Executive Compensation: Salary vs. Incentive Pay:
An Inconvenient Truth[*]

Jean-Pierre Danthine
Member of the Governing Board of the Swiss National Bank[†]
and CEPR

John B. Donaldson[‡]
Graduate School of Business, Columbia University

Natalia Gershun
Lubin School of Business, Pace University

September 3, 2010

We examine the issue of executive compensation within an intertemporal general equilibrium production context. Intertemporal optimality places strong restrictions on the form of a representative manager's compensation contract, restrictions that appear to be incompatible with the fact that the bulk of many high-profile managers' compensation is in the form of various options and option-like rewards. We therefore measure the extent to which "options-like" convex contracts alone can induce the manager to adopt near-optimal investment and hiring decisions. To ask this question is essentially to ask if such contracts can effectively align the stochastic discount factor of the manager with that of the shareholder-workers. We detail exact circumstances under which this alignment is possible and when it is not. As a corollary, we also explore the business cycle and welfare consequences of suboptimal contracting.

1 Introduction

Executive compensation issues have generally been discussed in an a-temporal partial equilibrium setting. This is due to the nature of dynamic agency theory which has largely been developed in partial equilibrium or under the hypothesis of risk neutrality. This state of affairs creates a tension with most of macroeconomic theory where intertemporal considerations are essential and the central actor is the representative agent's stochastic discount factor and its statistical properties.

In this paper we reexamine executive compensation within a general equilibrium intertemporal production context. We first derive the first-best socially optimal managerial compensation contract. Intertemporal optimality places strong restrictions on the form of this contract: in our fully explicit model, it must include an incentive component that is linear in the firm's free cash flow, and a salary component, indexed on aggregate state variables. Furthermore, the salary must be large relative to the incentive component.

With the current emphasis on the provision of incentives to managers, we note that contracts of this form are increasingly rare: the bulk of many high-profile managers' compensation is in the form of various options and option-like rewards.[1] These contracts are highly convex in various measures of firm performance. We therefore assess the extent to which a convex contract alone can induce the manager to adopt the first best investment and hiring decisions. To ask this question is essentially to ask if such contracts can effectively align the stochastic discount factor of

---

[1] According to Hall and Murphy (2002), "in fiscal 1999, 94% of S&P 500 companies granted options to their top executives. More significantly, the grant-date value of stock options accounted for 47% of total pay for S&P 500 CEOs in 1999." For March 2007, Mercer Consulting estimates that equity related incentive pay represented, on average, 2/3 of total compensation for the top executives of the 100 largest U.S. based firms by sales. Fixed salary compensation represented only 19% (Mercer Consulting Company (2008)).

the manager with that of the shareholder-workers. We detail exact circumstances under which this alignment is possible and when it is not. As a corollary to this enterprise we assess the business cycle and welfare implications of sub-optimal contracts: if managers are given contracts such as those widely observed, what distortions are introduced? Are the welfare losses large? In some cases these contracts lead to intertemporal equilibria close to the first best and in other cases they do not. We make this dichotomy precise.

An outline of the paper is as follows. Section 2 describes the model and the Pareto optimal contract, while Section 3 explores the business cycle consequences of departing from it. Section 4 details the extent to which high convexity, performance-based contracts are able to restore near-optimality to the economy, and measures the welfare loss due to sub-optimal contracting. Section 5 considers share price based contracts. Section 6 provides a review of the related literature, and Section 7 concludes.

2   The Model and Benchmark Optimal Contract

2.1   The model

Our model is a simplified version of the models described in Danthine and Donaldson (2008) and Donaldson, Gershun and Giannoni (2010). We abstract from both moral hazard and adverse selection considerations and consider a full-information equilibrium.[2] We assume that the entire economy's output is produced by a continuum of identical firms indexed by $f \in [0, 1]$. There is also a continuum of identical agents of measure $(1+\mu)$, a subset of which – of measure μ – are selected at the beginning of time to manage the firm permanently. The rest act as workers

---

[2]The optimal contract we derive will also apply to the context where the manager has more information than the shareholder-workers, and adverse selection considerations are present. This is the context of Danthine and Donaldson (2008).

In a full information equilibrium, why managers? Under one possible scenario, there is a fixed utility cost that each shareholder must independently bear to access information and coordinate with other shareholders in selecting the firm's investment and hiring policies, a cost that can be avoided if those decisions are delegated to a single manager.

and shareholders. Managers are self-interested and assumed to make all the relevant decisions in view of maximizing their own intertemporal utility. Accordingly, shareholders seek a contract that motivates the manager to select investment and hiring policies that are utility maximizing for the shareholders themselves. When they make the hiring and investment decisions on behalf of firm owners, managers are viewed as acting collegially and thus we refer to them collectively as "the manager". We now describe this economy more precisely.

Firm f is fully described by a CRS production function $f(k_t(f), n_t(f))\lambda_t$ where $k_t(f)$ is the capital stock available to firm f at the beginning of period t, $n_t(f)$ stands for its employment level, and λ_t is the aggregate technology shock common to all firms. The law of motion for $k_t(f)$ is $k_{t+1}(f) = (1-\Omega)k_t(f) + i_t(f)$ where $i_t(f)$ is investment by firm f and Ω is the rate of depreciation. With this notation $\hat{d}_t(f)$ denotes firm f's free cash flow before payment to managers, and satisfies $\hat{d}_t = f(k_t(f), n_t(f))\lambda_t - n_t(f)w_t - i_t(f)$. The labor market is assumed competitive with all firms hiring at the wage rate w_t.

At the beginning of period t, **the manager** of firm f observes the productivity parameter λ_t; she then undertakes her utility-maximizing decisions $(n_t(f), i_t(f))$ in light of her remuneration contract $g^m(f)$. The manager is not given access to capital markets and thus consumes her income.[3] Let $c_t^m(f)$ denote the manager's period t consumption; accordingly, $c_t^m(f) = g^m(f)$. Lastly, we denote $s_t = (k_t(f), \lambda_t)$ as the true state of the economy for firm f as perceived by all agents. In Danthine and Donaldson (2008) and Donaldson, Gershun and Giannoni (2010) it is shown, in a generalized version of the present model, that the dividend/free cash flow

---

[3] Under the optimal contract, security trading is redundant for the manager.

$d_t(f)$ is the appropriate measure of firm performance (the intuition for this result is provided

below in the discussion following Theorem 1), where $d_t(f) = \hat{d}_t(f) - \mu g^m(f)$ and that the

socially optimal contract is of the form $g^m(d_t(f), d_t, A_t; s_t)$. In this latter expression

$d_t = \int_0^1 d_t(f) df$ is the aggregate dividend and A_t is a time varying fixed salary component to be

identified.

Let $u^m(\cdot)$ represent the manager's utility-of-consumption function, β her subjective

discount factor and $F(\cdot)$ the probability transition function on λ_t. For firm f the manager's

problem then reads :

$$V^m(s_0) = \max_{\{k_t(f),\, n_t(f),\, c_t^m(f)\}} E_0 \sum_{t=0}^{\infty} \beta^t \left[u\left(c_t^m(f) \right) \right] \tag{1}$$

s.t.,

$$c_t^m(f) = g^m(d_t(f), d_t, A_t; s_t),$$

$$d_t(f) = f(k_t(f), n_t(f))\lambda_t - n_t(f)w_t - i_t(f) - \mu c_t^m(f) \equiv \hat{d}_t(f) - \mu c_t^m(f),$$

$$k_{t+1}(f) = (1-\Omega)k_t(f) + i_t(f), \quad k_0 \text{ given}$$

$$c_t^m(f),\, i_t(f),\, n_t(f) \geq 0,$$

$$\lambda_{t+1} \sim dF(\lambda_{t+1}; \lambda_t); \quad \lambda_0 \text{ given, and}$$

$$E_0\left(\sum_{t=0}^{\infty} \beta^t u^m\left(c_t^m(f) \right) \right) \geq \frac{\bar{u}^m}{1-\beta} \quad , \quad \text{where this final inequality represents the}$$

manager's participation constraint.[4]

---

[4] The manager is effectively guaranteed a minimum fixed utility level $\bar{u}^m$ every period.

Given $g_1^m \neq 0$, the necessary and sufficient first order conditions to problem (1) can be written as

$$u_1(c_t^m(f))g_1^m(d_t(f), d_t, A_t; s_t)(f_2(k_t(f), n_t(f))\lambda_t - w_t) = 0, \text{ and} \tag{2}$$

$$1 = \beta \int \frac{u_1\left(c_{t+1}^m(f)\right)g_1^m\left(d_{t+1}(f), d_{t+1}, A_{t+1}; s_{t+1}\right)}{u_1\left(c_t^m\right)g_1^m\left(d_t(f), d_t, A_t; s_t\right)} \left[f_1\left(k_{t+1}(f), n_{t+1}(f)\right)\lambda_{t+1} + (1-\Omega)\right]dF(\cdot). \tag{3}$$

The representative **shareholder-worker-consumer** is confronted with a work/leisure decision and a portfolio investment decision; her problem reads:[5]

$$V^s(s_0) = \max_{\{c_t^s, n_t^s, z_{t+1}\}} E\sum_{t=0}^{\infty} \beta^t [u^s(c_t^s) - H(n_t^s)] \tag{4}$$

s.t.,

$$c_t^s + \int q_t(f)z_{t+1}(f)df \leq \int [q_t(f) + d_t(f)]z_t(f)df + w_t n_t^s,$$

$$c_t^s, z_t(f), n_t^s \geq 0;$$

$$s_{t+1} \sim dG(s_{t+1}; s_t), s_0 \text{ given}.$$

In problem (4), $u^s(\cdot)$ is the consumer-worker-investor's period utility of consumption, $H(\cdot)$ her disutility of work function, c_t^s her period t consumption, n_t^s her period t labor supply, $z_t(f)$ the fraction of the single equity share of firm f held at the start of period t, and

---

[5]It adds unnecessary notational complexity to index the consumer-worker shareholders by $\gamma \in [0,1]$. We thus postulate a single, measure-one-agent that acts competitively. In order for the consumer-worker-investor's problem to be well defined, she needs only know the joint stochastic process governing the equity prices and dividends of the various firms and the wage; that is $s_t = (q_t(f), d_t(f), f\varepsilon[0,1]; w_t)$. This follows from the fact that problem (4) is fundamentally a Lucas (1978) style asset pricing formulation.

$q_t(f)$ the equity price of firm f. The expression $G(.)$ describes the transition probabilities on the

relevant state variables. For the moment we assume both agent types have the same discount

factor. We also make the standard assumptions that utility functions are homogeneous,

differentiable, etc.[6]

The necessary and sufficient conditions for problem (4) are:

$$u_1(c_t^s)w_t = H_1(n_t^s),$$ (5)

$$u_1(c_t^s)q_t(f) = \beta \int u_1(c_{t+1}^s)[q_{t+1}(f) + d_{t+1}(f)]dG(\cdot).$$ (6)

Market clearing requires:

$$n_t^s = n_t(f) = \int n_t(f)df = n_t$$ (7)

$$z_t(f) = 1 \text{ for all firms } (f)$$ (8)

$$y_t = \int y_t(f)df = c_t^s + \int i_t(f)df + \mu \int c_t^m(f)df$$ (9)

We note that financial markets are not complete in this economy: shareholder workers and

managers do not trade securities among themselves. The exclusion of stock trading seems natural

and, in fact, is a feature of many compensation contracts. The case of bond trading is treated in

Danthine and Donaldson (2008) and Donaldson et al. (2010). Under the optimal contract, security

trading between these groups is superfluous.

Equilibrium in the above-described economy can then be defined as follows:

---

[6] More precisely $u^m(\ )$, $u^s(\ )$, and $f(\ )$ are assumed to be strictly increasing, strictly concave, homogeneous and continuously differentiable on $R^+ \times R^+$. $G(\ )$ and $F(\ )$ are assumed to satisfy the "Feller Property"; $f(\ )$ is CRS and satisfies the Inada conditions in both arguments while λ_t is assumed to lie in a compact interval $[\underline{\lambda}, \overline{\lambda}]$ with $0 < \underline{\lambda} < \lambda_t < \overline{\lambda} < \infty$ for all t. The wage $w(k_t, \lambda_t)$, and the equity price $q^e(k_t, \lambda_t)$ are assumed to be continuous functions of their arguments, a fact confirmed in equilibrium. The manager's compensation contract is also assumed to be increasing and continuously differentiable. These assumptions are sufficient to guarantee $V^m(k_0, \lambda_0)$ and $V^s(k_0, \lambda_0)$ exist and are differentiable functions of their first arguments.

Definition of Equilibrium. Given a differentiable managerial compensation function

$g^m\left(d_t(f), d_t, A_t; s_t\right)$, equilibrium in the delegated management economy is a set of continuous

functions, an investment function $i_t = i(k_t, \lambda_t) = i(k_t(f), \lambda_t)$, a labor supply function

$n_t = n(k_t, \lambda_t) = n(k_t(f), \lambda_t)$, a wage function $w_t = w(k_t, \lambda_t)$, and an asset price function

$q^e(k_t(f), \lambda_t)$ which simultaneously solve (2), (3), (5), and (6) on which market clearing

conditions (7), (8) and (9) have been imposed.

Under entirely standard assumptions, equilibrium can be shown to exist and to be unique

for this model economy. We next exhibit the optimal contract.

Theorem 1. Consider a compensation contract of the form

$$g^m(f) = g^m\left(d_t(f), d_t, w_t n_t; s_t\right) = A + \varphi\left[\left(w_t n_t + d_t\right)^\gamma + \left(d_t(f) - d_t\right)\right]^\theta. \tag{10}$$

a) If $u^s(\ ) = u^m(\ )$. then a contract of the form (10), with $A = 0$, $\varphi > 0$, $\gamma = 1$, and $\theta = 1$, is

optimal in the sense that a manager subject to this contract will select investment and hiring plans

that lead to the first-best equilibrium for the model economy.

b) If $u^m\left(c_t^m\right) = \dfrac{\left(c_t^m\right)^{1-\eta_m}}{1-\eta_m}$, and $u^s\left(c_t^s\right) = \dfrac{\left(c_t^s\right)^{1-\eta_m}}{1-\eta_m}$, with $\eta_s \neq \eta_m$, contract (10) with $A = 0$, $\varphi > 0$,

$\theta = 1$, and $\gamma = \eta_s/\eta_m$ is optimal.

c) If $\mu = 0$, and $\eta_m \neq \eta_s$ where either (i) $\eta_m > 1$ and $\eta_s > 1$ or (ii) $0 < \eta_m < 1$, and

$0 < \eta_s < 1$, then contract (10) with $A = 0$, $\varphi > 0$, $\gamma = 1$ and $\theta = \left(1-\eta_s\right)/\left(1-\eta_m\right)$ is optimal.

Proof: see Danthine and Donaldson (2008), Theorem 2, or Donaldson, Gershun and

Giannoni (2010), Theorems 1 and 2.

In this paper, we will focus exclusively on the case where $u^m(c) = u^s(c)$ and $\mu = 0$. The

conflict of interest between our two agent classes will, in this case, be shown to arise endogenously

and not as a result of postulated differences in preferences. In equilibrium, $d_t(f) = d_t$ and the

contract in this case is an especially simple one:

$$g^m(f) \equiv \varphi w_t n_t + \varphi d_t \text{ for all firms } f.^7 \tag{11}$$

Note that $w_t n_t$ stands for the aggregate wage bill which is not under the control of a

competitive firm's manager. It identifies the variable payment A_t. We may simplify our notation

further and assume, in equilibrium, one firm that acts competitively in all markets in which it

participates. This allows us to drop the reference to firm f.

The general intuition for this result is as follows. Contracting in general equilibrium

requires not only aligning the "micro incentives" of managers and firm owners but also aligning

their stochastic discount factors. To insure that the trade-offs internal to the firm are properly

appreciated by the manager, it is appropriate that she be entitled to a (non tradeable) equity

position, hence to a claim to a fraction of present and future cash flows to capital. This will

naturally guarantee that the manager will want to maximize the discounted sum of future expected

dividends. In a multi-period world of risk averse agents, however, this is not sufficient.

Shareholders want to ensure that the same stochastic discount factor as their own is applied by

---

[7] The contract specified in Danthine and Donaldson (2008) corresponds to part (a) of Theorem 1. In that paper the contract, in equilibrium, is expressed as $\phi' w_t n_t + \phi' \hat{d}_t$ for some ϕ'. This contract and contract (11) above are the same up to a scale parameter:

$$c_t^m = g^m(f) = \phi' w_t n_t + \phi' d_t$$
$$= \phi' w_t n_t + \phi' \left(y_t - w_t n_t - i_t - \mu c_t^m \right)$$
$$= \phi' \left(y_t - i_t \right) - \mu \phi' c_t^m, \text{ or,}$$
$$c_t^m = \frac{\phi'}{1 + \mu \phi'} \left(y_t - i_t \right). \text{ In addition,}$$
$$c_t^m = \phi w_t n_t + \phi \hat{d}_t = \phi(w_t n_t + \hat{d}_t)$$
$$= \phi(y_t - i_t).$$

managers when tallying up future dividends. This is what the salary component of the first-best

contract helps to achieve. The message is fully general: if the stochastic discount factors are to be

aligned, the total compensation package of managers must be such that their consumption is

proportional to aggregate consumption, that is, to $y_t - i_t = d_t + w_t n_t$. For this to be the case under

the no-trading, no outside income assumption, the salary part of their remuneration must be the

same fraction of the aggregate wage bill as the incentive portion is of d_t. The overarching

principle is as follows: in order to select the investment and hiring policies the

shareholder-workers would like, the manager must receive, in equilibrium, an income stream with

identical characteristics. Since shareholder-workers receive the bulk of their income in the form of

wage payments, the manager must as well.[8]

For later reference we can summarize this intuitive discussion with the following

observations. The condition defining optimal investment for the economy of this section is

$$1 = \beta \int \frac{u_1(c_{t+1}^s)}{u_1(c_t^s)} \left[f_1(k_{t+1}, n_{t+1}) \lambda_{t+1} + (1-\Omega) \right] dF(\cdot). \tag{12}$$

A comparison between conditions (11) and (3) indicate that for optimality to obtain the

remuneration contract should ensure

$$\frac{u_1(c_{t+1}^s)}{u_1(c_t^s)} = \frac{u_1\left(c_{t+1}^m\right) g_1^m\left(d_{t+1}, s_{t+1}\right)}{u_1\left(c_t^m\right) g_1^m\left(d_t, s_t\right)}. \tag{13}$$

With a linear contract this is achieved by equalizing the two agent types' stochastic

discount factors as discussed.

Notice that under standard parameterizations, the magnitude of the salary component of the

---

[8]In a many firms extension of the present model, the same logic dictates managers' remuneration must be indexed not only to the aggregate wage bill but to the aggregate market portfolio as well. See Danthine and Donaldson (2008) for details.

manager's remuneration in the first-best contract (which is a fraction of the **aggregate** wage bill) will substantially exceed her incentive pay (which is the **identical fraction** of the **firm's** free-cash-flow).[9] [10]

Recognizing that actual contracts are typically not of the form prescribed in Theorem 1, presumably because of internal agency issues combined with constraints imposed by limited liability, we next explore several more incentive oriented variations.[11,12] Our objective is to assess the degree to which such contracts will cause the economy to diverge from its first best allocations.

3   Suboptimal Contracting: In Search of a Quiet Life!

The aim of this section is to understand the implications of a linear compensation contract based on d_t. From a partial equilibrium viewpoint, this contract form aligns the micro-incentives of the manager with the objectives of shareholders. Here we seek to understand why this is not sufficient in general equilibrium and what the quantitative implications of deviating from the identified first-best contract actually are.

The prototypical contract we shall focus on is the following:

---

[9] This result is quite general in that it imposes no restrictions on $u(\ )$, $f(\ )$ or the shock process beyond standard regularity conditions. There is also no a priori requirement that the optimal contract be chosen from the linear class of such objects. Shareholders need only be informed as to the general structure of the economy, and the fact that the manager's period utility of consumption function coincides with their own. The same optimal contract applies if the technology were to include, for example, an unknown-to-the-shareholders cost of capital adjustment component.

[10] In particular, with Cobb-Douglas technology, $f(k_t, n_t)\lambda_t = k_t^\alpha n_t^{1-\alpha} \lambda_t$, the ratio of the share of income to wages over the share of income to capital is $\frac{1-\alpha}{\alpha} = \frac{.64}{.36} = 1.78$ under the standard calibration. The ratio of aggregate wages to aggregate dividends will be larger still.

[11] In Danthine and Donaldson (2008), we show the existence of a generalized version of the first-best contract when moral hazard considerations are more directly present. If the latter are sufficiently severe, however, the first-best contract may entail off equilibrium violations of limited liability.

[12] In a very different model framework, but one also without managerial effort disutility, Benmelech et al. (2007) find that a linear dividend-based contract always evokes truth telling (regarding the firms exogenous underlying growth rate) and thus an optimal investment strategy. It can be shown that the optimal contract detailed in Theorem 1 also induces truth telling -- the reporting of the true $\hat{d}_t$ (and d_t) -- in the setting considered here.

$$g^m(\cdot) = A_t + \varphi d_t, \tag{14}$$

where A_t represents the time-varying salary component not influenced by the agent's decisions.[13] Under the first best contract it is equal to the aggregate wage bill. Deviations from the first best may include situations where the salary component has the right time series properties but the wrong relative size (typically with a lower proportionality factor than the one premultiplying the performance based component of the manager's remuneration); or it may have the right size but the wrong time series property, e.g., $A_t = A,$ a constant. It may also deviate in both dimensions.

Given the structure of our delegated management economy, the natural representative agent benchmark for these comparisons is the dynamic equilibrium model of Hansen (1985). Accordingly, in order to obtain quantitative comparisons of the type above, we specialize our model in an identical fashion: $y = f(k_t, n_t) = k_t^\alpha n_t^{1-\alpha} \lambda_t$, with $\alpha = .36$ (note that $w_t n_t = (1-\alpha) y_t$ under the competitive labor market assumption) and $\tilde{\lambda}_{t+1} = \rho \lambda_t + \tilde{\varepsilon}_{t+1}$, where $\tilde{\varepsilon}_t \sim N(0, \sigma^2)$, $\sigma = .00712$, $H(1-n_t) = -B n_t$ with $B = 2.85$, $\Omega = .025$, and $u(c_t) = \dfrac{c_t^{1-\gamma}}{1-\gamma}$, with $\gamma = 1$ corresponding to $\log c_t$.

The quantitative computations underlying Figure 2 and Tables 1 and 2 to follow are performed for $\varphi = .01$ while, for the sake of comparability with the Hansen economy, maintaining the hypothesis that the manager is of measure zero (so that $\mu c_t^m = 0$ and $d_t = \hat{d}_t$).[14] Note that, under contract $\varphi d_t + \varphi A_t$, the characteristics of the economy are absolutely identical

---

[13] As suggested in Bolton and Dewatripont (2005, p. 156), "in most cases a manager's compensation package in a listed company comprises a salary, a bonus related to the firm's profits in the current year, and stock options (or some other form of compensation based on the firm's share price)." Contracts of the form (14) illustrate the first two of these three features.

[14] With $\mu = 0$, the consumer-worker-shareholder's labor supply decision is thus not affected by the manager's consumption.

when φ is .02 or .005 instead of .01, that is, if the two components of the managers' income are increased or decreased in equal proportion.[15]

We start by exploring the properties of a contract of the form

$$g^m(d_t) = \varphi d_t, \tag{15}$$

that is, where $A_t \equiv 0$.

For contract form (14) (and more generally for the contract $\varphi d_t + A$ where A is a constant), the manager's IMRS essentially shares the time series properties of free cash flows or dividends. By contrast, the representative shareholder-worker's IMRS borrows its properties from aggregate consumption. This difference may be expected to have an impact on the investment decision of managers and consequently on the dynamics of the economy for at least two reasons. Indeed, operating leverage, that is, the quantitatively large priority payment to wage earners, makes the residual free cash flow a much more volatile variable than aggregate consumption.[16] Ceteris paribus, this implies that the manager will tend to be excessively prudent in his investment decisions. In addition, at the aggregate level, free cash flow is a countercyclical variable. It arises almost mechanically from calibrating properly the relative size of investment expenses vis-à-vis the wage bill, and generating an aggregate investment series that is significantly more variable than output[17]. This property can be expected to have an important impact on investment as well. To understand these implications, recall that, in a standard RBC model, a positive productivity shock has both a push and a pull effect on investment. On the one hand, shock persistence implies that the

---

[15]Note as well that the participation constraint could be satisfied by setting a large enough value for φ, without altering the dynamic properties which we emphasize.

[16]In the standard Hansen (1985) RBC model the non-filtered quarterly standard deviation of the former is about 14% vs. 3.3% for the latter.

[17]With $d_t = y_t - w_t n_t - i_t = \alpha y_t - i_t$ and $\alpha = .36$, if investment is about 20% of output on average, an investment series that is twice as volatile as output will make d_t countercyclical.

return to investment between today and tomorrow is expected to continue to be high. This is the pull effect. On the other hand, the high current productivity implies that output and consumption are relatively high today. The latter signifies that the cost of a marginal consumption sacrifice in order to increase investment is small. This is the push effect. While the pull effect is unchanged in a delegated management economy with the postulated contract form, the push effect would be absent, or even negative if the free cash flow variable were to remain countercyclical, which makes for a much weaker reaction of investment to a positive productivity shock.

Another way to express this is to note that, as a rational risk averse individual, the manager wants to increase his consumption upon learning of a positive productivity shock realization since the latter is indicative of an increase in his permanent income. But, for the manager with compensation proportional to dividends, such a consumption increase necessitates an increase in dividends, which obtains only if the response of investment to the shock is moderate enough. Note that the aforementioned effects arise endogenously and have nothing to do with excessive risk aversion on the part of managers versus shareholder-workers (which is not assumed), or any form of information asymmetry.

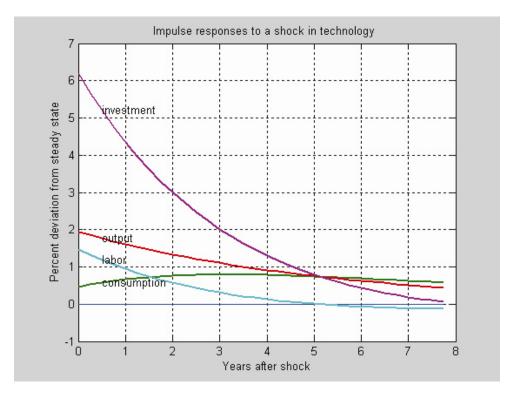**Figure 1: Hansen's (1985) Indivisible Labor Model IRF's**

Note: The functional forms and parameters underlying the indivisible labor model are: $u(\ ) = \log(\ )$, $H(1-n_t) = Bn_t$, $B = 2.85$, $\alpha = .36$, $\Omega = .025$, $\lambda_{t+1} = \rho\lambda_t + \tilde{\varepsilon}_t$, $\rho = .95$, $\tilde{\varepsilon}_t \sim N(0;\sigma^2)$, $\sigma = .00712$, , $y^{ss} = 1.14$.
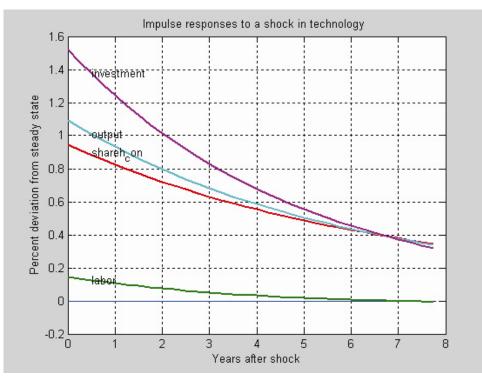
Figure 2: Delegated Management Model IRF's

Note: Same functional forms and parameter values as in the indivisible labor economy of Figure 1;
$g^m(d_t) = \varphi d_t, \varphi = .01, \mu = 0.$

Figures 1 and 2 display the Impulse Response Functions (IRFs) of the Hansen (1985) indivisible labor model and the delegated management economy with contract (15).[18] In both cases, $u(c_t) = \log c_t$, a functional form typical of the business cycle literature. The postulated contract is seen to induce an investment policy that significantly deviates from the first best and, as a result, profoundly alters the dynamics of the economy. The starting point is the much more sober reaction of investment to the productivity shock which we expect will lead to a much smoother behavior for the investment series. The natural consequence of this fact is to make aggregate (shareholders') consumption absorb a larger proportion of the shock and to be more variable. This in turn means that the marginal utility of consumption is very responsive to the exogenous shock

---

[18]These are the results of computing the dynamic equilibria of the model with the help of the algorithm provided by Harald Uhlig   (http://www.wiwi.hu-berlin.de/wpol/html/toolkit/version4_1.html).

16

implying that the reaction in the labor supply required to maintain the equality in (5) is smaller. That is, the reaction of employment to the shock is significantly smaller, yielding a weaker propagation mechanism and a smoother output series. These results stand in sharp contrast to the implications of models built upon the Jensen (1986) hypothesis that managers will invest all available free cash flow to build empires, a feature that tends to accentuate the volatility of investment, to enhance its procyclicity and to strengthen the propagation mechanism (see, e.g., Phillipon (2006)).

The intuition just developed is all we need to understand the more general case where the performance based contract is complemented by a salary component $A_t > 0$. As already argued, a link between the salary component and the aggregate wage bill is necessary to restore first-best investment decisions in a delegated management context. Such a link permits the requirement of pro-cyclical managerial consumption to be compatible with the reality of counter-cyclical free-cash-flows, thus making it more appealing for the manager to adopt an investment policy that is more responsive to productivity shocks. In addition, increasing the average size of the fixed component of the manager's remuneration makes the manager effectively less risk averse at the margin, or, in other words, more willing to substitute consumption across time. This makes him more prone to accept a counter-cyclical consumption pattern consistent with the first best investment policy.

Table 1 reports results for a broad set of macroeconomic variables obtained from simulating the dynamic equilibria of the same economy under various hypotheses on the manager's contract. The economy with the optimal contract is used as a benchmark. This purely descriptive approach permits visualizing the massive impact of the contract characteristics along the entire set of macroeconomic dimensions.

We start with the case of $A_t \equiv 0$ just discussed (col. 1 and 5). We then consider the case where $A_t = \varphi(.5w_t n_t)$ (col. 3 and 7), that is, where the salary component of the manager's remuneration is one half what it should be. We also look at the case where $A_t = \varphi(.5w^{ss} n^{ss})$, that is, where the salary component is constant and proportional to one half the steady state wage bill rather than being time varying (col. 2 and 6). This is done to illustrate the impact of the two specific properties of the first component of the manager's remuneration: it should be linked to the aggregate wage bill and the sensitivity to the wage bill should be given by the power of the performance based component.

These cases confirm the role played by the counter-cyclical nature of dividends. Without fixed remuneration ($A_t \equiv 0$ as in Figure 2), the manager decides on investment expenses compatible with *his* consumption being pro-cyclical. This leads to very smooth investment behavior. When the salary component remains fixed but increases from 0 to $\varphi(.5w^{ss} n^{ss})$, the variability of investment increases by 24%, and dividends move from being positively correlated with output to a negative correlation with output of -.81. With the salary component appropriately linked to the wage bill, $A_t = \varphi(.5w_t n_t)$, the volatility of investment further increases as the manager's consumption becomes pro-cyclical. The macroeconomic properties of the economy remain significantly different from those obtained under the optimal contract, however.

These last observations remind us that not only must the salary component display the same time series properties as the wage bill, but that it must have the correct relative magnitude as well. In particular, the magnitudes of the salary and incentive components must be approximately in the proportions of $w^{ss} n^{ss}$ to d^{ss}, the steady state level of free-cash-flow. By way of contrast, if we set $A_t = .01w^{ss} n^{ss}$ and the performance-based remuneration at $1.2d_t$, the time series

characteristics of the economy closely match those of Table 1, col. 1. In other words, over-emphasizing the incentive component is not a panacea for a misspecified salary component. The converse is also true: if the incentive component is too small relative to the salary component, extreme departures from Pareto optimality may also be observed, though in this case the problem is excessive volatility. The reasons for these distinct effects are as follows. In the former case the over-emphasis on the incentive component magnifies the perverse effect of counter-cyclical dividends. In the latter one, the delegated manager effectively becomes risk neutral as his aggregated consumption stream becomes essentially risk-free (large fixed salary component in conjunction with diminutive, volatile incentive component).

Table 1: Delegated Management Economy with Suboptimal Contracts[i]

	Standard Deviation in %				Correlation with output			
Col.	1	2	3	4	5	6	7	8
A_t	0	$\varphi(.5(wn)^{ss})$	$\varphi.5w_t n_t$	$OC^{(ii)}$	0	$\varphi(.5(wn)^{ss})$	$\varphi.5w_t n_t$	$OC^{(ii)}$
y	1.01	1.07	1.33	1.80	1.00	1.00	1.00	1.00
c^m	.13	.17	.29	.52	.26	-.81	.79	.87
d	.13	.69	3.23	8.08	.26	-.81	-.97	-.97
c^s	.88	.85	.71	.52	1.00	1.00	.99	.87
i	1.41	1.75	3.15	5.74	1.00	1.00	1.00	.99
k	.13	.15	.28	.49	.26	.32	.32	.35
n	.14	.24	.63	1.37	.99	.97	.99	.98
w	.88	.85	.71	.52	1.00	1.00	.99	.87

(i) $\eta_m = \eta_s = 1; \mu = 0; \varphi = .01$; $(wn)^{ss}$ = steady state wage bill - Other parameter values as in Figure 1.

(ii) Delegated management economy with optimal contract or, equivalently, the indivisible labor economy with log utility (Hansen, 1985).

The lessons of this section are two-fold. First, what appears as the appropriate incentive contract from a partial equilibrium perspective turns out to yield a very unresponsive and suboptimal investment policy when viewed in the light of intertemporal general equilibrium

considerations. In particular, a linear contract based on free cash flow results in the manager adopting an excessively passive investment policy. Complementing the linear performance based manager's remuneration with a fixed salary component turns out to resolve the problem only partially.

This characterization can be viewed as an alternative explanation for, and a confirmation in a general equilibrium context of, the "quiet life" hypothesis. According to this view, first expounded by Smith and Stulz (1985), risk averse managers forgo uncertain positive net present value projects because they are unable to diversify risk specific to their claims on the corporation.[19] Our analysis shows that the requirements of the optimal contract, which lead managers to possess the same marginal risk tolerance as shareholders and thus adopt the same investment policy, are severe. Deviations from the optimal contract, most plausibly inducing an excessively timid investment policy, are thus likely. In particular, contracts with a salary and bonus, the latter based on free cash flow or profit, are likely to induce passive investment behavior. Our analysis also shows that the problem is more related to the business cycle properties of free-cash-flows and the intertemporal elasticity of substitution of managers as it is to their risk position per se.

Second, as suggested in the introduction and confirmed in Table 1, it is the salary component, both as regards its magnitude and, most especially, its time series properties, that is crucial to inducing the optimal managerial decisions. Simply increasing the coefficient on a fixed salary component does nothing to induce the appropriate investment choices (column 1 vs. column 2). From an entirely different perspective, a reading of Table 1 from left to right suggests that as the salary component diminishes as a fraction of total compensation, the macroeconomy may be

---

[19]Bertrand and Mullainathan (2003) provides recent support for an enlarged definition of the quiet life hypothesis, one that includes a desire for peaceful labor relations in addition to a smoother-than-optimal investment policy.

expected to become more stable. It is, perhaps, no accident that the increasing fraction of executive compensation that is incentive based characteric of the 1990s coincided, until recently, with moderating macroeconomic volatility.

One would expect that solutions to the somewhat contradictory requirements of the first-best contract would be sought. One possibility expounded in the literature is to deviate from the *linear* properties of the optimal contract. In particular, part of the literature on executive compensation has attempted to justify convex performance-based remunerations as a way to provide incentives for managers to increase their risk taking. This hypothesis is reviewed in the next section.

4   Convex Performance-based Contracts

In this section we demonstrate a principal claim of the paper: only under certain specific conditions will a convex performance-based contract restore the responsiveness of manager's investment policy and permit reaching the first best allocation of resources.

4.1   Contracts with no salary component

It turns out the intuition can be made sharper when the manager's contract has a fixed salary component that is set equal to zero. We thus start with an analysis of contracts of the form

$$g^m(d_t) = \varphi(\bar{d})^{1-\theta}(d_t)^{\theta}, \tag{16}$$

where $\bar{d}$ is the steady state free-cash-flow level when $\theta = 1$ and $\hat{d}_t = d_t, \forall t$ as we continue to work under the $\mu = 0$ assumption. The constant multiplicative term $\bar{d}^{1-\theta}$ is included to insure that the manager's average remuneration is not affected by changes in θ, the curvature of her compensation function. With a contract specified as per (16) and a CES utility function for the manager, $u^m(c_t^m) = \dfrac{(c_t^m)^{1-\eta_m}}{1-\eta_m}, \eta_m > 0,$ the marginal utility term in the RHS of (3) takes the form:

$$u_1^m(g^m(d_t, s_t))g_1^m(d_t, s_t) = \theta\varphi[(\bar{d})^{1-\theta}]^{1-\eta_m}(d_t)^{\theta(1-\eta_m)-1}$$

and the effective IMRS of the manager becomes:

$$\beta\frac{u_1^m(g(d_{t+1}, s_{t+1}))g_1(d_{t+1}, s_{t+1})}{u_1^m(g^m(d_t, s_t))g_1^m(d_t, s_t)} = \beta\left(\frac{d_{t+1}}{d_t}\right)^{\theta(1-\eta_m)-1}. \tag{17}$$

Expression (17) provides the basis for the following observations:

Theorem 2. Under contract (16), the manager's effective risk aversion results from a combination of her subjective coefficient of relative risk aversion and the curvature of the contract. It is given by the expression: $1-\theta(1-\eta_m)$.

In practice this result implies that an economy with $\eta_m = 3$ and a linear contract $(1-\theta(1-\eta_m) = 3)$ is observationally equivalent (except for the volatility of the manager's consumption and its correlation with output) to one where $\eta_m = 2$ and $\theta = 2$ or $\eta_m = 4$ and $\theta = 2/3$, etc.

Theorem 2 has the following corollary implications:

Corollary 1. If the manager has logarithmic utility ($\eta_m = 1$), then her investment decision cannot be influenced by the curvature of the remuneration contract.

In fact, all aspects of the economy (volatility, correlation structure) are unaffected by the degree of contract convexity, except the manager's compensation and consumption.

Corollary 2. If the manager is less risk averse than log ($(1-\eta_m) > 0$), then a convex contract $\theta > 1$ makes the manager's effective rate of risk aversion smaller than her subjective rate of risk aversion, thus leading to a more aggressive investment policy. For the FOC on investment to be necessary and sufficient, however, the effective measure of risk aversion must be larger than unity, requiring that θ be strictly smaller than $\dfrac{1}{1-\eta_m}$.

The more aggressive investment policy leads to more volatile macroeconomic aggregates more or less across the board. Dividends and managerial consumption become more countercyclical. For high levels of θ sunspot equilibria are observed (this is discussed in a companion paper, Donaldson, Gershun, and Giannoni (2010)).

Corollary 3. If the manager is more risk averse than log, $(1-\eta_m) < 0$, then the larger θ, the *more effectively risk averse* the manager becomes. Macroeconomic volatility consequently declines.[20]

In the context of Corollary 3, if one wants the manager to behave more aggressively, that is, for her effective measure of risk aversion to be larger than her subjective rate of risk aversion, one would rather propose a concave contract $(\theta < 1)$! Moreover, if the manager's η_m is larger than 1, there is no way to make her effectively less risk averse than log short of proposing a contract with $\theta < 0$! A manager with risk sensitivity exceeding that of log utility does not strike us as likely to be that unusual. Yet in this case conventional wisdom (advocating contract convexity) would seem to break down completely. For the exponent of the effective IMRS to be negative, one needs $\theta > \dfrac{1}{1-\eta_m}$.[21]

---

[20]In many instances the decline in volatility is very modest. if for example, $\eta_m = 1.5$, an increase in θ from $\theta = 1$ to $\theta = 4$ only reduces output volatility from 1.0075 to 1.0062 (percent).

[21]If the manager and the shareholders differ in their attitude toward risk, Theorem 1 suggests that this alternative source of conflict can also be resolved by appropriately (that is, with the right curvature θ) designing a short term contract of the form (16). This is true, however, only if the manager's utility function is not logarithmic.

Table 2: Delegated Management Economy: Convex Contracts
of the Form $g^m(d_t) = A + \varphi \bar{d}^{1-\theta} d_t^\theta$: (various θ)

	Standard Deviations in %					Correlation with output				
Col.	1	2	3	4	5	6	7	8	9	10
$\theta =$	1.5 *A=0*	1.95 *A=0*	1.96 *A=0*	1.054 *A=$\varphi(\bar{w}\bar{n})$*	OC [(ii)]	1.5 *A=0*	1.95 *A=0*	1.96 *A=0*	1.054 *A=$\varphi(\bar{w}\bar{n})$*	OC [(ii)]
y	1.07	1.65	1.77	1.79	1.80	1.00	1.00	1.00	1.00	1.00
c^m	1.01	14.02	16.78	1.29	.52	-.81	-.89	-.89	-.89	.87
d	.67	7.19	8.56	8.79	8.08	-.81	-.89	-.89	-.89	-.97
c^s	.85	.69	.70	.70	.52	1.00	.76	.65	.63	.87
i	1.73	5.09	5.79	5.91	5.74	1.00	.97	.96	.96	.99
k	.15	.38	.42	.42	.49	.32	.48	.50	.50	.35
n	.23	1.21	1.42	1.45	1.37	.97	.93	.93	.93	.98
w	.85	.69	.70	.70	.52	1.00	.76	.65	.63	.87

[(i)] $\eta_m = 1/2$, $\eta_s = 1$, $\varphi = .01$, $\mu = 0$; other parameter values as in Table 1

[(ii)] Delegated management with optimal contract and log utility;

The upshot of these results is that the only plausible case where a short run non-linear contract is likely to have the desired effect is the case where the manager is less risk averse than log and she is offered a convex contract. Table 2 displays the characteristics of an economy where the manager is remunerated with convex contracts and her rate of risk aversion is $1/2$.

With such a combination of features it is possible to get very close to the time series properties of the first best economy. To obtain that result when $A = 0$, the manager must be effectively nearly risk neutral.[22] With $\theta = 1.96$ and $\eta_m = 1/2$, the exponent of dividend growth in the IMRS is $\theta(1 - \eta_m) - 1 = -.04$. Note that with these parameter values, the variability of

---

[22]Here, as in Table 1, we rely on the intuition that similar time series are the outcome of equally similar investment policies. Under standard conditions and provided $u(g^m(\cdot))$ is concave, the policy functions of the manager's problem are unique. Confronted by the same shocks and initial capital, the resultant time series will be the same, hence the resulting statistics (see Danthine and Donaldson (2008) for details). Note that the capital stock process in the case of $\theta = 1.96$ is well approximated by $k_t = .8023 k_{t-1} + .1674 \lambda_t$, while it is $k_t = .7986 k_{t-1} + .1706 \lambda_t$ when $\theta = 1.054$.

manager's consumption becomes quite extreme[23]. Moreover the manager's consumption is then highly countercyclical.

Essentially what these results stress is the importance of operating leverage naturally translating into countercyclical free-cash-flows. The incentive dimension of the manager's contract then has the natural property of inducing a countercyclical consumption path. To avoid this undesirable characteristic, a risk averse manager is led to moderate the response of investment to a favorable productivity shock. The more risk averse, that is the lower the elasticity of intertemporal substitution, the more pronounced is the effect. On the contrary, if the manager is almost risk neutral or if her contract makes her effectively close to risk neutral relative to changes in dividends, then she becomes again free to react to the pull effect on investment of a positive productivity shock.

4.2   Convex contracts in conjunction with a fixed salary component

Finally we check the possibility of combining the two dimensions discussed so far, an appropriate positive fixed 'salary' component and a convex incentive component.[24] The last set of results in Table 2 show that, with a rate of risk aversion of $\eta_m = 1/2$, the impact of a high fixed component in the manager's remuneration reinforces the effects of a convex contract. With a constant salary component of the right size, i.e., $A = .01(\overline{w}\overline{n})$, a very close match with the time series of the indivisible labor model is obtained with a contract curvature of only $\theta = 1.054$. In the

---

[23]As an application of Theorem 2, let us observe that the same macroeconomic dynamics would be obtained in an economy where the manager's risk aversion is $\eta_m = 2$ and the contract curvature is $\theta = -.98$. The only (important) difference is that with such a contract the manager's consumption would turn pro-cyclical: $\rho(y, c^m) = +.89$ instead of $-.89$.

[24]The contract then takes the form : $g^m(\cdot) = \varphi \overline{w}\overline{n} + \varphi(\overline{d})^{1-\theta}(d_t)^{\theta}$. We can observe again that if the manager is less risk averse than log ($\eta_m = 1/2$) , it is easier to have her adopt a pro-cyclical investment policy. This translates into the fact that a near-linear contract with $A = \varphi(wn)^{ss}$ now assures an almost perfect match with the time series properties of the indivisible labor model.

case of a less-risk-averse-than-log manager, a remuneration combining appropriately a fixed salary component with an incentive element that is a convex function of free cash flow thus appears as a plausible alternative to the optimal contract.

Another implication of the aforementioned case is that a fixed salary component can reliably be used as a substitute for contract convexity: as a general rule, the level of convexity necessary to reasonably approximate the first best allocation is much reduced in the presence of a fixed salary component. These two contract features reinforce one another even to the extent of being able to increase investment volatility in the case where $\eta_m > 1$ $\left(\varphi = .1, A = .1(\overline{w}\overline{n}) \right)$ and θ is increasing. All of these results require that the fixed component be large relative to the incentive one (see also remarks at close of Section 4). If the goal of the contract is to induce the manager to achieve the first best allocation, the import of these observations is that neither aspect of the contract can be specified independently of the other. In fact the degree of required convexity is particularly sensitive to the magnitude of the salary component. Modest levels of convexity when used in conjunction with a large salary component can, in fact, lead to extreme macroeconomic volatility, and ultimately to sunspot equilibria.

4.3 Welfare Consequences of Sub-optimal Contracting

How large are the welfare losses incumbent on sub-optimal contracting? To answer this question, the value functions of a representative manager and a representative shareholder-worker were estimated, respectively, as the average present value of their discounted period utilities computed from 10,000 independently constructed time series, each 10,000 periods in length. For every time series, the initial capital stock k_0 is the same and fixed at $k_0 = \overline{k}$, its certainty steady state value; so also the initial productivity shock λ_0, is common to all series at the value $\lambda \equiv 1$. More formally, we estimate

$$V^m(s_0) = V^m(k_0, \lambda_0) = \frac{1}{10,000} \left\{ \sum_{j=1}^{10,000} \left(\sum_{t=1}^{10,000} \beta^t u^m \left(c_{t,j}^m \right) \right) \right\}, \quad \text{and}$$

$$V^s(s_0) = V^s(k_0, \lambda_0) = \frac{1}{10,000} \left\{ \sum_{j=1}^{10,000} \left(\sum_{t=1}^{10,000} \beta^t \left[u^s \left(c_{t,j}^s \right) - H \left(n_{t,j}^s \right) \right] \right) \right\},$$

where $\left\{ c_{t,j}^m \right\}, \left\{ c_{t,j}^s \right\}$, and $\left\{ n_{t,j}^s \right\}$ represent, respectively, the equilibrium managerial consumption, shareholder-worker consumption and shareholder-worker labor service associated with feasible time path j. Underlying all 10,000 time paths is the same managerial contract of interest, whatever it may be, together with a chosen parameterization.

Let $V^m \left(k_0, \lambda_0 \right)^{OPT}$ and $V^s \left(k_0, \lambda_0 \right)^{OPT}$ denote the respective value functions, computed as per above, under the optimal, first-best inducing contract. Given $V^s \left(k_0, \lambda_0 \right)^{OPT}$, in particular, the cost of pure business cycle uncertainty measured as a percentage of steady state consumption in an environment of optimal contracting from the perspective of the shareholder-worker is obtained as the solution δ_{BC}^s to the following equation:

$$V^s \left(k_0, \lambda_0 \right)^{OPT} = \sum_{t=1}^{\infty} \beta^t \left[u^s \left(\overline{c}_{OPT}^s \left(1 - \delta_{BC}^s \right) \right) - H \left(\overline{n}_{OPT}^s \right) \right] \tag{18}$$

$$= \frac{1}{1 - \beta} \left[u^s \left(\overline{c}_{OPT}^s \left(1 - \delta_{BC}^s \right) \right) - H \left(\overline{n}_{OPT}^s \right) \right].$$

In the above expression $\overline{c}_{OPT}^s$ and $\overline{n}_{OPT}^s$ denote, respectively, steady state shareholder consumption and labor under the optimal contract. The δ_{BC}^s term represents the fraction of steady state consumption that shareholder-workers would be willing to forgo to avoid business cycle variation in their consumption and labor service streams. In the case of the Hansen (1985) parameterization, $u^s \left(c_t^s \right) = \log c_t^s$ and $H \left(n_t^s \right) = B n_t^s$, equation (18) has the explicit solution

$$\delta_{BC}^s = 1 - \left(\frac{1}{\overline{c}_{OPT}^s}\right)\left[e^{\left\{V_s(k_0,\lambda_0)^{OPT}(1-\beta)+B\overline{n}_{OPT}^S\right\}}\right] \qquad (19)$$

We interpret δ_{BC}^s as a measure of the utility loss due to consumption uncertainty under the optimal contract. In an analogous way the quantity $\delta_{SUB-OPT}^s$ was computed as the solution to:

$$V^s\left(k_0,\lambda_0\right)^{SUB-OPT} = \frac{1}{1-\beta}\left[u^s\left(\overline{c}_{OPT}^s\left(1-\delta_{SUB-OPT}^s\right)\right) - B\left(\overline{n}_{OPT}^s\right)\right]$$

In a like fashion $\delta_{SUB-OPT}^s$ measures the fraction of steady state consumption, relative to the Pareto optimum, that shareholder-workers would be willing to surrender in order to avoid both business cycle uncertainty and sub-optimal contracting.

Since, for any sub-optimal contract

$$V^s\left(k_0,\lambda_0\right)^{SUB-OPT} < V^s\left(k_0,\lambda_0\right)^{OPT}, \; \delta_{SUB-OPT}^s > \delta_{BC}^s,$$

and thus the difference, $\delta_{SUB-OPT}^s - \delta_{BC}^s$, measures the incremental consumption cost, to shareholder-workers, of sub-optimal contracting alone. We focus only on shareholder-workers as they alone have positive measure.

For the cases of Tables (1) and (2) these quantities are reported, respectively, in Table 3 below:

Table 3: Welfare Costs of Suboptimal Contracting as a Percentage of Steady State Shareholder-Worker Consumption

Panel A: Corresponds to Table 1 cases[i]				
Column:	1	2	3	4 (OC)
$\delta^s_{SUB-OPT} - \delta^s_{BC}$:	.03	.04	.03	.00

Panel B: Corresponds to Table 2 cases[ii]				
Column:	1	2	3	4
$\delta^s_{SUB-OPT} - \delta^s_{BC}$:	.04	.02	.02	.08

[i] Column j corresponds to the case detailed in the same column of Table 1. For all Panel A cases, $\eta_m = \eta_s = 1$, and $\varphi = .425$ in order to equate the welfare of both manager and shareholder-workers under the optimal contract. The change from $\varphi = .01$ to $\varphi = .425$ has no affect on Table 1 statistics.

[ii] For Panel B, the contract parameters are identical to those detailed in the headings to the corresponding columns in Table 2. In all panel B cases $\eta_m = ½$, $\eta_s = 1$. No attempt is made to equate welfare under the optimal contract as the welfare of the manager is a positive number whereas it is negative for the shareholder-worker (for economies of this "size").

The cost estimates presented in Table 3 are not large, generally in the range of .02% - .04% of steady state shareholder-worker consumption. For the year 2009, consumption in the U.S. was approximately $10T, giving a rough measure of the cost of inefficient contracting in the U.S. in the range of $2B - $4B, sizable change from the absolute dollar perspective, but not enough to endorse the view that sub-optimal managerial pay practices are a major source of inefficiency in U.S. economic life. Our estimates mirror the similarly low cost-of-the-business-cycle estimates obtained by Lucas (1987).[25]

These results are not surprising. In all the cases of Table 3, the shareholder-workers have utility specifications of log or near log. Such agents are simply not very sensitive in their welfare

---

[25] The Lucas (1987) methodology is essentially the same as ours, although stronger assumptions on the nature of the consumption process are made in that work. Our *endogenous* consumption process is much less volatile than the one assumed in Lucas (1987), and, as a result, our business cycle cost estimates are negligible, less than one fourth the cost of suboptimal contracting.

estimates to deviations from the Pareto-optimum. This observation goes hand-in-hand with the fact that the structure of the model prevents the contract from having any effect on steady-state capital stock, investment or labor supply. If this were not the case, substantial cost estimates would quickly arise. In contrast to these "excuses" for the model's not delivering dramatic results, perhaps its conclusions are valid: sub-optimal executive compensation design is simply not important from an overall social perspective.

5   Share Price Based Contracts

Our discussion in the text has been limited to contracts that are convex in the firm's free cash flow. Typical incentive contracts, however, are convex in the firm's stock price.[26] Options based incentive contracts are the most prevalent illustration of this case. The difference between the two contract forms is smaller than might appear at first sight because our model economy is one where the equity price is close to being (and in some cases, exactly is) proportional to the dividend. But note that we remain in an incomplete markets situation. Nevertheless, one might still expect the incentive component of a manager's remuneration based on the equity price to be somewhat more effective in aligning the stochastic discount factors of shareholders and managers because the forward looking nature of the equity price implies it is more pro-cyclical than dividend distributions. This is indeed the main lesson of this section. In addition, the results of Corollaries 1 to 3 are confirmed in this extended context as is the necessity of a correct balance between the salary and incentive components of the manager's remuneration package.

---

[26]In contrast to the many proffered justifications in the popular financial press, there is very little theoretical academic literature in support of convex price based CEO compensation contracts under market incompleteness. Benmalech et al. (2007) study price based contracts but they are linear. Bolton and Dewatripont (2005) explore compensation contracts with a price based component but the latter is also not convex. For contracts for which the distribution of the performance measure satisfies a monotone likelihood ratio property (a high performance realization is indicative of high effort), we would expect to see contracts where the managers compensation increases dramatically if the performance level exceeds a certain cutoff (see again Bolton and Dewatripont (2005)). Our model lacks a variable managerial effort component however. From the perspective of the first best allocation, we would thus not expect contact convexity to add much.

Options-based contracts are difficult to analyze directly in the present setting because of the absence of differentiability at the exercise price. In the spirit of options based incentive compensation, yet retaining a context which allows standard approximation techniques we next consider managerial contracts which, in equilibrium, contain a component that is convex to the pre-dividend value of the firm:

$$g^m(x_t) = g^m(d_t + q_t^e) = A + \varphi(\overline{d} + \overline{q}^e)^{1-\theta}(d_t + q_t^e)^\theta. \tag{20}$$

With our maintained assumption of $\mu = 0$, $d_t = \hat{d}_t$ as before. We thus retain d_t as part of the compensation base in order to retain the correct micro-incentives for it is this latter quantity that the manager's actions are presumed to affect directly. [27] Competitive security markets are otherwise presumed: the only influence the manager may have over the stock price is determined indirectly via his manipulation of free cash flows (d_t). [28] Rational expectations are maintained. Essentially, the equity price replaces the aggregate wage bill in the optimal contract.

We view the analysis of such a contract to be useful from a number of perspectives. Is it more efficient at encouraging the manager to select the Pareto optimal hiring and investment decisions from the shareholder worker perspective? Is the contract effective when $\eta_m = 1$; more generally, do Corollaries 1, 2 and 3 hold in this expanded setting? While it is appropriate for the manager to maximize firm value in a complete markets representative agent setting, the present context is one of restricted market participation. It is therefore not obvious how the inclusion of

[27] In the context of Theorem 1, the contract we propose is of the form

$g^m(f) = A + \varphi\left[(\overline{d} + \overline{q}^e)^{1-\theta}(d_t + q_t^e)^\theta + (d_t(f) - d_t)\right]^\gamma$. Contract (18), in equilibrium ($d_t(f) = d_t$), is the special case of the above where $\gamma = 1$. Since $d_t(f) = d_t$, $q_t^e(f) = q_t^e = \int q_t^e(f) df$, the latter representing aggregate stock market valuation.

No pretense is made that (20) is optimal. Our goal is to explore if, to an approximation, it leads to a near-optimal equilibrium, and to explore the extent of the welfare loss.

[28] In our computational algorithm, the manager's decisions and the equity price are thus determined simultaneously, the latter as per equation (6).

firms' value as a determinant of managerial compensation will contribute to achieving the first best allocation.

Accordingly, the manager's problem is now effectively:[29]

$$V^m(s_0) = \max_{\{n_t, i_t\}} E_0 \sum_{t=0}^{\infty} \beta^t \left[u\left(c_t^m\right) \right] \tag{21}$$

s.t.

$$c_t^m = g^m(d_t + q_t^e) = A + \varphi(\overline{d} + \overline{q}^e)^{1-\theta}(d_t + q_t^e)^{\theta},$$

$$d_t = y_t - n_t w_t - i_t - \mu c_t^m,$$

$$c_t^m, i_t, n_t, d_t, q_t^e \geq 0,$$

$$(\lambda_{t+1}, q_{t+1}^e) \sim dF\left(\lambda_{t+1}, q_{t+1}^e; \lambda_t, q_t^e\right)$$

$$E_0\left(\sum_{t=0}^{\infty} \beta^t u^m\left(c_t^m(f)\right)\right) \geq \frac{\overline{u}^m}{1-\beta}.$$

The necessary and sufficient first order conditions for this problem resemble the first order conditions for problem (1) but with significant differences in the investment equation.[30] The spirit of the equilibrium characterization, however, is as before.

---

[29]We consider $\mu = 0$ (base case) and $\mu > 0$.

[30]In equilibrium, the intertemporal optimality condition for investment - to be compared with (12) - (13) becomes

$$1 = \beta E_t \{ \frac{u_1\left(c_{t+1}^m\right)}{u_1(c_t^m)} \left(\frac{d_{t+1} + q_{t+1}^e}{d_t + q_t^e} \right)^{\theta-1} \left(\frac{1 + \mu \hat{\varphi}(\overline{d} + \overline{q}^e)\theta(d_t + q_t^e)^{\theta-1}}{1 + \mu \hat{\varphi}(\overline{d} + \overline{q}^e)\theta(d_{t+1} + q_{t+1}^e)^{\theta-1}} \right)$$

$$\left[f_1\left(k_{t+1}, n_{t+1}\right)\lambda_{t+1} + (1-\Omega) \right] dF\left(\cdot\right) \}.$$

Table 4: Equity Price Based Incentive Compensation:
Contract (16) vs. Contract (20)

	Standard Deviations in %						Correlation with output					
	$\eta_m = .5$		$\eta_m = 1$		$\eta_m = 2$		$\eta_m = .5$		$\eta_m = 1$		$\eta_m = 2$	
	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)
y	1.03	1.58	1.01	1.36	1.01	1.27	1.00	1.00	1.00	1.00	1.00	1.00
c^m	.25	.55	.13	.44	.11	.35	-.54	.76	.26	.89	.76	.95
d	.25	5.84	.13	3.62	.11	2.61	-.54	-.97	.26	-.98	.76	-.99
c^s	.87	.61	.88	.69	.88	.73	1.00	.94	1.00	.99	1.00	1.00
i	1.51	4.54	1.41	3.36	1.38	2.82	1.00	.99	1.00	1.00	1.00	1.00
k	.13	.39	.13	.29	.12	.25	.28	.36	.26	.31	.25	.28
n	.17	1.02	.14	.69	.13	.54	.98	.98	.99	.99	1.00	1.00
w	.87	.61	.88	.69	.88	.73	1.00	.94	1.00	.99	1.00	1.00

(a) Contract (16): $\varphi = .01, \bar{c}^m = .0012$;

(b) Contract (20): $\varphi = .0001, \bar{c}^m = .0012$

All cases: $\theta = 1$, $\eta_s = 1$, $\mu = 0$, $A = 0$; all other parameters as in Table 1. All statistics computed after H-P filtering.

Adding the equity price to the compensation base yields the following central results:

(1) For the same process on the productivity disturbances, the economy becomes more variable (larger detrended standard deviations for all series) and much more procyclical relative to its counterpart based on (16). This is the case for all levels of managerial risk aversion, and is evident from the results presented in Table 4 where the power of the incentive portion of the contract φ is adapted so that steady state managerial consumption is the same in both sets of economies.[31] We note that for contract (20), $\rho(d_t, y_t) < 0$ in all cases, suggesting a much more responsive investment decision in the presence of a favorable productivity disturbance. These effects are most strongly felt in the case of $\eta_m = .5$, where the shift to a price based contract causes the volatility of

---

[31] Since the steady state equity value is so much larger than the state state dividend we chose the parameter φ to be much lower in the price-based compensation cases. In particular $\varphi = .01$ in the case where managerial compensation is governed by (16); in the case of (20) the corresponding $\varphi = .0001$. In either case steady state manager consumption is $\bar{c}^m = .0012$.

investment to increase by a factor of 3; hours volatility increases by a factor of 6. These results follow from the fact that the magnitude of the managers compensation base is overwhelmingly determined by the equity price which is itself highly procyclical (with $\beta = .99$, the ratio q^e / d_t averages about 100). Reinforcing this phenomenon is the simple fact that the managers consumption is not much diminished if she elects to increase investment since the price component of the base is not correspondingly affected. Note that these results do not constitute a response to an increase in mean managerial consumption. Across both sets of cases, the φ parameter is altered to make mean consumption the same in both families of cases.

The results of Table 4 also carry over to the cases where $A \neq 0$ and $\mu \neq 0$. In general the observed phenomena they illustrate, e.g., that volatility generally declines with managerial risk aversion, are fully consistent with those derived from pure cash flow based contracts.

(2) The conclusions of Corollaries 1, 2 and 3 of the prior section are perfectly replicated with equity price based contracts of the form (20): Contract convexity enhances volatility only if $\eta_m < 1$. In these cases (not reported), macro volatility of output, investment and hours increases more dramatically with contract convexity under the price based contract (20) than under the dividend based one (16). Managerial consumption volatility increases less rapidly, however, due to the relative smoothness of the price series. Shareholder consumption volatility is not much affected in either case.

(3) The relative magnitudes of the salary and incentive components continue to influence the effects of contract convexity. When a fixed salary component is added, the phenomena noted earlier remain in effect with exaggerated consequences (unreported).

Table 5: Macroeconomic Volatilities - Differing Salary and Incentive Magnitudes in the Presence of Changing $\theta^{(i)}$

	Standard Deviations in %						Correlation with output					
	$\varphi=.01$			$\varphi=.0001$			$\varphi=.01$			$\varphi=.0001$		
θ	1	1.5	2	1	1.02	1.05	1	1.5	2	1	1.02	1.05
y	1.61	2.13	.48	2.97	3.21	3.75	1.00	1.00	1.00	1.00	1.00	1.00
c^m	.53	1.30	27.19	.23	.26	.33	.68	.23	-.92	-.22	-.31	-.48
d	6.12	11.9	5.61	22.65	25.68	32.63	-.96	-.94	.98	-.93	-.94	-.95
c^s	.61	.63	1.19	1.20	1.38	1.80	.93	.43	.99	-.32	-.43	-.60
i	4.69	7.68	1.60	13.14	14.68	18.26	.99	.98	-.96	.97	.97	.97
k	.40	.59	.14	.75	.76	.79	.37	.44	.06	.51	.52	.54
n	1.07	1.93	.71	3.54	4.00	5.04	-.98	-.96	-.98	.95	.95	.96
w	.61	.63	1.19	1.19	1.38	1.80	.99	.43	.99	-.32	-.43	-.60
q^e	.60	.93	14.63	1.55	1.71	2.05	.74	.36	-.92	-.10	-.20	-.38

[i] In all cases: $A = .00716 = .01(wn)^{ss}$; $\eta_s = 1$, $\eta_m = .5$, $\alpha = .36$, $\beta = .99$, $B = 2.85$; $\mu = 0$, $\varphi = .01$; shock process as previously.

When the fixed component is small relative to the incentive component, the statistical properties of the dividend series dominate. There is thus a tendency for a less-risk-averse-than- log manager to behave in a more risk-averse manner as contract convexity increases (Table 5, $\varphi = .01$ panel). This reflects the enormous increase in his own consumption volatility as contract convexity doubles from $\theta = 1$ to $\theta = 2$ (the detrended volatility of managerial consumption rises from .53% to 27.19%). Ultimately ($\theta = 2$) the manager attempts to mute volatility by enacting countercyclical investment and hiring plans (these policies are also consistent with a procyclical dividend). Output volatility falls dramatically.

When φ is much smaller ($\varphi = .0001$ panel), the salary component of the manager's compensation dominates. With a large fixed salary component the managers overall consumption volatility is hardly affected by increases in θ: the manager is essentially risk neutral. This fact leads to highly procyclical investment and labor service plans.

These cases again remind us of the importance of the proper balance between salary and

incentive compensation. If the former is too small, increasing contract convexity has the perverse effect of inducing even a less-risk-averse-than-log manager to act in a more risk adverse fashion. If the latter is too small, very small changes in contract convexity can have fairly large implications for macroeconomic time series volatility. Note that the $\varphi = .0001$ panel of Table 5 explores a very narrow range of convexity. For θ only as large as $\theta = 1.1$ (not reported), the entire system becomes unstable and extremely volatile.

Our results suggest that the principal advantage of an equity price based contract is the added procyclicality it can contribute to the manager's actions (Table 5). The equity price is also a quantity that is objectively determined in the marketplace, and thus free from moral hazard related distorting measurements. Nevertheless the importance of a correct balance between salary and incentive components, and the total ineffectiveness of contract convexity as a motivational device when $\eta_m \geq 1$, are qualifications that apply fully to this setting as well.

6 Literature Review

While the contracting literature is itself enormous, the portion of it that considers the aggregate consequences of various contracting arrangements is not large. Most closely related to the present paper are the works of Philippon (2006) and Dow et al.(2005). In the case of Philippon (2006), the delegated manager desires to over-invest and over-hire relative to what is profit maximizing. Shareholders may closely monitor the manager, but at a cost to firm productivity. As a result it is optimal for shareholders to monitor less closely in times of high productivity and output growth than in low productivity periods, a practice that exacerbates the volatility of investment and of the business cycle. In Dow et al. (2005), managers prefer to invest all the firms' cash flow, and investors can make only positive additions to it. Shareholders may contravene the managers by hiring auditors who effectively sequester output for distribution to shareholders after

appropriating a fraction of this output for themselves as compensation for their services. As such, managers have no explicit decision to make; shareholders effectively trade off the level of investment versus the number of auditors hired. These authors are able to replicate the basic stylized facts of the business cycle, and the cyclical behavior of interest rates and the yield curve. In a strong form of the private benefits assumption, Albuquerque and Wang (2007) assume that managers may steal of fraction of the firm's output by incurring a convex cost of doing so. They study the asset pricing implications of such arrangements in a multi-country context and find that countries with weaker investor protections will display, among other things, lower average Tobin's Q, greater equity return volatility and higher equity premiums, implications they find are supported in the data. While these three papers are probably the closest to our own, our framework differs in several respects of which two are most noteworthy. First, we do not assume that managers have special preferences. Rather, our results are dependent only upon the equilibrium properties of the capital income stream on which managerial compensation must ultimately be based. Second, we cast our analysis in a contracting framework deriving the properties of the optimal contract and analyzing the implications of deviating from it.

There are numerous other strands to this literature. Murphy (1999, 2003) provides exhaustive empirical documentation for the historical structure of executive compensation and its increasing incentive basis. Cunat and Guadalupe (2005) document a causal link between greater product market competition and greater pay-to-performance sensitivity in US CEO compensation. Dow and Raposo (2005) argue that these higher incentives are justified by increased volatility in the business environments faced by individual firms. In a competitive assignment model, Gabaix and Landier (2007) argue that small differences is in CEO ability can nevertheless justify large pay differentials. They are able directly to link the sixfold increase in average CEO pay over the period

1990-2003 to the similar magnitude increase in the market capitalization of large US firms over the same period. They also provide an excellent survey of the literature that focuses on explaining the large increases in CEO pay. In contrast, Benmelech et al. (2007) focus on the structure of CEO contracts, contrasting the motivational potential of dividend/cash flow based contracts with price based contracts. Their paper contains a similarly excellent literature review. Acharya and Bisin (2002) remind us that managers are confronted with choices between high risk-high return, firm-specific projects and more standard (e.g., cost reducing) ones with greater aggregate risk that is largely business cycle determined. This idea is further developed in Aghion and Stein (2007). None of these studies, however, considers the impact of executive compensation practices within a dynamic stochastic general equilibrium context.

Lastly, we mention Shorish and Spear (2005), which focuses on the asset pricing implications of contracting. Their model is one in which the agent can influence the output process via his effort and the principal is interested to maximize the price of the equity security within an otherwise Lucas (1978) asset pricing exchange context. They then study a version of the model when the agent accepts a series of one period static contracts and find that it is able to explain very well the observed time variation in return volatility and persistence characteristic of equity return data. Our model extends the Shorish and Spear construct to a more conventional business cycle production setting while exploring variations on the optimal contract.

7   Conclusions

In this paper we have shown that in the general equilibrium of an economy where shareholders delegate the management of the firm, a manager paid on the basis of her firm's performance naturally inherits an income position that may lead her to make very different investment decisions than firm owners, or the representative agent of the standard business cycle

model, would want to make. The conflict of interests is endogenous, that is, it does not result from postulated behavioral properties of the manager; it is generic, that is, it characterizes the situation of the ``average'' manager as a necessary implication of market clearing conditions; and, it is severe in the sense that, if it is unmitigated by appropriate contracting or monitoring, it results in macro dynamics widely at variance with the Pareto optimum.

In our model context, the incentive performance-based component of the manager's remuneration is akin to a non-tradable equity position in the firm. It perfectly solves the 'micro' level agency issues raised by delegation. It is not sufficient, however, to fully align the incentives of managers with those of firm owners. To do so requires including an additional "salary" component in the manager's remuneration package. The salary component must be indexed on aggregate state variables and it must be large in proportion to the incentive part of the remuneration package. We show that a failure to properly adapt the manager's salary component may result in severe distortions in the investment policy of the firm with significant macroeconomic consequences. We argue that the most plausible deviations from the optimal contract may help rationalize observations made on managers' behavior under the quiet life hypothesis.

Specifically if the salary component is too small or too smooth, the manager adopts an excessively passive investment policy resulting in a very unresponsive economy. In these circumstances, the consumption profile of the manager under the optimal investment policy is otherwise too variable and too counter-cyclical. In order to align the interests of a manager, so remunerated, with those of firm owners, one must make him highly willing to substitute consumption across time. If this is the case, he will be prepared to sacrifice his consumption in good times (choosing to delay dividend payments in order to finance large investment expenses)

and he will respond sufficiently vigorously to favorable investment opportunities.

We explore the potential of convex contracts to resolve the incentive problem of an excessively timid manager and conclude that they are no panacea. This is true first because a logarithmic manager is insensitive to the curvature of the contract. Second, if the manager is more risk averse than log, there is no solution but to propose an unconventional remuneration that is inversely related to the firm's results, paying high compensation when free cash flows are low and conversely. Only in the case of a less-risk-averse-than-log manager is it possible to approximate closely the optimal contract by a remuneration package composed of a convex performance-based component in conjunction with a smaller-than-optimal constant salary feature. The degree of curvature of the performance-based component must, however, be precisely estimated and adapted to the size of the constant salary component.

References

Acharya, V. and A. Bisin, "Managerial Hedging and Incentive Compensation in Stock Market Economies," working paper, London Business School, 2002.

Aghion, Ph. and J. Stein, "Growth vs. Margins: Destabilizing Consequences of Giving the Stock Market What It Wants," forthcoming *Journal of Finance*, 2007.

Albuquerque, R. and N. Wang, "Agency Conflicts, Investment, and Asset Pricing," forthcoming *Journal of Finance*, 2007.

Benmelech, E., Kandel E., and P. Veronesi, "Stock-Based Compensation and CEO (Dis)incentives," CEPR Working Paper 6516, 2007.

Bertrand, M. and Mullainathan, S., "Enjoying the Quiet Life? Corporate Governance and Managerial Preferences," *Journal of Political Economy*, 111 (2003), 1043-1075.

Bolton, P. and M. Dewatripont, *Contract Theory*, MIT Press Cambridge Mass. 2005

Cunat, V. and M. Guadalupe, "How Does Product Market Competition Shape Incentive Contracts?", *Journal of the European Economic Association*, 3 (2005) 1058-1082.

Danthine, J. P., and J. B. Donaldson, "Executive Compensation; A General Equilibrium Perspective," mimeo, University of Lausanne, 2008.

Donaldson, J. B., N. Gershun, and M. Giannoni, "Some Unpleasant General Equilibrium Implications of Executive Incentive Compensation Contracts," mimeo (2010).

Dow, J., Krishnamurthy A, and Gorton G, "Equilibrium Investment and Asset Prices Under Imperfect Corporate Control," *American Economic Review*, 95 (2005), 659-681.

Dow, J. and C. Raposo, "CEO Compensation, Change, and Corporate Strategy," *Journal of Finance*, 560 (2005), 2701-2727.

Gabaix, X. and A. Landier, "Why Has CEO Pay Increased So Much?" NBER Working Paper

2007.

Hansen, G., "Indivisible Labor and the Business Cycle," *Journal of Monetary Economics*, 16 (1985), 309-327.

Jensen, M., "The Agency Costs of Free Cash Flow: Corporate Finance and Takeovers," *American Economic Review*, 76, 2, 323-330, 1986.

Lucas, R.E.Jr., "Asset Pricing in an Exchange Economy," *Econometrica*, 46 (1978), 1429-1444.

Murphy, K., "Executive Compensation," in O. Ashenfelter and D. Card (eds) *Handbook of Labor Economics*, vol. 3B, North Holland, 1999, 2485-2567.

Murphy, K.J., "Stock Based Pay in New Economy Firms," *Journal of Accounting and Economics*, 34 (2003), 129-147.

Philippon, Th., "Corporate Governance over the Business Cycle," *Journal of Economics Dynamics and Control*, 30 (2006), 2117-2141.

Shorish, S., and S. Spear, "Shaking the Tree: An Agency-Theoretic Model of Asset Prices," *Annals of Finance*, 1 (2005), 51-72.

Smith, C.W., and R.M. Stulz, "The Determinants of Firms' Hedging Policies," *Journal of Financial and Quantitative Analysis*, 20, 391-405, 1985.