it is likely that this quantity reveals information about the extent of speculation that is taking place in the market. It is straightforward to extend the model that we presented to allow for the opening of a speculative market once the company is sold to outside investors, which would drive up valuations by outside investors further, in analogy to SX. This would be equivalent to an increase in the average offer that outside investors make. Hence from a theoretical perspective, increases in turnover present a possible way to identify "location shifts" in the average offers made due to *speculative* reasons.

This motivates the use of this variable throughout.

[10] In the model developed there are arguably two types of "investment": the choice of "working capital" and "exit" since the outside investors will take over the firm to restructure it at the cost c which can be seen as an investment. Both types of investment will be more relevant to young companies.

5.1 Data

The majority of the data that we use come from BRS, and we refer the reader to that paper for details of data construction. BRS compiled data on aggregate investment, capital, profits, q, and the CPI from 1900-1990 and we extended this dataset to 2003 by using the procedure in their paper. Just like BRS our data on profits start in 1916, whereas all other quantities start in 1900. The data on volume is from the NYSE and it also starts in 1900. We added up the daily observations to produce yearly aggregates. In constructing turnover, we used CRSP data to obtain the number of shares traded in the NYSE in any given year. Hence the data for turnover start in 1926. The final data series that we used was disbursements to portfolio companies by Venture Capitalists. We believe that this series captures "real" investment much better than IPO's for many reasons. First, disbursements are not market prices and hence are not subject to potential overpricing biases. Second, disbursements are much closer to the quantities in the theoretical model that we presented rather than IPO prices which would correspond to the price at "exit" in our model. We obtained this series from various issues of the Venture Capital Association Yearbook from 1978 to 2003.

5.2 Aggregate Investment and Investment in new Ventures

It appears sensible to start the analysis by examining the basic "positive" prediction in the model: Investment by young companies should be more sensitive to potential mispricing than aggregate investment.

Figure 5 presents some figures of the data. The three panels on the left plot first differences in aggregate (log) disbursements to portfolio companies by Venture Capitalists against first differences in logs of aggregate q, volume in the NYSE and aggregate profits. The three figures on the right depict the behavior of first differences in (log) aggregate investment/capital ratio against the same quantities. The data covers the last 25 years.

Even though all quantities commove quite closely, a pattern that emerges is that q and volume are most important for "new company investment" while profits seem to be relatively more important for aggregate investment.

As a first step to confirm this visual impression we proceeded as BRS. We regressed first differences in (log) investment/capital ratio on first differences in the (log) profit rate and aggregate (log) q and first lags of these quantities. Since the data for investment, q, volume and aggregate profits span 88 years while the data on investment in new companies only 25 years, we first ran these regressions on the entire sample. The results of these regressions are contained in Table 1.

The pattern that emerges is in line with the results in BRS and figure 5. The coefficients on the profit rate (both contemporaneously and at the first lag) are large and significant across all specifications, while the coefficient on q (especially at the first lag) is significant even after controlling for profits.

In BRS this is interpreted as evidence that even after controlling for "fundamentals" (namely profits) there is some residual role for the stock market. The next table (Table 2) runs the same regressions for both "new company investment" and aggregate investment. We also include changes in log volume[11] in the NYSE to capture variations in short termism. The reasoning is the following: q will react to shocks about future expectations beyond what is captured by variables observable to an econometrician. Hence by adding a variable that is correlated with speculative trading we can partial out the effect of speculation.[12] To keep things comparable we estimated regressions for aggregate investment for the same timespan. For new company investment the coefficients on q and volume (at the first lag) are significant even after controlling for profits. Aggregate profit rates themselves are insignificant for new company investment. By contrast, for aggregate investment we obtain the same results as in Table 1: the profit rate (both contemporaneous and at the first lag) is significant for aggregate investment even after controlling for q and volume. q and volume are insignificant for this shorter sample.

Arguing in the same spirit as BRS, we interpret this as evidence that new company creation is more sensitive to shocks in speculative trading (captured by the coefficients on volume) and expectations about the future (as captured by the coefficients on q). This is perfectly in line with the model that we presented since both would amount to increases in the average offer size upon

[11] The results are practically identical whether volume or turnover is used.

[12] An important caveat here is that q theory may hold even in the presence of mispricing as [Panageas 2003] shows. However, it is conceivable that at the aggregate a simple investment - q regression might fail. A number of reasons might be possible for this: for some firms marginal and average q might not be the same, there could be financing constraints, aggregate q could be measured with error etc. This would mean that variables like current profits could be significant. Moreover, if investment is reacting to speculative component one could expect for exactly the same reasons volume to have independent explanatory power.

exit. The extent of this "excess" sensitivity is striking: A 1% change in q will lead to a 2% change in new company investment and similarly for volume. These sensitivities are about 5-10 times as large as the equivalent sensitivities of aggregate investment to either q or profits.

These findings are in line with existing literature[13]. The theoretical model of the previous section can be seen as a potential explanation for these findings. However, one could explain these results by purely rational models of investment, assuming (for instance) different adjustment technologies for newly created versus established firms. Moreover, the coefficients on volume could be seen as capturing purely rational needs for reallocation due to variations in expectations about the future beyond what is captured by a potentially mismeasured aggregate q.

To be able to distinguish different theories, it is thus important to find a variable for which the two theories could have different predictions. A natural such candidate is aggregate profits. If indeed volume (or turnover) captures rational reallocation that leads to increased and efficient investment, or if volume is associated with speculative trading that in turn ends up relaxing financing constraints without distorting investment, then one would expect to see an increase in profits at the aggregate. If -by contrast- increases in speculative trading end up distorting investment decisions, then one should expect to see declines in profits.

In the next subsection we address these issues by investigating impulse responses of the various quantities to different types of shocks.

5.3 A simple vector autoregression

Assuming that shocks to volume in the financial markets capture (at least partially) changes in short-termism and speculative motives, we can pose the question of how profits and investment respond to such shocks both in the short and the long run. We start by posing the following simple VAR model:

$$(I - A(L))y_t = B\varepsilon_t \tag{14}$$

where

$$y_t = \begin{bmatrix} d\log(profits) \\ d\log(turn) \end{bmatrix}$$

[13] As [Kaplan and Stromberg 2004] show, stock market valuations played an important role in VC decisions during the stock market boom.

and $A(L)$ is a 2x2 matrix polynomial of lags, B is a 2x2 matrix of coefficients and ε_t is a 2x1 vector of mutually orthogonal shocks. We shall refer to the the first shock to this vector as the "fundamental" shock while the second shock will be taken to be a shock to "average holding horizon". To account for inflationary episodes, we defined changes in log profits as:

$$d\log(profits) = d\log(\text{nominal profits}) - d\log(CPI)$$

where CPI is the CPI index.

In practical terms such a VAR is estimated by running OLS for each of the variables in y_t on a number of lags of each of the variables in y_t. To identify B, we impose the extra restriction that it is a lower triangular matrix. Economically, this amounts to assuming that the fundamental shock affects both profits and turnover contemporaneously, while shocks to "average holding horizons" will affect the economy with lags. This is an intuitive assumption: One would expect speculation to affect the optimal financing and investment of corporations, and accordingly profits with considerable delay. However, there is no reason to exclude the possibility that current fundamentals shouldn't be correlated with contemporaneous changes in turnover and speculation.

As a first step towards understanding the results of this VAR we present the results of some regressions of changes in (log) profits on changes in (log) turnover. These are included in Table 3. Each column in this table contains a regression of changes in log profits on 3 lags of changes in log profits and 3 lags of changes in (log) turnover and 3 lags of changes in log q. Throughout the specifications, turnover has a negative coefficient that is particularly large and significant at the second lag. Controlling for q does not change this result.

This strong negative coefficient at the second lag is a key component behind the behavior of many of the impulse response functions that follow. It suggests that changes in average holding horizons have a negative influence on aggregate profits even after controlling for changes in expectations (captured by the coefficients on q at various lags) and pure reversion effects (captured by the coefficients on profits at various lags).

Of course this result is only suggestive. To make statements about the behavior of future profits we next adopt the VAR framework of equation (14). For our base case specification, we used 3 lags in estimating the VAR[14] and used the Cholesky decomposition (i.e. the assumption that B is lower triangular) to identify structural innovations.

[14]To determine the number of lags, we examined various model selection criteria (AIC, Hannan and Quinn, LR

Throughout we are interested in how an innovation to "average holding horizon" affects the *level* of profits over the next periods $t = 0, 1, ...$ years, namely:

$$\sum_{i=0}^{t} d\log(profits_i), \quad t = 0, 1, ...$$

The answer to this question is given by the so-called cumulative orthogonalized impulse response functions (the progressive sums of the impulse responses).

Figure (6) displays the answer to this question. Irrespective of whether one uses volume or turnover as an indicator of changes in holding horizons, the effect of such a shock has negative effects on the level of profits over the next periods. It attains a minimum around period 2-3 depending on whether turnover or volume is used and partially rebounces after that, but stays negative throughout. The upper 95% confidence interval is also below 0 after 2 years, and stays below 0 for almost all periods.

Figure (6) suggests that following a shock to the average holding horizon, profits decline and continue to decline until year 2-3. Compared to their level upon impact of the shock, the profits are about 8% lower after 2-3 years. Moreover, the effect of such a shock has lasting consequences even over the longer run. This is to be expected: investment is to a large extent irreversible and inefficient investments that divert the capital stock into such loss making ventures should be expected to have a lasting effect.

5.4 Robustness checks

Figure (7) performs various robustness checks to examine whether the result depends on a) the number of the lags included, b) the way we identified the VAR, and c) whether turnover should be first differenced or not. It contrasts the base model of Figure (6) with various models that make different assumptions.

The top two panels and the two middle panels examine the sensitivity of the results to the number of lags chosen. The top two panels use turnover, while the middle two use volume instead of turnover. We investigate whether allowing for 2 (respectively 4) instead of 3 lags has any effect.

test of lag order, Bayesian Information Criterion). The first three favored a model of up to 4 lags, while the Bayesian information criterion favored a one lag model. We chose a model with 3 lags for most of the presentation, but also report robustness checks for models of alternative orders.

We plot *regular* (not cumulative) impulse response functions, in order to be able to exactly see at which lags the different models imply different behavior[15]. Except for the top right panel all four models imply strikingly similar behaviour. It is important to note that even the top right panel would give a very similar *cumulative* impulse response function, since the individual impulse responses are negative before year 5 and almost exactly 0 thereafter.

The bottom left panel in figure (6) shows what happens when one uses different assumptions to identify the structural innovations in the VAR. The bottom left panel uses a long run restriction in the sense of [Blanchard and Quah 1993]. Simply put, we examine the model assuming that a shock to fundamentals can have no long run effect on volume. This identifying assumption makes sense, if one were to accept the hypothesis that volume is non-stationary *and* that profits and volume are not cointegrated.[16] The results once again are strikingly similar to the base case.

The bottom right panel investigates the sensitivity of the results to using levels instead of first differences of (log) turnover. This assumption makes sense only if one assumes that turnover is stationary. As is many times the case, statistically this hypothesis was hard to test[17]. However, one could make the following economic argument: One would expect volume to be non-stationary since it should be a time varying "multiple" of the number of shares outstanding, which in turn is likely to be non-stationary. Turnover avoids this problem by normalizing volume with the number of existing shares and hence should be a stationary quantity. However, to be safe, we use both turnover and volume in first differences for our baseline specification[18] and just study the sensitivity of the results with respect to different assumptions. However, as the bottom right panel shows, even when we use turnover in levels the results remain the same.

[15] We chose to plot regular instead of cummulative impulse responses, because else some differences might cancel out in the summation of the impulse responses.

[16] One needs both assumptions: a) long run restrictions make sense only for non-stationary (or at least trending) variables and b) there should be no cointegration, else the VAR representation is not correct. We checked both assumptions with Phillips Perron and Phillips-Ouliaris-Hansen tests for unit roots and cointegration respectively.

[17] The statistical evidence is weak unfortunately: Phillips-Perron tests were somewhat sensitive to the exact specification of lags chosen in constructing the Newey-West "long run" covariance.

[18] This raises the concern that turnover or volume could be non-stationary and cointegrated with profits. In that case one should be estimating a vector error correction model instead of a VAR. We found no evidence of cointegration between profits and turnover however. The residuals of the assumed cointegrating relation between profits and turnover were accepted as random walks irrespective of the specification of the Phillips-Ouliaris-Hansen procedure described in [Hamilton 1994]

5.5 Adding q and Investment

If our interpretation of the data sofar is correct, then we should expect to also see that shocks to "short-termism" should increase investment. This is the topic of the present subsection. The only modification that we introduce is to add investment and q into the vector autoregression (VAR). This is important, since the theory predicts that shocks to "short-termism" should have an unambiguous and positive effect on investment, despite the fact that they could potentially reduce profits in expectation.

In particular in this section we expand the vector y_t to[19]

$$y_t = \begin{bmatrix} d\log(profits_t) \\ d\log(vol_t) \\ d\log(q_t) \\ d\log(i_t/K_{t-1}) \end{bmatrix}$$

and use the usual Cholesky decomposition to identify the structural shocks. In mathematical terms, this means that the matrix B in the VAR representation:

$$(I - A(L))y_t = B\varepsilon_t$$

is lower triangular. In economic terms this means that the vector ε_t contains four types of mutually orthogonal shocks. Shocks to "fundamentals", "short-termism", "future expectations", and "investment specific ". The first variable (profits) is *contemporaneously* affected only by the first type of shock. Volume is *contemporaneously* affected by shocks to both fundamentals and short-termism. Similarly q is *contemporaneously* affected by the first 3 types of shocks and investment by all shocks.

We used 3 lags in estimating this VAR. The results were quite robust to alternative assumptions about the number of lags.

Figure 8 investigates whether the basic results sofar extend to this 4 variable VAR environment and the answer is affirmative. The top left panel depicts the cumulative impulse response function of a shock to "short-termism" on profits. The results are identical to the 2 variable VAR case. The top right panel investigates the robustness of the result to an alternative ordering of the variables

[19] We use volume instead of turnover, because we have 26 more observations on volume and we are estimating significantly more variables than in the 2 variable VAR.

in the VAR, and hence a different structural identification of the shocks. In particular, we reversed the order of q and volume in the above VAR and re-ran the impulse response functions. As can be seen there is no significant difference.

The bottom left panel addresses the question of whether shocks to "future expectations" have the anticipated effect on future profits. The reasoning is as follows: Since the VAR includes controls for "short-termism", variations in q should capture mostly changes about expectations about the future and thus a positive shock to "q" should be followed by increased profits. The bottom left panel accordingly depicts the cumulative IRF of a shock to "future expectations" on profits. The panel shows that indeed a shock to "future expectations" is followed by increases in profits (statistically insignificant though).

The bottom right figure contrasts the cumulative IRF one would obtain if turnover was used instead of volume. As can be seen, the results are very similar.

Hence a first conclusion is that the results of the 2-variable VAR estimation do not change if one expands the setting to 4 variables.

Figure 9 depicts the *regular* (not cumulative) impulse response functions of each of the four shocks in the VAR on the investment to capital ratio. As can be seen "short-termism", has a small (statistically marginally insignificant), but positive effect on investment at the first lag. The bulk of the behavior of investment however is driven by shocks to "fundamentals" and shocks that are "investment specific". This can be most easily seen by comparing the magnitude of the responses in the two left panels to the equivalent quantities in the right panels. Hence, the investment impulse responses effectively replicate the results of tables 1 and 2. Shocks to "fundamentals" capture the "lion's share" in terms of affecting investment. However both shocks to "short-termism" and "future expectations" have the predicted positive sign. This confirms once again the basic prediction of the theory that investment should react positively to all four types of shocks.

5.6 The performance of the model in the period 1997-2002

It is particularly interesting to investigate how well the 4 variable VAR model is able to capture the behavior of macroeconomic aggregates in the period 1997-2002. The results are contained in figure 10.

The figure depicts the predictions of the model for changes in profits and investment against actual data. The model performs well from 1997-2000. Once the downturn starts, the model is unable to capture the full drop in profits and investment that followed, even though it predicts negative growth in profits for most of this period. Part of the reason is that the increases in investment from 1997-1999 are underestimated as the left panel shows. The rapid drop in investment at the onset of the recession is also not fully captured.

In a nutshell, it appears that according to the historical experience the recent expansion and contraction was -if anything - *more dramatic* than what one would have expected in light of the historical experience.

6 Conclusion

In this paper we were interested in answering the following two questions: a) Why does the stock market seem to be more important for the investment decisions of younger firms and b) Does mispricing in the stock market distort the "real" magnitudes in the economy?

In answering these questions we first developed a theoretical dynamic contracting model between an entrepreneur and a financier, in an environment with mispricing. Mispricing enhanced the "exit" options of the contractual relationship, and hence functioned as collateral. Just like collateral is a lower bound of the value of a firm in the event of "exit", in the same manner overvalued offers by outside investors increase the total amount to be reaped in the event of "exit".

As a result, financing constraints get relaxed by the effective increase in collateral and the investment behavior of younger firms (which are likely to be more financing-constrained) gets affected more than the investment of established ones.

This makes the efficiency question a particularly interesting one. If indeed financing constraints get relaxed because of mispricing, then it could be that mispricing is efficient from a *rational* perspective. However, this has to be weighed against the investment distortions introduced by the presence of mispricing. As a matter of fact we show how to *robustly* construct cases where mispricing is beneficial and cases when it is not.

The model makes some simple predictions about the data. Mispricing should affect older companies less than younger ones. Mispricing will affect the size of a company once started, and it will also tend to increase the set of financially feasible projects. The time to "exit" should be shorter the younger the company. In a nutshell, investment by younger companies and new company creation is likely to be more responsive to such shocks than aggregate investment.

We test this basic prediction by comparing the results of regressions of aggregate investment on q, the profit rate and changes in volume (or turnover). Shocks to volume (or turnover) are likely to identify changes in the average holding horizon and hence increases in speculative trading. We find that even after controlling for profits and q, volume has independent explanatory power for the behavior of log disbursements to portfolio companies by Venture capitalists. The role of q and volume is minor for aggregate investment however.

In a next step we explore in some simple VAR's how aggregate profits behave in response to shocks to volume (or turnover). A robust and statistically significant result is that changes in the extent of trading in financial markets affect profits negatively in the short-medium run, especially over a 2-3 year horizon. This suggests that the distortionary effect of increases in speculative trading outweigh the benefits of the apparent relaxation of financing constraints at the aggregate level.

It is also unlikely that purely rational theories could explain our findings. Even if one views volume changes as rational reallocation of stocks between investors, it is unclear why such reallocation should lead to decreased profits over the next 2-3 years. If anything -controlling for past profits, q and investment- such increases in "liquidity" should have positive effects on profits.

We believe that it would be worthwhile in future research to look at disaggregated data and try to determine whether the effect that we find at the aggregate is indeed due to the bad performance of companies created during speculative episodes.

7 Appendix

A Proofs

Proof. (Proposition 3) To establish the first result, note that the following upper bound on W holds irrespective of V :

$$W(V) \leq \sup_{\tau} E\left[\int_{t}^{\tau} e^{-r(s-t)}\pi(\overline{K})dt + e^{-r(\tau-t)}P_{\tau}\right]$$

Moreover, since the choice of K_t is restricted by V only (through 1) it also follows that:

$$W(V) = W(\overline{K}) = \sup_{\tau} E\left[\int_{t}^{\tau} e^{-r(s-t)}\pi(\overline{K})dt + e^{-r(\tau-t)}P_{\tau}\right] \text{ for all } V > \overline{K}$$

Hence:

$$W_V = 0 \text{ for all } V \geq \overline{K}$$

since the upper bound on the value function is attained with equality for all $V \geq \overline{K}$. It is also straightforward to compute $W(\overline{K})$, since it solves the (algebraic) Bellman equation:

$$\pi(\overline{K}) + \lambda\left(\int_{\underline{P}+\kappa}^{W(\overline{K})} W(\overline{K})H(\xi-\kappa)d\xi + \int_{W(\overline{K})}^{\overline{P}+\kappa} \xi H(\xi-\kappa)d\xi\right) - (r+\lambda)\,W(\overline{K}) = 0 \tag{15}$$

To keep notation simple let us also agree throughout that:

$$\int_{x}^{y} f(z)dz = 0$$

whenever $x > y$. To show part ii) note that the law of motion for V (which is the only state variable) is given by:

$$\dot{V} + D = rV - \lambda(V_{\tau} - V) \tag{16}$$

so that the Bellman equation for W_t is:

$$\max\left\{\pi(K_t) + \lambda\int_{\underline{P}+\kappa}^{\overline{P}+\kappa} \max\{W,\xi\}H(\xi-\kappa)d\xi - (r+\lambda)\,W + W_V\left(rV - \lambda(V_{\tau} - V) - D\right)\right\} = 0 \tag{17}$$

where the max is taken over:

$$V \leq V_{\tau} \leq P_{\tau}, 0 \leq D_t \leq \pi(K_t), K_t \leq V$$

Since $V < \overline{K}$, the optimal solution implies that:

$$K_t = V \tag{18}$$

and as long as W_V it also follows that:

$$D_t = 0, V_\tau = V \tag{19}$$

Hence it remains to verify that indeed $W_V > 0$ under the policy (19), (18).To see this substitute (19) and (18) into (17) to get:

$$\pi(V) + \lambda \left(\int_{\underline{P}+\kappa}^{W} WH(\xi - \kappa)d\xi + \int_{W}^{\overline{P}+\kappa} \xi H(\xi - \kappa)d\xi \right) - (r + \lambda) W + W_V rV = 0 \tag{20}$$

subject to the boundary condition:

$$\lim_{V \to \overline{K}} W(V) = W(\overline{K})$$

for $W(\overline{K})$ given by equation (15). By standard results the ODE in (20) possesses a (classical) solution as long as $H(\cdot)$ is sufficiently regular (which was assumed in assumption 2. Note also that

$$W_V \to 0$$

as $V \to \overline{K}$ since the first three terms in 20 approach 0, because:

$$\pi(\overline{K}) + \lambda \left(\int_{\underline{P}+\kappa}^{W(\overline{K})} WH(\xi - \kappa)d\xi + \int_{W(\overline{K})}^{\overline{P}+\kappa} \xi H(\xi - \kappa)d\xi \right) - (r + \lambda) W(\overline{K}) = 0$$

Differentiating (20) w.r.t. V gives:

$$0 = \pi_V + rW_{VV}V - \lambda W_V \left(1 - \int_{\underline{P}+\kappa}^{W} H(\xi - \kappa)d\xi \right)$$

Suppose now that there is a $0 < V^* < \overline{K}$ s.t. $W_V = 0$. This implies that:

$$0 = \pi_V + rW_{VV}V^*$$

and hence

$$W_{VV} < 0 \tag{21}$$

i.e. W has to have a local maximum at V^*. Moreover, this maximum must satisfy

$$W(V^*) \leq W(\overline{K})$$

by the upper bound on W. This however means that there must be a local minimum at some V^{**} satisfying $V < V^{**} < \overline{K}$, which is impossible by (21). Hence we are led to verify our conjecture that $W_V > 0$ for $0 < V < \overline{K}$. The concavity W_{VV} can be established by a perfectly analogous argument on W_{VVV} and is omitted. The claim that

$$\dot{V} = rV$$

is a direct consequence of (16), (19). ■

Proof. (Proposition 4) Rewrite (15) under the new probability measure for P to get:

$$\pi(\overline{K}) + \lambda \left(\int_{\underline{P}+\kappa}^{W(\overline{K})} W(\overline{K}) H(\zeta - \kappa) d\zeta + \int_{W(\overline{K})}^{\overline{P}+\kappa} \zeta H(\zeta - \kappa) d\zeta \right) - (r + \lambda) W(\overline{K}) = 0$$

It will be convenient to substitute $x = \zeta - \kappa$ to get:

$$\pi(\overline{K}) + \lambda \left(\int_{\underline{P}}^{W(\overline{K})-\kappa} W(\overline{K}) H(x) dx + \int_{W(\overline{K})-\kappa}^{\overline{P}} (x + \kappa) H(x) dx \right) - (r + \lambda) W(\overline{K}) = 0$$

Then it is straightforward to apply the implicit function Theorem to get:

$$\frac{dW(\overline{K})}{d\kappa} = \frac{\lambda \left(\int_{W(\overline{K})-\kappa}^{\overline{P}} H(x) dx \right)}{r + \lambda \left(\int_{W(\overline{K})-\kappa}^{\overline{P}} H(x) dx \right)}$$

which implies the result. ■

Proof. (Proposition 5) Combining results in Propositions 4 and 3 one obtains:

$$\pi(V) + \lambda \left(\int_{\underline{P}}^{W-\kappa} W H(x) dx + \int_{W-\kappa}^{\overline{P}} (x + \kappa) H(x) dx \right) - (r + \lambda) W + W_V r V = 0$$

Differentiating the above Bellman equation w.r.t. κ gives:

$$\lambda \int_{W-\kappa}^{\overline{P}} H(x) dx - \left(r + \lambda \int_{W-\kappa}^{\overline{P}} H(x) dx \right) W_\kappa + W_{V\kappa} r V = 0 \tag{22}$$

subject to the B.C.

$$W_\kappa(\overline{K}) = \frac{\lambda \left(\int_{W(\overline{K})-\kappa}^{\overline{P}} H(x) dx \right)}{r + \lambda \left(\int_{W(\overline{K})-\kappa}^{\overline{P}} H(x) dx \right)} \equiv \Xi \tag{23}$$

To simplify notation define:

$$
\begin{aligned}
f(V) &= \frac{\left(r + \lambda \int_{W-\kappa}^{\overline{P}} H(x)dx\right)}{rV} \\
g(V) &= \frac{\lambda \int_{W-\kappa}^{\overline{P}} H(x)dx}{rV}
\end{aligned}
$$

Impose the boundary condition 23 to obtain the solution to (22)

$$
W_\kappa(V) = e^{-\int_V^{\overline{K}} f(s)ds}\Xi + \int_V^{\overline{K}} e^{-\int_V^x f(s)ds} g(x)dx > 0 \tag{24}
$$

To establish that $W_{\kappa V} \geq 0$, suppose otherwise. Indeed, suppose that there exists $V^* < \overline{K}$ such that:

$$
W_{\kappa V}(V^*) = 0
$$

If there are multiple such points, select the largest such V^*. At that point

$$
W_\kappa(V^*) = \frac{\lambda\left(\int_{W(V^*)-\kappa}^{\overline{P}} H(x)dx\right)}{r + \lambda\left(\int_{W(V^*)-\kappa}^{\overline{P}} H(x)dx\right)} > \Xi
$$

since $W(V^*) < W(\overline{K})$. Moreover $0 \leq W_\kappa(V^*) < 1$. This implies that at $W_\kappa(V^*)$ is a local max. But differentiating (22) w.r.t. V and evaluating it the resulting expression at V^* yields:

$$
W_{VV\kappa} rV^* = \lambda H(W-\kappa) W_V \left(1 - W_\kappa(V^*)\right) \geq 0
$$

and hence $W_\kappa(V^*)$ would have to be a local min. Hence, it must be the case that $W_{\kappa V}(V^*) < 0$ or $W_{\kappa V}(V^*) > 0$ throughout. Suppose then that $W_{\kappa V}(V) > 0$ for $V < \overline{K}$. Then:

$$
W_\kappa(V) = \frac{\lambda \int_{W(V)-\kappa}^{\overline{P}} H(x)dx + W_{V\kappa} rV}{r + \lambda\left(\int_{W(V)-\kappa}^{\overline{P}} H(x)dx\right)} > \Xi
$$

since $W(V) < W(\overline{K})$ implies:

$$
\frac{\lambda \int_{W(V)-\kappa}^{\overline{P}} H(x)dx}{r + \lambda\left(\int_{W(V)-\kappa}^{\overline{P}} H(x)dx\right)} > \Xi
$$

which is impossible by the continuity of $W_\kappa(V)$ and the fact that $W_\kappa(V) \to W_\kappa(\overline{K})$ as $V \to \overline{K}$. Hence we are led to conclude that $W_{\kappa V} < 0$.

Finally to show that $W_\kappa < 1$ suppose otherwise. Then there exists some V^{**} such that $W_\kappa(V^{**}) = 1$. But then (22) becomes:

$$-rW_\kappa + W_{V\kappa} rV < 0$$

which is impossible. Hence $W_\kappa < 1$. ■

Proof. (Proposition 6) Notice that Ω satisfies a Bellman equation similar to $W(\overline{K})$ namely:

$$\pi(\overline{K}) + \lambda \left(\Omega \int_{\underline{P}}^{W(\overline{K})-\kappa} H(\xi) d\xi + \int_{W(\overline{K})-\kappa}^{\overline{P}} \left(\frac{\pi(\overline{K})}{r} - c \right) H(\xi) d\xi \right) - (r + \lambda) \Omega = 0 \tag{25}$$

or:

$$\Omega = \frac{\pi(\overline{K}) + \lambda \left(\int_{W(\overline{K})-\kappa}^{\overline{P}} H(\xi) d\xi \right) \left(\frac{\pi(\overline{K})}{r} - c \right)}{r + \lambda \int_{W(\overline{K})-\kappa}^{\overline{P}} H(\xi) d\xi}$$

Applying the implicit function Theorem to (25) gives:

$$\frac{d\Omega}{d\kappa} = \frac{H(W(\overline{K}) - \kappa) \left(\left(\frac{\pi(\overline{K})}{r} - c \right) - \Omega \right)}{r + \lambda \int_{W(\overline{K})-\kappa}^{\overline{P}} H(\xi) d\xi} \leq 0 \tag{26}$$

since:

$$\frac{\lambda \left(\int_{W(\overline{K})-\kappa}^{\overline{P}} H(\xi) d\xi \right)}{r + \lambda \int_{W(\overline{K})-\kappa}^{\overline{P}} H(\xi) d\xi} < 1$$

■

Proof. (Proposition 7) Ω solves the ODE:

$$\pi(V) + \lambda \left(\int_{W(V)-\kappa}^{\overline{P}} H(\xi) d\xi \right) \left(\frac{\pi(\overline{K})}{r} - c - \Omega \right) - r\Omega + \Omega_V rV = 0 \tag{27}$$

Observe first that this equation implies that:

$$\Omega_V \geq 0$$

The argument is similar to the one used to show that $W_V > 0$. Assume that there existed a point where $\Omega_V = 0$. Differentiating w.r.t. V and using that $\Omega_V = 0$ gives

$$\pi_V - \left(\frac{\pi(\overline{K})}{r} - c - \Omega \right) \lambda H \left(W(V) - \kappa \right) W_V + \Omega_{VV} rV = 0$$

which implies that $\Omega_{VV} < 0$. From this point on, one can repeat the arguments in Proposition (3).

Differentiating (27) w.r.t. κ gives:

$$\lambda \left(1 - W_{\kappa}\right) \left(\frac{\pi(\overline{K})}{r} - c - \Omega \right) - r\Omega_{\kappa} + \Omega_{\kappa V} rV = 0$$

subject to the boundary condition

$$\frac{d\Omega(\overline{K})}{d\kappa} = \frac{H(W(\overline{K}) - \kappa) \left(\left(\frac{\pi(\overline{K})}{r} - c \right) - \Omega(\overline{K}) \right)}{r + \lambda \left(1 - \int_{\underline{P}}^{W(\overline{K})-\kappa} H(\xi) d\xi \right)} \leq 0$$

which is taken from equation (26). Moreover,

$$\lambda \left(1 - W_{\kappa}\right) \left(\frac{\pi(\overline{K})}{r} - c - \Omega \right) < 0$$

since $\frac{\pi(\overline{K})}{r} - c$ is a lower bound on Ω[20] and hence:

$$\Omega_{\kappa V} \geq 0$$

which in turn implies that

$$\Omega_{\kappa} \leq 0 \text{ for all } V < \overline{K}$$

since at the boundary $\overline{K}$, $\Omega_{\kappa}(\overline{K}) < 0$ by (26). ■

[20] To see this, set $\pi(V) = 0$ in (27) and $W_V = 0$.

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	(1)	(2)	(3)
	D.log(inv) 1900-2003	D.log(inv) 1900-2003	D.log(inv) 1900-2003
D.log(q)	0.212		-0.018
	(2.64)**		(0.25)
L.D.log(q)	0.339		0.228
	(4.95)**		(2.69)**
D.log(prof)		0.253	0.24
		(6.15)**	(4.91)**
L.D.log(prof)		0.155	0.1
		(3.49)**	(1.99)
R-squared	0.28	0.37	0.44

Table 1: Regressions of first differences in log investment to capital (labeled "inv") on first differences in log q (labeled "q") and first differences in log profits to capital (labeled "prof") . An "L." before a variable dentoes that it has been once lagged. White heteroskedasticity robust t-statistics are reported below the estimates. The entire sample ranges from 1900-2003. Data for profits start in 1916. A constant is included but not reported. An asterisk indicates a variable that is significant at the 5 percent level, while two asterisks at the 1 percent level. For details of the data see text.

	(1)	(2)	(3)	(4)
	D.log(VC) 78-03	D.log(VC) 78-03	D.log(inv) 78-03	D.log(inv) 78-03
D.log(q)	1.67	2.011	0.057	0.048
	(2.71)*	(2.72)*	(0.87)	(0.64)
L.D.log(q)	0.304	-0.163	0.121	0.125
	(0.5)	(0.36)	(1.53)	(1.56)
D.log(prof)	0.023	-0.308	0.12	0.121
	(0.06)	(0.63)	(2.48)*	(2.11)*
L.D.log(prof)	-0.026	0.331	0.183	0.197
	(0.08)	(1.22)	(3.54)**	(3.74)**
D.log(vol)		0.074		0.048
		(0.11)		(0.46)
L.D.log(vol)		1.992		0.017
		(2.65)*		(0.18)
R-squared	0.29	0.48	0.61	0.62

Table 2: Regressions of first differences in log investment to capital (labeled "inv") and log disbursements to portfolio companies by VC's (labeled "VC") on first differences in log q (labeled "q"), first differences in log profits to capital (labeled "prof") and first differences in log volume in the NYSE (labeled "vol"). White heteroskedasticity robust t-statistics are reported below the estimates. The sample ranges from 1978-2003. A constant is included but not reported. An asterisk indicates a variable that is significant at the 5 percent level, while two asterisks at the 1 percent level. For details of the data see text.

	(1)	(2)	(3)
	d.log.profits	d.log.profits	d.log.profits
L.d.log.profits	-0.233	-0.262	-0.236
	(1.26)	(1.37)	(1.18)
L2.d.log.profits	-0.186	-0.299	-0.283
	(0.96)	(2.06)*	(1.88)
L3.d.log.profits	-0.06	-0.24	-0.18
	(0.36)	(1.54)	(1.13)
L.d.log.turn		-0.029	0.016
		(0.18)	(0.07)
L2.d.log.turn		-0.342	-0.391
		(2.22)*	(2.21)*
L3.d.log.turn		-0.131	0.026
		(0.86)	(0.14)
L.d.log.q			-0.083
			(0.32)
L2.d.log.q			0.046
			(0.21)
L3.d.log.q			-0.426
			(1.68)
R-squared	0.06	0.19	0.23

Table 3: Regressions of the first difference of log (real) profits (labeled "profits") on once, twice and thrice lagged first differences of real (log) profits along with once, twice and thrice lagged differences of log turnover (labeled "turn"), and log q (labeled "q"). The data for profits starts in 1916. The data for turnover in 1925. The rest of the variables start in 1900. All variables end in 2003. White heteroskedasticity robust standard t-stats are reported. A constant is included but not reported. An asterisk indicates a variable that is significant at the 5 percent level, while two asterisks at the 1 percent level. For details of the data see text.

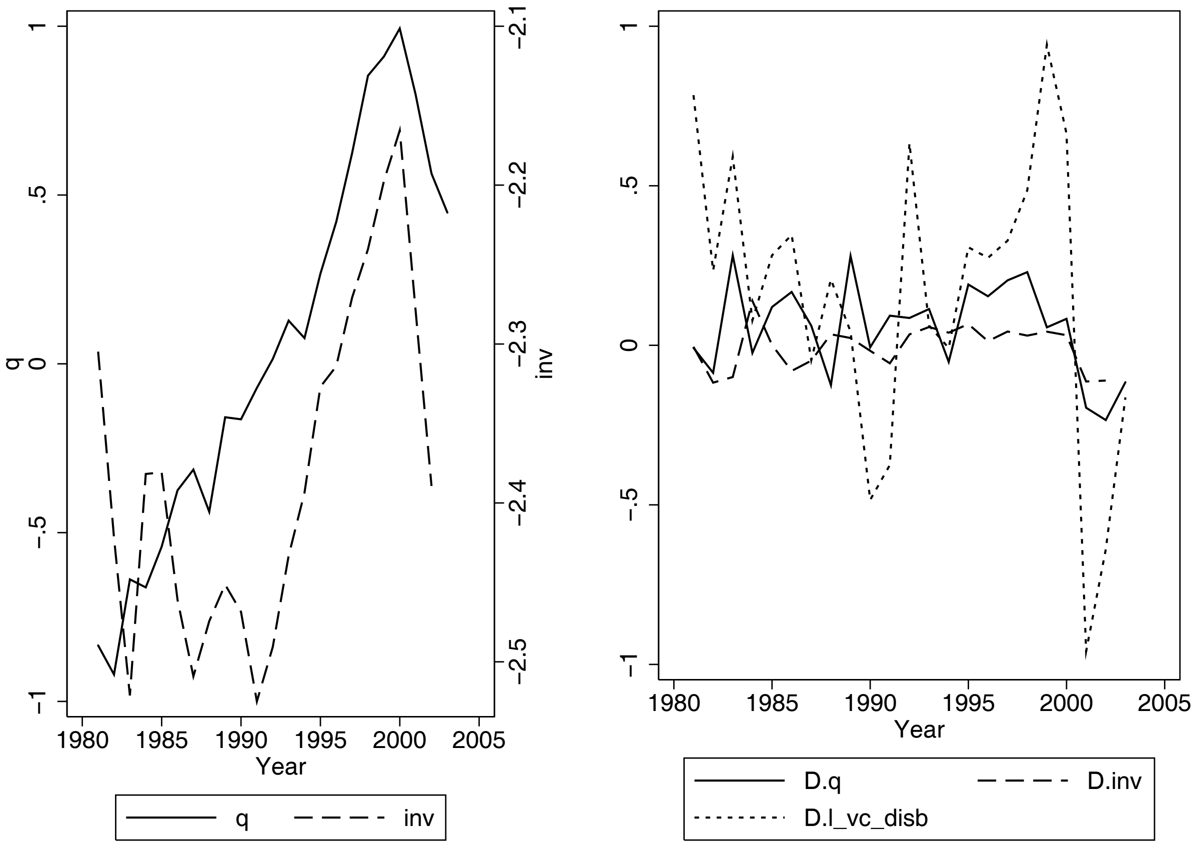

Figure 1: Left panel: Plot of log q (labeled "q") and the log of the investment to capital ratio (labeled "inv"). The scale for log q is on the left and the scale for the log investment to capital ratio is on the right. Right panel: First differences in (log) q, (log) investment to capital ratio and (log) disbursements to venture capital companies (labeled "l_vc_disb") from 1980-2003. Sources: Flow of Funds data of the U.S. (Federal Reserve) and Venture Capital Association Yearbook.

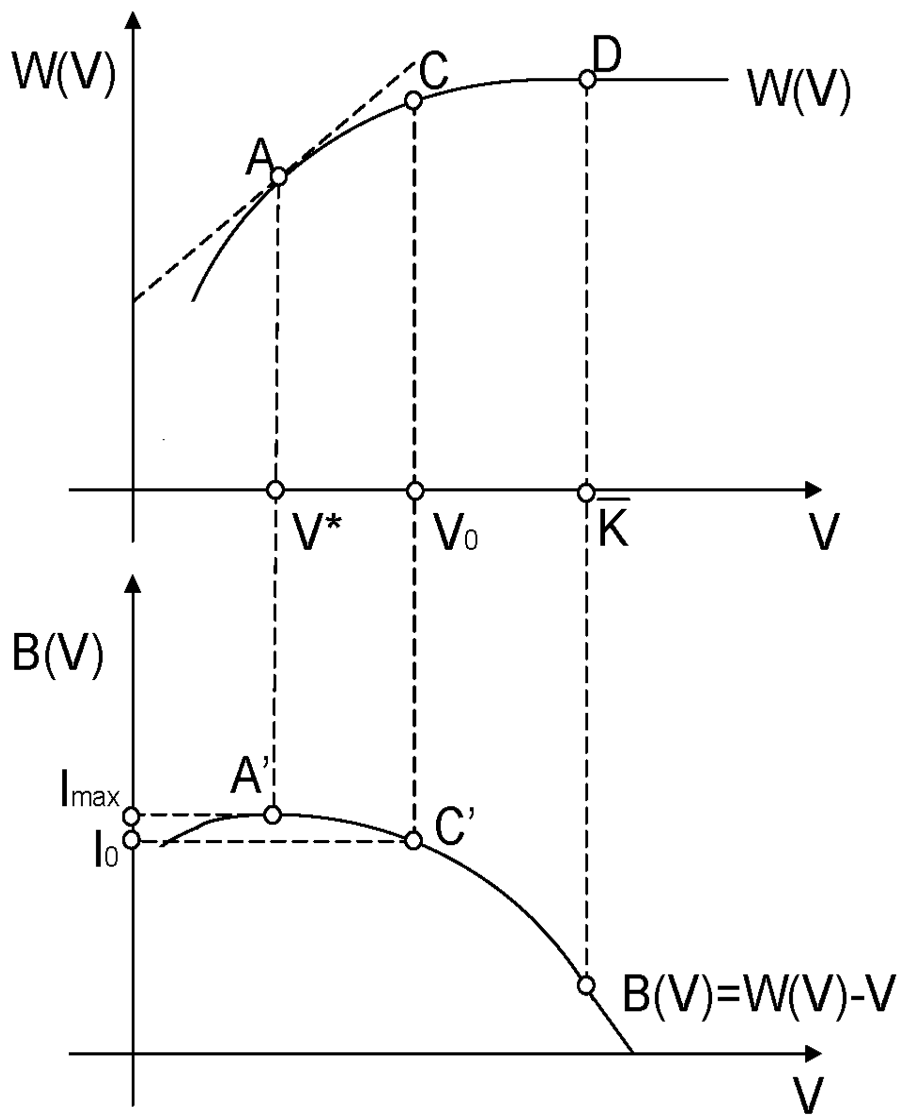

Figure 2: Optimal contract. The top panel depicts the total surplus, while the bottom panel depicts the financier's share of the contract.

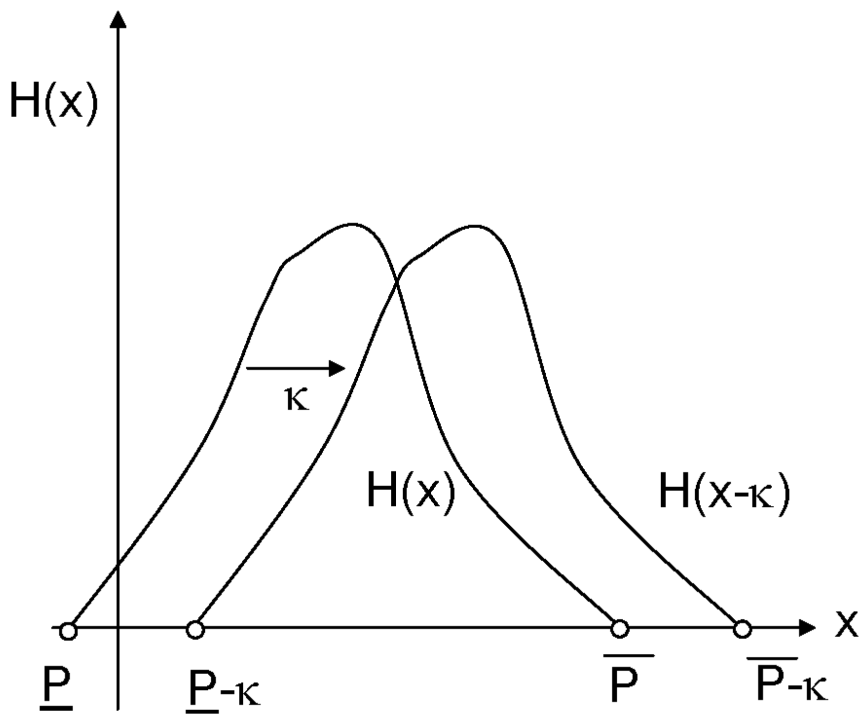

Figure 3: Illustration of a location shift by κ.

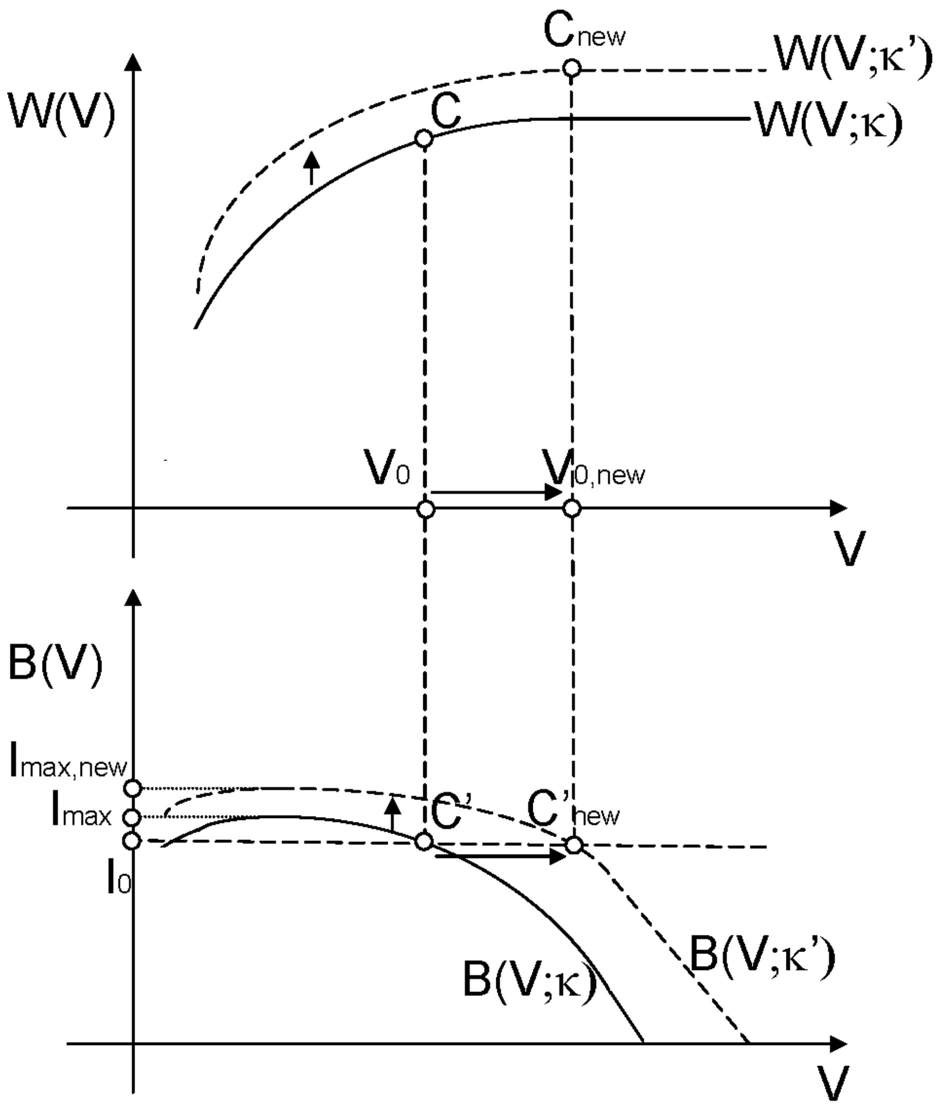

Figure 4: Implications of a location shift from κ to κ'.

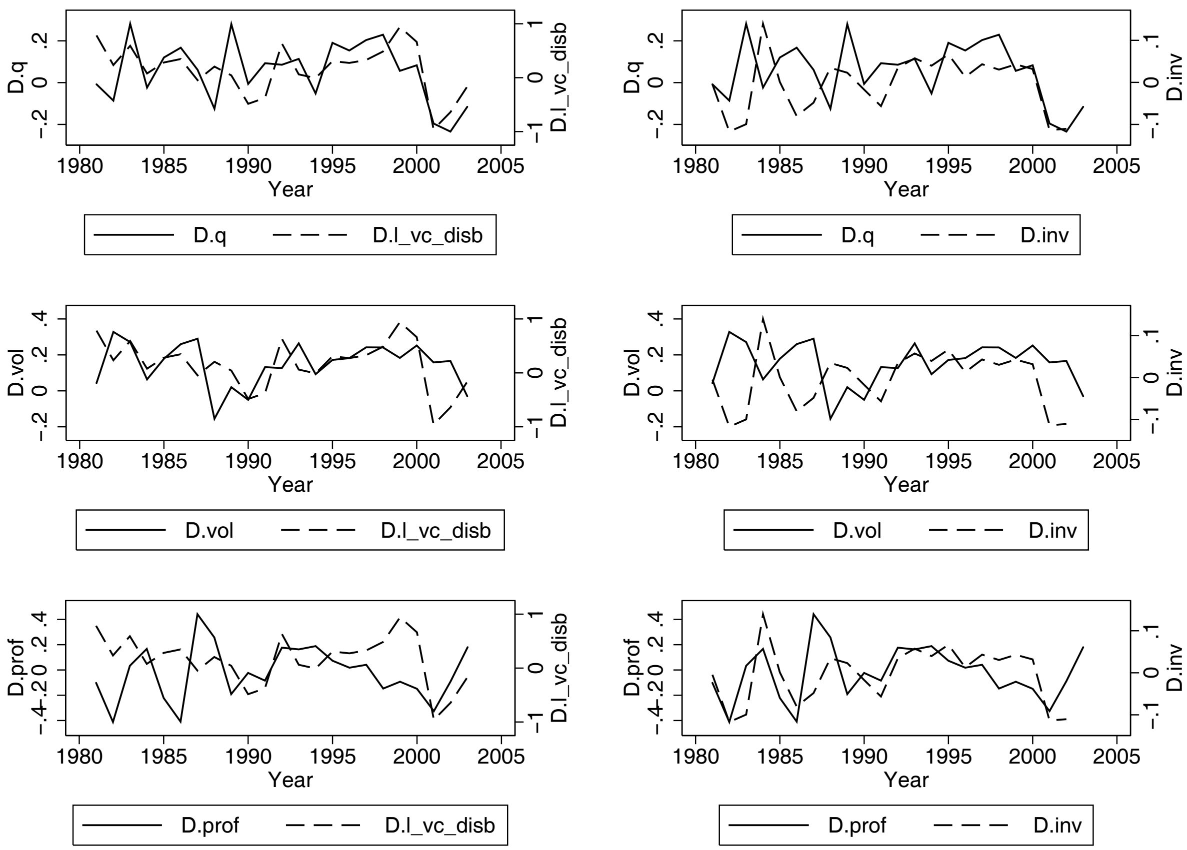

Figure 5: Left panel: First differences in log q (labeled "q") , log volume (labeled "vol") in the NYSE and log profits/capital ratio (labeled "prof") (left scale) are plotted against first differences in log of disbursements to potfolio companies by VC's (right scale) (labeled "l_vc_disb"). Right panel: First differences in log q, log volume in the NYSE and log profits/capital ratio (left scale) are plotted against first differences in log of investment to capital ratio (right scale) (labeled "inv"). Sources: Flow of funds data of the US (Federal Reserve), Venture Capital Association Yearbook and NYSE Website. For details on the data see text.

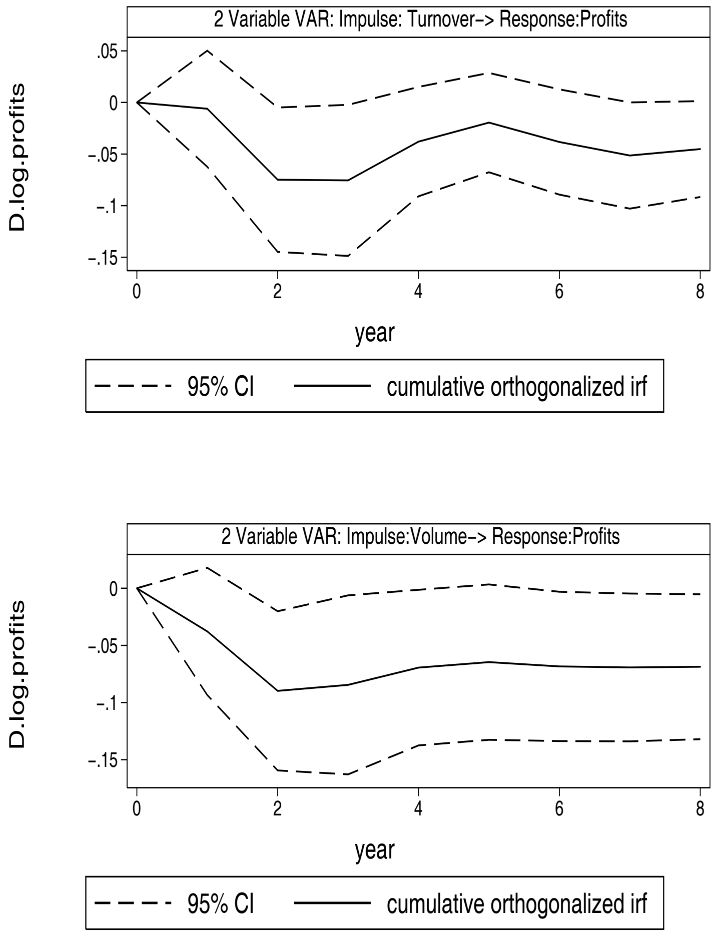

Figure 6: Cummulative (Orthogonalized) Impulse response functions of shocks to "short-termism" on $\sum_{i=0}^{\tau} d\log(profits_t)$. The top panel is based on a 2x2 VAR of the first (log) differences of profits and turnover (labeled "turn"). The bottom panel uses volume (labeled "vol") instead of turnover. Standard errors are computed by bootstraping residuals in order to determine the confidence interval for the regular impulse responses. Then the delta method is used to determine the confidence intervals of the cummulative impulse response functions.

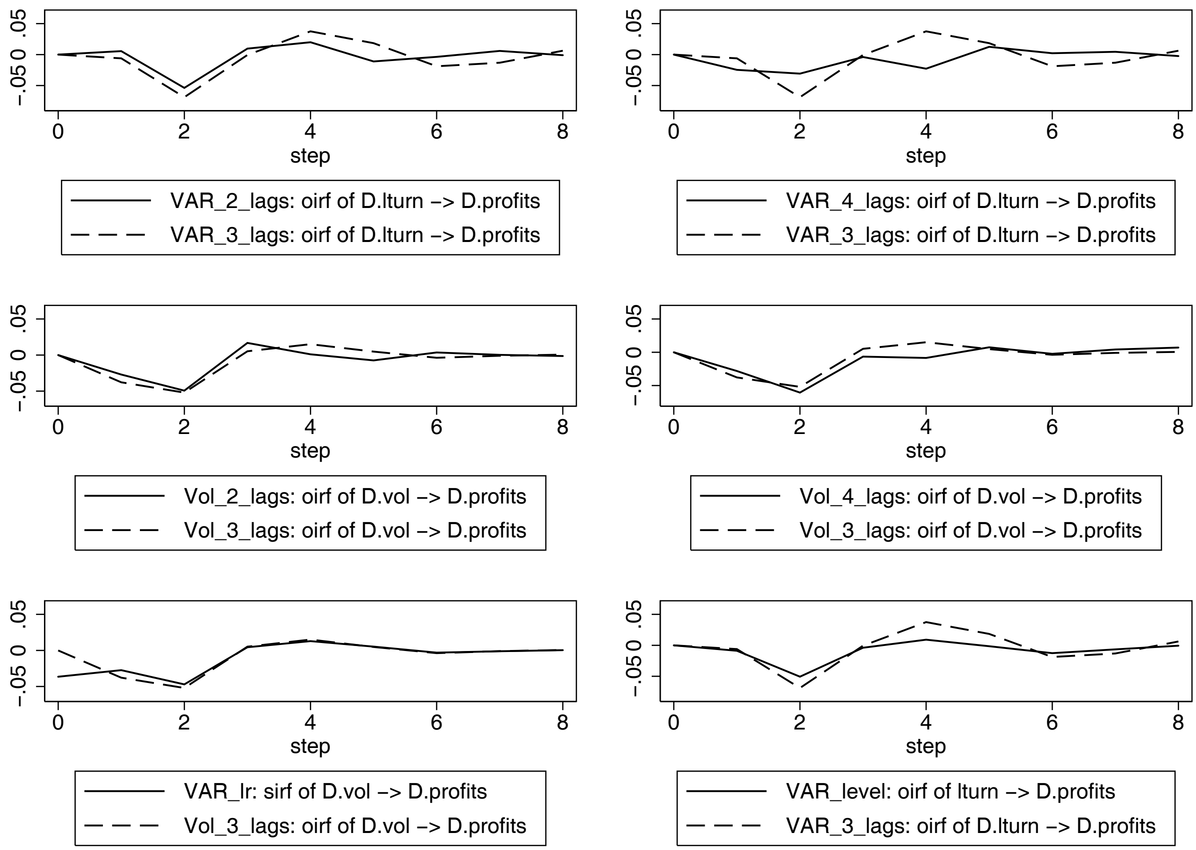

Figure 7: Robustness Checks: (Orthogonalized) Impulse response functions (OIRF) of shocks to "short-termism" on $d\log(profits_t)$. The top left figure plots the OIRF when the VAR is estimated using first differences in log turnover (labeled "lturn") and 2 lags vs. the base case which uses 3 lags. The top right figure performs the same exercise using 4 lags. The middle left figure repeats the same exercise as the top left figure with the sole exception that differences in log volume (labeled "vol") are used instead of differences in log turnover. The middle right figure performs the same exercise as the top right figure with the sole exception that differences in log volume are used instead of differences in log turnover. The bottom left figure contrasts the OIRF with the structural impulse response function (SIRF) of a VAR estimated imposing the long run restriction that shocks to fundamentals can have no long run effect on volume. The bottom right figure contrasts the base case with estimates of a VAR with 3 lags in levels of log(turnover) instead of first differences.

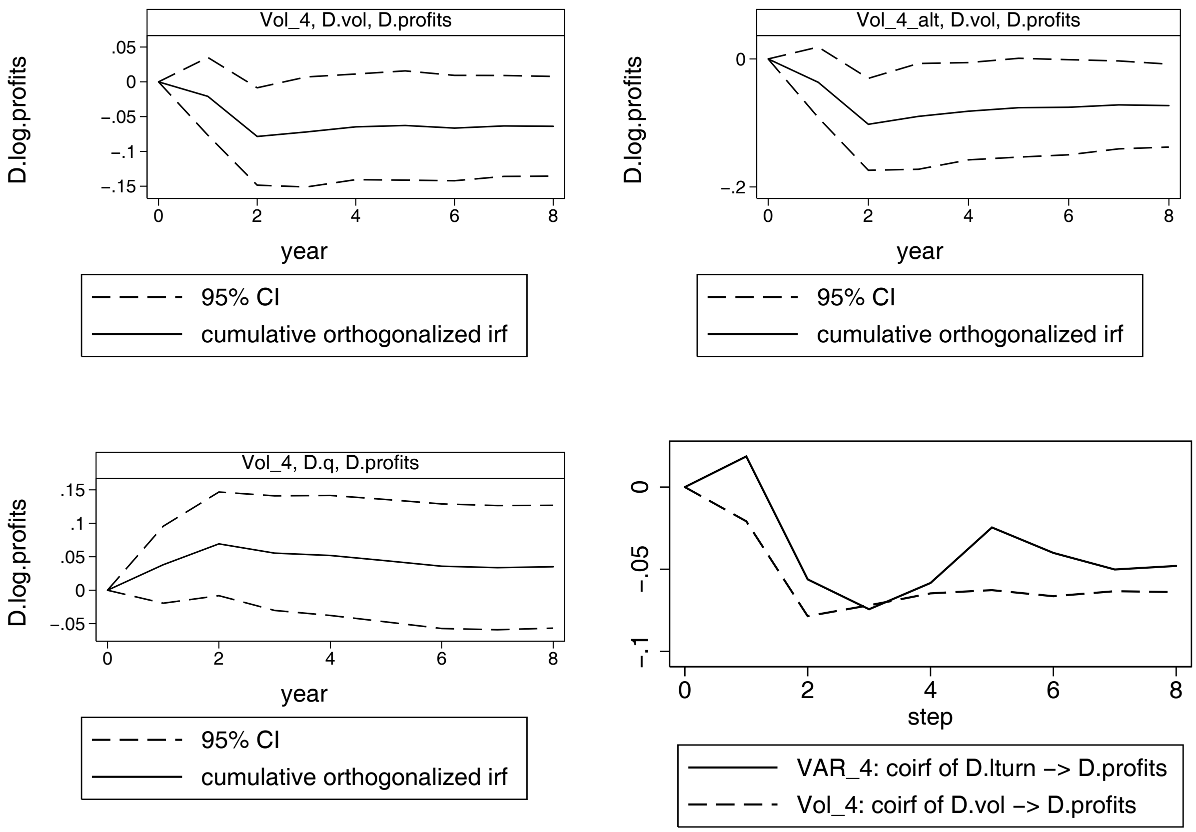

Figure 8: Cummulative (Orthogonalized) Impulse response functions for 4 variable VAR's. The top left panel depicts shocks to "short-termism" on $\sum_{i=0}^{\tau} d\log(profits_t)$ ordering the variables in the order:

$$d\log(profits_t), d\log(vol_t), d\log(q_t), d\log(i_t/K_{t-1})$$

The top right panel depicts the same quantity using the alternative ordering:

$$d\log(profits_t), d\log(q_t), d\log(vol_t), d\log(i_t/K_{t-1})$$

The figure on the bottom (left) produces the analogous results for the cummulative orthogonalized response function of a shock to "future expectations" on $\sum_{i=0}^{\tau} d\log(profits_t)$. The right figure on the bottom right depicts the cummulative orthogonalized IRF's when turnover is used instead of volume. Standard errors are computed by bootstraping residuals in order to determine the confidence interval for the regular impulse responses. Then the delta method is used to determine the confidence intervals of the cummulative impulse response functions.

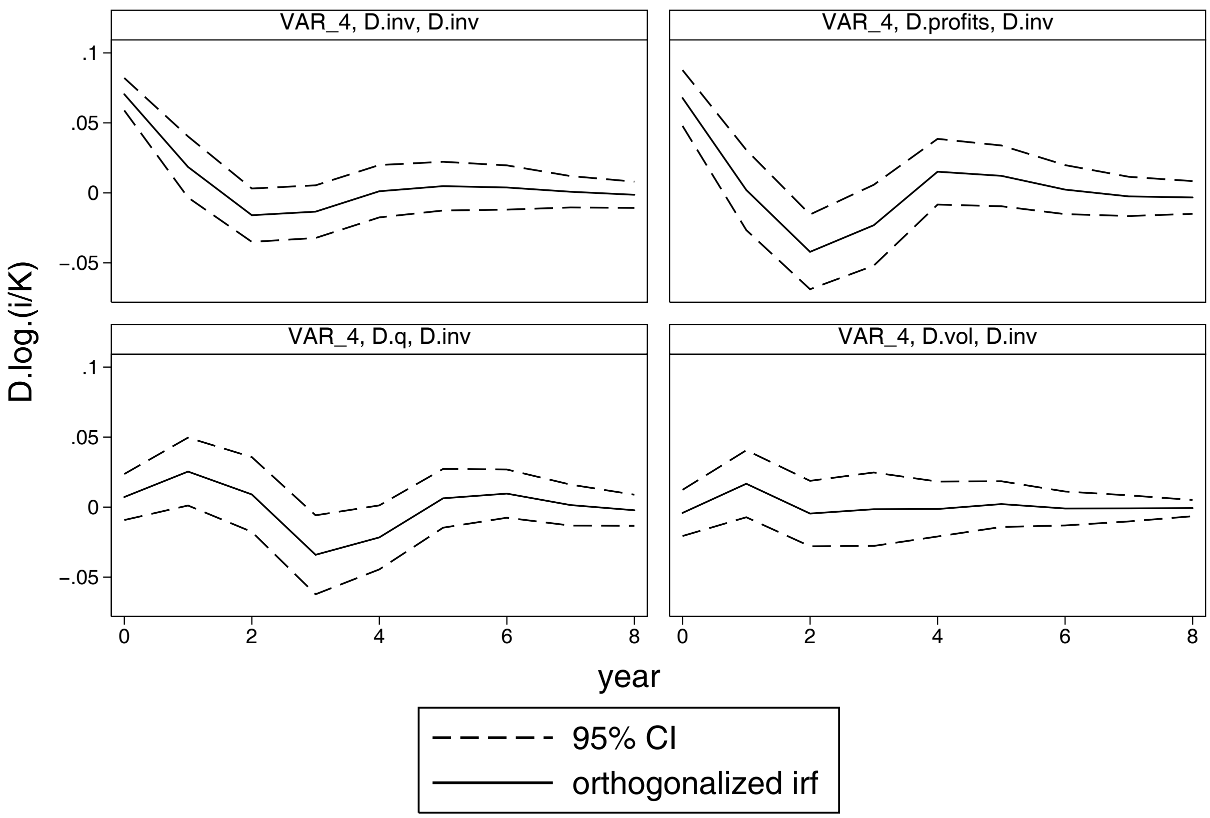

Figure 9: Orthogonalized Impulse response functions for 4 variable VAR's. The response variable is the first difference in the log(investment/capital) ratio (labeled "i/K"). The impulses correspond to the four shocks described in the text. The variables in the VAR are ordered as follows:

$$d\log(profits_t), d\log(vol_t), d\log(q_t), d\log(i_t/K_{t-1})$$

Standard errors are computed by bootstraping residuals.

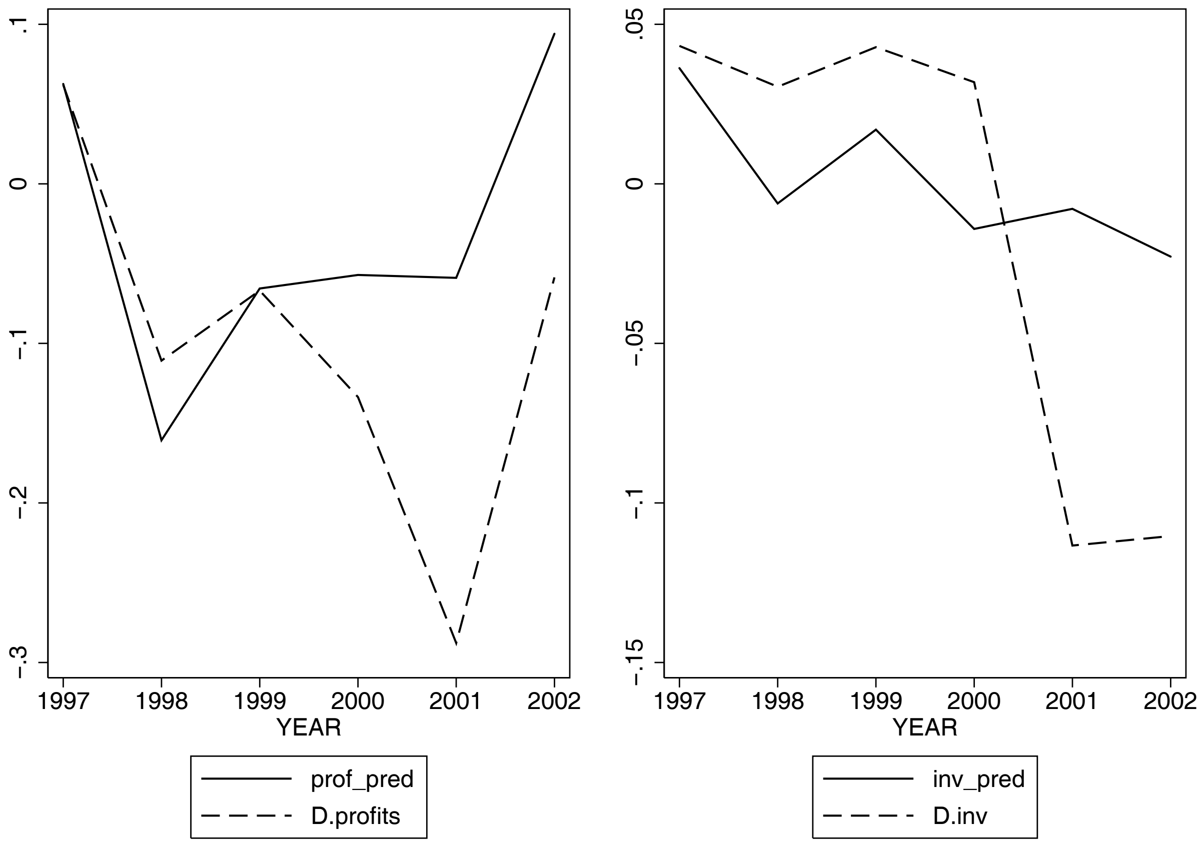

Figure 10: Predictions of a 4 Variable VAR using the following ordering of variables:

$$d \log(profits_t), d \log(turn_t), d \log(q_t), d \log(i_t/K_{t-1})$$

and 3 lags. The left panel shows the model's performance for $d \log(i_t/K_{t-1})$, while the right hand side shows the model's performance for $d \log(profits_t)$. The solid line denotes the forecast, while the dashed line denotes the actual observations.