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Insider Trading and Real Investment†

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Abstract

In this paper I analyze the effects of insider trading on real investment and the insurance role of financial markets. There is a single entrepreneur who, at a first stage, chooses the level of investment in a risky business. At the second stage, an asset with random payoff is issued and then the entrepreneur receives some privileged information on the likely realization of production return. At the third stage, trading occurs on the asset market, where the entrepreneur faces the aggregate demand coming from a continuum of rational uniformed traders and some noise traders. I compare the equilibrium with insider trading (when the entrepreneur trades on her inside information in the asset market) with the equilibrium in the same market without insider trading. I find that permitting insider trading tends to decrease the level of real investment. Moreover, the asset market is thinner and the entrepreneur's net supply of the asset and the hedge ratio are lower, although the asset price is more informative and volatile.

1. Introduction

Insider trading regulations are commonly based on fairness considerations, so that most rules try to promote *fair* trading and *confidence* in financial markets. However, economists have argued that allowing insider trading improves the efficiency of asset prices and may increase the level of real investment (by creating the right incentives for managers) and welfare.

During the last decade there have appeared many papers on the financial effects of insider trading. Grossman and Stiglitz (1980), Hellwig (1980 and 1982), and Kyle (1985 and 1989) have studied, among others, the financial effects of trading based on private information. More recently, attention is being paid to the real effects of insider trading. Ausubel (1990), Leland (1992), Repullo (1994), Leland and Pyle (1977), and Dennert (1991, 1992, and 1993) have studied the effects of insider trading on the cost of capital and real investment.

My objective is to contribute to the second line of research. Specifically, I analyze the interaction between insider trading and the insurance role of financial markets in order to characterize the effects of this interaction on real investment and on the efficiency of the asset prices. Moreover, I study the economic impact of common insider trading regulations, that is, I analyze the consequences of prohibiting it via a *disclose-or-abstain* rule.

The main features of the model are the following. There are two rational agents, with exponential utility functions, and a set of liquidity traders. Agent 2 is a representative agent for a continuum of risk averse investors who do not have any private information. Agent 1 is an entrepreneur who, at a first stage, chooses the level of investment in a risky business with stochastic return per unit of investment $\tilde{e}$. At the second stage, a risky asset is issued and then the entrepreneur receives some privileged information $\tilde{s}$ on the likely realization of production return $\tilde{e}$. At the third stage, trading occurs on the asset market. Finally, at the ex post stage, all uncertainty is resolved.

My model is similar in spirit to the models of Leland (1992) and Repullo (1994), and can be contrasted with them. I assume that the insider is the entrepreneur while Leland and Repullo assume that the unique informed trader is an outsider. In my view, it is natural to assume that the entrepreneur has access to information about his own business. On the other hand, the models of Leland and Repullo present a special feature. They assume that the risk neutral entrepreneur is forced to sell the whole firm in the asset market. In my view, since the expected price is lower than the expected asset return, the entrepreneur has no reasonable motive to float his firm on an exchange, but this means that the asset supply would be equal zero (and then insider trading would not play any role). In my model, since the entrepreneur is risk averse, he issues the asset to obtain the insurance provided by the market. Moreover, there is another motive to issue the new asset. Since I allow the entrepreneur to trade any amount of the asset, he can achieve some speculative gains coming from his inside information. Finally, in contrast to Leland's model, I give market power to the entrepreneur, since he is the only informed trader and the primary issuer of the asset.

In Leland's model, the level of real investment increases when insider trading is permitted, since average stock price will rise. Repullo (1994), who studies a version of Leland's model in which the investment decision is prior to the placing of the asset in the market and the supplier of the asset has market power, finds that insider trading does not have any effect on the average stock price but increases its volatility. Both Leland and Repullo compare the equilibrium when insider trading is permitted with the equilibrium when no information is available. Instead, I compare the equilibrium when insider trading is permitted with the two possible equilibria in the same economy when insider trading is prohibited via the well known disclose-or-abstain rule.

In my model, the entrepreneur's ex ante expected utility is the product of three terms: the utility level derived from the speculative demand, the utility coming from real investment, and the utility level derived from the insurance achieved via the hedge supply. Insurance gains comes from two sources. The entrepreneur achieves insurance by selling the asset (since the asset return and the investment return are positively correlated). Moreover, there are some insurance gains coming from the correlation between the production return and the insider's speculative demand.

The entrepreneur's hedge supply is directly proportional to the unknown part of the correlation between the production return and the asset return. Fundamentals information received by the entrepreneur after choosing the level of real investment reduces the hedging quality of the asset market at the third stage. Alternatively, this fundamentals information lowers the ex-post riskiness of real investment from the entrepreneur's point of view, which causes a reduction in his ex-ante real investment. In this setup, insider trading decreases risk-sharing opportunities by creating an adverse selection problem (and, therefore, making the outsider less willing to trade) and by reducing the unknown part of the correlation between the production return and the asset return.

When I do the same comparison as Leland and Repullo, I find that permitting insider trading decreases the level of real investment since it reduces the risk-sharing opportunities provided by the asset market. This is due to the fact that inside information reduces the unknown part of the correlation between the production return and the asset return and, moreover, it creates an adverse selection problem which makes the outsider less willing to share the risk coming from real production. On the other hand, insider trading decreases the depth of the market and increases the precision, the expected value and the volatility of the asset price.

On the other hand, if we compare the equilibrium when insider trading is permitted with the equilibrium when the insider publicly reveals his inside information, then we find that insider trading does decrease the price precision and the market depth. The effect of making public the inside information on real investment depends upon the trade-off between the following effects. If inside information is made public, there are more risk-sharing opportunities since the adverse selection problem faced by the outsider is eliminated (therefore, the outsider is more willing to share the risk due to real investment). On the other hand, since the informational asymmetry disappears, the entrepreneur's speculative demand and the expected production return (conditional on the entrepreneur's information) are uncorrelated and, therefore, the risk-sharing opportunities provided by financial markets are reduced[3]. If the correlation between the production return and the asset liquidation value is very high and fundamentals information is very precise, real investment is reduced by insider trading since the latter effect dominates the former. Otherwise, the opposite result holds.

The paper is organized as follows. In section 2 the model is presented. Section 3 studies the equilibrium with insider trading. The two equilibria which arise when insider trading is prohibited via the disclose-or-abstain rule are analyzed in section 4. Section 5 compares the equilibrium characterized in section 3 with the two equilibria found in sections 4. Conclusions are collected in section 6. An appendix containing all the proofs concludes the paper.

2. The model

I consider an economy where a risky asset, with random fundamental value $\tilde{v}$, is traded against a riskless asset (the numéraire) whose return is normalized to zero. The risky asset is traded at a price p and thus generates return $\tilde{v}-p$. In the notation employed in this paper, a tilde distinguishes a random variable from its realization. For instance, $\tilde{v}$ denotes the random variable generating the liquidation value of the risky asset, and v is the

[3] See the remarks after proposition 3.1.

liquidation value for a particular realization of $\tilde{v}$. Moreover, I will use $\bar{x}, \sigma_x^2$ and σ_{xy} to denote the expected value of $\tilde{x}$, the variance of $\tilde{x}$, and the covariance between $\tilde{x}$ and $\tilde{y}$, respectively.

There are two rational traders: agent *1* is an entrepreneur, who by virtue of his position has inside information, and agent 2, whom I refer to as the *outsider*. Throughout this paper the subscript *i* will refer to the *insider*, the entrepreneur, and the subscript *o* will refer to the *outsider*. Both rational traders have exponential utilities in their terminal wealth, with risk aversion coefficients ρ_i and ρ_o for the insider and the outsider respectively. Furthermore, there are noise traders demanding an exogenous random quantity $\tilde{u}$, which is independent of all other variables in the economy. Positive amounts represent purchases and negative amounts represent sales.

At a first stage, the entrepreneur chooses the level of investment q in a risky business. The stochastic return per unit of investment is $\tilde{e}$. The technology is represented by a deterministic quadratic cost function of the form $C(q) = c_1 q + \frac{c_2}{2} q^2$ where c_1 and c_2 are greater than zero. At the second stage, a risky asset with random payoff $\tilde{v}$ is issued. Then the entrepreneur receives some privileged information $\tilde{s}$ on the likely realization of production return. At the third stage, trading occurs on the asset market. Finally, at the ex post stage, all uncertainty is resolved ($\tilde{v}$ and $\tilde{e}$ are realized) and consumption takes place. Given an investment level q and a net asset position d_i, the net wealth[4] of the entrepreneur is $\tilde{w}_i = \tilde{e}q - C(q) + (\tilde{v} - p)d_i$.

If d_i is positive, the entrepreneur is a net buyer of the asset while he is a supplier of the risky asset if d_i is negative. I will often refer to $-d_i$ as the agent 1's net supply of the risky asset. In equilibrium, the expected value of d_i will generally be negative so that the entrepreneur will be a supplier of the risky asset.

Agent 1 knows the relation between the net supply of the asset and its price. Moreover, he is aware of the fact that an increase in his speculative demand for the risky asset has an effect on the informativeness of the price and, therefore, on the outsider's demand and the price.

[4] As it is well-kown, with constant absolute risk aversion, a trader's demand for a risky asset does not depend on his initial non-random wealth, so that we assume that both the insider and the outsider have zero initial wealth.

The outsider is a representative agent[5] for a continuum of risk averse investors who do not have any private information. Hence he is assumed to behave as a price-taker. Since he has rational expectations, he uses his observation of the price to update his beliefs. Thus, he takes a position d_o in the risky asset to maximize the utility function $U_o(\tilde{w}_o) = -\exp\{-\rho_o \tilde{w}_o\}$ of his terminal wealth $\tilde{w}_o = (\tilde{v} - p)d_o$.

All random variables are assumed to be normally distributed: $\tilde{v} \sim N(\bar{v}, \sigma_v^2)$, $\tilde{e} \sim N(\bar{e}, \sigma_e^2)$, $\tilde{u} \sim N(0, \sigma_u^2)$ and $\tilde{s} \sim N(\bar{s}, \sigma_s^2)$. Furthermore, it is assumed that $\tilde{v}$ and $\tilde{s}$ can be written as $\tilde{s} = (\bar{s} - \bar{e}) + \tilde{e} + \tilde{\varepsilon}_s$ and $\tilde{v} = (\bar{v} - \bar{e}) + \tilde{e} + \tilde{\varepsilon}_v$, where $\tilde{\varepsilon}_s$ and $\tilde{\varepsilon}_v$ are independent. That is, the production return, the asset return, and inside information are assumed to be positively correlated. Let R_{xy} denote the square of the correlation coefficient between $\tilde{x}$ and $\tilde{y}$, that is, $R_{xy} = \dfrac{(\text{cov}[\tilde{x}, \tilde{y}])^2}{\text{var}[\tilde{x}]\text{var}[\tilde{y}]}$. From the above characterizations of $\tilde{s}$ and $\tilde{v}$, we can establish the relation $R_{sv} = R_{ve} R_{se}$ where $R_{se} = \sigma_e^2 / \sigma_s^2$ and $R_{ve} = \sigma_e^2 / \sigma_v^2$.

We first introduce the appropriate concept of equilibrium in the asset market, which is similar in spirit to the rational expectations equilibrium with imperfect competition defined by Kyle (1989).

> ***Definition:*** *An imperfectly competitive rational expectations equilibrium in the asset market is defined as the set of functions* $\{P(\tilde{s}, \tilde{u}), d_i(\tilde{s}, \tilde{p}), d_o(\tilde{p})\}$ *such that:*
>
> *- inside information* $\tilde{s}$ *enters in the price function* $P(\tilde{s}, \tilde{u})$ *only through insider's demand* $d_i(\tilde{s}, \tilde{p})$,
>
> *- price* $\tilde{p} = P(\tilde{s}, \tilde{u})$ *clears the market (with probability one)*
>
> $$d_i(\tilde{s}, \tilde{p}) + d_o(\tilde{p}) + \tilde{u} = 0 \qquad [1]$$

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[5] It is well-known that in the CARA-Gaussian set-up agents with the same information structure can be aggregated into one. In particular, suppose that there is a continuum of rational uninformed risk averse investors, indexed in the interval [0,1] endowed with the Lebesgue measure (so that each of them is "small" and then price taker), and that agent j takes a position d_j in the risky asset to maximize the CARA utility $U_j(\tilde{w}_j) = -\exp\{-\rho_j \tilde{w}_j\}$ of his terminal wealth $\tilde{w}_j$. As we will justify bellow, agent j's optimal demand is given by $d_j(p) = \dfrac{E[\tilde{v}|p] - p}{\rho_j \,\text{var}[\tilde{v}|p]}$. Therefore, the uninformed investors' aggregate demand is given by $\int_0^1 \{d_j(p)\} d_j = \left(\dfrac{E[\tilde{v}|p] - p}{\text{var}[\tilde{v}|p]}\right) \int_0^1 \{1/\rho_j\} d_j$, which coincides with the optimal demand of a representative agent, the *outsider*, with risk aversion coefficient $\rho = 1 \Big/ \int_0^1 \{1/\rho_j\} d_j$.

- $d_i(\tilde{s},\tilde{p})$ *is chosen to maximize the insider's expected utility of his wealth conditional on the price function and inside information subject to the relation between the price and the insider's demand,*

- $d_o(\tilde{p})$ *is chosen to maximize the outsider's expected utility of his wealth conditional on the price function..*

The insider behaves as monopsonist so that he recognizes that the price depends upon his demand through the implicit relation established by the market clearing condition. On the contrary, the outsider behaves as price-taker since he represents a continuum of uninformed risk-averse traders.

Although the price has no information to aggregate, it is still useful from the insider's point of view since it allows him to infer the exact amount of noise trading (and thus eliminate the price risk it creates).

3. Equilibrium with insider trading

As it is well known, for any $\tilde{\varepsilon}$ normally distributed random variable

$$E[\exp\{\tilde{\varepsilon}\}] = \exp\{E[\tilde{\varepsilon}] + \text{var}[\tilde{\varepsilon}]/2\}. \qquad [2]$$

Hence, the outsider's objective function given his information set $\{p\}$ can be written as $E_o[U_o(\tilde{w}_o)] = E[-\exp\{-\rho_o\tilde{w}_o\}| p] = -\exp\left\{-\rho_o\left(E[\tilde{w}_o| p] - \frac{\rho_o}{2}\text{var}[\tilde{w}_o| p]\right)\right\}$. This expression follows because we restrict ourselves to linear equilibria, which keeps the normality of w_o conditional on p. Since $E[\tilde{w}_o| \tilde{p}] = d_o E[\tilde{v} - \tilde{p}| \tilde{p}]$ and $\text{var}[\tilde{w}_o| \tilde{p}] = d_o^2\, \text{var}[\tilde{v} - \tilde{p}| \tilde{p}]$, maximizing with respect to d_o yields a demand function for the risky asset

$$d_o(\tilde{p}) = \frac{E[\tilde{v}| \tilde{p}] - \tilde{p}}{\rho_o\, \text{var}[\tilde{v}| \tilde{p}]} \qquad [3]$$

which is linear in p since $\text{var}[v-p|p]$ is constant and $E[v-p|p]$ is linear due to the normality assumption. Since d_o is linear on p, it may be written as $d_o(p) = \varphi_o - \beta_o p$, where β_o denotes the *outsider's trading intensity*, which may be defined as the sensitivity of the outsider's demand to changes in the price. Then, from the market clearing condition [1], the relation between the insider's asset position and the price is given by $p = \lambda[\varphi_o + \tilde{u} + d_i]$ where $\lambda = 1/\beta_o$.

The entrepreneur's maximization problem can be written as the dynamic program

$$J_{1i} \equiv \max_q J_{2i}(q)$$

$$J_{2i}(q) \equiv \max_{d_i} E\left[-\exp\left\{-\rho_i\left[\tilde{e}q - C(q) + (\tilde{v} - p)d_i\right]\right\}\middle|\tilde{s}, p\right] \text{ subject to } p = \lambda[\varphi_o + \tilde{u} + d_i].$$

At the first stage, the entrepreneur chooses the level of real investment. Then, at the second stage, he chooses his optimal demand schedule for the risky asset after observing the realization of his privileged information. The mathematical resolution proceeds backwards by applying the Bellman's Principle of Optimality.

If the second order condition holds, $2\lambda + \rho_i \operatorname{var}[\tilde{v}|\tilde{s}] > 0$, then the insider has the well-defined demand function

$$d_i(\tilde{s}, \tilde{p}) = \frac{E[\tilde{v}|\tilde{s}] - \tilde{p}}{\rho_i \operatorname{var}[\tilde{v}|\tilde{s}] + \lambda} - \frac{\rho_i \operatorname{cov}[\tilde{e}, \tilde{v}|\tilde{s}]}{\rho_i \operatorname{var}[\tilde{v}|\tilde{s}] + \lambda} q \qquad [4]$$

The entrepreneur's asset position can be decomposed into two terms. The first term, which depends on his information, may be denoted as his speculative demand. According to this term, the insider buys (sells) if his estimate of the asset liquidation value is greater (lower) than the price. Moreover, speculative demand is increasing in the precision of inside information and is decreasing in the insider's risk aversion and the slope of his residual supply. The opposite of the second term, $HS_i = \frac{\rho_i \operatorname{cov}[\tilde{e}, \tilde{v}|\tilde{s}]}{\rho_i \operatorname{var}[\tilde{v}|\tilde{s}] + \lambda} q$, may be interpreted as the entrepreneur's hedge supply of the asset. It depends on real investment, which determines the initial risk born by the entrepreneur before trading on the asset market, but it is independent of the realization of his information.

In this model, the entrepreneur undertakes a risky business and then sells the risky asset to obtain insurance. We can think of $E[-d_i]/q$ HS_i/q as the hedge ratio and it is an index of the amount of initial risk born by the outsider. Analogously, $1 - HS_i/q$ $E[-d_i]/q$ measures the amount of risk coming from the risky business that the entrepreneur does not hedge on the asset market.

Proposition 3.1. *There is a unique linear imperfectly competitive rational expectations equilibrium in the asset market. It is given by* [3], [4], *and the price function*

$$\tilde{p} = \bar{v} - (\delta/\Lambda)HS_i + \Lambda^{-1}\{\tilde{u} + g_i R_{se}(\tilde{s} - \bar{s})\} \qquad [5]$$

where $HS_i = \rho_i g_i \operatorname{cov}[\tilde{e},\tilde{v}|\tilde{s}]q$, $\operatorname{cov}[\tilde{e},\tilde{v}|\tilde{s}] = \sigma_{ev} - \sigma_{es}\sigma_{vs}/\sigma_s^2 = (1-R_{se})\sigma_e^2$, $\Lambda = g_i + \beta_o$, $g_i = 1/[\rho_i(1-R_{sv})\sigma_v^2 + \lambda]$, $\beta_o = 1/\lambda$, $\delta = 1 - R_{sv}(\sigma_v^2/\sigma_u^2)g_i\beta_o$, *and where the equilibrium value of* λ *is implicitly defined by*

$$\lambda = \rho_o\sigma_v^2 + \frac{R_{sv}\sigma_v^2}{\sigma_u^2}\frac{[(\rho_i+\rho_o)(1-R_{sv})\sigma_v^2 + \lambda]}{[\rho_i(1-R_{sv})\sigma_v^2+\lambda]^2} \qquad [6]$$

The insider's ex ante expected utility is given by

$$E[-\exp\{-\rho_i\tilde{w}_i\}] = -|SG|\exp\{-\rho_i[q\bar{e} - C(q) - (\rho_i/2)q^2(\sigma_e^2 - D)]\} \qquad [7a]$$

where $|SG| = \left\{1 + \frac{\rho_i(R_{sv}\sigma_v^2 + \lambda^2\sigma_u^2)}{\rho_i(1-R_{sv})\sigma_v^2 + 2\lambda}\right\}^{-1/2}$ *and*

$$D = \frac{\rho_i}{\rho_i\sigma_v^2 + 2\lambda + \rho_i\lambda^2\sigma_u^2}\left\{\sigma_{ev} + g_i^2\frac{R_{sv}\sigma_v^2}{\sigma_u^2}\operatorname{cov}[\tilde{e},\tilde{v}|\tilde{s}]\right\}^2.$$

The outsider's ex ante expected utility is given by

$$E[-\exp\{-\rho_o\tilde{w}_o\}] = -|SG_o|\exp\{-(\rho_o^2/2)\operatorname{var}[\tilde{v}|\tilde{p}]|SG_o|^2 HS_i^2(1-\delta g_i/\Lambda)^2\} \qquad [7b]$$

where $|SG_o| = \{1 + \rho_o^2(\beta_o/\Lambda)^2\sigma_v^2[\sigma_u^2 + R_{sv}(1-R_{sv})g_i^2\sigma_v^2]\}^{-1/2}$ *and*

$$\operatorname{var}[\tilde{v}|\tilde{p}] = \sigma_v^2\left[\frac{\sigma_u^2 + R_{sv}g_i^2(1-R_{sv})\sigma_v^2}{\sigma_u^2 + R_{sv}g_i^2(1-R_{sv})\sigma_v^2}\right].$$

Finally, the level of real investment chosen by the entrepreneur is given by

$$q = \frac{\bar{e} - c_1}{c_2 + \rho_i(\sigma_e^2 - D)} \qquad [8]$$

Proof. See the Appendix.

Remarks: The expected price is equal to the prior expected liquidation value minus a risk premium. Since the production return and the asset return are positively correlated, the risk premium is positive. Moreover, it is directly proportional to the entrepreneur's hedge supply and inversely proportional to the market depth, $RP = (\delta/\Lambda)HS_i$ where $\delta \in (0,1]$.

We define the price precision as the inverse of the variance of the liquidation value given the information contained in the price. It is an index of the informativeness of the price about the liquidation value, v. The price contains information about v if and only if traders with fundamentals information trade on the basis of that information. Thus, it is natural to expect that the higher the traders' sensibility to fundamentals information, the more informative the price. This is true in equilibrium.

The insider's demand function for the risky asset may be written as

$$d_i(\tilde{s},\tilde{p}) = \alpha_i(\tilde{s}-\tilde{p}) + g_i(\bar{v}-\tilde{p}) - \rho_i g_i \operatorname{cov}[\tilde{e},\tilde{v}|\tilde{s}]q$$

where $\alpha_i = g_i R_{se}$. The weight put on the inside information, which may be defined as the *insider's trading intensity* α_i, is increasing in the precision of private information and decreasing in the insider's risk aversion and the slope of the insider's residual supply.

Since I assume that the production return $\tilde{e}$ and the asset return $\tilde{v}$ are positively correlated, the entrepreneur is a net supplier of the risky asset. That is, the expected value of his asset position d_1 is negative. On one hand, since the risk premium is positive, the ex ante expected value of the speculative demand is positive. That is, in order to achieve some speculative gains, the insider acts as a buyer of the risky asset. But, on the other hand, the entrepreneur sells a non-random quantity of the risky asset to hedge his real investment. In equilibrium, the entrepreneur's hedge supply is greater than his expected speculative demand. Analytically, as it is shown in the proof of proposition 3.1., $E[d_i(\tilde{s},\tilde{p})] = -HS_i\left(1-\delta\frac{g_i}{g_i+\beta_o}\right) < 0$, since $HS_i>0$ and $0<\delta<1$.

The entrepreneur's hedge supply is directly proportional to the unknown part of the correlation between the production return and the asset return. To some extent, R_{ve} is a measure of the prior hedging quality of the asset market. Obviously, if R_{ve} equals zero, the entrepreneur cannot achieve any insurance from the asset market. Fundamentals information received by the entrepreneur after choosing the level of real investment reduces the hedging quality of the asset market at the third stage. Alternatively, this fundamentals information lowers the riskiness of real investment from the entrepreneur's point of view, which causes a reduction in his hedge supply.

The insider's ex ante expected utility is the product of three terms: the utility level derived from the speculative demand $|SG|$, the utility coming from real investment, and the utility level derived from the insurance achieved via the hedge supply $|IG|$. That is,

$$E[-\exp\{-\rho_i\tilde{w}_i\}] = -|SG|\exp\{-\rho_i[q\bar{e} - C(q) - (\rho_i/2)q^2\sigma_e^2]\}|IG|$$

where $|IG| = \exp\{-(\rho_i^2/2)Dq^2\}$. Insurance gains comes from two sources. On the one hand, since the asset return and the investment return are positively correlated, the entrepreneur achieves insurance by selling the asset. These gains are directly related to $E[d_i]$, which is negative since the entrepreneur is a net seller of the asset. The expected value of the insider's speculative demand is positive[6] so that the greater the entrepreneur's hedge supply and/or the lower his speculative demand, the greater his insurance gains coming from trading in the asset market.

On the other hand, there are some insurance gains coming from the correlation between the production return and the insider's speculative demand. Analytically, these gains are directly related to $\operatorname{cov}\{d_i(\tilde{s},\tilde{p}), E[\tilde{e}|\tilde{s}]\}$ or, equivalently, to $\operatorname{cov}\{g_i\{E[\tilde{v}|\tilde{s}] - \tilde{p}\}, E[\tilde{e}|\tilde{s}]\}$. If the entrepreneur was not allow to speculate, then his insurance opportunities would be lower, since his asset position would be uncorrelated with the production return[7]. We can think of $E[\tilde{v}|\tilde{s}]$ and p as the insider's private estimate and the public estimate of the asset liquidation value, respectively. In this sense, the variance of $E[\tilde{v}|\tilde{s}] - \tilde{p}$ is an index of the relative inefficiency of the price or, equivalently, it is an index of the profitability of private information. The entrepreneur's insurance gains coming from the correlation between his speculative demand and the production return are high when the difference between the price and the private estimate of v is high, or equivalently, when inside information is very valuable. Analytically, $\operatorname{cov}\{d_i(\tilde{s},\tilde{p}), E[\tilde{e}|\tilde{s}]\}$ is proportional to $\sigma_e^2\, g_i\beta_o/(g_i + \beta_o)$, so that these insurance gains are high when the outsider trades aggressively (β_o high) and/or when the entrepreneur's speculative demand is high.

The optimal level of real investment is obtained by equating marginal value to marginal cost. At the first stage, the entrepreneur's marginal valuation curve is given by $\bar{e}$ while the marginal cost schedule is given by $MC(q) = C'(q) + \rho_i q^2(\sigma_e^2 - D)q$, which is the sum of the marginal production costs and the (opportunity) cost related to the riskiness of real investment. Obviously, the optimal level of real investment is increasing in D, which is a measure of hedging effectiveness of the asset market from the entrepreneur's point of view.

The allocations of risk at the equilibrium is given by

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[6] The entrepreneur's speculative demand is given by $g_i\{E[\tilde{v}|\tilde{s}] - \tilde{p}\}$. Conditional on $\tilde{s}$, its expected value is $g_i\{-(\beta_o/\Lambda)(\tilde{s} - \bar{s}) + (\delta/\Lambda)HS_i\}$. Therefore, the expected value of the entrepreneur's speculative demand is equal to $(\delta g_i/\Lambda)HS_i$, where $HS_i = \rho_i g_i \operatorname{cov}[\tilde{e}, \tilde{v}|\tilde{s}]q$>0 and $0 < (\delta g_i/\Lambda)HS_i < 1$.

[7] Remmember that hedge supply is non-random.

$d_i(\tilde{u}) = \alpha_i \xi_o (\tilde{s} - \bar{s}) - \xi_i \tilde{u} - (1 - \delta\xi_i) HS_i$ and $d_o(\tilde{u}) = -\alpha_i \xi_o (\tilde{s} - \bar{s}) - \xi_o \tilde{u} + (1 - \delta\xi_i) HS_i$, where ξ_o denote the "marginal market share of the quantity traded by noise traders going to the outsider", in the sense that when the realization of u goes up by one dollar, the quantity traded by the outsider goes up by ξ_o units. Analogously, let ξ_i denote the "marginal market share of the quantity traded by noise traders going to the entrepreneur".

Finally, by substituting the optimal level of real investment into [7a], the insider's ex ante expected utility may be written as $E[-\exp\{-\rho_i \tilde{w}_i\}] = -|SG_i| \exp\{-.5\rho_i(\bar{e} - c_1)q\}$.

4. Equilibria without insider trading

I wish to compare the equilibrium with insider trading, which is described in Proposition 3.1, with the equilibrium in the same market without insider trading. What exactly is meant with "market without insider trading"? A wide variety of restrictions on insider trading could be considered. I will explore the consequences of prohibiting insider trading via a *disclose-or-abstain rule*. That is, I will analyze what would happen if the entrepreneur should either publicly reveal his inside information $\tilde{s}$ or abstain to trade on the basis of that information.

In the first case, when the insider publicly reveals his private information $\tilde{s}$ to the outsider before trading in the asset market, both traders share the same information. The next corollary describes the unique equilibrium of the model with symmetric information.

Proposition 4.1. *If the entrepreneur publicly discloses his inside information before trading on it, then the unique linear imperfectly competitive rational expectations equilibrium in the asset market is characterized by*

$$\tilde{p} = E[\tilde{v}|\tilde{s}] + \Lambda^{-1}\{\tilde{u} - HS_i\} \qquad [9a]$$

$$d_i(\tilde{s}, \tilde{p}) = g_i\{E[\tilde{v}|\tilde{s}] - \tilde{p}\} - HS_i \text{ where } HS_i = \rho_i g_i \operatorname{cov}[\tilde{e}, \tilde{v}|\tilde{s}]q \qquad [9b]$$

$$d_o(\tilde{s}, \tilde{p}) = \beta_o(E[\tilde{v}|\tilde{s}] - \tilde{p}) \qquad [9c]$$

where $\Lambda = g_i + \beta_o$, $g_i = 1/[(\rho_i + \rho_o)(1 - R_{sv})\sigma_v^2]$, $\beta_o = 1/[\rho_o(1 - R_{sv})\sigma_v^2]$, $E[\tilde{v}|\tilde{s}] = \bar{v} + R_{se}(\tilde{s} - \bar{s})$, *and* $\operatorname{cov}[\tilde{e}, \tilde{v}|\tilde{s}] = \sigma_{ev} - \sigma_{es}\sigma_{vs}/\sigma_s^2 = (1 - R_{se})\sigma_e^2$.

The insider's ex ante expected utility is given by

$$E\left[-\exp\left\{-\rho_i \tilde{w}_i\right\}\right] = -|SG|\exp\left\{-\rho_i\left[q\bar{e} - C(q) - (\rho_i/2)q^2\left(\sigma_e^2 - D\right)\right]\right\} \quad [10a]$$

where $|SG| = \left\{1 + \frac{\rho_i\rho_o^2(1-R_{sv})\sigma_v^2\sigma_u^2}{\rho_i + 2\rho_o}\right\}^{-1/2}$ *and* $D = \frac{\rho_i|SG|^2\left\{\text{cov}\left[\tilde{e},\tilde{v}|\tilde{s}\right]\right\}^2}{(\rho_i + 2\rho_o)(1-R_{sv})\sigma_v^2}$.

The outsider's ex ante expected utility is given by

$$E\left[U_o\left(\tilde{W}_o\right)\right] = -|SG_o|\exp\left\{-\frac{HS_i^2}{2\left(\sigma_u^2 + \Lambda^2\,\text{var}\left[\tilde{v}|\tilde{s}\right]\right)}\right\} \quad [10b]$$

where $|SG_o| = \left\{1 + \frac{\sigma_u^2}{\Lambda^2\,\text{var}\left[\tilde{v}|\tilde{s}\right]}\right\}^{-1/2}$.

Finally, the level of real investment chosen by the entrepreneur is given by [8] *with the above value of D.*

Proof: See the appendix.

Remarks: The price equals the expected liquidation value conditional on the fundamentals-information shared by the insider and the outsider plus a term that measures the price risk due to the presence of noise traders minus the risk premium.

The outsider's optimal demand for the risky asset becomes $d_o(p) = \frac{E\left[\tilde{v}|\tilde{s}\right] - p}{\rho_o\,\text{var}\left[\tilde{v}|\tilde{s}\right]}$, since he knows $\tilde{s}$. As a consequence, the relation between d_i and the asset price becomes $p = E\left[\tilde{v}|\tilde{s}\right] + \rho_o\,\text{var}\left[\tilde{v}|\tilde{s}\right](\tilde{u} + d_i)$, so that $\lambda = \partial p/\partial d_i = \rho_o\,\text{var}\left[\tilde{v}|\tilde{s}\right]$.

The outsider does not face adverse selection since the entrepreneur does not have any informational advantage. As a consequence, he is more willing to provide liquidity, which directly implies that the price impact of the entrepreneur's demand will tend to be lower. Moreover, the riskiness of the asset, from the outsider's point of view, is now lower since he has more information (s). Both effects tend to increase the outsider's trading intensity and, consequently, the depth of the market. Finally, the outsider's expected utility conditional on his information set is given by

$$E\left[U_o\left(\tilde{W}_o\right)|\tilde{s},\tilde{p}\right] = -\exp\left\{-\rho_o\left(\frac{\rho_o}{2}\text{var}\left[\tilde{v}|\tilde{s}\right]\right)\left[d_o(\tilde{s},\tilde{p})\right]^2\right\}$$

Since there is no informational asymmetry between the insider and the outsider, the entrepreneur's speculative demand and the expected production return (conditional on the entrepreneur's information) are uncorrelated. Analytically, price deviations from $E\left[\tilde{v}|\tilde{s}\right]$ are due to noise trading and the risk premium. Since the risk premium is non random and noise trading is not related with fundamentals risks ($\tilde{e}$, $\tilde{v}$), speculating in the asset market does not provide any insurance to the entrepreneur. That is $\text{cov}\{d_i(\tilde{s},\tilde{p}), E[\tilde{e}|\tilde{s}]\} = 0$. Nevertheless, still the entrepreneur can achieve some insurance by selling the asset. Direct insurance coming from the net supply HS_i is partly reduced by speculative position, which has a positive expected value.

The allocations of risk at the equilibrium is given by $d_i(\tilde{u}) = -\xi_i\tilde{u} - \xi_o HS_i$ and $d_o(\tilde{u}) = -\xi_o\tilde{u} + \xi_o HS_i$, where ξ_o and ξ_i are the marginal market shares of the quantity traded by noise traders going to the outsider and the insider respectively. In equilibrium, $\xi_o = \frac{(\rho_i + \rho_o)}{(\rho_i + 2\rho_o)} \in [.5,1]$ and, obviously, $\xi_i = 1 - \xi_o$.

I now derive the equilibrium of the model when the insider abstain to collect any private information $\tilde{s}$ before trading in the asset market. In this case, the rational expectations equilibrium may be directly derived from proposition 3.1. That is, the model with the entrepreneur abstaining to obtain any inside information is identical to the model of the previous section where $\tilde{s}\equiv 0$, or equivalently, $\sigma_{es} = \sigma_{vs} = R_{se} = R_{sv} = 0$. More specifically, the next corollary describes the unique linear rational expectations equilibrium of the model without fundamentals information.

Corollary 4.2. *If the entrepreneur abstains to trade on his inside information, then the unique linear imperfectly competitive rational expectations equilibrium in the asset market is characterized by*

$$\tilde{p} = \bar{v} + \Lambda^{-1}\{\tilde{u} - HS_i\} \qquad [11a]$$

$$d_i(\tilde{s},\tilde{p}) = g_i\{\bar{v} - \tilde{p}\} - HS_i \text{ where } HS_i = \rho_i g_i \,\text{cov}[\tilde{e},\tilde{v}]q \qquad [11b]$$

$$d_o(\tilde{p}) = \beta_o(\bar{v} - \tilde{p}) \qquad [11c]$$

where $\Lambda = g_i + \beta_o$, $g_i = 1/[(\rho_i + \rho_o)\sigma_v^2]$, $\beta_o = 1/(\rho_o\sigma_v^2)$.

The insider's ex ante expected utility is given by

$$E[-\exp\{-\rho_i\tilde{w}_i\}] = -|SG|\exp\{-\rho_i[q\bar{e} - C(q) - (\rho_i/2)q^2(\sigma_e^2 - D)]\} \qquad [12]$$

where $|SG| = \left\{1 + \frac{\rho_i\rho_o^2\sigma_v^2\sigma_u^2}{\rho_i + 2\rho_o}\right\}^{-1/2}$ *and* $D = \frac{\rho_i R_{ev}^2\sigma_v^2}{\rho_i + 2\rho_o + \rho_i\rho_o^2\sigma_v^2\sigma_u^2}$.

Finally, the level of real investment chosen by the entrepreneur is given by [8] *with the above value of D.*

Proof: To compute the equilibrium we have to proceed as in proposition 3.1 taking into account that $\sigma_{es} = \sigma_{vs} = R_{se} = R_{sv} = 0$.

###

Remarks: Now the entrepreneur's hedge supply tends to be higher since he has no fundamentals information, so that the unknown part of the correlation between e and v equals the prior correlation between them.

The next proposition analyzes the main effects of changes in the precision of fundamentals information in the symmetric-information model. Equivalently, it allows us to compare the equilibria described in the proposition 4.1 and the corollary 4.2.

Proposition 4.3. *Assume that the entrepreneur publicly discloses his inside information before trading takes place. If the precision of fundamentals information* R_{se} *increases (taken* R_{ve} *as given), then*

(i) both the insider and the outsider will trade more aggressively,

(ii) the risk premium will be lower and the average stock price will be higher,

(iii) the market will be deeper,

(iv) the stock price will be more informative and more volatile (for reasonable parameters values),

(v) the level of real investment will decrease, and

(vi) the insider's ex ante expected utility and the outsider's ex ante expected utility will decrease.

Proof: See the appendix.

This proposition collects the main effects of public information on real investment and on the efficiency of financial markets. All of these results are very intuitive. If the precision of fundamentals information, which is publicly observable, increases, both the insider and the outsider trade more aggressively because the ex-post volatility of the risky asset is lower; that is, buying the risky asset becomes less risky. As a direct consequence, the stock price will be more informative, since traders react more to their fundamentals information, and more volatile, for the price is more sensitive to changes in that fundamentals information. Moreover, the market depth is higher, since it is proportional to the traders' aggregate price sensibility.

In this setting, the risk premium is decreasing in the precision of public information because this kind of information makes the market deeper and also makes the outsider, who represents a continuum of uninformed traders, more willing to share the risk created by real investment. This directly implies that the expected stock price will be higher.

Concerning the level of real investment, there are two effects working in opposite directions. On the one hand, there are more risk-sharing opportunities since the adverse selection problem faced by the outsider is eliminated when fundamentals information becomes public. But, on the other hand, public information reduces the risk-sharing opportunities provided by financial markets since it reduces the unknown part of the correlation between the production return and the asset return. The latter effect dominates the former so that real investment is decreasing in the precision of public information. Moreover, as the public information becomes more precise, the ex-post volatility of the production return goes down and, therefore, the entrepreneur hedges a lower amount of the initial risk due to real investment. As a consequence, at the ex-ante stage, it is optimal to reduce the level of production (since this production will not be hedged ex-post).

If the precision of s increases, the entrepreneur's hedge supply decreases, dHS_i/dR_{se}, and, as a consequence, his expected net asset position goes down as well, $dE[d_i]/dR_{se}$. On one hand, the entrepreneur's hedge supply per unit of real investment decreases because the correlation between the asset return and the production return conditional on s goes down as the precision of s increases, $d(HS_i/q)/dR_{se}$. On the other hand, the optimal level of real investment is also decreasing in R_{se}. Both effects tend to diminish the entrepreneur's hedge supply.

5. Effects of insider trading

Throughout this section superscripts "IT", "S", and "A" will refer to the equilibrium with insider trading, the equilibrium with symmetric information (where the entrepreneur publicly reveals his private information before trading on it), and the equilibrium of the model without fundamentals information (where the entrepreneur abstains to collect inside information) respectively.

Insider trading versus no fundamentals-information

In this subsection I compare the rational expectations equilibrium when insider trading is permitted with the equilibrium in a similar market in which the entrepreneur does have any fundamentals-information. That is, I compares the equilibrium described in proposition 3.1

with the equilibrium described in corollary 4.2. The main results are collected in the next proposition.

Proposition 5.1: *(i) The outsider's trading intensity will be lower with insider trading,* $\beta_o^{IT} < \beta_o^A$. *Analytically,* $\frac{d\beta_o}{dR_{sv}} < 0$, $\frac{d\beta_o}{dR_{se}} \leq 0$, *and* $\frac{d\beta_o}{dR_{ve}} \leq 0$.

(ii) The insider's trading intensity will be higher when insider trading is permitted, $\alpha_i^{IT} > \alpha_i^A$. *In fact, Analytically,* $\frac{d\alpha_i}{dR_{sv}} > 0$ *and* $\frac{d\alpha_i}{dR_{se}} > 0$.

(iii) For reasonable parameter values, market depth is reduced by insider trading, $\Lambda^{IT} < \Lambda^A$. *In particular, if* ρ_i *is not too high, then* $\frac{d\Lambda}{dR_{sv}}$ *<0,* $\frac{d\Lambda}{dR_{ve}}$ *<0, and* $\frac{d\Lambda}{dR_{se}}$ *<0 for all* $\rho_o, \sigma_v^2, \sigma_u^2$, *and for all* R_{ve}, R_{se}, *and* R_{sv} *strictly greater than zero.*

(iv) Price precision is increased by insider trading, $\tau^{IT} > \tau^A$. *Analytically,* $d\tau/dR_{sv}$, $d\tau/dR_{se}$, *and* $d\tau/dR_{ve}$ *are strictly greater than zero for all* R_{ve}, R_{se}, *and* R_{sv} *strictly greater than zero.*

(v) The marginal market share of the quantity traded by noise traders going to the entrepreneur (outsider) is higher (lower) when insider trading is permitted, $\xi_i^{IT} > \xi_i^A$ *(*$\xi_o^{IT} < \xi_o^A$*). Analytically,* $d\xi_i/dR_{sv}$, $d\xi_i/dR_{se}$, *and* $d\xi_i/dR_{ve}$ *are strictly greater than zero for all* R_{ve}, R_{se}, *and* R_{sv} *strictly greater than zero.*

(vi) For reasonable parameter values, current prices will be more volatile with insider trading, $\mathrm{var}[\tilde{p}^{IT}] > \mathrm{var}[\tilde{p}^A]$. *In particular, if* ρ_i *is not too high, then* $d\,\mathrm{var}[\tilde{p}]/dR_{sv}$ *>0,* $d\,\mathrm{var}[\tilde{p}]/dR_{se}$ *>0, and* $d\,\mathrm{var}[\tilde{p}]/dR_{ve}$ *>0 for all* $\rho_o, \sigma_v^2, \sigma_u^2$, *and for all* R_{ve}, R_{se}, *and* R_{sv} *strictly greater than zero.*

(vii) For reasonable parameter values, real investment is reduced by insider trading, $q^{IT} < q^A$. *Moreover,* dq/dR_{se} *and* dq/dR_{sv} *are strictly lower than zero for all* R_{ve} *sufficiently close to zero, for all* R_{se} *sufficiently close to one, and/or for all* R_{se} *sufficiently close to zero.*

(viii) For reasonable parameter values, the average stock price will be higher with insider trading, $\bar{p}^{IT} > \bar{p}^A$. *Moreover, this results holds for all parameter values if inside information is sufficiently precise or* R_{ve} *is sufficiently close to zero.*

(ix) If insider trading is permitted, the insider's speculative gains will be higher while his insurance gains will be lower, $|SG_i^{IT}| < |SG_i^A|$ *and* $\exp\{-.5\rho_i(\bar{e}-c_1)q^{IT}\} > \exp\{-.5\rho_i(\bar{e}-c_1)q^A\}$.

(x) If inside information is sufficiently precise, the outsider's ex ante expected utility will be reduced by insider trading, $E[U_o]^{IT} < E[U_o]^A$.

Proof: See the appendix.

Let me point out some intuitions and remarks.

1. When insider trading is permitted, the insider trades more aggressively. Two reasons explains this result. On the one hand, the expected return from the insider's point of view is increasing in the precision of insider information. And, on the other hand, he feels a lower risk because he has more information.

2. The outsider trades less aggressively with insider trading, because he faces adverse selection. Since the entrepreneur trades more aggressively, the order flow received by the outsider is more likely to reflect the inside information and, as a result, the outsider should become less willing to trade. Moreover, as a direct consequence of this fact, the marginal impact of the entrepreneur's asset position on current price will be higher when insider trading is permitted.

3. For reasonable parameter values, market depth is reduced by insider trading. The market depth when the asset demands of the outsider and the entrepreneur are very sensitive to current price. When insider trading is permitted, the outsider is less willing to trade, that is,.become less sensitive to changes in current price. Moreover, the entrepreneur reduces the weight put on current price because he include his inside information to estimate the asset return. Equivalently, since the price impact of his asset position is higher, he will tend to reduce his trades. Both effects tends to makes the market thinner.

4. Price precision is increased by insider trading. This follows immediately from the fact that the informativeness of current price is increasing in the amount of trading motivated by fundamentals-information, impact, price precision is increasing in the precision of inside information.

5. For reasonable parameter values, current prices will to more volatile with insider trading. Price volatility is caused by noise trading and by fundamentals-information (if there is any). When insider trading is permitted, there is price volatility caused by fundamentals-

information and, moreover, price volatility clue to noise trading increases for the market is thinner.

6. The marginal market share of the quantity traded by noise traders going to the entrepreneur (outsider) is higher (lower) when insider trading is permitted. Liquidity trading is absorbed by the entrepreneur and the outsider, being their market shares proportional to their respective price sensibilities. In the presence of insider trading, the entrepreneur increases his market share and the outsider reduces his due to the fact that the former increases his informational advantage over the latter (equivalently, the latter faces a more severe adverse-selection problem).

7. Permitting insider trading reduces the level of real investment since it reduces the risk-sharing opportunities provided by the asset market. This is caused by two reasons: inside information reduces the unknown part of the correlation between the production return and the asset return and, moreover, it creates an adverse selection problem which makes the outsider less willing to share the risk coming from real production.

8. The average stock price is increased by insider trading. Two effects explain this result. The insider's hedge supply is lower since the level of real investment is lower. Furthermore, the insider's speculative demand is higher since it is increasing in the precision of inside information.

Insider trading versus public fundamentals-information

Finally, I now compares the rational expectations equilibrium when insider trading is permitted with the equilibrium when the entrepreneur publicly announces his fundamentals-information before trading takes place. That is, I compares the equilibria described in propositions 3.1 and 4.1. The main results are presented in the next proposition.

Proposition 5.2: *(i) Both the insider and the outsider will trade more aggressively when fundamentals-information is public,* $\alpha_i^{IT} < \alpha_i^S$ *and* $\beta_o^{IT} < \beta_o^S$.

(ii) The asset market will be thinner whit insider trading, $\Lambda^{IT} < \Lambda^S$.

(iii) Price precision is reduced by insider trading, $\tau^{IT} < \tau^S$.

(iv) The marginal market share of the quantity traded by noise traders going to the entrepreneur (outsider) will be lower (higher) when fundamentals-information is public, $\xi_i^{IT} > \xi_i^S$ *and* $\xi_o^{IT} < \xi_o^S$.

(v) If R_{ve} is sufficiently low or R_{ve} and R_{se} are sufficiently high, real investment is increased by insider trading, $q^S < q^{IT}$. On the contrary, for reasonable parameter values, real investment is reduced by insider trading, $q^S > q^{IT}$, if R_{ve} is sufficiently high and R_{se} is sufficiently low.

(vi) If R_{ve} is sufficiently low or R_{ve} and R_{se} are sufficiently high, the entrepreneur's ex ante expected utility is increased by insider trading, $E[U_i]^{IT} > E[U_i]^S$. On the contrary, for reasonable parameter values, the entrepreneur's ex ante expected utility is reduced by insider trading, $E[U_i]^{IT} < E[U_i]^S$, if R_{ve} is sufficiently high and R_{se} is sufficiently low.

(vii) If inside information is sufficiently precise, the outsider's ex ante expected utility will be increased by insider trading, $E[U_o]^{IT} > E[U_o]^S$. On the contrary, for reasonable parameter values, the outsider's ex ante expected utility will be reduced by insider trading if inside information is not too precise, $E[U_o]^{IT} < E[U_o]^S$.

Proof: See the appendix.

Remarks:

1. If inside information becomes public, the informational asymmetry and the adverse selection problem disappear. This clearly makes the outsider more willing to trade. As a direct consequence, the insider´s residual supply is less sensitive to the his demand and, therefore, the insider also trades more aggressively.

2. Market depth is equal to the traders' price sensibility. From the above result, it is obvious that it will be higher if inside information becomes public.

3. Due to the same reason the asset price is more informative if the inside information is made public since more traders are reacting more to fundamentals information.

4. The marginal market share of the quantity traded by noise traders going to the outsider is higher when fundamentals-information is public for he is more willing to trade. This directly implies that the entrepreneur's marginal market share of the quantity traded by noise traders is lower.

5. The effect of making public the inside information on real investment depends upon the trade-off between the following effects. If inside information is made public, there are more risk-sharing opportunities since the adverse selection problem faced by the outsider is

eliminated (therefore, the outsider is more willing to share the risk due to real investment). On the other hand, since the informational asymmetry between the insider and the outsider disappears, the entrepreneur's speculative demand and the expected production return (conditional on the entrepreneur's information) are uncorrelated and, therefore, the risk-sharing opportunities provided by financial markets are reduced[8]. If R_{ve} is sufficiently high and R_{se} is sufficiently low, real investment is reduced by insider trading since the latter effect dominates the former. Otherwise, the opposite result holds.

Conclusions

In this paper I have analyzed the interaction between insider trading and the insurance role of financial markets. As a result, I have characterized the economic impacts of insier trading and the most common insider trading regulations.

The main results I have obtained can be summarized as follows. The entrepreneur's nsurance gains comes from two sources: he achieves insurance by selling the asset and, oreover, he achieves insurance by *speculating* on inside information (since the production return and the entrepreneur's speculative demand are correlated). The entrepreneur's hedge supply is directly proportional to the unknown part of the correlation between the production return and the asset return so that fundamentals information received after choosing the level of real investment reduces the ex-post hedging quality of the asset market. Furthermore, insider trading decreases risk-sharing opportunities by creating an adverse selection problem.

When I compare the rational expectations equilibrium when insider trading is permitted with the equilibrium in a similar market in which the entrepreneur does have any fundamentals-information, I find that permitting insider trading decreases the level of real investment since it reduces the ex-post hedging quality of the asset market and creates an adverse selection problem which makes the outsider less willing to share the risk coming from real production.

On the other hand, if we compare the equilibrium when insider trading is permitted with the equilibrium when the insider publicly reveals his inside information, then the effect of insider trading on real investment depends upon the trade-off between the following effects. If inside information is made public, there are more risk-sharing opportunities since

[8] See the remarks after proposition 3.1.

the adverse selection problem faced by the outsider is eliminated. But, on the other hand, since the informational asymmetry disappears, the entrepreneur's speculative demand and the expected production return are uncorrelated, which reduces the risk-sharing opportunities provided by financial markets.

Appendix

Lemma 1. Let us assume that $\tilde{x} \sim \mathrm{N}(\bar{x}, \sigma_x^2)$ and $\tilde{y} \sim \mathrm{N}(\bar{y}, \sigma_y^2)$. Then

$$E\left[\exp\{\tilde{x} - \tilde{y}^2\}\right] = \frac{1}{\sqrt{1+2\sigma_y^2}} \exp\left\{\bar{x} + \frac{1}{2}\sigma_x^2 - \frac{\left[\bar{y} + \mathrm{cov}(\tilde{x}, \tilde{y})\right]^2}{1+2\sigma_y^2}\right\}. \qquad [A.1]$$

Proof: see Demange and Laroque (1995).

Proof of proposition 3.1: Let us assume that the outsider uses the general linear strategy $d_o(p) = \varphi_o - \beta_o p$. Then, the insider's optimal linear strategy is given by [4] provided that the second order condition holds $2\lambda + \rho_i \,\mathrm{var}[\tilde{v}|\tilde{s}] > 0$, where $\lambda = 1/\beta_o$.

From the market clearing condition [1] and the linear strategies $d_o(p) = \varphi_o - \beta_o p$ and [4], the price function is given by

$$\tilde{p} = (g_i + \beta_o)^{-1}\left\{\varphi_o - \rho_i g_i \,\mathrm{cov}[\tilde{e}, \tilde{v}|\tilde{s}]q + \tilde{u} + g_i E[\tilde{v}|\tilde{s}]\right\} \qquad [A.2]$$

where $g_i = 1/\left[\rho_i(1 - R_{sv})\sigma_v^2 + \lambda\right]$. Since $E[\tilde{v}|\tilde{s}] = \bar{v} + R_{se}(\tilde{s} - \bar{s})$ and cov[e,v|s] is non-random, the price is informationally equivalent to $\tilde{u} + g_i R_{se}(\tilde{s} - \bar{s})$. Given this price function, by applying standard normal theory, we obtain

$$E[\tilde{v}|\tilde{p}] = \bar{v} + \frac{\alpha_i \sigma_{sv}(g_i + \beta_o)}{\alpha_i^2 \sigma_s^2 + \sigma_u^2}(\tilde{p} - \bar{p}) \quad \text{and} \quad \mathrm{var}[\tilde{v} - \tilde{p}|\tilde{p}] = \sigma_v^2 - \frac{(\alpha_i \sigma_{sv})^2}{\alpha_i^2 \sigma_s^2 + \sigma_u^2}$$

where $\alpha_i = g_i R_{se}$. Substituting these expressions into [3] leads to the outsider's optimal strategy. By equating this optimal strategy with the general linear function initially conjectured, we find that

$$\varphi_o = \frac{\left[\alpha_i^2\sigma_s^2 + \sigma_u^2\right]\bar{v} - \alpha_i\sigma_{sv}(g_i + \beta_o)\bar{p}}{\rho_o\left\{\sigma_v^2\left[\alpha_i^2\sigma_s^2 + \sigma_u^2\right] - (\alpha_i\sigma_{sv})^2\right\}} \quad \text{and} \quad \beta_o = \frac{\alpha_i^2\sigma_s^2 + \sigma_u^2 - \alpha_i\sigma_{sv}(g_i + \beta_o)}{\rho_o\left\{\sigma_v^2\left[\alpha_i^2\sigma_s^2 + \sigma_u^2\right] - (\alpha_i\sigma_{sv})^2\right\}} \qquad [A.3]$$

Substituting $\alpha_i = g_i R_{se}$, $\sigma_s^2 = \sigma_e^2/R_{se}$, $\sigma_{sv} = \sigma_e^2$, $g_i = 1/\left[\rho_i(1 - R_{sv})\sigma_v^2 + \lambda\right]$, and $\beta_o = 1/\lambda$ into the last equation leads to the equation in λ

$$\lambda = \rho_o\sigma_v^2 + \frac{R_{sv}\sigma_v^2}{\sigma_u^2}\frac{\left[(\rho_i + \rho_o)(1 - R_{sv})\sigma_v^2 + \lambda\right]}{\left[\rho_i(1 - R_{sv})\sigma_v^2 + \lambda\right]^2} \qquad [A.4]$$

A rational expectations equilibrium in the asset market is characterized by

$$\tilde{p} = \bar{v} - (\delta/\Lambda)HS_i + \Lambda^{-1}\{\tilde{u} + g_i R_{sv}(\tilde{s} - \bar{s})\} \quad \text{[A.5a]}$$

$$d_i(\tilde{s}, \tilde{p}) = g_i\{E[\tilde{v}|\tilde{s}] - \tilde{p}\} - HS_i \text{ where } HS_i = \rho_i g_i \operatorname{cov}[\tilde{e}, \tilde{v}|\tilde{s}]q \quad \text{[A.5b]}$$

$$d_o(\tilde{p}) = \beta_o(\bar{v} - \tilde{p}) + (1 - \delta)(R_{se}/R_{sv})HS_i \quad \text{[A.5c]}$$

where $\Lambda = g_i + \beta_o$, $g_i = 1/[\rho_i(1 - R_{sv})\sigma_v^2 + \lambda]$, $\beta_o = 1/\lambda$, $\delta = 1 - R_{sv}(\sigma_v^2/\sigma_u^2)g_i\beta_o$, $E[\tilde{v}|\tilde{s}] = \bar{v} + R_{se}(\tilde{s} - \bar{s})$, $\operatorname{cov}[\tilde{e}, \tilde{v}|\tilde{s}] = \sigma_{ev} - \sigma_{es}\sigma_{vs}/\sigma_s^2 = (1 - R_{se})\sigma_e^2$. All of the above endogenous parameters may be written as monotone functions depending only on λ, so that there is one equilibrium for each value of λ satisfying [A.4] and the second order condition $2\lambda + \rho_i \operatorname{var}[\tilde{v}|\tilde{s}] > 0$, where $\operatorname{var}[\tilde{v}|\tilde{s}] = (1 - R_{sv})\sigma_v^2$. That is, there is one equilibrium for each fixed point of the function $f(\lambda) = \rho_o\sigma_v^2 + \dfrac{R_{sv}\sigma_v^2}{\sigma_u^2}\dfrac{[(\rho_i + \rho_o)(1 - R_{sv})\sigma_v^2 + \lambda]}{[\rho_i(1 - R_{sv})\sigma_v^2 + \lambda]^2}$ that satisfies the above second order condition. It is easy to show that there is no equilibrium for λ lower than zero. A necessary condition for $f(\lambda)$ lower than zero is $\lambda < -(\rho_i + \rho_o)(1 - R_{sv})\sigma_v^2$. But then the second order condition is not satisfied, since
$2\lambda + \rho_i(1 - R_{sv})\sigma_v^2 < (-\rho_i - 2\rho_o)(1 - R_{sv})\sigma_v^2 < 0$. On the other hand, $\forall\lambda > 0$,
$f(\lambda) \in \left[\rho_o\sigma_v^2, \rho_o\sigma_v^2 + \dfrac{(\rho_i + \rho_o)R_{sv}}{\rho_i^2(1 - R_{sv})\sigma_v^2}\right]$ and $f(\lambda)$ is strictly decreasing. Thus, there is only one strictly positive fixed point, which obviously satisfies $2\lambda + \rho_i \operatorname{var}[\tilde{v}|\tilde{s}] > 0$. This fixed point characterizes the unique rational expectations equilibrium.

Conditional on (s,p), the entrepreneur's expected utility is equal to
$E[U_i(\tilde{w}_i)|\tilde{s}, \tilde{p}] = -\exp\left\{-\rho_i\left(E[\tilde{w}_i|\tilde{s}, \tilde{p}] - \dfrac{\rho_i}{2}\operatorname{var}[\tilde{w}_i|\tilde{s}, \tilde{p}]\right)\right\}$ where
$E[\tilde{w}_i|\tilde{s}, \tilde{p}] = qE[\tilde{e}|\tilde{s}] - C(q) + d_i(\tilde{s}, \tilde{p})\{E[\tilde{v}|\tilde{s}] - \tilde{p}\}$ and
$\operatorname{var}[\tilde{w}_i|\tilde{s}, \tilde{p}] = q^2 \operatorname{var}[\tilde{e}|\tilde{s}] + \operatorname{var}[\tilde{v}|\tilde{s}]\{d_i(\tilde{s}, \tilde{p})\}^2 + 2qd_i(\tilde{s}, \tilde{p})\operatorname{cov}[\tilde{e}, \tilde{v}|\tilde{s}]$. Substituting into the above expression and simplifying yield

$$E[U_i(\tilde{w}_i)|\tilde{s}, \tilde{p}] = -\exp\left\{-\rho_i\left[-C(q) - \frac{\rho_i}{2}q^2 \operatorname{var}[\tilde{e}|\tilde{s}]\right]\right\}\exp\left\{-\rho_i qE[\tilde{e}|\tilde{s}] - \frac{\rho_i}{2}\left(\frac{1}{g_i} + \frac{1}{\beta_o}\right)[d_i(\tilde{s}, \tilde{p})]^2\right\}$$

where the first exponential is non-random.

To obtain the entrepreneur's ex ante (unconditional) expected utility it suffices to apply [A.1] by taking $\tilde{x} = -\rho_i qE[\tilde{e}|\tilde{s}]$ and $\tilde{y} = \left[\dfrac{\rho_i}{2}\left(\dfrac{1}{g_i} + \dfrac{1}{\beta_o}\right)\right]^{1/2} d_i(\tilde{s}, \tilde{p})$. From standard normal theory, $E\{E[\tilde{e}|\tilde{s}]\} = \bar{e}$ and $\operatorname{var}\{E[\tilde{e}|\tilde{s}]\} = R_{se}\sigma_e^2$. On the other hand, from [A.5] we have

$E[d_i(\tilde{s},\tilde{p})] = -HS_i\left(1-\delta\frac{g_i}{g_i+\beta_o}\right)$, $\text{var}[d_i(\tilde{s},\tilde{p})] = \frac{g_i^2}{\Lambda^2}[\sigma_u^2 + \beta_o^2 R_{sv}\sigma_v^2]$, and

$\text{cov}\{E[\tilde{e}|\tilde{s}], d_i(\tilde{s},\tilde{p})\} = g_i\frac{\sigma_{es}\sigma_{vs}}{\sigma_s^2}\frac{\beta_o}{(g_i+\beta_o)}$. Now substituting these expressions into [A.1] and doing some tedious manipulations lead to the following expression for the entrepreneur's ex ante expected utility

$$E[-\exp\{-\rho_i\tilde{w}_i\}] = -|SG|\exp\{-\rho_i[q\bar{e} - C(q) - (\rho_i/2)q^2(\sigma_e^2 - D)]\} \qquad \text{[A.6]}$$

where $D = \frac{\rho_i}{\rho_i\sigma_v^2 + 2\lambda + \rho_i\lambda^2\sigma_u^2}\left\{\sigma_{ev} + g_i^2\frac{R_{sv}\sigma_v^2}{\sigma_u^2}\text{cov}[\tilde{e},\tilde{v}|\tilde{s}]\right\}^2$ and

$|SG| = \left\{1 + \frac{\rho_i(R_{sv}\sigma_v^2 + \lambda^2\sigma_u^2)}{\rho_i(1-R_{sv})\sigma_v^2 + 2\lambda}\right\}^{-1/2}$.

Similarly, the outsider's expected utility conditional in his information (p) is equal to $E[U_o(\tilde{w}_o)|\tilde{p}] = -\exp\left\{-\rho_o\left(E[\tilde{w}_o|\tilde{p}] - \frac{\rho_o}{2}\text{var}[\tilde{w}_o|\tilde{p}]\right)\right\}$ where $E[\tilde{w}_o|\tilde{p}] = d_o(\tilde{p})\{E[\tilde{v}|\tilde{p}] - \tilde{p}\}$ and $\text{var}[\tilde{w}_o|\tilde{p}] = d_o^2(\tilde{p})\text{var}[\tilde{v}|\tilde{p}]$. Substituting into the above expression and simplifying yields

$$E[U_o(\tilde{w}_o)|\tilde{p}] = -\exp\{-(\rho_o^2/2)\text{var}[\tilde{v}|\tilde{p}][d_o(\tilde{p})]^2\}.$$

To obtain the entrepreneur's ex ante (unconditional) expected utility it suffices to apply [A.1] by taking $\tilde{x} \equiv 0$ and $\tilde{y} = \rho_o\{\text{var}[\tilde{v}|\tilde{p}]/2\}^{1/2} d_o(\tilde{p})$. From the market clearing condition, it is clear that $E[d_o(\tilde{p})] = -E[d_i(\tilde{s},\tilde{p})] = HS_i(1-\delta g_i/\Lambda)$. On the other hand, from [A.5a], $\text{var}[d_o(\tilde{p})] = \beta_o^2\,\text{var}[\tilde{p}] = (\beta_o^2/\Lambda^2)[\sigma_u^2 + R_{se}g_i^2\sigma_e^2]$. Finally, substituting $\alpha_i = g_iR_{se}$ into $\text{var}[\tilde{v} - \tilde{p}|\tilde{p}] = \sigma_v^2 - \frac{(\alpha_i\sigma_{sv})^2}{\alpha_i^2\sigma_s^2 + \sigma_u^2}$ and doing some simplifications, we get $\text{var}[\tilde{v}|\tilde{p}] = \sigma_v^2\left[\frac{\sigma_u^2 + R_{sv}g_i^2(1-R_{sv})\sigma_v^2}{\sigma_u^2 + R_{sv}g_i^2(1-R_{sv})\sigma_v^2}\right]$. Now substituting these expressions into [A.1] and doing some tedious manipulations lead to the following expression for the outsider's ex ante expected utility $E[-\exp\{-\rho_o\tilde{w}_o\}] = -|SG_o|\exp\{-(\rho_o^2/2)\text{var}[\tilde{v}|\tilde{p}]|SG_o|^2 HS_i^2(1-\delta g_i/\Lambda)^2\}$,

where $|SG_o| = \left\{1 + \frac{\text{var}[E(\tilde{v}|\tilde{p}) - \tilde{p}]}{\text{var}[\tilde{v}|\tilde{p}]}\right\}^{-1/2} = \{1 + \rho_o^2(\beta_o/\Lambda)^2\sigma_v^2[\sigma_u^2 + R_{sv}(1-R_{sv})g_i^2\sigma_v^2]\}^{-1/2}$.

At the first stage, the entrepreneur chooses the level of real investment to maximize his ex ante expected utility. Since $|SG|$ does not depend on q, it is obvious that the optimal level of real investment is given by

$$q = \frac{\bar{e} - c_1}{c_2 + \rho_i(\sigma_e^2 - D)} \qquad [A.7]$$

####

Proof of Proposition 4.1. If the insider publicly reveals his private information before trading on the asset market, the outsider will know $\tilde{s}$ so that the his objective function conditional on his information set $\{\tilde{s},p\}$ may be written as $E[-\exp\{-\rho_o \tilde{w}_o\}|\tilde{p}] = -\exp\left\{-\rho_o\left(E[\tilde{w}_o|\tilde{s},\tilde{p}] - \frac{\rho_o}{2}\text{var}[\tilde{w}_o|\tilde{s},\tilde{p}]\right)\right\}$. Since $E[\tilde{w}_o|\tilde{s},\tilde{p}] = d_o(E[\tilde{v}|\tilde{s}] - \tilde{p})$ and $\text{var}[\tilde{w}_o|\tilde{s},\tilde{p}] = d_o^2 \text{var}[\tilde{v}|\tilde{s}]$, maximizing with respect to d_o yields the demand function for the risky asset [9c], that is,

$$d_o(\tilde{s},\tilde{p}) = \frac{E[\tilde{v}|\tilde{s}] - \tilde{p}}{\rho_o \text{var}[\tilde{v}|\tilde{s}]}. \qquad [A.8]$$

As a consequence, the relation between the insider's asset position and its price becomes $\tilde{p} = E[\tilde{v}|\tilde{s}] + \rho_o \text{var}[\tilde{v}|\tilde{s}](\tilde{u} + d_i)$ so that $\lambda = \rho_o \text{var}[\tilde{v}|\tilde{s}]$. Given this value of λ, the insider's optimal demand schedule [9b] is directly derived from [4]. Moreover, it obviously satisfies the second order condition $2\lambda + \rho_i \text{var}[\tilde{v}|\tilde{s}] > 0$, since λ is greater than zero.

From the market clearing condition and the optimal strategies of the insider and the outsider, the equilibrium price [9a] is obtained.

To obtain the entrepreneur's ex ante expected utility one proceeds as in proposition 3.1 taking into account that now the asset market equilibrium is characterized by [9a], [9b], and [9c]. In particular, the bias $E[\tilde{v}|\tilde{s}] - \tilde{p}$ does not depend on fundamentals information (s,v), which implies that $\text{cov}\{E[\tilde{e}|\tilde{s}], d_i(\tilde{s},\tilde{p})\} = 0$. On the other hand, $E[d_i(\tilde{s},\tilde{p})] = -HS_i(1 - g_i/\Lambda)$ and $\text{var}[d_i(\tilde{s},\tilde{p})] = \frac{g_i^2}{\Lambda^2}[\sigma_u^2 + \beta_o^2 R_{sv}\sigma_v^2]$. After some manipulations, expression [10] is achieved. Finally, the optimal level of real investment is (obviously) given by [A.7] (or [8]), where $D = \frac{\{\rho_i/[(1-R_{sv})\sigma_v^2]\}\{\text{cov}[\tilde{e},\tilde{v}|\tilde{s}]\}^2}{[\rho_i + 2\rho_o + \rho_i\rho_o^2(1-R_{sv})\sigma_v^2\sigma_u^2]}$ (see the proof of proposition 3.1).

Similarly, the outsider's expected utility conditional on (s,p) is equal to $E[U_o(\tilde{w}_o)|\tilde{s},\tilde{p}] = -\exp\left\{-\rho_o\left(E[\tilde{w}_o|\tilde{s},\tilde{p}] - \frac{\rho_o}{2}\text{var}[\tilde{w}_o|\tilde{s},\tilde{p}]\right)\right\}$ where $E[\tilde{w}_o|\tilde{s},\tilde{p}] = d_o(\tilde{s},\tilde{p})\{E[\tilde{v}|\tilde{s}] - \tilde{p}\}$ and $\text{var}[\tilde{w}_o|\tilde{s},\tilde{p}] = \text{var}[\tilde{v}|\tilde{s}]\{d_o(\tilde{s},\tilde{p})\}^2$. Substituting into the above expression and simplifying yield

$$E\left[U_o\left(\tilde{W}_o\right)|\tilde{s},\tilde{p}\right] = -\exp\left\{-\rho_o\left(\frac{\rho_o}{2}\text{var}[\tilde{v}|\tilde{s}]\right)\left[d_o(\tilde{s},\tilde{p})\right]^2\right\}.$$

To obtain the outsider's ex ante (unconditional) expected utility it suffices to apply [A.1] by taking $\tilde{x} \equiv 0$ and $\tilde{y} = \left\{\rho_o^2 \text{var}[\tilde{v}|\tilde{s}]/2\right\}^{1/2} d_o(\tilde{s},\tilde{p})$. From standard normal theory, $E[\tilde{y}] = \left\{\rho_o^2 \text{var}[\tilde{v}|\tilde{s}]/2\right\}^{1/2} E[d_o(\tilde{s},\tilde{p})]$ and $\text{var}[\tilde{y}] = \left\{\rho_o^2 \text{var}[\tilde{v}|\tilde{s}]/2\right\} \text{var}[d_o(\tilde{s},\tilde{p})]$. By substituting the equilibrium price into [A.8], the outsider's demand for the risky asset may be written as $d_o(\tilde{u}) = \frac{(\rho_i+\rho_o)}{(\rho_i+2\rho_o)}(HS_i - \tilde{u})$, so that $E[d_o] = \frac{(\rho_i+\rho_o)}{(\rho_i+2\rho_o)}HS_i$ and $\text{var}[d_o] = \frac{(\rho_i+\rho_o)^2}{(\rho_i+2\rho_o)^2}\sigma_u^2$. Now substituting these expressions into [A.1] and doing some tedious manipulations lead to the following expression for the outsider's ex ante expected utility $E[U_o(\tilde{w}_o)] = -|SG_o|\exp\left\{-\frac{1}{2}\frac{\rho_o^2(\rho_i+\rho_o)^2(1-R_{sv})\sigma_v^2 HS_i^2}{(\rho_i+2\rho_o)^2+\rho_o^2(\rho_i+\rho_o)^2(1-R_{sv})\sigma_v^2\sigma_u^2}\right\}$ where $|SG_o| = \left\{1+\frac{\rho_o^2(\rho_i+\rho_o)^2(1-R_{sv})\sigma_v^2\sigma_u^2}{(\rho_i+2\rho_o)^2}\right\}^{-1/2}$. It can be easily proved that these expressions are equivalent to [10b].

####

Proof of Proposition 4.3.: (i) From the proposition 4.1., the trading intensities of the insider and the outsider are given by $\alpha_i = R_{se}/\left[(\rho_i+\rho_o)(1-R_{sv})\sigma_v^2\right]$ and $\beta_o = 1/\left[\rho_o(1-R_{sv})\sigma_v^2\right]$. Taken R_{ve} as given, $\frac{df(R_{se},R_{sv})}{dR_{se}} = \frac{\partial f}{\partial R_{se}} + R_{ve}\frac{\partial f}{\partial R_{sv}}$ for all $f(R_{se},R_{sv})$. Therefore, it is obvious that $d\alpha_i/dR_{se} > 0$ and $d\beta_o/dR_{se} > 0$.

(ii) The risk premium may be written as $RP = \frac{\rho_i\rho_o}{(\rho_i+2\rho_o)}q(1-R_{se})\sigma_e^2$. Since $dq/dR_{se} \le 0$ (see part (v) of this proof), it is directly derived that $dRP/dR_{se} \le 0$.

The average stock price is given by $\bar{p} = \bar{v} - RP$, so that $d\bar{p}/dR_{se} = -dRP/dR_{se} \ge 0$.

(iii) From the proposition 4.1., the market depth may be written as $\Lambda = (\rho_i+2\rho_o)/\left[(\rho_i+\rho_o)\rho_o(1-R_{sv})\sigma_v^2\right]$, which is clearly increasing in R_{se}.

(iv) The price precision is defined as the inverse of the variance of the liquidation value given the information contained in the price, $\tau = \frac{1}{\text{var}[\tilde{v}|p]}$. It is an index of the informativeness of the price about the liquidation value. From the proposition 4.1., it is given by $\tau = \left\{\sigma_v^2 - \frac{R_{se}^2\sigma_e^4}{R_{se}\sigma_e^2 + \sigma_u^2/\Lambda^2}\right\}^{-1}$. After some manipulations, it can be written as

$\tau = \tau_v + R_{ve}\tau_v\tau_u\left\{\tau_u\left(\frac{1}{R_{se}} - R_{ve}\right) + \frac{\tau_e}{R_{se}^2\Lambda^2}\right\}^{-1}$. Since $d\Lambda/dR_{se} \geq 0$ (see part (iv) of this proof), it is obvious that the price precision is increasing in R_{se}.

The volatility of the stock price is given by $\text{var}[\tilde{p}] = R_{se}\sigma_e^2 + \sigma_u^2/\Lambda^2$, where $\Lambda = (\rho_i + 2\rho_o)/[(\rho_i + \rho_o)\rho_o(1 - R_{sv})\sigma_v^2]$. Direct computations lead to

$\frac{d\,\text{var}[\tilde{p}]}{dR_{se}} = \sigma_e^2\left[1 - 2\frac{(\rho_i + \rho_o)^2\rho_o^2}{(\rho_i + 2\rho_o)^2}\frac{(1 - R_{sv})}{R_{ve}}\sigma_e^2\sigma_u^2\right]$. This expression is greater than zero unless $\sigma_e^2\sigma_u^2$ is extremely large[9]. For the parameters taken as "base case" by Leland[10] (1992) (σ_e^2=.04, σ_u^2=.01, $\rho_i = \rho_o = 2$), the volatility of the stock price is increasing in R_{se}.

(v) The level of real investment is given by [8], where D may be written as

$D = \frac{\rho_i(1 - R_{se})^2\sigma_e^4}{[\rho_i + 2\rho_o + \rho_i\rho_o^2(1 - R_{sv})\sigma_v^2\sigma_u^2](1 - R_{sv})\sigma_v^2}$. Therefore,

$$\frac{dD}{dR_{se}} = \frac{\rho_i(1 - R_{se})\sigma_e^4}{[\rho_i + 2\rho_o + \rho_i\rho_o^2(1 - R_{sv})\sigma_v^2\sigma_u^2]\sigma_v^2}\frac{d}{dR_{se}}\left\{\frac{(1 - R_{se})}{(1 - R_{sv})}\right\} +$$
$$+ \frac{\rho_i(1 - R_{se})\sigma_e^4}{(1 - R_{sv})\sigma_v^2}\frac{d}{dR_{se}}\left\{\frac{(1 - R_{se})}{\rho_i + 2\rho_o + \rho_i\rho_o^2(1 - R_{sv})\sigma_v^2\sigma_u^2}\right\}$$

Since $R_{sv} = R_{se}R_{ve}$, it is obvious that

$$\frac{d}{dR_{se}}\left\{\frac{(1 - R_{se})}{(1 - R_{sv})}\right\} = \frac{-1 + R_{sv} + (1 - R_{se})R_{ve}}{(1 - R_{sv})^2} = \frac{-1 + R_{ve}}{(1 - R_{sv})^2} \leq 0 \text{ and}$$

$$\frac{d}{dR_{se}}\left\{\frac{(1 - R_{se})}{\rho_i + 2\rho_o + \rho_i\rho_o^2(1 - R_{sv})\sigma_v^2\sigma_u^2}\right\} = \frac{-\rho_i - 2\rho_o - (1 - R_{ve})\rho_i\rho_o^2\sigma_v^2\sigma_u^2}{[\rho_i + 2\rho_o + \rho_i\rho_o^2(1 - R_{sv})\sigma_v^2\sigma_u^2]^2} \leq 0,$$

so that $\frac{dD}{dR_{se}} \leq 0$. Finally, $\frac{dq}{dR_{se}} = \frac{\rho_i q}{[c_2 + \rho_i(\sigma_e^2 - D)]}\frac{dD}{dR_{se}} \leq 0$.

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[9] For instance, if the coefficients of risk aversion are equal to 2, the volatility of the stock price is decreasing in R_{se} if and only if σ_e^2 and σ_u^2 are close (or higher than) 1; that is, if the annual standard deviations of the stok price and the liquidity supply are above (or higher than) 100%.

[10] See Leland (1992) page 876. Leland suggests that these values reflect average market data.

(vi) The outsider's ex ante expected utility may be written as (see the proof of the proposition 4.1) $E[U_o(\tilde{w}_o)] = -|SG_o|\exp\left\{-\frac{HS_i^2}{2}\left[\sigma_u^2 + \frac{(\rho_i+2\rho_o)^2}{\rho_o^2(\rho_i+\rho_o)^2(1-R_{sv})\sigma_v^2}\right]^{-1}\right\}$ where $|SG_o| = \left\{1+\frac{\rho_o^2(\rho_i+\rho_o)^2(1-R_{sv})\sigma_v^2\sigma_u^2}{(\rho_i+2\rho_o)^2}\right\}^{-1/2}$ and $HS_i = \frac{\rho_i q(1-R_{se})\sigma_e^2}{(\rho_i+\rho_o)(1-R_{sv})\sigma_v^2}$. Therefore,

$$\frac{dE[U_o(\tilde{w}_o)]}{dR_{se}} = -\exp\{\circ\}\frac{d|SG_o|}{dR_{se}} - |SG_o|\frac{d\exp\{\circ\}}{dR_{se}}.$$

If R_{se} increases, then HS_i and $\left[\sigma_u^2 + \frac{(\rho_i+2\rho_o)^2}{\rho_o^2(\rho_i+\rho_o)^2(1-R_{sv})\sigma_v^2}\right]^{-1}$ decrease, which implies that the exponential term of $E[U_o(\tilde{w}_o)]$ is increasing in R_{se}; that is, $\frac{d\exp\{\circ\}}{dR_{se}}$. On the other hand, it is clear that $\frac{d|SG_o|}{dR_{se}}$. Thus, $\frac{dE[U_o(\tilde{w}_o)]}{dR_{se}} < 0$.

By substituting the optimal level of real investment into [10a], the insider's ex ante expected utility may be written as $E[-\exp\{-\rho_i\tilde{w}_i\}] = -|SG_i|\exp\{-.5\rho_i(\bar{e}-c_1)q\}$ where $|SG_i| = \left\{1+\frac{\rho_i\rho_o^2(1-R_{sv})\sigma_v^2\sigma_u^2}{\rho_i+2\rho_o}\right\}^{-1/2}$. From the above expression,

$$\frac{dE[U_i(\tilde{w}_i)]}{dR_{se}} = -\exp\{\circ\}\frac{d|SG_i|}{dR_{se}} - |SG_i|\frac{d\exp\{\circ\}}{dR_{se}}$$

It can be directly derived that $\frac{d|SG_i|}{dR_{se}}$ is greater than zero. On the other hand, $signo\left(\frac{d\exp\{\circ\}}{dR_{se}}\right) = -signo\left(\frac{dq}{dR_{se}}\right) \geq 0$ since $\frac{dq}{dR_{se}} \leq 0$. Thus, $\frac{dE[U_i(\tilde{w}_i)]}{dR_{se}} < 0$.

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Proof of proposition 5.1: (i) Let us prove that λ is increasing in R_{sv}. The equilibrium value of λ is implicitly defined by $\lambda - f(\lambda, R_{sv}) = 0$ where $f(\lambda, R_{sv}) = \rho_o\sigma_v^2 + \frac{R_{sv}\sigma_v^2}{\sigma_u^2}\frac{[(\rho_i+\rho_o)(1-R_{sv})\sigma_v^2+\lambda]}{[\rho_i(1-R_{sv})\sigma_v^2+\lambda]^2}$. By applying the implicit function theorem, $\frac{d\lambda}{dR_{sv}} = -\left(-\frac{\partial f}{\partial R_{sv}}\right)\Big/\left(1-\frac{\partial f}{\partial\lambda}\right)$. It directly follows that $\frac{\partial f}{\partial\lambda} < 0$ and $\frac{\partial f}{\partial R_{sv}} > 0$, since $\rho_o(1-2R_{sv})\sigma_v^2 + \lambda \geq -\rho_i\sigma_v^2 + \lambda > 0$ where the last inequality is directly derived from [6].

Thus, $\frac{d\lambda}{dR_{sv}} > 0$. It is now clear that $\frac{d\beta_o}{dR_{sv}} < 0$ since, by definition, $\beta_o = 1/\lambda$. Moreover, $\frac{d\beta_o}{dR_{se}} = R_{ve}\frac{d\beta_o}{dR_{sv}}$ and $\frac{d\beta_o}{dR_{ve}} = R_{se}\frac{d\beta_o}{dR_{sv}}$ for $R_{sv} = R_{se}R_{ve}$. Therefore, $\frac{d\beta_o}{dR_{se}} \leq 0$ and $\frac{d\beta_o}{dR_{ve}} \leq 0$.

There is insider trading when the entrepreneur has and trades on some fundamentals-information, that is, when R_{sv}>0. Therefore, it is clear that $\beta_o^{IT} < \beta_o^{A}$ since $\beta_o^{IT} = 1/\lambda^{IT} < 1/(\rho_o\sigma_v^2) = \beta_o^A$ for all R_{sv}>0.

(ii) From [A.3], the outsider's trading intensity may be written as $\beta_o = \frac{\sigma_u^2/\sigma_v^2}{\rho_o[\alpha_i^2\sigma_v^2(1-R_{sv})R_{ve}^2/R_{sv} + \sigma_u^2] + R_{ve}\alpha_i}$, since $\alpha_i^2\sigma_s^2 = \alpha_i\sigma_{sv}g_i$. Given this expression, $\frac{d\beta_o}{dR_{sv}} = \frac{\partial\beta_o}{\partial R_{sv}} + \frac{\partial\beta_o}{\partial\alpha}\frac{d\alpha_i}{dR_{sv}}$, where it is obvious that $\frac{\partial\beta_o}{\partial\alpha} < 0$ and $\frac{\partial\beta_o}{\partial R_{sv}} > 0$. Moreover, we have previously proved that $\frac{d\beta_o}{dR_{sv}} < 0$, so that $\frac{d\alpha_i}{dR_{sv}} > 0$ for all R_{sv}>0. Similarly, $\frac{d\alpha_i}{dR_{se}} > 0$ for all R_{ve}>0. Finally, α_i^A is just the limit of α_i^{IT} as R_{sv} goes to zero. Therefore, it is clear that $\alpha_i^{IT} > \alpha_i^A$ for α_i^{IT} is decreasing in R_{sv}.

(iii) From the proposition 3.1, $\frac{dg_i}{dR_{sv}} = -g_i^2\left[-\rho_i\sigma_v^2 + \frac{d\lambda}{dR_{sv}}\right]$ where

$$\frac{d\lambda}{dR_{sv}} = \frac{\sigma_v^2\{\rho_i(\rho_i+\rho_o)(1-R_{sv})\sigma_v^4 + \lambda[\rho_i(2-R_{sv})\sigma_v^2 + \rho_o(1-2R_{sv})\sigma_v^2 + \lambda]\}}{\sigma_u^2[\rho_i(1-R_{sv})\sigma_v^2+\lambda]^3 + R_{sv}\sigma_v^2[(\rho_i+2\rho_o)(1-R_{sv})\sigma_v^2+\lambda]}$$

$$\frac{d\lambda}{dR_{sv}} = \frac{(\lambda-\rho_o\sigma_v^2)}{R_{sv}} \times \frac{\{\rho_i(\rho_i+\rho_o)(1-R_{sv})\sigma_v^4 + \lambda[\rho_i(2-R_{sv})\sigma_v^2 + \rho_o(1-2R_{sv})\sigma_v^2 + \lambda]\}}{\{[\rho_i(\rho_i+\rho_o)(1-R_{sv}) - \rho_o(\rho_i+2\rho_o)]\rho_i(\rho_i+\rho_o)(1-R_{sv})\sigma_v^4 + \lambda[3\rho_i(1-R_{sv})\sigma_v^2 + \rho_o(2-3R_{sv})\sigma_v^2 + 2\lambda]\}}$$

Given this last expression, it is obvious that λ is strictly increasing in R_{sv} (for all R_{sv}>0) and that the elasticity of λ with respect to R_{sv} is lower than 1. For reasonable parameter values (see Leland[1992]), $(d\lambda/dR_{sv})$ is of the same order of magnitude as (λ/R_{sv}) and dg_i/dR_{sv} is lower than zero. For instance, if $\rho_o = 2, \sigma_v^2 = .04, \sigma_u^2 = .01$ and $R_{ve} = 1$, dg_i/dR_{sv} is lower than zero if and only if the insider's coefficient of risk aversion is lower than 45. Analogously, dg_i/dR_{se} is lower than zero for reasonable parameter values. Moreover, if ρ_i is sufficiently close to zero (that is, if ρ_i is not too high), then it is clear that dg_i/dR_{sv} <0.

Market depth is equal to $g_i + \beta_o$. We have previously proved that $d\beta_o/dR_{sv}$ is lower than zero for all parameter values and dg_i/dR_{sv} is lower than zero for reasonable parameter values, so that $d\Lambda/dR_{sv}$ is lower than zero for reasonable parameter values as well. For the same reasons, $d\Lambda/dR_{se}$ and $d\Lambda/dR_{ve}$ are lower than zero for reasonable parameter values. As a direct consequence, $\Lambda^{IT} < \Lambda^{A}$ for Λ^{A} is just the limit of Λ^{IT} as R_{sv} goes to zero.

(iv) In the proof of the proposition 3.1 it has been shown that price precision is given by $\tau = \dfrac{1}{\text{var}[\tilde{v}|\tilde{p}]} = \left[\sigma_v^2 - \dfrac{(\alpha_i\sigma_{sv})^2}{\alpha_i^2\sigma_s^2 + \sigma_u^2}\right]^{-1}$. Since $\sigma_{sv} = \sigma_e^2 = R_{ve}\sigma_v^2$ and $\sigma_s^2 = R_{ve}\sigma_v^2/R_{se}$, price precision may be written as $\tau = \dfrac{1}{\sigma_v^2}\left[\dfrac{R_{sv}\sigma_u^2 + \alpha_i^2 R_{ve}^2\sigma_v^2}{R_{sv}\sigma_u^2 + \alpha_i^2 R_{ve}^2(1-R_{sv})\sigma_v^2}\right]$. Taking into account that $d\alpha_i/dR_{sv}$ is greater than zero, it is clear that $d\tau/dR_{sv}$ is greater than zero as well. Similarly, $d\tau/dR_{se}$ and $d\tau/dR_{ve}$ are greater than zero. Finally, it directly follows that $\tau^{IT} > \tau^{A}$ for τ^{A} is just the limit of τ^{IT} as R_{sv} goes to zero.

(v) The insider's marginal market share is given by $\xi_i = \dfrac{g_i}{g_i + \beta_o}$. By substituting $\beta_o = 1/\lambda$ and $g_i = 1/\left[\rho_i(1-R_{sv})\sigma_v^2 + \lambda\right]$, it can be written as $\xi_i = \left\{2 + \rho_i(1-R_{sv})\sigma_v^2/\lambda\right\}^{-1}$, which is clearly increasing in R_{sv} since $d\lambda/dR_{sv}$>0. Similarly, $d\xi_i/dR_{se}$ and $d\xi_i/dR_{ve}$ are greater than zero. For ξ_i^A is the limit of ξ_i^{IT} as R_{sv} goes to zero, it follows that $\xi_i^{IT} > \xi_i^A$ and, as a direct consequence, $\xi_o^{IT} < \xi_o^A$ since $\xi_i + \xi_o = 1$.

(vi) From [A.5a], price volatility is given by $\text{var}[\tilde{p}] = \dfrac{\sigma_u^2}{\Lambda^2} + R_{sv}(g_i/\Lambda)^2\sigma_v^2$. It has been proved that, if R_{sv} increases, then $\xi_i = g_i/\Lambda$ goes up. Therefore, $d\,\text{var}[\tilde{p}]/dR_{sv}$ will be greater than zero if the conditions that makes Λ decreasing in R_{sv} holds. That is, if the parameters of the model take reasonable values or if ρ_i is sufficiently close to zero, $d\,\text{var}[\tilde{p}]/dR_{sv}$, $d\,\text{var}[\tilde{p}]/dR_{se}$, and $d\,\text{var}[\tilde{p}]/dR_{ve}$ will be greater than zero. Finally, it is clear that $\text{var}[\tilde{p}^{IT}] > \text{var}[\tilde{p}^{A}]$ for $\text{var}[\tilde{p}^{A}]$ is the limit of $\text{var}[\tilde{p}^{IT}]$ as R_{sv} goes to zero.

(vii) The optimal level of real investment is given by [8] where

$$D^A = \frac{\rho_i}{\left[\rho_i\sigma_v^2 + 2\lambda^A + \rho_i(\lambda^A)^2\sigma_u^2\right]}\{\sigma_{ev}\}^2 \text{ and}$$

$$D^{IT} = \frac{\rho_i}{\left[\rho_i\sigma_v^2 + 2\lambda^{IT} + \rho_i(\lambda^{IT})^2\sigma_u^2\right]}\left\{\sigma_{ev} + \frac{R_{sv}\sigma_v^2}{\sigma_u^2}g_i^2(1-R_{se})\sigma_e^2\right\}^2.$$

Since $\lambda^{IT} > \lambda^{A}$, it is clear that $D^{IT} < D^{A}$ if R_{se}=1. By continuity, the same result holds for R_{se} sufficiently close to one. Since the optimal level of real investment is strictly increasing in *D*, we can directly derived that $q^{IT} < q^{A}$ for all R_{se} sufficiently close to one.

Analytically, $\frac{dq}{dR_{se}} = \frac{\rho_i q}{c_2 + \rho_i(\sigma_e^2 - D)} \frac{dD^{IT}}{dR_{se}}$ where, after some tedious manipulations,

$$\frac{dD^{IT}}{dR_{se}} = \frac{2\rho_i\sigma_e^4\left[1 + (1 - R_{se})(\lambda - \rho_o\sigma_v^2)/\{(\rho_i + \rho_o)(1 - R_{sv})\sigma_v^2 + \lambda\}\right]}{\left[\rho_i\sigma_v^2 + 2\lambda + \rho_i\lambda^2\sigma_u^2\right]^2\left[(\rho_i + \rho_o)(1 - R_{sv})\sigma_v^2 + \lambda\right]^2} \times$$

$$\{-\left[\rho_i\sigma_v^2 + 2\lambda + \rho_i\lambda^2\sigma_u^2\right](\lambda - \rho_o\sigma_v^2)\left[(\rho_i + \rho_o)(1 - R_{sv})\sigma_v^2 + \lambda\right]$$
$$+\left[\rho_i\sigma_v^2 + 2\lambda + \rho_i\lambda^2\sigma_u^2\right](1 - R_{se})R_{ve}\left[(\rho_i + \rho_o)(1 - R_{sv})\sigma_v^2 + \rho_o\sigma_v^2\right](d\lambda/dR_{se})$$
$$-(1 + \rho_i\lambda\sigma_u^2)R_{ve}(d\lambda/dR_{se})(\lambda - \rho_o\sigma_v^2)(1 - R_{se})$$
$$-(1 + \rho_i\lambda\sigma_u^2)R_{ve}(d\lambda/dR_{se})\left[(\rho_i + \rho_o)(1 - R_{sv})\sigma_v^2 + \lambda\right]\}$$

If R_{ve}=0 and/or R_{se}=1, dD^{IT}/dR_{se}<0 for all R_{ve}>0. By continuity, the same result holds for all R_{ve} sufficiently close to zero and/or for all R_{se} sufficiently close to one.

Moreover, if R_{se}=0, then

$$\frac{dD^{IT}}{dR_{se}} = \frac{2\rho_i\sigma_e^4 R_{ve}(\rho_i + 2\rho_o)\sigma_v^2(d\lambda/dR_{se})}{\left[(\rho_i + 2\rho_o)\sigma_v^2 + \rho_i(\rho_o\sigma_v^2)^2\sigma_u^2\right]^2\left[(\rho_i + 2\rho_o)\sigma_v^2\right]^2} \times$$
$$\{(\rho_i + 2\rho_o)\sigma_v^2 - 1 + \rho_i\rho_o\sigma_v^2\sigma_u^2(\rho_o\sigma_v^2 - 1)\}$$

which is lower than zero if $(\rho_i + 2\rho_o)\sigma_v^2 < 1$. For reasonable parameter values this condition is satisfied. By continuity, the same result holds for all R_{se} sufficiently close to zero. Thus, we can state that dq/dR_{se}<0 and dq/dR_{sv}<0 for all R_{ve} sufficiently close to zero, for all R_{se} sufficiently close to one, and/or for all R_{se} sufficiently close to zero.

Finally, for reasonable parameter values ($\rho_o = 2, \rho_i = 2, \sigma_e^2 = .04, \sigma_u^2 = .01$), dq/dR_{se} is lower than zero for all R_{se}.

(viii) From [5], the average stock price is given by $\bar{p} = \bar{v} - (\delta/\Lambda)HS_i$ where $(\delta/\Lambda)HS_i$ represents the risk premium. If the entrepreneur does not have any private information, the risk premium may be written as $RP^A = \rho_i q^A \xi_i^A \sigma_e^2$. On the other hand, if insider trading is allowed, it may be written as $RP^{IT} = \rho_i \delta^{IT} q^{IT} \xi_i^{IT}(1 - R_{se})\sigma_e^2$ where δ^{IT}<1, $q^{IT} < q^A$, and $\xi_i^{IT} > \xi_i^A$. If R_{se}=1, then $RP^{IT} = 0 < RP^A$ and, as a direct consequence, $\bar{p}^{IT} > \bar{p}^A$. By continuity, these results also hold for R_{se} sufficiently close to one.

On the other hand, after some manipulations, it can be proved that

$$\frac{d\left[(1 - R_{se})\xi_i^{IT}\right]}{dR_{se}} = -(\xi_i^{IT})^2\left\{2 + \frac{\rho_i\sigma_v^2}{\lambda}\left[1 - R_{se} - R_{ve}(1 - R_{se})(1 - R_{sv})\frac{1}{\lambda}\frac{d\lambda}{dR_{se}}\right]\right\}.$$

If R_{se}=1, R_{sv}=1, and/or R_{ve}=0, the above expression is strictly lower than zero, which implies that $(1-R_{se})\xi_i^{IT} < \xi_i^A$. By continuity, this inequality holds for R_{se} and/or R_{sv} sufficiently high, and/or for R_{ve} sufficiently low. Since δ^{IT}<1 and $q^{IT} < q^A$, it is clear that $RP^{IT} < RP^A$ and $\bar{p}^{IT} > \bar{p}^A$ if any of these conditions is satisfied. Finally, for reasonable parameter values, the risk premium is lower, and the average stock price higher, when insider trading is permitted.

(ix) The insider's ex ante expected utility may be written as

$E[-\exp\{-\rho_i\tilde{w}_i\}] = -|SG_i|\exp\{-.5\rho_i(\bar{e}-c_1)q\}$ where $|SG| = \left\{1+\dfrac{\rho_i(R_{sv}\sigma_v^2+\lambda^2\sigma_u^2)}{\rho_i(1-R_{sv})\sigma_v^2+2\lambda}\right\}^{-½}$.

From this last expression, $\dfrac{d|SG_i|}{dR_{sv}} = \dfrac{\partial|SG_i|}{\partial R_{sv}} + \dfrac{\partial|SG_i|}{\partial\lambda}\dfrac{d\lambda}{dR_{sv}}$. It can be directly proved that $\dfrac{\partial|SG_i|}{\partial R_{sv}} < 0$, $\dfrac{\partial|SG_i|}{\partial\lambda} < 0$ and $\dfrac{d\lambda}{dR_{sv}} > 0$ [see (iii)], so that $\dfrac{d|SG_i|}{dR_{sv}} < 0$. As a direct consequence, $|SG_i|^{IT} < |SG_i|^A$. On the other hand, the exponential term is higher when insider trading is permitted, since $q^{IT} < q^A$. That is, $\exp\{-.5\rho_i(\bar{e}-c_1)q^{IT}\} > \exp\{-.5\rho_i(\bar{e}-c_1)q^A\}$.

Thus, when insider trading is permitted, the exponential term is higher while the term $|SG_i|$ is lower.

(x) The outsider's ex ante expected utility is given by

$$E[-\exp\{-\rho_o\tilde{w}_o\}] = -|SG_o|\exp\{-(\rho_o^2/2)\operatorname{var}[\tilde{v}|\tilde{p}]|SG_o|^2 HS_i^2(1-\delta g_i/\Lambda)^2\}$$

where $|SG_o| = \{1+\rho_o^2\xi_o^2\sigma_v^2[\sigma_u^2+R_{sv}(1-R_{sv})g_i^2\sigma_v^2]\}^{-1/2}$. If the entrepreneur does not have any private information, his speculative gains may be written as $|SG_o|^A = \{1+\rho_o^2(\xi_o^A)^2\sigma_v^2\sigma_u^2\}^{-1/2}$ where $\xi_o^{IT} < \xi_o^A$ (as seen above).

If R_{sv}=1, then $|SG_o|^{IT} = \{1+\rho_o^2(\xi_o^{IT})^2\sigma_v^2\sigma_u^2\}^{-1/2} > |SG_o|^A$, since $\xi_o^{IT} < \xi_o^A$, and the exponential term is higher when insider trading is permitted, $\exp\{\circ\}^{IT} = 1 > \exp\{\circ\}^A$. By continuity, these inequalities hold for R_{sv} sufficiently close to one. Thus, we can state that $E[U_o]^{IT} < E[U_o]^A$ for all R_{sv} sufficiently high, since utilities are negative.

Moreover, it can be easily proved that $d|SG_o|^{IT}/dR_{se}$ is strictly greater than zero for R_{se} close to one while it may be lower than zero for R_{se} close to zero (in fact, this happens for reasonable parameter values if R_{ve} is not too low). On the other hand, for reasonable parameter values, the exponential term is strictly increasing in R_{se} for all R_{ve}>0.

Proof of proposition 5.2: (i) From [A.4], it is clear that $\lambda^{IT} > \rho_o \sigma_v^2$ for all R_{sv}>0. Moreover, $\lambda^S = \rho_o(1 - R_{sv})\sigma_v^2$ (see the proof of the corollary 4.2), so that for all R_{sv}>0 $\lambda^S < \rho_o \sigma_v^2 < \lambda^{IT}$. As a direct consequence, $\beta_o^{IT} < \beta_o^A < \beta_o^S$ for all R_{sv}>0, since $\beta_o = 1/\lambda$. On the other hand, the insider's trading intensity may be written as $\alpha_i = R_{se}/[\rho_i(1 - R_{sv})\sigma_v^2 + \lambda]$. Since $\lambda^S < \rho_o \sigma_v^2 < \lambda^{IT}$, it is clear that $\alpha_i^{IT} < \alpha_i^S$.Finally, if R_{sv}=0, then $\lambda^{IT} = \lambda^A = \lambda^S = \rho_o \sigma_v^2$ and $\alpha_i^{IT} = \alpha_i^A = \alpha_i^S$.

(ii) Market depth is given by $\Lambda = g_i + \beta_o$. Since $g_i = 1/[\rho_i(1 - R_{sv})\sigma_v^2 + \lambda]$ and $\lambda^S < \lambda^{IT}$, it is clear that $g_i^{IT} < g_i^S$. Therefore, $\Lambda^{IT} < \Lambda^S$ for it has been proved that $\beta_o^{IT} < \beta_o^S$.

(iii) From [5], the asset price is informationally equivalent to $\tilde{u} + g_i^{IT} R_{se}(\tilde{s} - \bar{s})$ when insider trading is permitted, so that the volatility of the asset return conditional on the price may be evaluated as $\operatorname{var}[\tilde{v}|\tilde{p}^{IT}] = \sigma_v^2 - \dfrac{R_{se}^2 (g_i^{IT})^2 \sigma_e^4}{R_{se}^2 (g_i^{IT})^2 \sigma_s^2 + \sigma_u^2}$. Taking into account that $\sigma_e^2 = R_{ve}\sigma_v^2$, $\sigma_s^2 = \sigma_e^2 / R_{se}$, and $R_{sv} = R_{se}R_{ve}$, price precision may be written as

$$\tau^{IT} = \frac{1}{\operatorname{var}[\tilde{v}|\tilde{p}^{IT}]} = \tau_v + \frac{R_{sv}^2}{R_{sv}(1 - R_{sv})\sigma_v^2 + \sigma_u^2/(g_i^{IT})^2}.$$

Analogously, when the entrepreneur discloses his inside information, the asset price is informationally equivalent to $\tilde{u} + R_{se}\Lambda^S(\tilde{s} - \bar{s})$ (see [9a]). By repeating the same operations, price precision is now given by $\tau^S = \tau_v + \dfrac{R_{sv}^2}{R_{sv}(1 - R_{sv})\sigma_v^2 + \sigma_u^2/(\Lambda^S)^2}$.

Since $g_i^{IT} < g_i^S$ (see part [ii] of this proof), it is obvious that $g_i^{IT} < g_i^S + \beta_o^S = \Lambda^S$ and, as a direct consequence, $\tau^S > \tau^{IT}$ for all R_{sv}>0.

(iv) The insider's marginal market share can be written as $\xi_i = \{2 + \rho_i(1 - R_{sv})\sigma_v^2/\lambda\}^{-1}$ (see the proof of proposition 5.1). Since $\lambda^S < \lambda^{IT}$, $\xi_i^{IT} > \xi_i^S$ and $\xi_o^{IT} < \xi_o^S$ for $\xi_i + \xi_o = 1$.

(v) The optimal level of real investment is given by [8], so that $q^S < (>) q^{IT}$ if and only if $D^S < (>) D^{IT}$. When insider trading is permitted, D may be written as $D^{IT} = \dfrac{\rho_i(|SG_i^{IT}|)^2}{\rho_i(1 - R_{sv})\sigma_v^2 + 2\lambda^{IT}} \left\{ R_{se}\sigma_e^2 + \left[1 + \dfrac{R_{sv}\sigma_v^2}{\sigma_u^2}(g_i^{IT})^2 \right] \operatorname{cov}[\tilde{e}, \tilde{v}|\tilde{s}] \right\}^2$, and, when the entrepreneur discloses his inside information, it is given by $D^S = \dfrac{\rho_i(|SG_i^S|)^2}{\rho_i(1 - R_{sv})\sigma_v^2 + 2\lambda^S} \{\operatorname{cov}[\tilde{e}, \tilde{v}|\tilde{s}]\}^2$. We have previously proved that $\dfrac{d|SG_i^{IT}|}{dR_{se}}$<0 and

$\frac{d|SG_i^S|}{dR_{se}}$>0 (see propositions 5.1 and 4.3 respectively), so that it is obvious that $|SG_i^{IT}| < |SG_i^S|$ for all R_{se}>0. Since $\lambda^{IT} > \lambda^S$, we can conclude that the first term of D is lower in the equilibrium with insider trading, that is, $\frac{\rho_i(|SG_i^{IT}|)^2}{\rho_i(1-R_{sv})\sigma_v^2 + 2\lambda^{IT}} < \frac{\rho_i(|SG_i^S|)^2}{\rho_i(1-R_{sv})\sigma_v^2 + 2\lambda^S}$. On the contrary, the second term is obviously greater when insider trading is allowed.

If R_{ve}=0 or R_{ve}= R_{se}=1, then $\text{cov}[\tilde{e},\tilde{v}|\tilde{s}]$=0 and, therefore, $D^S = 0 < D^{IT}$. By continuity, the same result holds if R_{ve} is sufficiently low or if R_{ve} and R_{se} are sufficiently high.

On the other hand, for reasonable parameter values, D^{IT} is lower than D^S provided that R_{ve} is sufficiently high and R_{se} is sufficiently low. In particular, if R_{se} is close to zero, then $R_{se}\sigma_e^2$ is close to zero and $1 + R_{sv}(g_i^{IT})^2 \sigma_v^2/\sigma_u^2$ is close to one, so that $\left\{R_{se}\sigma_e^2 + \left[1 + \frac{R_{sv}\sigma_v^2}{\sigma_u^2}(g_i^{IT})^2\right]\text{cov}[\tilde{e},\tilde{v}|\tilde{s}]\right\} \cong \text{cov}[\tilde{e},\tilde{v}|\tilde{s}]$ and $\frac{\rho_i(|SG_i^{IT}|)^2}{\rho_i(1-R_{sv})\sigma_v^2 + 2\lambda^{IT}} < \frac{\rho_i(|SG_i^S|)^2}{\rho_i(1-R_{sv})\sigma_v^2 + 2\lambda^S}$, which implies that $q^S > q^{IT}$. For instance, if $\rho_i = \rho_o = 2, \sigma_u^2 = .01, \sigma_e^2 = .04$, and $R_{ve} = .99$, then $q^S > q^{IT}$ for all R_{se} lower than or equal to 0.90. Notice that, given a high value of R_{ve}, q^{IT} may be greater than q^S for all R_{se} only if some parameter takes unreasonable values. For instance, if $\rho_i = \rho_o = 2, \sigma_e^2 = .04$, and $R_{ve} = .99$, then q^{IT} is greater than q^S for all R_{se} if and only if σ_u^2 is equal to or greater than 0.3, which is clearly unreasonable for it implies an annual standard deviation of liquidity demand equal to about 54.8% of total demand.

Thus, we can state that (i) if R_{ve} is sufficiently close to zero, $q^S < q^{IT}$ for all R_{se}>0, (ii) if R_{ve} is sufficiently close to one, $q^S < q^{IT}$ for all R_{se} sufficiently high, and (iii) for reasonable parameter values, if R_{ve} is sufficiently close to one and R_{se} is not too high, then $q^S > q^{IT}$.

(vi) The insider's ex ante expected utility may be written as the product of two terms, $E[-\exp\{-\rho_i\tilde{w}_i\}] = -|SG_i|\exp\{-.5\rho_i(\bar{e} - c_1)q\}$. It has been proved that $|SG_i^{IT}| < |SG_i^S|$, so that it is obvious that the insider's ex ante expected utility will be higher when insider trading is permitted whenever $q^S < q^{IT}$ for the exponential term is decreasing in q and utilities are negative. Therefore, if R_{ve} is sufficiently close to zero or if R_{ve} and R_{se} are sufficiently close to one, then the insider's ex ante expected utility will be higher when insider trading is permitted.

On the contrary, for reasonable parameter values, if R_{ve} is sufficiently close to one, then $|SG_i^{IT}| < |SG_i^S|$ and $\exp\{-.5\rho_i(\bar{e}-c_1)q^{IT}\} > \exp\{-.5\rho_i(\bar{e}-c_1)q^S\}$ whenever R_{se} is not too close to one. If R_{se} is low and ρ_i is not too close too zero, then the insider's ex ante expected utility will be lower when insider trading is permitted because the ratio $\exp\{-.5\rho_i(\bar{e}-c_1)q^{IT}\}/\exp\{-.5\rho_i(\bar{e}-c_1)q^S\}$ will be much greater than $|SG_i^S|/|SG_i^{IT}|$, since inside information is not very valuable while insurance gains are highly appreciated. For instance, if $\rho_i = \rho_o = 2, \sigma_u^2 = .01, \sigma_e^2 = .04$, and $R_{ve} = .99$, then the insider's ex ante expected utility will be lower when insider trading is permitted for all R_{se} lower than .90.

(vii) The outsider's ex ante expected utility is given by $E[U(\tilde{w}_o)] = -|SG_o||IG_o|$ where

$$|SG_o^{IT}| = \left\{1+\rho_o^2(\xi_o^{IT})^2\left[1+R_{sv}(1-R_{sv})(g_i^{IT})^2\sigma_v^2/\sigma_u^2\right]\sigma_v^2\sigma_u^2\right\}^{-1/2},$$

$$|SG_o^S| = \left\{1+\rho_o^2(\xi_o^S)^2[1-R_{sv}]\sigma_v^2\sigma_u^2\right\}^{-1/2},$$

$$|IG_o^S| = \exp\left\{-.5\rho_o^4\operatorname{var}[\tilde{v}|\tilde{s}]\left(|SG_o^S|\xi_o^S q^S g_i^S \operatorname{cov}[\tilde{e},\tilde{v}|\tilde{s}]\right)^2\right\}, \text{ and}$$

$$|IG_o^{IT}| = \exp\left\{-.5\rho_o^4\operatorname{var}[\tilde{v}|\tilde{p}]\left(|SG_o^{IT}|\xi_o^{IT}q^{IT}g_i^{IT}\left[1+R_{sv}(g_i^{IT})^2\sigma_v^2/\sigma_u^2\right]\operatorname{cov}[\tilde{e},\tilde{v}|\tilde{s}]\right)^2\right\}.$$

Let us compare $|SG_o^{IT}|$ with $|SG_o^S|$. It can be easily seen that, on the one hand, $|SG_o^{IT}|$ tends to be lower than $|SG_o^S|$ because $\left[1+R_{sv}(g_i^{IT})^2\sigma_v^2/\sigma_u^2\right]>1>1-R_{sv}$, while, on the other hand, $|SG_o^S|$ tends to be lower than $|SG_o^{IT}|$ because $\xi_o^S > \xi_o^{IT}$.

If R_{sv} equals one, then $|SG_o^S| = 1 > |SG_o^{IT}| = \{1+.25\rho_o^2\sigma_v^2\sigma_u^2\}^{-1/2}$. The same result holds if ρ_i equals zero, since then $\xi_o^S = \xi_o^{IT}$. By continuity, if R_{sv} is sufficiently close to one or if ρ_i is sufficiently close to zero, then $|SG_o^{IT}|$ is lower than $|SG_o^S|$. Moreover, for reasonable parameter values, $|SG_o^{IT}|<|SG_o^S|$ for all $R_{se}>0$.

Let us now compare $|IG_o^S|$ with $|IG_o^{IT}|$. It is clear that $|IG_o^S|$ equals $|IG_o^{IT}|$ if R_{se} is equal to zero or one. On the other hand, for reasonable parameter values, $|IG_o^S|$ is lower than $|IG_o^{IT}|$ for all $R_{se} \in (0,1)$.

Therefore, we find that, for reasonable parameter values, $|SG_o^{IT}|<|SG_o^S|$ and $|IG_o^S|\leq|IG_o^{IT}|$. Nevertheless, it is directly proved that $E[U_o]^{IT}$ is greater than $E[U_o]^S$ if R_{se} is sufficiently close to one or if ρ_i is sufficiently close to zero, for in both cases $|IG_o^S|$ is (almost) equal to $|IG_o^{IT}|$ while $|SG_o^{IT}|$ is lower than $|SG_o^S|$ (and utilities are negative) On the contrary, for reasonable parameter values, $E[U_o]^{IT}$ is lower than $E[U_o]^S$ if R_{se} is not too high, for $|SG_o^S|/|SG_o^{IT}|$ is lower than $|IG_o^{IT}|/|IG_o^S|$.

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