THE "BIRD IN THE HAND" IS NOT A FALLACY: A MODEL OF DIVIDENDS BASED ON HIDDEN SAVINGS

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Abstract

We develop a model where cash is only observable by the manager and she can save the cash. Our model is similar to Fudenberg and Tirole (1995) but extended to account for an infinite time horizon. We get consistent results about the interpretation of dividends as a good signal and that dividends are less volatile than the underlying cash flow of the firm (smoothnees). Empirical evidence support the idea that there is an asymmetric reaction in prices of shares after the announcement of initiations and omissions of dividend payment respectively. The jump- down is about two times bigger in absolute value than the jump-up. Existing models about dividends are not able to explain this asymmetry. With infinite time horizon we are able to explain the asymmetric reaction of the price of a share following the announcement of initiations or omissions of dividend payment. The model predicts that firm value will increase over time if there is no news about the firm. We also find that the existence of a manager with discretionary funds increase firm value.

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1 Introduction

Since Modigliani-Miller's work (1958), economists have devoted much effort to understanding firms' financial policies. Dividends are among the most important of such policies. Dividends are an inneficient instrument in corporate finance due to tax on dividends. While in a *Modigliani-Miller's world* dividends may not exist, we know that a lot of firms pay dividends. Lintner (1956) showed that managers are concerned about dividend policy. Furthermore, managers first decide on dividend policy, and then, they decide on debt and equity.

Yet there is no general agreement on what is the information structure and the enforcement mechanism between stockholders (or the board) and the manager (or management team) that allows the former to set the appropriate dividend policy ex-ante, without the need to monitor the manager's action ex-post. Existing corporate finance models about dividends can not explain the reaction to dividend policy announcements we see in the data. Michaely, Thaler and Womack (1995) show that there is an asymmetric response to changes in dividend policy. The jump upwards after an initiation of dividend payment is smaller in absolute value than the drop that follows an omission of dividend payment.

For this asymmetry to exist the situation of the firm when the manager pays dividends for the first time must be different than the situation of the firm when the manager pays dividends, given a history of dividend payment. In this model the difference is due to the existence of hidden savings. Both whe cash flows and stock of savings are only observable by the manager. The manager can save all or part of the cash generated in the firm. This implies that the longer the tenure of a manager, the higher the expected hidden savings of the firm. We will see that the manager's optimal decision is to pay the dividend target whenever she can. Hence not paying the dividend target means the firm is in the worst situation possible. Thus the value of a firm whose manager is paying dividends is increasing with the tenure, but the value of a firm whose manager is not able to pay the dividend is constant over time. The jump upwards after an initiation in dividend payment is fixed. The drop after an omission in dividend payment is increasing in absolute value with tenure.

We present a model similar to Fudenberg and Tirole (1995). Both models explain dividend smoothing when cash flows are only observable by the manager. She could save the residual cash generated when high and she could use savings to pay dividends when the cash is low. We expand their model by assuming an infinite time horizon and specifying the cash flow generating process. This apparently simple expansion will allow us to explain some issues related to the price of shares and dividends tenure. We allow too for hidden savings and hidden "stealing", so that there is an agency problem between the shareholders and the manager, who has a trade-off between stealing the money or staying longer in office. We formulate the problem in continuous time and stipulate a simple Poisson process to determine changes in the state of the firm, which in turn determines the cash flows generated. In equilibrium, dividends are used by the market to imperfectly infer the state (high or low) of the cash flows and the amount of hidden savings inside the firm.

There is an agency problem between the shareholders and the manager. The latter is the only one that observes the cash flow and the cash stock. If shareholders have no way to force the manager to payout, the manager simply consumes all the cash generated instantaneously and the shareholders will get zero "discounted cash". Shareholders are the owners of the firms. They can establish a dividend target and fire the manager if she does achieve it. We will show that under a broad parameter space it is optimal to establish a dividend smaller than the cash generated. This is optimal even if the shareholders know that the firm is in the high state. Hence, smoothing is "second-best" optimal in our framework.

Two mechanisms are needed for this smoothness solution to be optimal. First, the manager has absolute discretion over the cash. We can justify this as long as the manager is the only one that observes the cash generated and hence the stock of cash. The manager chooses optimally what to do with the cash in every moment of time. Since the manager will be fired instantaneously if she does not pay the dividend target, she would find optimal to pay the dividend target whenever she can. There is a trade-off for the manager between consuming or saving in the firm. The utility that the manager gets from cash is linear. Saving in the firm when the firm is in the high state will allow the manager to remain longer in office when the firm is in the low state. She will be able to pay dividends for some time when the firms goes to the low state. Since the manager has a time discount factor, the returns to remain longer in the firm has decreasing returns. Since consuming has constant returns and savings has decreasing returns, it will be optimal for the manager to save until the returns of savings equals the returns of consuming.

The second mechanism needed is to make it costly for the shareholders to fire the manager. Otherwise the shareholders will ask the manager the maximum amount of cash generated in the high state and instantaneously. They will fire her and hire a new one when the current manager is not able to pay the dividend target. This would convince the manager to pay the maximum whenever she can. We acount for the case where shareholders demand the entire amount of cash in each period with the threat of firing the manager if she fails to comply. We find that this solution is optimal when the cost of firing the manager is very low. In this case the manager cannot save in the firm and the manager will be fired when the firm goes to the low state.

Under some parameter values the drop after an omission is two or three times greater in absolute value than the jump after an initiation of dividend payment. The value of the firm during a crisis remains constant. For this asymmetry to exist the value of the firm during an expansion should increase as time evolves. Such assumption is consistent with the widely extended idea in finance that "NO NEWS IS GOOD NEWS"[1]. The value of the firm after an announcement of an omission in the dividend payment (after a drop) will remain constant at the lowest possible value for a firm. The value of a firm after an announcement of an initiation in the dividend payment, i. e. after a jump, will increase until it converges to a value (the highest value for a firm in our model). That is why the drop is bigger than the jump. The reason why this happens is that, conditioning that the manager remains in the firm, the expected value due to the distribution of savings in the firm makes the probability of survival of the manager greater as time evolves. When the tenure of the manager is very long the probability of survival is close to 1. The maximum value is the value (the expected net discounted flow) of a firm whose probability of firing the manager (and paying the cost associated to this situation) is 0.

Lintner (1956) showed that managers smooth the payout of cash to the shareholders and that managers are reluctant to cut dividends. Our model is consistent with both facts. Under some parameter values, the manager finds it optimal to have a totally constant dividend policy while the cash generated varies over time. Our model is also consistent with the reluctance of cut dividend payment because in equilibrium the manager will pay the dividend whenever she can. As in most of the literature, there must be incentive compatible for the manager to payout cash (dividends or repurchases), so there must be a disciplinary mechanism. Following Allen, Bernardo and Welch (2000), the presence of large outside shareholders on the board is an effective way to do so. In general, any mechanism that makes the probability of survival of the manager in the firm increasing with the amount (or existence) of payouts, is an effective way to mitigate the moral hazard problem (as in

[1]See Campbell and Hentschel (1992).

Stiglitz-Weiss, 1983). In our case, the target dividend is fixed at the beginning of the game, and the probability of survival goes from 1 to 0 if the manager misses the target dividends in the current period. The inclusion of a mixed strategy (i.e. prob. of survival greater than zero if the manager missed the target) would not change qualitatively the results of our model, but would introduce more technical difficulties. We take into account this limitation. The effect of an entrenched manager, that is, a manager hard to get fired could be understood as a manager more unlikely to be successfully fired or just more expensively fired. We take the second option, using a cost of firing the manager that could be a measure of entrenchment.

The paper is organized as follows. Section 2 presents the model. In Section 3 we solve the problem under perfect information, we solve the problem for the manager and for the shareholders and we present the implications of the solutions in market valuations. In section 4 we summarize the numerical results. In section 5 we describe and discuss the relative size of the jumps (jump upward and downwards) in stock price that our model predicts. Section 6 concludes. Appendix A shows the steps followed to solve the Bellman equations that represent shareholders' value in a perfect information set up and can be used as a bench mark solution to the asymmetric information problem. Appendix B shows the steps followed to solve the system of linear first-order differential equations that summarize the manager's problem.

2 The Model

Consider an economy where there is only one class of firms, characterized by a cash flow generating process following a Markov chain with two states (high or low). Time is continuous and state transitions are determined by Poisson processes. These processes are independent across firms. In this economy there are two classes of risk-neutral agents, managers and shareholders. Managers are penniless and obtain utility U per unit of time while they remain employed as managers of a firm and zero otherwise. U accounts for wages or any other benefit the manager receives from the firm. There are many more managers than firms, so that managers compete for positions at firms. Once a manager is fired from a firm the probability of being hired again by the same or another firm is zero. Managers have no access to financial markets. The time horizon is infinite. Every agent has a discount rate of δ. The technology is such that every firm needs one manager to generate some cash flow that is observable only to the manager. All the parameters of the model (subjective discount rates, probabilities of transition, taxes) are common knowledge.

Let the discretionary cash flow X follow a continuous time Markov switching process so that:

$$X_t = \begin{cases} 1 & \text{if} \quad Y_t = H, \\ 0 & \text{if} \quad Y_t = L, \end{cases}$$

where $Y_t = H, L$ is the state of the firm at date t. Changes of state are governed by Poisson processes with intensities λ from H to L and μ from L to H.

In each date the manager has three possible uses for the cash flows generated; They can be paid in form of dividends to the shareholders, kept in the form of hidden savings or consumed by the manager. The cash is saved by the manager at an interest rate of zero. This is a simplification but is not restrictive.[2] The manager has full discretion over the use of the funds generated or accumulated by the firm. The manager may choose to quit at no cost.

We assume that shareholders establish a contract with the manager such that the manager is fired if she does not achieve a previously specified dividend target d at any moment of time. The dividend is subject to a proportional tax, denoted by ϕ. The target d is agreed upon hiring the manager, and cannot be renegotiated afterwards. We will assume that the target is fixed in a "second-best" optimal manner so as to maximize shareholders' wealth. Shareholders have to incur a "crisis" cost c each time a manager is fired. One could think of c as the administrative costs of firing a manager and hiring her successor, or whatever restructuring cost a firm must incur while changing its management team (i.e. lawyers, taxes, delays). One could thing of c as a parameter increasing in the degree of entrenchment of the incumbent manager. The more entrenched a manager is, the more costly it is for the shareholders to fire her.

We can think of this model as a 2-stage game:

- In the first stage, shareholders (anticipating the decisions that the manager will take in the second stage) establish a dividend target d. They will choose the value for d that maximizes their expected discounted net payoffs.

[2] Is easy to see that if we allow the manager to have access to save the cash at a rate $r < \delta$ the solution would be of the same kind, but the manager would find optimal to save more cash. If $r \geq \delta$ the manager would find optimal to save an infinite amount of cash, which is not realistic.

- In the second stage, the manager decides on dividends, hidden savings and consumption conditional on the state of the cash flow generating process and the amount of savings. The manager knows that she will be fired if she misses the dividend target.

Outsiders look at the path of dividends paid by each firm and the tenure of their managers. Then, if they know the parameters and solve the model, as we do, they should be able to form modeled beliefs about the state of cash flow process and the amount of hidden savings of an individual firm, and impute a market value to its shares.

We will solve the problem by backwards induction. First we focus on the problem of the manager for any d taken as given. Then, knowing the best strategy for the manager for each d, we will solve the problem of the shareholders that choose their optimal dividend target d. Once the model is solved, we will look at its implications for firms valuation. In the maximization problem for the shareholders and in the valuation analysis we will resort to numerical methods.

3 Solution

This section is organized as follows. In subsection 3.1 we present the analytical solution of the model in the presence of perfect information. In subsection 3.2 we derive the analytical solution to the problem of the manager in the second stage of the game(given all the parameters and every value for d chosen by shareholders in the first stage). Thus, we get a solution to the problem of the manager for every value of d . In subsection 3.3 we compute the optimal choice of d. Using $s^*(d)$ we compute the expected value of the discounted payoffs of the shareholders. The shareholders choose the value for d that maximizes this expected value. This results will be used in subsection 3.4 to analyze the impact of this mechanism on the valuation of the firm's equity.

3.1 Perfect Information case

In the perfect information case the shareholders get always the cash flow. The manager is never fired, so the shareholders never pay the cost associated with firing the manager, c. Shareholders receive an instantaneous net flow of $(1-\phi)$ when the firm is in the high state $(Y_t = H)$ and get zero otherwise. Shareholders discount time at a rate δ. The Bellman equations are then:

$$\delta W_H^{PI} = (1-\phi) + \lambda \left(W_L - W_H\right)$$

$$\delta W_L^{PI} = 0 + \mu \left(W_H - W_L\right)$$

Where W_i^{PI} is the discounted payoffs the shareholders under perfect information if the firm is in the state i. The left hand side is the instantaneous value. The right hand side are the istantaneous payment and the isntantaneous probability of changing from state time the difference in the value of being in each state. Solving the system we get:[3]

$$W_H^{PI} = \frac{(1-\phi)(\delta+\mu)}{\delta(\delta+\lambda+\mu)}$$

$$W_L^{PI} = \frac{(1-\phi)\mu}{\delta(\delta+\lambda+\mu)}$$

In the perfect information case there are no asymmetric reactions. W_H^{PI} is the value when the firm is in the high state and W_L^{PI} is the expected discount value when the firm is in the low state. The jump is the difference between both values. Here, and in the imperfect information case the value of the firm when the firm is in the low state is constant. Here the value of the firm when the manager pays the divident target remains constant. The value of a firm whose manager pays the dividend target is independent of the tenure of the manager here.

3.2 The Manager's Problem

Using the results displayed below we are going to focus on a strategy whereby the manager will pay the target dividend whenever she can. There is a threshold s^* of hidden savings, endogenously chosen by the manager. If savings are below the threshold, the manager saves the residual cash flows. If savings rise to the threshold, the manager consumes the residual cash flows.

Result 1. The manager will pay the target dividend whenever she can if $Y_t = H$.

Justifying this is trivial since the manager will be fired instantaneously if she does not pay the dividend target, so the "stock" utility of not paying is equal to zero. In turn, the

[3] The steps are in the appendix.

utility of paying a dividend and staying in the firm is strictly greater than zero, since the manager will remain in the firm for an expected length of time greater than zero and she will get an instantaneous utility of U during this time interval.

Result 2. The manager will never steal all or part of the hidden savings if $s < s^*$ and $Y_t = L$.

In our model exponential law holds. This implies that the probability of changing of state is independent of the time the firm has been in that state. As a consequence if the manager would like to consume the stock of savings when $Y_t = L$, she will do this as soon as possible. It would be worse for the manager to decide to consume the cash later since there is a discount factor δ, and the probability of arrival of a shock that changes the state remains constant.

Notice also that the only reason a manager has to save in the firm is because she does not want to be fired when $Y_t = L$. Saving allows her to remain in the firm for a period of time when $Y_t = L$, until the state changes to $Y_t = H$ again.[4] There is no reason to save up to an amount of savings s_0 when $Y_t = H$ if the manager will consume this amount of savings as soon as the state changes to $Y_t = L$. That is, if it is optimal for the manager to consume an amount of cash equal to s_0 when $Y_t = L$, it will be better not to save this amount of cash. Since there is a time discount factor for the manager the same amount of cash gives higher utility if consumes earlier. Hence it would be better to consume this cash when it was generated.

Result 3. The manager will save in the firm until the stock of savings makes the manager indifferent between saving an infinitely small amount of cash generated or consuming it. This defines the threshold $s^* \in [0, +\infty)$ for savings accumulation, so that any residual cash flow $(X_t - d)$ is saved while $s < s*$.[5]

The manager decides on savings conditional on the state of the firm and conditional on the amount of savings already in the firm.[6] We are interested in the strategy follows by

[4]For an amount of hidden savings of s and a dividend target of d if the firm remains in the low state, the manager will be able to pay the dividend target and remain in the firm for a period of $t = \frac{s}{d}$. That is, she will pay a flow of d during a period of $\frac{s}{d}$ until savings get exhausted.

[5]We take into account the case of $s^* = 0$, but later we will see that if the manager is not going to save any cash, it is optimal for the shareholders to establish a dividend target of $d = 1$ and the solution is analytical.

[6]In general the strategy of the manager should be a complete book of instructions of what to do for every amount of savings and every state of the firm. Here, we only need the threeshold when the firm is in $Y = H$.

the manager conditioning on $Y = H$. Thus (conditional on $Y = H$) the manager should decides on savings conditional on the amount of saving in the firm. Note that conditional on $Y = H$, the savings in the firm grows linearly at a rate $(1 - d)$. Hence the manager should decide when to stop saving and begin consuming.

Notice first that the utility the manager gets from consuming the cash is linear. However the utility a manager gets from savings is increasing in the amount of savings and concave. Given the time discount factor, the instantaneous utility U received in the future is the less valuable than it is in the present.

Under the referred strategy of the manager, the law of motion of the hidden savings is:

$$\dot{s} = \begin{cases} 0 & \text{if} \quad s > s^* \quad \text{and} \quad Y = H \\ 1 - d & \text{if} \quad s < s^* \quad \text{and} \quad Y = H \\ -d & \text{if} \quad s > 0 \quad \text{and} \quad Y = L \end{cases} \tag{1}$$

The manager can observe the cash flow generating process and the hidden savings at every moment, so we can describe the value function of the manager in every state by the following system of differential equations:

$$\delta V_L(s) = \begin{cases} U - dV_L'(s) + \mu \left[V_H(s) - V_L(s) \right] & \text{if} \quad s > 0 \\ 0 & \text{if} \quad s = 0 \end{cases} \tag{2}$$

$$\delta V_H(s) = \begin{cases} U + (1 - d)V_H'(s) - \lambda \left[V_H(s) - V_L(s) \right] & \text{if} \quad s < s^* \\ U + (1 - d) - \lambda \left[V_H(s^*) - V_L(s^*) \right] & \text{if} \quad s = s^* \end{cases} \tag{3}$$

These equations are identities: the value $V_i(\cdot)$ and the flow returns must be consistent. If the discount rate is δ, $\delta V_H(s)$ must be equal to the flow returns. Thus, the left-hand side of these equations are the flow returns of the manager in state i with savings s and equals the sum of utility flow from being a manager, consumption and capital gains. Capital gains (loses) are associated with $Y = H$ ($Y = L$). While $Y = H$ ($Y = L$) savings grow at a rate $(1 - d)$ (decrease at a rate d).

Equations (2) and (3) define a linear differential first-order equation system for $s \in [0, s^*]$, and boundary conditions at 0 and s^*. Thus we will be able to derive an analytical solution for the manager's value maximizing problem. That is a value for s^* and a explicit function for $\mathrm{V}_H(s)$ and $\mathrm{V}_L(s)$. For $s \in (0, s^*)$, the system becomes:

$$\begin{pmatrix} V_L'(s) \\ V_H'(s) \end{pmatrix} = \begin{pmatrix} \frac{-(\delta+\mu)}{d} & \frac{\mu}{d} \\ \frac{-\lambda}{1-d} & \frac{\delta+\lambda}{1-d} \end{pmatrix} \begin{pmatrix} V_L(s) \\ V_H(s) \end{pmatrix} + \begin{pmatrix} \frac{U}{d} \\ \frac{-U}{1-d} \end{pmatrix} \tag{4}$$

We will solve this problem like any dynamic linear system.[7] We need two conditions in order to fix the solution for the system. Beginning at $s = 0$ and using two initial conditions the general solution of the model is:

$$\begin{pmatrix} V_L(s) \\ V_H(s) \end{pmatrix} = \begin{pmatrix} \phi_1(s) & \phi_2(s) \\ \phi_3(s) & \phi_4(s) \end{pmatrix} \begin{pmatrix} V_L(0) \\ V_H(0) \end{pmatrix} + \begin{pmatrix} h_1(s) \\ h_2(s) \end{pmatrix} \tag{5}$$

where $\phi_{ij}$and $h_k$are functions of s and the underlying parameters.

$$\phi_1(s) = \frac{1}{|P|} \left(P_1 P_2 e^{(\lambda_1 s)} - P_2 P_3 e^{(\lambda_2 s)} \right) \tag{6}$$

$$\phi_2(s) = \frac{P_1 P_2}{|P|} \left(e^{(\lambda_2 s)} - e^{(\lambda_1 s)} \right) \tag{7}$$

$$\phi_3(s) = \frac{P_3 P_4}{|P|} \left(e^{(\lambda_1 s)} - e^{(\lambda_2 s)} \right) \tag{8}$$

$$\phi_4(s) = \frac{1}{|P|} \left(P_1 P_4 e^{(\lambda_2 s)} - P_2 P_3 e^{(\lambda_1 s)} \right) \tag{9}$$

$$\begin{aligned} h_1(s) = \tfrac{U}{|P|} \Big\{ & \tfrac{1}{d} \left[\tfrac{P_2 P_3}{\lambda_2} \left(1 - e^{(\lambda_2 s)}\right) - \tfrac{P_1 P_4}{\lambda_1} \left(1 - e^{(\lambda_1 s)}\right) \right] + \\ & + \tfrac{1}{1-d} \left[\tfrac{P_1 P_2}{\lambda_2} \left(1 - e^{(\lambda_2 s)}\right) - \tfrac{P_1 P_2}{\lambda_1} \left(1 - e^{(\lambda_1 s)}\right) \right] \Big\} \end{aligned} \tag{10}$$

$$\begin{aligned} h_2(s) = \tfrac{U}{|P|} \Big\{ & \tfrac{1}{d} \left[\tfrac{P_3 P_4}{\lambda_2} \left(1 - e^{(\lambda_2 s)}\right) - \tfrac{P_3 P_4}{\lambda_1} \left(1 - e^{(\lambda_1 s)}\right) \right] + \\ & + \tfrac{1}{1-d} \left[\tfrac{P_1 P_4}{\lambda_2} \left(1 - e^{(\lambda_2 s)}\right) - \tfrac{P_2 P_3}{\lambda_1} \left(1 - e^{(\lambda_1 s)}\right) \right] \Big\} \end{aligned} \tag{11}$$

where λ_j, P_j and $|P|$ are functions of the underlying parameters only. Where λ_j are the eigenvalues of the system and P_j are the elements of the eigenvector matrix.[8]

The way we have defined the system we have a value for $V_L(0) = 0$ and a value for $V_H(s^*)$, but using (5) evaluated at $s = s^*$ and (4) we get:

[7] The complete process is in the appendix.

[8] We provide detailed steps and complete formulas in the Appendix .

$$
\begin{aligned}
V_L(s^*) &= \phi_2 V_H(0) + h_1(s^*) \\
V_H(s^*) &= \phi_4 V_H(0) + h_s(s^*) \\
\delta V_H(s^*) &= U + (1-d) + \lambda \left[V_L(s^*) - V_H(s^*)\right]
\end{aligned}
\tag{12}
$$

So we can express $V_H(0)$ as a function of s^* and the original parameters only:

$$
V_H(0) = \frac{U + (1-d) - (\delta+\lambda)h_2(s^*) + \lambda h_1(s^*)}{(\delta+\lambda)\phi_4(s^*) - \lambda\phi_2(s^*)}
\tag{13}
$$

This way of expressing the system (using two initial values) is very helpful for solving the system. We compute the values and function of this system for a given value of s^*. What remains is to determine the s^*that is optimal for the manager. This is the value of s^* that satisfies the so-called "smooth pasting condition". In our case:

$$
V_H^{'}(s^*) = 1
\tag{14}
$$

meaning that the manager will save cash inside the firm until the marginal value of saving equals the marginal value of stealing, that is constant and equal to 1. Notice that in order to solve the shareholders maximization problem we only need the values of the parameters and the value of s^* given a value of d.

3.3 Shareholders' problem

In the previous subsection we have characterized the manager's optimal decision on savings. Now we take the value of s^* as a function of d ($s^* = s^*(d)$). Shareholders choose a dividend target d that maximizes the expected value of the discounted dividend flow. We must distinguish two cases: $d < 1$ and $d = 1$.

Interior solution, $d < 1$

The problem has no close-form solution, so we simulate the total tenure T of the manager for a given set of parameters. Note that given a set of parameters (including d) there exist only one value for s^* that solves the problem of the manager. In what follows we are going to compute the expected discount value for the shareholders conditioning on the firm being in the high state ($Y_t = H$) and the hidden savings are zero ($s = 0$) (i.e $W^{PI} = W_H^{PI}$, $W = W_H$ and $W^N = W_H^N$).

First of all we generate N simulations of Markov chain.[9] Using equation (1) and the optimal value for s^* the manager will chose we compute the evolution of savings through time. When savings drop to zero the manager is fired, so we take this step as the tenure T of the manager.

Once we have simulated the tenure T of the manager given the parameters, d and s^*, we compute the expected discounted value of the cash flow for the shareholders. The shareholders receive a continuous flow $d(1-\phi)$ (after taxes). Shareholders discount at a rate δ the cash flow received. For a given value of T, the expected value for the shareholders is:

$$d(1-\phi)\int_0^T \left(e^{-\delta t}\right) dt - C\left(e^{-\delta T}\right) = \frac{d(1-\phi)}{\delta}\left(1-e^{-\delta T}\right) - C\left(e^{-\delta T}\right) \tag{15}$$

$$C = E\left[\int_0^\tau ce^{-\delta t}dt\right] = E\left[\frac{c}{\delta}\left(1-e^{-\delta\tau}\right)\right] = \int_0^{+\infty}\left[\frac{c}{\delta}\left(1-e^{-\delta\tau}\right)\right]\left(\mu e^{-\mu\tau}\right)d\tau = \frac{c}{\delta+\mu} \tag{16}$$

where C is the expected cost of crisis the shareholders must incur at time T when the manager is fired. When the manager is fired the shareholders have to incur an instantaneous cost of c until a new manager is able to pay the dividends again. A new manager will only be able to pay the target dividend if the firm reaches $Y_t = H$ again. Note that C is also the difference of the expected value of the firm of being in the high state or in the low state with a amanager who keeps zero savings (i.e. $C = W_H - W_L$).

The next step is to take expectations on T. The distribution of the total tenure of the manager T has no close form solution. We take the N simulations and for each one we compute the value for the shareholders of this particular simulation.

$$w_i(d, T_i) = \left[\frac{d(1-\phi)}{\delta}\left(1-e^{-\delta T_i}\right) - \frac{c}{\delta+\mu}\left(e^{-\delta T_i}\right)\right] \tag{17}$$

The expected value of a complete cycle is then:

[9] Every chain begin at $Y_t = H$. We now that the first time a manager is able to pay d the firm is in $Y_t = H$ and $s = 0$.

$$w(d) = \frac{1}{N}\sum_{i=1}^{N} w_i(d, T_i) \tag{18}$$

We have to take into account that shareholders are interested in every cycle, not only in the first one. For every simulation the duration of the cycle is the sum of the duration of the total tenure of the manager T_i and the duration of the crisis z_i:

$$D_i = T_i + z_i$$

Hence, the expected total discount value for a simulation is:

$$W_i(d, T_{ji}) = w_i(d, T_{1i}) + w_i(d, T_{2i})e^{-\delta D_{1i}} + w_i(d, T_{3i})e^{-\delta(D_{1i}+D_{2i})} + \cdots + w_i(d, T_{Ji})e^{-\delta\left(\sum_{k=1}^{J-1} D_{ki}\right)} + \cdots$$

$$W_i(d, T_{ji}) \simeq w_i(d, T_{1i}) + \sum_{j=2}^{J} w_i(d, T_{ji})e^{-\delta\left(\sum_{k=1}^{j-1} D_{ki}\right)} \tag{19}$$

Where j is the position of the cycle over time ($j = 1$ denotes the first cycle, $j = 2$ denotes the second cycle, etc) for each simulation. The total value for the shareholders is:

$$W(d) = \frac{1}{N}\sum_{i=1}^{N} W_i(d, T_i)$$

$W(d)$ is the shareholders' object of interest. We compute a value of $W(d)$ for each value of $d \in (0, 1)$. [10] Shareholders will choose a dividend target d that maximizes their expected value of the discounted dividend flow.

$$\underset{d\in(0,1)}{Max} W(d)$$

In this case the shareholders do not ask the manager for all the cash generated, but just

[10] We have found that for some extreme values of d the problem of the manager has no interior solution. These cases are not important as the shareholders will never choose such values of d. When the manager chooses a value of $s^* = 0$, the optimal choice for the shareholders is $d = 1$. In particular, for the baseline case we found that the value for the shareholders is zero or negative if they choose values of d greater then 0.499.

a fraction. This allows the manager to save the residual cash while $s < s^*$ and consume the residual while $s < s^*$. The manager will eventually consume part of the cash if savings rise to s^*. Shareholders will not have to pay the cost c while the firm is in the low state if there is a positive amount of cash in the firm. Hence dividend smoothing is optimal as it makes the value for the shareholders greater than if they ask for the total cash generated.[11]

The "Naïve" solution $d = 1$

The manager is not able to save any cash. Thus the manager will be fired as soon as the firm turns into the low level of cash flow (i.e. when $Y = L$). This is what we call the "Naive" solution. This solution will be optimal for the shareholders whenever the optimal choice for the manager in the second step is $s^* = 0$, unless the value for the shareholders is negative. This is due to the fact that the only reason the shareholders have to establish a dividend target smaller than 1 is in order to make less frequent the cost associated with a crisis. If the manager is not going to save any cash the frequency of the crisis would be the same as the frequency of the low state (this is the maximal frequency of crisis).

We proceed here as in the perfect information case. The only difference is that now the shareholders will have to pay the cost of firing the manager c each time the firm is in the low state, $Y_t = L$. Shareholders receive an instantaneous net flow of $(1 - \phi)$ when the firm is in the high state $Y_t = H$ and pay c if the firm is in the low state, $Y_t = L$. Shareholders discount at a rate δ. The Bellman equations are then:

$$\delta W_H^N = (1 - \phi) + \lambda (W_L - W_H)$$

$$\delta W_L^N = -c + \mu (W_H - W_L)$$

Where W_i^N is the discounted payoffs the shareholders under perfect information if the firm is in the state i. Solving the system we get:[12]

$$W_H^N = \frac{(1 - \phi)(\delta + \mu) - \lambda c}{\delta (\delta + \lambda + \mu)}$$

[11] We will see that this is the case for values of c big enough.

[12] The complete process is in the appendix.

$$W_L^N = \frac{(1-\phi)\,\mu - c\,(\delta+\lambda)}{\delta\,(\delta+\lambda+\mu)}$$

Note that the shareholders always have the option to establish a dividend target of 1, so the firm's value is at least W_H^N. In this case the solution is analytical and it is not necessary to simulate any chain in order to get the expectations. This is a corner solution, and will be optimal when the value of c is low enough or when the volatility of the Markov chain is low (i.e. low values for λ and μ). It is interesting to note that for values of c big enough this expression would take negative values while the solution for $d < 1$ (and the solution in the perfect information case) would not, in this case if the shareholders would not have the possibility of establish a dividend target, they would not find optimal to ever fire the manager.

3.4 Market valuations

The more interesting feature of our model is that it can explain the asymmetric reaction in the stock price of the shares of a firm after the manager announces an initiation of dividend payment and when they announce an omission of dividend payment.

The positive jump in the price of the stock after an announcement of the payment of the dividend is due to the different discounted expected cash flow for the shareholders when the firm is in $Y_t = H$ and $Y_t = L$, and the manager has no hidden savings in the firm. When the firm is not paying dividends, that means that $Y_t = L$ and $s = 0$. The shareholders will have to incur an instantaneous cost of c while the firm remains in that situation. Which has an expected cost of this is $C = \frac{c}{\delta+\mu}$. [13] Note that $Y_t = L$ and $s = 0$ is the worst situation a firm can be in our model. But as long as there is a positive probability that the firm goes to the high state ($Y_t = H$) and thus, that the manager is able to pay the target dividend again, the value of the firm could be positive. When the firm goes back to $Y_t = H$ the shareholders are in the same situation as before (i.e. $s = 0$) but they do not have to pay C. So the size of this increase in the stock price is C.

When the firm begins to pay a dividend this means that $Y_t = H$ and $s = 0$. When the firm has been paying dividends for some time, there is some probability that the firm is in $Y_t = L$ or $Y_t = H$ and the firm could have different amounts of hidden saving. We

[13] Notice that the exponential distribution has no memory, so the expected cost is the same independently of the time that has past and the amount of costs paid.

compute the evolution over time of $Prob(Y_t = H)$ and s, conditioning on the firm paying dividends. We find that $Prob(Y_t = H)$ begins at 1 and is decreasing until it stabilizes at its ergodic value and s begins at 0 and is increasing until it stabilizes at its ergodic value (this value being smaller than s^*). What is not surprising.

The drop in the price of the stock after the announcement of the omission of the payment of the dividend depends on how much time has passed since the firm began to pay dividends. Since the value after the announcement is fixed but the value before the announcement is a function of $Prob(Y_t = H)$ and s. The latter is increasing over time until $Prob(Y_t = H)$ and s stabilize at their ergodic values.

4 Numerical results

In this section we present some results using reasonable values for the parameters. Our intention is not to calibrate or to make qualitative predictions. Our aim is to show the sign of the comparative statics and the qualitative effect of each of the parameters on the results. We focus our analysis in some topics very common in the literature. Some of them have been largely accepted by most of economists but there is some degree of disagreement about others. In the next section we present the results about the asymmetric reactions in the market after the manager announces a change in dividend policy. The jump-up after an initiation is smaller than the drop after an omission. The drop is about two or three times bigger than than the jump-up in absolute value.

Baseline case

Our unit of time is a quarter. A value of $\delta = 0.015$ means a 1.5% quarterly interest rate or 6% annual interest rate. We have chosen reasonable values for λ and μ. They are reasonable in the sense that are smaller than one half and they are close to zero. We have taken $\lambda = \mu$ for transparency. We will see that even in that case with symmetric underlying cash flows the duration of the cycles of the firm are of different length and not symmetric. The value of c is chosen to be one half also for transparency. The value of U has been chosen arbitrarily small and does not change the results. We have chosen the parameters of the baseline as an illustration, we do no intend our parameters to replicate exactly what we see in reality.

Dividends as good signals

In Table 3 we present the results when we change the values of λ and μ and we remain close to the baseline case. The unconditional probability of the firm to be in the high state ($Y_t = H$) when time goes to infinity is $Prob(Y_t = H) = \frac{\mu}{\lambda+\mu}$. This probability is increasing in λ and decreasing in μ. The greater the value of μ, the greater the expected underlying cash flow. The lower the value of λ, the greater the expected underlying cash flow. If we look at Table 3 we can see that greater expected underlying cash flow means greater expected value for the shareholders (W). This relation is also true for the *naïve* solution (W^N). The fact that the dividend target is increasing in λ and decreasing in μ is consistent with the idea that dividends convey information of good cash flows. The greater the dividend the greater the underlying cash flow.

It is interesting to see that the *naïve* solution is more sensitive to changes in λ and μ than the interior solution is. Very small changes (smaller than 5%) in λ and μ make the gains of choosing the interior solution two times bigger.

Entrenchment

There is empirical evidence that firms that are hold mainly by institutional investors are very likely to pay dividends and that firms hold by institutional investors have managers that are not entrenched. Hence we will expect non-entrenched firms to be very likely to pay dividends and to pay higher dividends.

In our model the parameter that measures the degree of entrenchment of a manager is c. In most of the literature entrenchment is included with a parameter that measures the probability of success when shareholders try to fire the manager. We do not assume that the manager is fired with some probability at zero cost. We assume that the manager is fired with probability one at a cost c. The greater the value of c the more entrenched is a manager.

If we look at Table 4 we can see that the gains associated with the existence of hidden savings are decreasing in c. Even more, for values of c of 0.2 or smaller there is no gains in allowing the manager to save and eventually consume the cash. In this case the value of the *naïve* solution is greater than the value of the interior solution.

Maturity Hypothesis

Most of the early literature has associated the existence of dividends with greater cash flows. Late research in this field has claim that, on the contrary, dividends reflect less volatile cash flows. Thus, not greater cash flows but more stable cash flows. Both hypothesis agree that dividends are good signals, but the implication of each of them in terms of future cash flows of a dividend payment firm, are very different.

Note that taking $\mu = \lambda$ the underlying state of the firm Y_t will be (on average) in each of the states H and L. But the greater the value of λ (μ), the greater the volatility. With $\mu = \lambda = 1$, there will not be any change in state, so there is no volatility. With $\mu = \lambda \rightarrow 1$, state will change at every moment of time, so volatility is maximum.

According with the *maturity hypothesis*, the greater the values of $\mu = \lambda$ the less likely is that a firm pays dividends. In Table 5 we can see that in our model this is not the case. The relation between volatility and dividends is ambiguous. However, it is true that for small values of μ and λ the *naïve* solution is likely to be better (greater expected discount value) than the interior solution. Those firms whose managers are less entrenched (low c) and whose cash flows are less volatile are most likely to choose the *naïve* solution and, hence, pay the maximum amount of dividends ($d = 1$) (this argument support the *maturity hypothesis*).

There is an arm-wrestling between the manager and the shareholders. Both are risk-neutral, but the manager is more affected by changes in the state than the shareholders are. Notice that manager is only concerned about what happen in the firm during the first cycle because after that the manager is out of the firm and has no utility. Nevertheless, shareholders are interested in what happens in all the cycles of the firm. Remaining for a long time interval in the low state is bad for the shareholders since they have to fire the manager, pay the costs associated to it and wait until the firm reaches the high state again. But firing the manager is worse for the manager since she is fired and she get zero after that. These differences in how changes in volatility affect the utility of the manager and the utility of the shareholders means that s^* is increasing with volatility. The manager chooses greater buffers in response to greater volatility. This fact is interesting because what we found is that higher volatility (greater values of μ and λ) means higher firm's value (greater values for W), if the solution is interior. On the contrary, if the *naïve* solution is optimal, the firm's value is lower for greater values of μ and λ.

Managers responds to increases in volatility with increases in precautionary buffers, which in turn increases the value for the shareholders. In other words, managers perform better if the probability of being fired increases. But in any case the solution for s^* is finite, meaning that the manager may eventually consume part of the cash generated.

5 Asymmetric reactions

In our model asymmetric reactions only occurs under the interior solution. Under the *naïve* solution there is not asymmetry since there are no hidden savings and there is no uncertainty about the state of the firm, i. e. if the firm is paying dividends, the firm is the high state.

Traditional models about dividends as a signal make not distinction between initiations and omissions of dividend payment. Dividends are good news and no-dividend are bad news. In a static framework not much can be said about that. We present a model of infinite time horizon and we found that not only the existence of a current dividend, but also the immediate past history of dividend payments give us valuable information - even with a cash flow generating process with no memory (1st order Markov chain).

Empirical papers about this topic found that the average abnormal returns to dividend increases are between two and three times bigger than the average abnormal reaction to dividend decreases (in absolute value). For dividend initiations and omissions, the magnitude is even bigger. [14]

We can see in (4) that the jump after an initiation of a dividend payment is 2.3. The drop in the value of the firm after an omission of dividend payment is 4.3, 6.4, 7.6 or 8.0 respectively. This means that under the baseline case the drop after an omission is between 1.5 and 3.5 times greater than the jump after an initiation. Which is consistent with the relative size observed in empirical works.

It is interesting to see that after a manager announces a change in dividend policy (an initiation in dividend payment) and does not change this decision, the value of the firm increases over time. That is, *no news are good news.* One might think that this is a problem of under reaction, and the market should anticipate this upward trend and adjust the value of the firm. But this is not the case, since the values showed in Figure 4 are the

[14]See Allen and Michaeli (2002) for details.

true values of the firm (i.e the expected discount cash flow). One may argue that it is not possible that the expected discount flow (the stock price) of a firm changes if there are no changes in the information available to the market. This point is right, but this is not in contradiction with the results in Figure 4. What this results suggest is that the time has passed without any change in the information given by the manager or the firm give us also valuable information. If a researcher is interested in pricing such an asset we would find useful the information relative to the tenure of the manager and the past history about payout policy, and not only the amount of the last dividend already paid.

6 Conclusions

We have taken an approach similar to Fudenberg and Tirole (1995) and expanded it with infinite time horizon and a more structural approach. We show that allowing the manager to save in the firm can increase the expected discount value for the shareholders. This is true even if this is inefficient in two ways: it is inneficient because saving in the firm at a zero rate is less attractive than paying out all the cash generated and because the manager would eventually consume some cash. The reasons for this are the high cost associated when firing the manager and the frequency associated with more volatile cash flows.

Our results show that the model is (at least qualitatively) consistent with the empiric facts observed in the data:

1. Smoothing is a result of the equilibrium and solves partially the agency problem between the manager and the shareholders.

2. Higher dividend payment is associated with higher underlying cash flows and hence, greater value (stock price).

3. Dividends are more likely to be paid in firms whose managers are non entrenched.

4. Firms with institutional investors are less likely to have an entrenched manager and hence, are more likely to pay dividends.

While our model generates implications that are consistent with the available empirical data, it also provides a micro-founded explanation about the asymmetric reaction after announcements of initiations and omissions. It predicts an smaller reaction after an initiation (relative to the reaction after an omission) and an increasing path in stock price. The observed pattern in the real data is not under-reaction, but exact reaction when facing a problem of asymmetric information. The increasing path in stock price is due to the fact that the problem of asymmetric information is smaller as time evolves, and negligible after some time (about 20 quarters in our baseline case).

Our model also suggests other ways of looking at the data. We show that the tenure of the manager of a firm and the immediate past of payout policy are informative when one is interested in pricing assets.

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A Solving the Bellman equations:

A.1 Perfect Information case

These Bellman equations show the payoffs of the shareholders when the firm is in each state (H, L) under perfect information. While the firm is in the high state (H) the shareholders get an instantaneous flow of 1 unit ($(1-\phi)$ after taxes) and receive a shock with intensity λ that bring the firm to the low state (L). While the firm is in the low state (L) the shareholders get an instantaneous flow of 0 and will receive a shock with intensity μ that bring the firm to the high state (H). Shareholders has a time discount factor of δ.

$$\delta W_H^{PI} = (1-\phi) + \lambda \left(W_L^{PI} - W_H^{PI}\right)$$

$$\delta W_L^{PI} = 0 + \mu \left(W_H^{PI} - W_L^{PI}\right)$$

From the second equation we rearrange and get W_L^{PI} as a function of W_H^{PI}:

$$W_L^{PI} = \frac{\mu}{\delta + \mu} W_H^{PI}$$

We substitute the value of W_L^{PI} in the first equation and get the value of W_L^{PI}:

$$\delta W_H^{PI} = (1-\phi) + \frac{\lambda\mu}{\delta + \mu} W_H^{PI} - \lambda W_H^{PI}$$

$$\left(\delta + \lambda - \frac{\lambda\mu}{\delta + \mu}\right) W_H^{PI} = (1-\phi)$$

$$W_H^{PI} = \frac{(1-\phi)(\delta+\mu)}{(\delta+\lambda)(\delta+\mu) - \lambda\mu}$$

$$W_H^{PI} = \frac{(1-\phi)(\delta+\mu)}{\delta(\delta+\lambda+\mu)}$$

Hence:

$$W_H^{PI} = \frac{(1-\phi)(\delta+\mu)}{\delta(\delta+\lambda+\mu)}$$

$$W_L^{PI} = \frac{(1-\phi)\,\mu}{\delta\,(\delta+\lambda+\mu)}$$

A.2 Naïve solution

These Bellman equations show the payoffs of the shareholders when the firm is in each state (H, L) and the shareholders choose the naive solution. While the firm is in the high state (H) the shareholders get an instantaneous flow of 1 unit ($(1-\phi)$ after taxes) and receive a shock with intensity λ that bring the firm to the low state (L). While the firm is in the low state (L) the shareholders pay an instantaneous cost of c and will receive a shock with intensity μ that bring the firm to the high state (H). Shareholders has a time discount factor of δ.

$$\delta W_H^N = (1-\phi) + \lambda\left(W_L^N - W_H^N\right)$$

$$\delta W_L^N = -c + \mu\left(W_H^N - W_L^N\right)$$

From the second equation we rearrange and get W_L^N as a function of W_H^N:

$$W_L^N = \frac{\mu}{\delta+\mu} W_H^N - \frac{c}{\delta+\mu}$$

We substitute the value of W_L^N in the first equation and get the value of W_L^N:

$$\delta W_H^N = (1-\phi) + \frac{\lambda\mu}{\delta+\mu} W_H^N - \lambda W_H^N$$

$$\left(\delta+\lambda-\frac{\lambda\mu}{\delta+\mu}\right) W_H^N = (1-\phi) - \frac{\lambda c}{\delta+\mu}$$

$$W_H^N = \frac{(1-\phi)\,(\delta+\mu) - \lambda c}{(\delta+\lambda)\,(\delta+\mu) - \lambda\mu}$$

$$W_H^N = \frac{(1-\phi)\,(\delta+\mu) - \lambda c}{\delta\,(\delta+\lambda+\mu)}$$

Now we substitute the value of W_H^N into the equation for W_L^N:

$$W_L^N = \frac{\mu}{\delta+\mu}\frac{(1-\phi)(\delta+\mu)-\lambda c}{\delta(\delta+\lambda+\mu)} - \frac{c}{\delta+\mu}$$

$$W_L^N = \frac{(1-\phi)\mu}{\delta(\delta+\lambda+\mu)} - \frac{\lambda c}{\delta(\delta+\lambda+\mu)}\frac{\mu}{(\delta+\mu)} - \frac{c}{(\delta+\mu)}\frac{\delta(\delta+\lambda+\mu)}{\delta(\delta+\lambda+\mu)}$$

$$W_L^N = \frac{(1-\phi)\mu}{\delta(\delta+\lambda+\mu)} - \frac{c}{\delta+\mu}\left(\frac{\lambda\mu+(\delta+\lambda)(\delta+\mu)-\lambda\mu}{\delta(\delta+\lambda+\mu)}\right)$$

$$W_L^N = \frac{(1-\phi)\mu}{\delta(\delta+\lambda+\mu)} - \frac{c(\delta+\lambda)}{\delta(\delta+\lambda+\mu)}$$

Hence:

$$W_H^N = \frac{(1-\phi)(\delta+\mu)-\lambda c}{\delta(\delta+\lambda+\mu)}$$

$$W_L^N = \frac{(1-\phi)\mu - c(\delta+\lambda)}{\delta(\delta+\lambda+\mu)}$$

B Solving the linear first-order differential equation system

1. Find the eigenvalues[15] of the system:

$$|A-\lambda_i I| = 0$$

$$\begin{vmatrix} -\left(\frac{\delta+\mu}{d}\right)-\lambda_i & \frac{\mu}{d} \\ -\frac{\lambda}{1-d} & \frac{\delta+\lambda}{1-d}-\lambda_i \end{vmatrix} = \frac{1}{d(1-d)}\left[(-\delta-\mu-\lambda_i d)(\delta+\lambda-\lambda_i(1-d))+\lambda\mu\right] = 0$$

$$\lambda_i = \frac{d(\delta+\lambda)-(1-d)(\delta+\mu)}{2d(1-d)} \pm \frac{\sqrt{[(1-d)(\delta+\mu)-d(\delta+\lambda)]^2+4\delta(\delta+\lambda+\mu)d(1-d)}}{2d(1-d)}$$

[15]Notice that given reasonable values for the original parameters, there will always be one eigenvalue positive and one will be negative, so any critical point of the system will be a saddle point solution.

2. Find the eigenvectors associated to these eigenvalues:

$$(A - \lambda_i I) \begin{pmatrix} X \\ Y \end{pmatrix} = 0$$

For (λ_1) we get:

$$\frac{-\delta + \mu + \lambda_1 d}{d} X + \frac{\mu}{d} Y = 0$$

And take as a vector :

$$(\mu, \delta + \mu + \lambda_1 d)$$

For (λ_1) we get:

$$\frac{\delta + \lambda - \lambda_2(1-d)}{1-d} Y - \frac{\lambda}{1-d} X = 0$$

And take as a vector :

$$(\delta + \lambda - \lambda_2(1-d), \lambda)$$

We call the eigenvectors matrix P so that:

$$P = \begin{pmatrix} \mu & \lambda \\ \mu + \delta + \lambda_1 d & \lambda + \delta - \lambda_2(1-d) \end{pmatrix}$$

$$P^{-1} = \begin{pmatrix} \lambda + \delta - \lambda_2(1-d) & -\lambda \\ -(\mu + \delta + \lambda_1 d) & \mu \end{pmatrix} \frac{1}{|P|}$$

$$|P| = \mu[\lambda + \delta - \lambda_2(1-d)] - \lambda(\mu + \delta + \lambda_1 d)$$

3. Let's call the transitions probability matrix $\Phi(s, s_0)$ define as follows:

$$\Phi(s, s_0) = e^{A(s-s_0)} = P \begin{pmatrix} e^{\lambda_1(s-s_0)} & 0 \\ 0 & e^{\lambda_2(s-s_0)} \end{pmatrix} P^{-1} = \begin{pmatrix} \phi_1 & \phi_2 \\ \phi_3 & \phi_4 \end{pmatrix}$$

4. The solution to the system as a function of the initial values is then:

$$\begin{pmatrix} V_L(s) \\ V_H(s) \end{pmatrix} = P \begin{pmatrix} e^{\lambda_1(s-s_0)} & 0 \\ 0 & e^{\lambda_2(s-s_0)} \end{pmatrix} P^{-1} \begin{pmatrix} V_L(s_0) \\ V_H(s_0) \end{pmatrix} +$$
$$+P \begin{pmatrix} \int\limits_{s_0}^{s} e^{\lambda_1(s-\sigma)} d\sigma & 0 \\ 0 & \int\limits_{s_0}^{s} e^{\lambda_2(s-\sigma)} d\sigma \end{pmatrix} P^{-1} \begin{pmatrix} \frac{U}{d} \\ \frac{-U}{1-d} \end{pmatrix}$$

Tables

Table 1: Underlying parameters

Definition	Symbol
Intensity of shocks per unit of time in low state (L)	μ
Intensity of shocks per unit of time in high state (H)	λ
Time discount factor	δ
Instantaneous utility of the manager while managing a firm	U
Dividend tax rate	ϕ
Instantaneous cost of firing a manager	c
Target dividend	d

Table 2: Baseline parameters

Definition	Symbol	Baseline Value
Intensity of shocks per unit of time in low state (L)	μ	0.2
Intensity of shocks per unit of time in high state (H)	λ	0.2
Time discount factor	δ	0.015
Instantaneous utility of the manager while managing a firm	U	0.1
Dividend tax rate	ϕ	0.3
Instantaneous cost of firing a manager	c	0.5

Table 3: Variations in λ and μ

Parameters	d	s^*	W	W^N	W^{PI}	% A	% B
Baseline	0.449	16.16	14.9	8.1	24.1	38.2%	84.1%
$\lambda = 0.18$	0.478	15.75	16.4	10.2	25.4	35.0%	61.5%
$\lambda = 0.22$	0.426	16.02	14.0	6.2	23.0	39.0%	126.5%
$\mu = 0.18$	0.427	15.54	13.7	6.1	23.0	40.4%	122.7%
$\mu = 0.22$	0.466	17.11	16.0	9.8	25.2	36.4%	62.2%

- % A are the loss in shareholders value due to the fact of asymmetric information ($\%A = \frac{W^{PI}-W}{W^{PI}} \times 100$).
- % B are the gains in shareholders value due to the existence of hidden savings ($\%B = \frac{W-W^N}{W^N} \times 100$).

Table 4: Entrenchment

Parameters	d	s^*	W	W^N	W^{PI}	% A	% B
Baseline	0.449	16.16	14.9	8.1	24.2	38.2%	84.1%
$c = 0.1$	0.462	14.29	17.2	20.9	24.2	28.5%	0%
$c = 0.2$	0.462	14.29	16.9	17.7	24.2	30.0%	0%
$c = 0.3$	0.450	16.02	16.1	14.5	24.2	33.3%	10.8%
$c = 0.4$	0.460	14.58	15.5	11.3	24.2	35.8%	37.0%

- % A are the loss in shareholders value due to the fact of asymmetric information ($\%A = \frac{W^{PI}-W}{W^{PI}} \times 100$).
- % B are the gains in shareholders value due to the existence of hidden savings ($\%B = \frac{W-W^N}{W^N} \times 100$).

Table 5: Maturity Hypothesis

Parameters	d	s^*	W	W^N	W^{PI}	% A	% B
$\mu = \lambda = 0.1$	0.445	16.10	14.0	9.5	25.0	43.9%	48.1%
Baseline	0.449	16.16	14.9	8.1	24.1	38.2%	84.1%
$\mu = \lambda = 0.3$	0.426	19.46	15.4	7.6	23.9	35.6%	101.4%

- % A are the loss in shareholders value due to the fact of asymmetric information ($\%A = \frac{W^{PI}-W}{W^{PI}} \times 100$).
- % B are the gains in shareholders value due to the existence of hidden savings ($\%B = \frac{W-W^N}{W^N} \times 100$).

Graphics

Figure 1: Evolution of the hidden savings for different simulations.

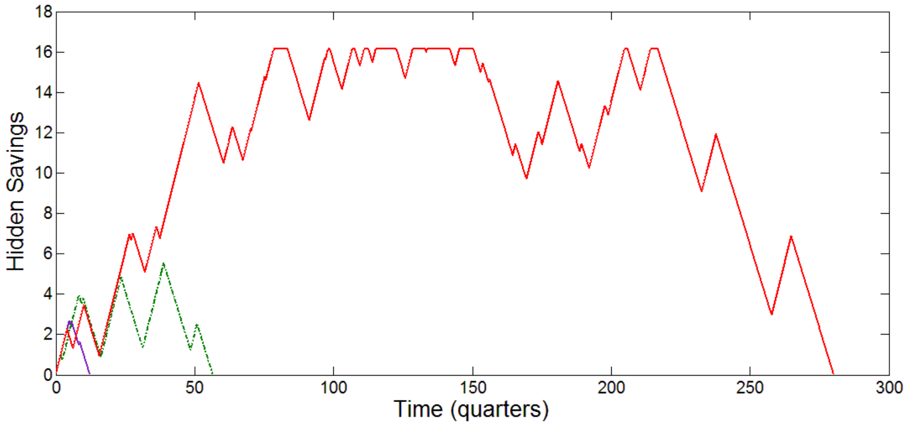


Figure 2: Maximization in d.

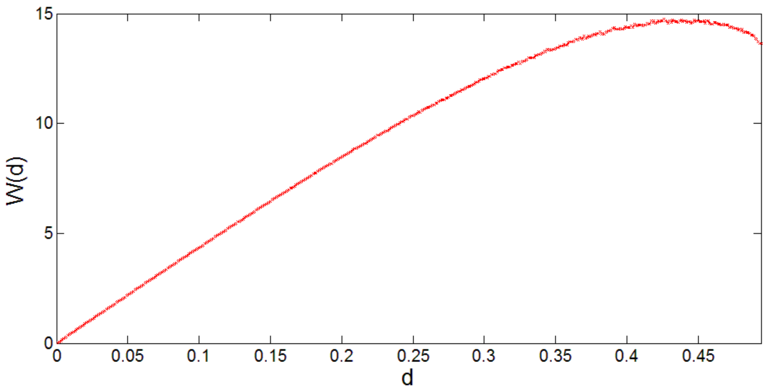


Figure 3: Evolution of the state of the firm (H, L) and hidden savings over time.

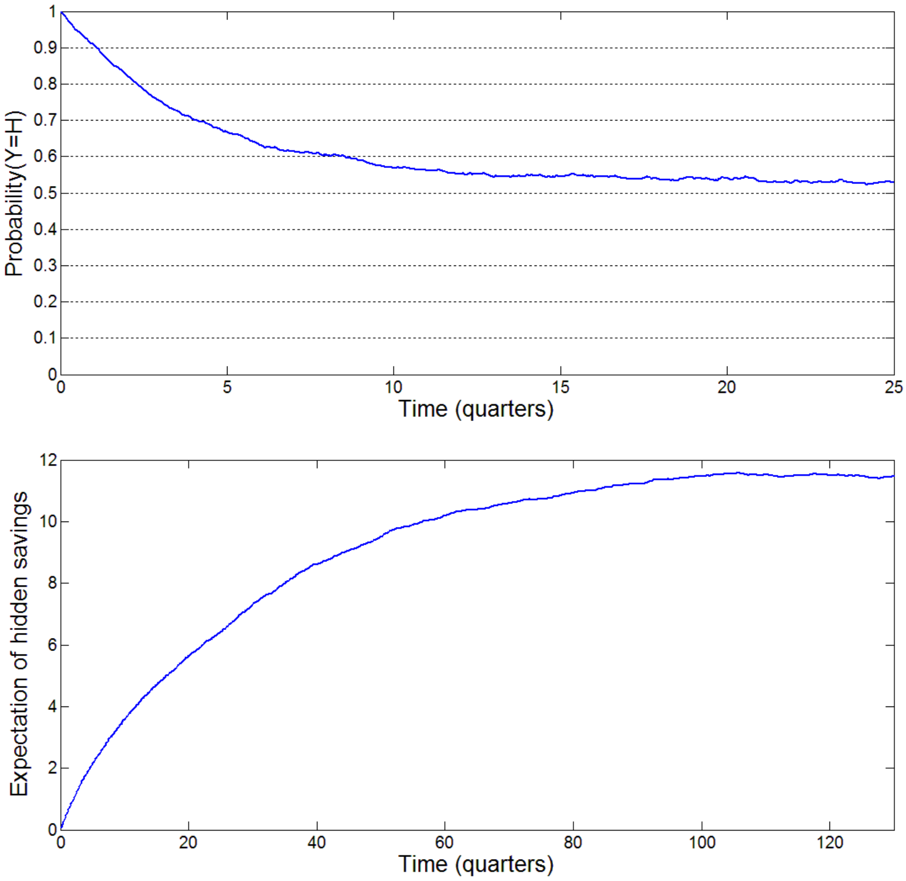
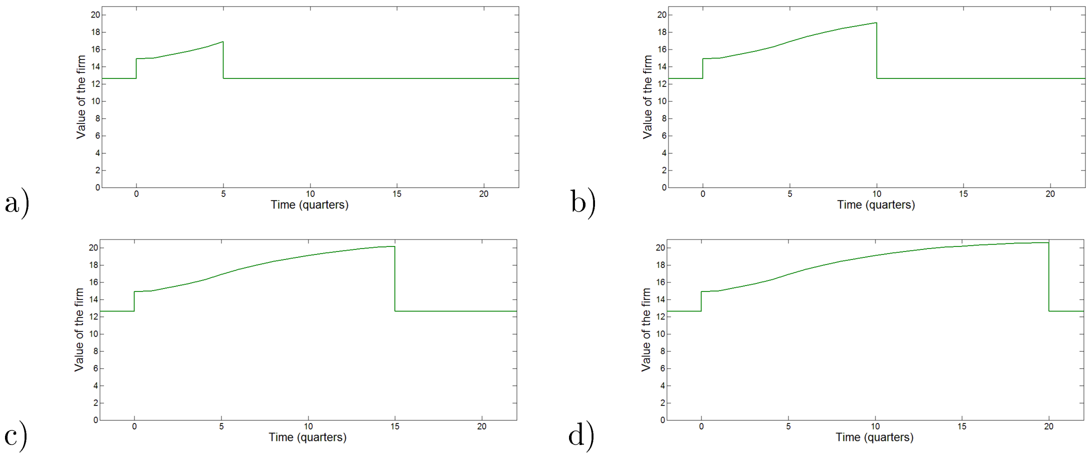


Figure 4: Asymmetric reactions



Evolution over time of the value of the firm if the manager initiate the dividend payment at $t = 0$ and she has been able to pay the dividend target during 5 quarters (a), 10 quarters (b), 15 quarters (c) or 20 quarters (d).

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