Insider Trading, Investment and Liquidity. A Welfare Analysis.

***The Journal of Finance**, Vol. 56(3), 2001, p.1141-1156*

DOI: http:// 10.1111/0022-1082.00359

Insider Trading, Investment, And Liquidity: A Welfare Analysis

SUDIPTO BHATTACHARYA and GIOVANNA NICODANO*

ABSTRACT

We compare equilibrium trading outcomes with and without participation by an informed insider, assuming inflexible *ex ante* aggregate investment choices by agents. Noise trading arises from aggregate uncertainty regarding other agents' intertemporal consumption preferences. The welfare levels of outsiders can thus be ascertained. The allocations without insider trading are not *ex ante* Pareto-efficient, since our model differs from standard ones with negative exponential utility functions and normal returns. We characterize the circumstances under which the revelation of payoff-relevant information via prices -- arising from insider trading -- benefits outsiders with stochastic liquidity needs, by improving risk-sharing among them.

In models of informed trading (Grossman and Stiglitz (1980), Allen (1984), Dennert (1992), Leland (1992), Repullo (1994)) it has been customary -- in order not to have an unrealistic *fully* revealing Rational Expectation Equilibrium (REE) and no profits for informed traders -- to postulate some portion of the market demand for securities as arising from unmodeled "noise traders", whose endowments and preferences for consumption are left unspecified. This makes it difficult to reach a *welfare judgement* regarding the impact of insider trading, even when the implications for the informativeness of asset prices and investment can be ascertained. Thus, an important issue in financial regulatory policy regarding the desirability of allowing trading by asymmetrically informed corporate insiders remains largely unresolved at the conceptual level.

Our major goal in this paper is to rectify this shortcoming by modeling both noise traders and rational (a priori) uninformed traders together, as agents with well-specified preferences. These agents allocate their endowments across a risky long-term and a riskless short-term investment *ex ante*, when their intertemporal consumption preferences are uncertain. A shock to their preferences[1] is then realized, inducing a subset of them (the "early-diers") to consume by selling their risky assets in the interim asset market, before the payoff to their long-term investment is realized. The *aggregate* proportion of agents wishing to consume early is also uncertain *ex ante*. Thus, our methodology "transplants" modeling techniques from the literature on banking (Bryant (1980), Diamond and Dybvig (1983)) to the arena of insider trading, as pioneered by Qi (1996).

Our second methodological contribution is to note that, with privately observed and not-separately-insured shocks to agents' preferences, markets are incomplete as in Hart (1975). Thus, interim traded outcomes with *ex ante* investment choices, made in a one-commodity (at each time-point) model, would in general be Pareto-inferior to what could be attained by a planner, even if she had no information on agents' realized liquidity shocks; see Bhattacharya and Gale (1987). Hence, to examine the *incremental* impact of insider trading on other agents' welfare, we consider a scenario in which interim traded outcomes are *ex ante* Pareto inefficient even without the insider, and then characterize the impact of her trading on the other agents' expected utilities. Our framework differs from the negative exponential utility functions and normal returns modeling of Grossman and Stiglitz (1980), Leland (1992), and Dow and Rahi (1996), who work with settings in which the interim traded outcomes are *ex-ante* Pareto efficient for the agents they model, in the absence of private information about asset returns.[2]

Recent work on insider trading (Leland (1992), Repullo (1994), as well as some related work by Allen (1984)), emphasizes that the greater interim informativeness of asset

prices brought about by informed trading may benefit other investors' welfare, if *aggregate* investment choices are sufficiently flexible at the *interim* stage. Thus, for example, the average level of risky interim investment is higher with than without insider trading in Leland (1992). This is due to the lower conditional variance of future asset returns in a noisy REE with insider trading, which leads rational outsiders to augment their demand schedules for the risky investment.[3] Diamond and Verrecchia (1982) and recently Holmstrom and Tirole (1993) have pointed out that interim share prices which reflect a greater degree of otherwise unverifiable payoff-relevant information may also be useful to construct more precise performance measures for motivating effort by risk-averse managers. In this paper, *we deemphasize these interim productive effects*, and assume instead inflexible *ex ante* aggregate investment portfolio choices by the firm's investors. Our choice is justified in environments in which the time lag between the accrual of *insider* information and subsequent public knowledge thereof, for example for accounting earnings or tender offers, is short and/or the nature of such interim information allows its costless and verifiable disclosure ex post. At a more basic level, we wish to argue that future-payoff-relevant insider information that might be useful for the interim collective choices of a firm need *not* be reflected in its interim share price via insider trading in order to impact on the firm's choices. Insiders who receive such information would use it in making appropriate choices for the firm, as long as they are otherwise suitably rewarded via *ex post* bonuses etc. to reflect the firm's owners' welfare. Hence, any analysis of the impact of insider trading on the welfare of the outside shareholders of a firm should not assign a prominent role to its effect on the *firm's* interim choices.

In our model interim asset prices are influenced by the stochastic proportion of outsiders who sell and can be further modified by the presence of insider trading. The interim consumption and portfolio allocations of non-insiders are clearly affected by a greater

informativeness of asset prices brought about by informed insider trading. The insider, in turn, is a strategic player and takes the others agents' selling and optimal portfolio choices into account in deciding on her trading strategy, given her private information regarding future asset returns at the interim stage. We study the resulting equilibrium impact of insider trading on the information contained in the long-term asset price regarding its future return, and on the outsiders' *ex ante* expected utilities. In the process we characterize the *ex ante* investment choices and the *interim* and *ex post* consumption levels of the early- and late-dier outsiders.

We compare agents' optimal choices, given aggregate resource constraints and/or budget constraints at equilibrium prices, as well as their welfare levels across *three scenarios*: (A) choices by a welfare-maximising planner; (B) interim trading among outsider agents only; and (C) interim trading with possible participation by the insider. These comparisons are carried out numerically, for reasons of tractability in the face of possibly binding interim liquidity constraints or "corner solutions", which in turn affect the agents' *ex ante* optimal choices. We find that outsiders' welfare is always the highest in scenario (A), which is not surprising since our planner is endowed with more interim information than the insider. She can thus adjust early- and late-dying agents' consumption levels to the information on the return on the long-term asset as well as on the realized aggregate liquidity shock. Such responsiveness of allocations is in general beneficial for outsiders' welfare. Our comparisons across the two trading scenarios generate subtler and perhaps surprising conclusions. Often the outsiders' expected utility levels are higher in scenario (C), in which the insider may take part in the interim asset trading, as compared to scenario (B) in which outsiders carry out such trading among themselves. This outcome is more likely to arise when their adverse selection losses to the insider are lower, which happens for example when the lowest possible return on the risky technology rises, or when the variability in the aggregate liquidity demand of outsiders

diminishes. This net beneficial impact of insider trading on outsiders is more likely to arise when the average proportion of agents requiring early consumption increases – provided it is not so large as to make trading by the insider unprofitable for her.[4]

The main beneficial impact of insider trading for outsiders, which compensates for the adverse selection losses incurred by them in trading, arises as follows. Since the insider does not sell[5] the long-term asset when its anticipated return is high, and if in addition the aggregate liquidity shock is low, the market price of the long-term asset fully reflects its high return. This enhances the consumption level of early-diers, subject to the liquid endowments of late-dier agents. This impact of insider trading on the outsider agents' consumption profiles is the dominant factor behind the possibility of outsiders' welfare improving with insider trading.[6] It arises without any interim flexibility in *aggregate* real investment choices, unlike in the models of Allen (1984), Leland (1992), and Dow and Rahi (1996). However, outside investors are less likely to be better off with insider trading when the range of *variation* in the proportion of early-dying agents in the economy is greater, because the insider is thereby able to sell higher quantities of the long-term asset when its anticipated future return is low.[7] As a result the adverse selection losses arising from her sales to the late-dier outsiders, at a price that is not fully revealing of her information, increase.

Insider trading might also reduce outsiders' *ex ante* under- or over- investment in the long-term asset relative to its first-best level. This possibility is logically present in an incomplete-markets setting with agents subject to uninsured private liquidity shocks, in which interim traded allocations are generically *ex ante* inefficient (Bhattacharya and Gale (1987)). However, this effect does not appear to arise uniformly in our numerical simulations.

Our paper is set out as follows. In Section I, we describe the main features of our model,

and the solution methods for it. Numerical comparisons of investment choices, asset prices and agents' welfare levels are carried out in Section II. In Section III we conclude.

I. ALTERNATIVE ALLOCATIONAL MECHANISMS

There are three time points t=0,1,2. All agents are born at t=0 and supply inelastically endowments of unity in aggregate. There is a continuum of agents with an aggregate Lebesgue measure of unity, and in addition, possibly an Insider with a strictly positive measure. Endowments can be invested either in a *risky* technology paying off at t=2, or in a riskless storage technology paying off at t=1 and, if reinvested at t=1, at t=2. Holdings of the two-period risky technology can, however, be traded in a *secondary market* at t=1, with selling by agents who wish to consume early. The storage technology has unit gross returns and the risky technology with constant returns to scale has final payoffs per unit investment of $\tilde{\theta}$ distributed as:

$$\tilde{\theta} = \begin{cases} \theta_L \text{ with probability } (1-\pi) \\ \theta_H \text{ with probability } (1-\pi) \end{cases} \tag{1}$$

as viewed from the ex ante time point t=0, where $\theta_H > 1 > \theta_L$. It is assumed that π is common knowledge among all the agents and so is the expected return on the risky asset:

$$\pi\theta_L + (1-\pi)\theta_H > 1. \tag{2}$$

For convenience, we sometimes denote $\{\pi,(1-\pi)\}$ as $\{\pi_L, \pi_H\}$.

The outside agents' intertemporal preferences for consumption, at t=1or at t=2, can be described as follows. There are two *aggregate liquidity states* l and h, and associated conditional probabilities $0<\alpha_l<\alpha_h<1$, such that conditional on the aggregate state l(h), each agent's utility function for consumption at times t=1 and t=2 is an independently identically distributed random variable:

$$U(C_1) \text{ with probability } \{[\alpha_l], \text{ or } [\alpha_h]\}, \text{ or}$$

$$U(C_1,C_2) = U(C_2) \text{ with probability } \{[1-\alpha_l], \text{ or } [1-\alpha_h]\} \tag{3}$$

These aggregate liquidity states, l and h, are assumed to arise with ex ante probabilities q and (1-q), sometimes denoted $\{q_l, q_h\}$. We assume that $\{q, \alpha_l, \alpha_h\}$ are common knowledge, but that each uninformed agent *only* knows her own realized $U(C_1,C_2)$, but *not* the aggregate state l(h). These *ex ante* random interim preferences, coupled with their aggregate variability, have effects on interim asset prices similar to those arising from "noise traders" in REE models.[8]

Agents make per capita *real investment choices* across the two technologies, the short- and the long-term, in proportions K and (1-K) respectively at t=0. Further net investment in, or liquidation of, the risky technology at the interim date t=1 is assumed to be *infeasible*. However, individual agents who wish to consume at t=1, and those who wish to postpone their consumption until t=2, can anticipate trading their long-term investment in the risky technology at equilibrium prices $P(K, \theta_j, \alpha_i)$, $j\in \{L,H\}$, $i\in \{l,h\}$, per unit investment. Here, $P(K, \theta_j, \alpha_i)$ is the Rational Expectation Equilibrium price mapping from the underlying aggregate state, which includes the equilibrium investment choice K at t=0. This mapping must be measurable with respect to the information possessed by the collection of trading agents, possibly including the insider when she participates. The insider is assumed to have an exogenous endowment of the risky technology, from which she may choose to sell an amount and reinvest the proceeds in the short-term technology at the interim (t=1) date.

A. Ex Ante Optimal Allocations

The central planner, endowed with interim information about the future risky asset payoff and the aggregate liquidity state, would choose $C_{t,ij}$ and K to maximize:

$$\sum_{i=l.h} \sum_{j=L,H} q_i \pi_j \left[\alpha_i U(C_{1ij}) + (1-\alpha_i)U(C_{2ij})\right] \tag{4}$$

subject to the resource constraints that, for each aggregate state $(i,j) \in \{l,h\}\times\{L,H\}$:

$$\alpha_i C_{1,ij} \leq K$$

(5a)

$$(1-\alpha_i) C_{2,ij} = [\theta_j (1-K) + K - \alpha_i C_{1,ij}] \tag{5b}$$

where the subscripts (i,j) refer to the states of liquidity, l (h), and of risky asset return, L (H).

B. Traded Equilibria Without Inside Information

The consumption levels of early- and late- diers are, respectively:

$$C_{1ij} = \left[(1-K)P_{ij} + K\right] \tag{6a}$$

$$C_{2ij} = \left[(K - P_{ij} X_{ij}(P_{ij})) + q_j (1 - K + X_{ij}(P_{ij}))\right] \tag{6b}$$

where $X_{ij}(P_{ij})$ is the net amount of the long-term asset bought per unit of late-diers, at t=1. In an equilibrium *without* the insider trading, $\{P_{ij}, X_{ij}\}$ can only depend on the liquidity state i. Furthermore, we must have market clearing:

$$(1-\alpha_i)X(P_i) = \alpha_i (1-K) \tag{7a}$$

and since the late-diers wishing to consume only at t=2 have, in the aggregate, no agents to borrow from[9], we must also have:

$$K - P_i X(P_i) \geq 0. \tag{7b}$$

Equations (7a) and (7b) together imply the aggregate liquidity constraint on market-clearing prices:

$$P_i \alpha_i (1-K) \leq (1-\alpha_i) K. \tag{8}$$

In their *ex ante* choice of K, the representative agents maximize their ex ante expected utility:

$$\underset{\{K,X_i\}}{Max} \sum_{i=l.h} \sum_{j=L,H} q_i p_j \left[a_i U(C_{1i}) + (1-a_i)U(C_{2ij})\right] \tag{9}$$

whereas at t=1, given P_i (which in equilibrium will only reveal state l or h to traders without private information about $\tilde{\theta}$), the "late diers" choose X_i for I = {l, h}, in order to:

$$\underset{\{X_i\}}{Max}[\sum_{j=L,H} p_j U(C_{2ij}) \mid P_i] \tag{10}$$

leading to a uniquely maximal $X_i(P_i)$ which, in the interim equilibrium represented by equation (7a) must also satisfy equation (7b), given the ex ante optimal choice of K that anticipates the equilibrium evolution of $\{X_i, P_i\}$ at time t=1.

Using the first-order conditions for the maximization problem in equations (10) and equation (7a), we determine candidate interim equilibrium prices $P_i(K)$ for a given K. These are found from among the positive real roots of a non-linear equation in P_i[10], unless the no-borrowing constraint (7b) binds, in which case the market price is derived from equality in equation (8). We then calculate the implied *ex ante* choice of K using the maximization program in equation (9) taking the interim prices and trades as being given by the earlier set of calculations, and iterate until convergence in K.

C. Noisy REE with Insider Trading and Market Orders

We now postulate that, in addition to the agents we have already modeled, there is an insider endowed at t=0 with $n \geq [\alpha_h - \alpha_l]$ units of the long-term technology only, which she may sell at time t=1 and invest in the riskless technology. This insider only wishes to consume at time t=2, and she knows *perfectly* at t=1 the return θ_j on the long-term asset. Solely for simplicity in computing her expected utility, which determines her decision to participate in the interim trading at t=1 or not, we assume that the insider is *risk-neutral*.

The outside late-diers' trades are now allowed to depend on the partitions of the aggregate state space, $\{\alpha_l, \alpha_h\} \times \{\theta_L, \theta_H\}$, that are revealed to them by the equilibrium prices with the insider trading. The outside agents take the market-clearing REE prices in these

partitions as given parametrically, and the late-diers submit demand functions {X(P)} with domain restricted to these prices only; the early-diers supply their long-lived assets inelastically. The insider chooses her trading rule strategically to take these outsiders' behavior into account. We assume that the insider can submit market orders only, so that in effect she can condition her sales only on her realised information about $\tilde{\theta}$, but *not* on the aggregate liquidity shock among non-insiders, $\{\alpha_i\}$. This assumption is consistent with the feature of our model that early-dier outsiders supply their long-term assets inelastically, and hence the insider can mimic their sales only via (many small) market orders. Since it is in the interest of the insider to "mask" her private information about $\tilde{\theta}$, strategic trading by the insider will result in a noisy REE in which the following *three partitions* of the aggregate state space are revealed by equilibrium prices:

$$(h,L) \tag{11a}$$

$$\{(l,L) \cup (h,H)\} \tag{11b}$$

$$(l,H) \tag{11c}$$

with the associated (weakly increasing) set of interim prices $\{P_a,P_b,P_c\}$ respectively. In such an equilibrium, the insider sells a quantity Q>0 of the risky asset in states {h,L} and {l,L}, and does not trade otherwise. In particular, we rule out any borrowing at t=1 by the insider from late-dier outsiders to buy the long-lived asset. Even if the insider were to possess some endowment of the short-term asset, it is easy to show that she could not profitably carry out *both* buying and selling at t=1, without revealing one of these trades through its impact on the market-clearing interim asset price. Hence, for simplicity, we focus on insider sales only. The insider's choice of Q is made subject to the knowledge that late-dier outsiders would now choose their net purchases per capita (per unit measure) of the risky asset X_{ij}, in aggregate state {i,j}, to maximize their conditional expected utility:

$$\underset{X_{ij}}{Max} \sum_{j\in\{L,H\}} \left[\hat{p}_{ij} U\left[\left(K - P_{ij} X_{ij}\right) + q_j \left(1 - K + X_{ij}\right)\right] \middle| P_{ij}\right] \tag{12a}$$

where P_{ij} is the noisy REE equilibrium price at t=1 in state {i,j} per unit of the risky technology, $\hat{\pi}_{ij}$ is the outsiders' revised beliefs about $\tilde{\theta}$, and X_{ij} must satisfy:

$$X_{ij} = X_{kl}\ ,\ i \neq k \text{ and/or } j \neq l, \text{ if } P_{ij} = P_{kl.} \tag{12b}$$

The outsiders' trades at t=1 must also satisfy a no-borrowing constraint:

$$P_{ij} X_{ij} \leq K, \ \forall_{ij}. \tag{12c}$$

Equivalently, taking market clearing into account, the REE prices must meet the aggregate liquidity constraint (where Q_j equals Q for j=L, and 0 otherwise):

$$P_{ij}\ [\alpha_i (1-K) + Q_j] \leq (1-\alpha_i)\ K. \tag{13}$$

The revised beliefs $\{\hat{p}_{ij}\}$ of outsiders depend, of course, on the partitions of the aggregate state space generated by the trading of themselves and the insider. Finally, the outsiders' ex ante investment is computed to maximize in equation (9), taking into account the $\{X_{ij},P_{ij}\}$ configurations that would arise from such an *ex ante* K choice. Finally, in examining the existence of an equilibrium with Q>0 trades by the insider, we must compare her expected utility in such an equilibrium versus one in which -- as in Section I.B above – she desists from trading, and thus one obtains an equilibrium in which prices are P_1 in states [{l,L} and {l,H}], and $P_h \leq P_l$ in states[{h,L} and {h,H}]. We are now in a position to describe fully the noisy REE arising with the informed insider trading.

PROPOSITION. If condition (16) below is satisfied, then there exists a noisy REE in which the insider sells Q>0 in states {l,L} and {h,L} where Q satisfies:

$$(1-K)\alpha_h = (1-\alpha_h)X(P_b) \tag{14a}$$

$$(1-K)\alpha_l + Q = (1-\alpha_l)X(P_b) \tag{14b}$$

where $X(P_b)$ is the late-diers' per capita demand for trade in the risky technology in states [{l,L}and {h,H}] given equilibrium price P_b therein, chosen to maximize in equation (12a) given their revised beliefs:

$$\left(\hat{\pi}_H \middle| P_b\right) = \frac{q_h \pi_H}{\left(q_h \pi_H + q_l \pi_L\right)} \tag{14c}$$

with the complementary conditional probability $\hat{\pi}_L = 1 - \hat{\pi}_H$. In the other states, equilibrium prices and beliefs satisfy:

$$(1-\alpha_h)\, X(P_a) = (1-K)\alpha_h + Q \tag{14d}$$

in state {h,L} with $\left(\hat{\pi}_H \middle| P_a\right)$=0, where $X(P_a)$ maximizes in equation (12a) given P_a and $\left(\hat{\pi}_{H/L} \middle| P_a\right)$; and

$$(1-\alpha_l)\, X(P_c) = (1-K)\alpha_l \tag{14e}$$

in state {l,H} with $\left(\hat{\pi}_H \middle| P_c\right)$ = 1, where $X(P_c)$ maximizes in equation (12a) given P_c and $\left(\hat{\pi}_{H/L} \middle| P_C\right)$. Interim net trade demands of the late-dier outsiders clearly must satisfy the conditions:

$$X(P_a) = K/P_a \quad \text{if } P_a < \theta_L \tag{15a}$$
$$\in [0, (K/P_a)] \quad \text{otherwise} \tag{15b}$$

and, similarly,

$$X(P_c) = K/P_c \quad \text{if } P_c < \theta_H \tag{15c}$$
$$\in [0, (K/P_c)] \quad \text{otherwise.} \tag{15d}$$

Together, the outsiders' investment choice K and the interim equilibrium prices must satisfy the aggregate liquidity constraint (13). Finally, in order to satisfy the condition for profitability of this insider trading strategy we must have that, in equilibrium, given the ex ante optimal choice of K by non-insiders:

$$q_l(P_b-\theta_L) + q_h(P_a-\theta_L) \geq 0. \tag{16}$$

Remark 1: Violation of inequality (16) is possible since $P_a<\theta_L$ is feasible.

Remark 2: For simplicity, our insider is endowed only with the risky asset and can only sell it because any interim borrowing reveals her identity. If she also had some of the riskless asset, she would not buy the risky asset in state H and then sell it in state L via market orders, since then the equilibrium would be fully revealing and her profits would be driven to zero.

Remark 3: As noted above, the insider would not send limit (i.e., price-contingent) orders that reveal her identity, given that the early-dier outsiders submit market orders.

The insider sells the risky asset when the risky asset payoff is low and does not trade otherwise. Since she masks her trades, the quantity sold by her depends on the range of variation in the proportion of early-dying agents, in such a way that late-diers do not know whether they are buying from early-diers or from the insider. However she cannot condition her orders on prices. It follows that the state {l,H} is revealed because the proportion of early-diers is low and the insider has no incentive to sell. Similarly, the state {h,L} is revealed by the sales coming from the insider and also a high proportion of outsiders with liquidity needs.

II. NUMERICAL RESULTS ON INVESTMENTS, PRICES, AND WELFARE

The possibility of "corner solutions" vis-à-vis interim $\{X_{ij}\}$ trades appears to rule out a fully analytic solution for computing equilibria. Hence, even for our agents with *additively separable power utilities*, we have to resort to numerical calibrations[11] in order to compare equilibrium outcomes across alternative informational regimes. We seek to understand under what circumstances one would expect to see one trading regime to do better than another for the other agents' ex ante welfare levels. Such understanding is of importance in order to establish guidelines for desirable regulatory restrictions on insider trading which is ex-post detectable and adequately punishable.

We have computed equilibrium allocations for the grid of parameter values below:

(i) $\{q,\pi\} = \{½ , ½\}$;

(ii) $\{\alpha_l, \alpha_h\} = \{0.1, 0.15\}$, $\{0.9, 0.95\}$,$\{0.48, 0.53\}$, $\{0.45, 0.55\}$, $\{0.4, 0.6\}$; and

(iii) $\{\theta_L\} \in \{0.75, 0.8, 0.85, 0.9, 0.95\}$, with $\{\theta_H\} \in \{1.25, 1.3, 1.35, 1.4, 1.45, 1.5\}$.

For most of our simulations, we have worked with $U(C)=-C^{-2}$, with a relative risk aversion coefficient of three, though other U(C) were tried as well. We have taken n=1, i.e., an insider with at least equal shareholdings as that of non-insiders. However, it is only the equilibrium extent of selling of the risky technology in some states of nature at t=1 by the insider (Q>0) that has an impact on interim prices. Such trading is bounded above by the difference in the aggregate selling of the long-term asset by the early-dier outsiders across the states {l,L} and {h,H}, a difference which the insider "masks" via her trading.

From the comparisons in Table I, we see that: (1) the first-best solution (A) always dominates the uninformed only trading (B) and insider trading (C) scenarios in *ex ante* welfare, (2) that for $\{\alpha_h - \alpha_l\} = 0.05$, the outsiders' welfare is higher with insider trading (C) than without in 26 of the 30 cells of the matrix in the $\{\theta_L,\theta_H\}$ space[12], and (3) this outcome arises only in 10 cells when $\{\alpha_h - \alpha_l\} = 0.1$ and in only four cells if $\{\alpha_h - \alpha_l\} = 0.2$. Note also that insider trading is more likely to improve outsiders' welfare when θ_L is high, and the <u>*extent*</u> to which it does so is greater when θ_H goes up. However, as the gap $\{\alpha_h - \alpha_l\}$ widens allowing the amount of insider selling Q to increase, equilibria with insider trading tend to become worse for outsiders than equilibria without such trading, owing to the adverse selection losses of the late-diers to the insider in the state {l,L}.

In Panel 1 of Table II, we look at outsiders' ex ante investment (K) choices across scenarios (A), (B), and (C), focusing on the case $\{\alpha_l, \alpha_h\}=\{0.48, 0.53\}$. No clear pattern of comparison emerges, except to note that K(B)>K(C)>K(A) when $\{\theta_L,\theta_H\}$ are low, whereas

K(A)>K(B)>K(C) or K(A)>K(C)>K(B) when $\{\theta_L,\theta_H\}$ are high. Hence, there appears to be no universal pattern of investment choice with insider trading, K(C), being closer to the first-best choice K(A) than is K(B), the agents' choice in the equilibrium without the insider. In Panel 2 of Table II, we look at interim prices -- in the two partitions $\{\alpha_l, \alpha_h\}$ for trading scenario (B) and in the three partitions $\{[(\alpha_l ,\theta_H], [\alpha_l ,\theta_L) \cup (\alpha_l ,\theta_H)], [\alpha_h ,\theta_L]\}$ for scenario (C) -- for different values of $\{\theta_L,\theta_H\}$. Note that in the partition $[\alpha_l ,\theta_H]$ the equilibrium with insider trading often has the interim long-term asset price equaling θ_H, which leads to consumption gains for early diers, that are beneficial for of the ex ante welfare of outsider agents. The interim traded outcome without the insider is ex ante inefficient in this respect.

We have also computed some welfare comparisons for lower and higher *average* level of α. For $\{\alpha_l, \alpha_h\} = \{0.1, 0.15\}$, the insider trading solution (C) is welfare superior to the solution (B) only when $\theta_L \geq 0.9$, as compared to $\theta_L \geq 0.8$ when $\{\alpha_l, \alpha_h\} = \{0.48, 0.53\}$. However, the insider chooses not to trade when $\theta_L=0.95$ and $\theta_H \geq 1.4$, so that insider trading effectively aids outsiders' welfare in only nine of the 30 cells. The reasons for these patterns are that (i) with lower α, fewer early-diers gain from the price improvement in the $\{\alpha_l, \theta_H\}$ state brought about by insider trading, and (ii) with high $\{\theta_L ,\theta_H\}$ the insider's losses in the state $\{\alpha_h, \theta_L\}$ overwhelm her gains in $\{\alpha_l ,\theta_L\}$. With $\{\alpha_l, \alpha_h\} = \{0.9, 0.95\}$, the insider chooses not to trade whenever $\theta_L \geq 0.09$ and $\theta_H \geq 1.35$, or $\theta_L=0.95$, so that the trading scenario (C) improves outsiders' welfare as compared to scenario (B) in only five of the 30 $\{\theta_L ,\theta_H\}$ cells.[13]

III. CONCLUDING REMARKS

We have shown, with an intertemporal model of individual as well as aggregate liquidity shocks to uninformed agents, that insider trading can improve outsiders' welfare, even when aggregate investment choices *can not* respond to any partial revelation of information brought about by such insider trading via prices. The rationale behind our finding is the beneficial impact of insider trading on outsiders' selling prices and consumption in some states, which more than compensates for their adverse selection losses in other states of nature. When short-term traders sell their shares, informationally-efficient share prices lead to larger transfers from long-term traders to short-term traders when the future returns are high, and smaller transfers from long-term traders to short-term traders when the future returns are low. As a result, insider trading improves risk-sharing among the outsiders, which can compensate for their adverse selection losses to her. We find these results to be interesting, because the impact of insider trading via prices on *interim* investment choices by a firm -- an "alternative channel" for its beneficial effect -- is artificial at best, when the same insiders choose the firm's investment policy.

A net beneficial impact of insider trading on outsiders' welfare, which we have documented, is particularly likely to arise when (1) the insider's equilibrium trades are small, relative to outsiders' liquidity-based trades, and (2) the riskiness (lower bound) of returns on the risky investment, about which the insider is privately informed at the interim date, is not too high (low). Otherwise, as is conventionally thought, insider trading is harmful to the outsiders' welfare, owing to the adverse selection losses to them arising from her trades.

REFERENCES

Allen, Franklin, 1984, A welfare analysis of rational expectations equilibria in markets, Manuscript, Wharton School, University of Pennsylvania.

Bhattacharya, Sudipto, and Douglas Gale, 1987, Preference shocks, liquidity and central bank policy, in William A. Barnett and Ken J. Singleton eds.: *New Approaches to Monetary Economics,* (Cambridge University Press, New York, NY).

Bryant, John, 1980, A model of reserves, bank runs, and deposit insurance, *Journal of Banking and Finance* 4, 335-344.

Dennert, Jurgen, 1992, Insider trading and the cost of capital in a multi-period economy, Discussion Paper no.128, LSE Financial Markets Group.

Diamond, Douglas W., and Philip H. Dybvig, 1983, Bank runs, deposit insurance, and liquidity, *Journal of Political Economy* 91, 401-419.

Diamond, Douglas W., and Robert E. Verrecchia, 1981, Information aggregation in a noisy rational expectations economy, *Journal of Financial Economics* 9, 221-235.

Diamond, Douglas W., and Robert E. Verrecchia, 1982, Optimal managerial contracts and equilibrium security prices, *The Journal of Finance* 37, 275-287.

Dow, James, and Rohit Rahi, 1999, Informed trading, investment, and welfare, *The Journal of Business*, forthcoming.

Grossman, Sanford, and Joseph E. Stiglitz, 1980, On the impossibility of informationally efficient markets, *American Economic Review* 70, 393-406.

Hart, Oliver D., 1975, On the optimality of equilibrium when the market structure is incomplete, *The Journal of Economic Theory* 11, 418-443.

Holmström, Bengt, and Jean Tirole, 1993, Market liquidity and performance monitoring, *Journal of Political Economy* 101, 678-709.

Leland, Haine, 1992, Insider trading: Should it be prohibited?, *Journal of Political Economy* 100, 859-887.

Kyle, Albert S., 1985, Continuous auctions and insider trading, *Econometrica* 53, 1315-35.

Qi, Jianping, 1996, Efficient investment and financial intermediation, *Journal of Banking and Finance* 20 , 891-900.

Repullo, Rafael, 1994, Some remarks on Leland's model of insider trading, Working paper, CEMFI (Madrid).

Table I

Ex Ante Optimal Expected Utilities of Outside Agents

This table shows the ex ante optimal expected utilities of outside agents. Section (A) reports values for the first best, while sections (B) and (C) portray the no-insider and the insider trading cases respectively. The θ_i are the realized payoffs to the risky technology. The α_i are the realized shares of early-diers among the outsiders. The range of variation for α_i increases from Panel 1 (0.05) to Panel 3 (0.2). Cells have a dark frame when outsiders' welfare is higher with than without insider trading. Values are marked with * when the liquidity constraint is imposed in state lH, and with ^ when the liquidity constraint is imposed in states lH, lL and hH. In the shaded areas it does not pay the insider to trade and equilibrium values coincide with those in (B).

	(A)First Best Submitting Market Orders					(B)Without Insider Trading					(C)With Insider				
θ_H / θ_L	0.75	0.8	0.85	0.9	0.95	0.75	0.8	0.85	0.9	0.95	0.75	0.8	0.85	0.9	0.95
						Panel 1: $\alpha_l = 0.48$, $\alpha_h = 0.53$									
1.25	-0.5	-0.497939	-0.489502	-0.477079	-0.46507	-0.5	-0.498982	-0.494808	-0.484431	-0.470024	-0.499945	-0.499217	-0.494371	-0.48182^	-0.46739^
1.3	-0.498621	-0.493293	-0.482096	-0.469815	-0.45792	-0.499319	-0.496688	-0.490697	-0.478592	-0.464251	-0.499554	-0.496632	-0.489255	-0.47523^	-0.46094^
1.35	-0.495351	-0.487462	-0.475247	-0.463101	-0.451316	-0.497705	-0.493809	-0.486493	-0.473364	-0.459077	-0.497814	-0.493145	-0.483884	-0.46933^	-0.45517^
1.4	-0.491052	-0.481171	-0.468892	-0.456876	-0.445198	-0.495582	-0.490697	-0.482415	-0.468667	-0.454418	-0.495311	-0.489255	-0.478584	-0.46403^	-0.44999^
1.45	-0.486223	-0.475106	-0.462978	-0.451089	-0.439513	-0.493197	-0.487538	-0.478552	-0.464429	-0.450206	-0.492389	-0.485228	-0.47349*	-0.45926^	-0.44533^
1.5	-0.481159	-0.469443	-0.457461	-0.445693	-0.434229	-0.490697	-0.484431	-0.474934	-0.460591	-0.446384	-0.489255	-0.481213	-0.46871*	-0.45494^	-0.44112^
						Panel 2: $\alpha_l = 0.45$, $\alpha_h = 0.55$									
1.25	-0.5	-0.497939	-0.489559	-0.477782	-0.46636	-0.5	-0.49898	-0.494794	-0.484391	-0.470851	-0.499772	-0.499713	-0.495645	-0.483396	-0.4693^
1.3	-0.498621	-0.493293	-0.48241	-0.470768	-0.459455	-0.499317	-0.49668	-0.49067	-0.478643	-0.465204	-0.499931	-0.497637	-0.490946	-0.476624	-0.4624^
1.35	-0.495351	-0.487462	-0.47579	-0.464277	-0.45307	-0.497699	-0.493792	-0.486453	-0.473484	-0.460122	-0.498632	-0.494538	-0.485874	-0.470464	-0.4561^
1.4	-0.491052	-0.481248	-0.469641	-0.458252	-0.447146	-0.49557	-0.49067	-0.482359	-0.46883	-0.455527	-0.496483	-0.490946	-0.480794	-0.464829	-0.4505^
1.45	-0.486223	-0.475378	-0.463912	-0.452643	-0.441635	-0.493179	-0.487501	-0.478481	-0.464613	-0.451353	-0.493847	-0.487153	-0.475874	-0.45967^	-0.4455^
1.5	-0.481159	-0.469891	-0.458562	-0.447407	-0.436494	-0.49067	-0.484383	-0.474847	-0.46078	-0.44755	-0.490946	-0.483322	-0.471186	-0.45499^	-0.4409^
						Panel 3: $\alpha_l = 0.4$, $\alpha_h = 0.6$									
1.25	-0.5	-0.497939	-0.489866	-0.479649	-0.469658	-0.5	-0.49901	-0.494948	-0.485	-0.473394	-0.499007	-0.500455	-0.498212	-0.487293	-0.471477
1.3	-0.498621	-0.493293	-0.483381	-0.473281	-0.463389	-0.499338	-0.496779	-0.490943	-0.479651	-0.46818	-0.500398	-0.499562	-0.494519	-0.480712	-0.465296
1.35	-0.495351	-0.487486	-0.477357	-0.46737	-0.457571	-0.497768	-0.493976	-0.48684	-0.474815	-0.463463	-0.500118	-0.497387	-0.490182	-0.474719	-0.459634
1.4	-0.491052	-0.481749	-0.471746	-0.461866	-0.452155	-0.495702	-0.490943	-0.482853	-0.47042	-0.45916	-0.498806	-0.494519	-0.485649	-0.469237	-0.454139
1.45	-0.486223	-0.476387	-0.466504	-0.456726	-0.447101	-0.49338	-0.48786	-0.479068	-0.466407	-0.455219	-0.496856	-0.491297	-0.481145	-0.464201	-0.449322
1.5	-0.481178	-0.471363	-0.461595	-0.451915	-0.442372	-0.490943	-0.484825	-0.475517	-0.462728	-0.451597	-0.494519	-0.487923	-0.47678	-0.459555	-0.444871

Table II

Ex Ante Optimal Investment Choices by Outside Agents and Asset Prices

This table reports the outsiders' ex ante investment choices and the risky asset prices when α_l =0.48 and α_h=0.53. Values are marked with * when the liquidity constraint is imposed in state lH, and with ^ when the liquidity constraint is imposed in states lH, lL and hH.

	(A)First Best					(B)Without Insider Trading					(C)With Insider Submitting Market Orders				
θ_H / θ_L	0.75	0.8	0.85	0.9	0.95	0.75	0.8	0.85	0.9	0.95	0.75	0.8	0.85	0.9	0.95
Panel 1: Ex Ante Investment Choices															
1.25	1.	0.8341	0.5842	0.5712	0.5592	1.	0.9181	0.7857	0.5425	0.5193	1.	0.9056	0.7336	0.5265^^	0.5205^^
1.3	0.8892	0.7264	0.5885	0.5751	0.5628	0.9453	0.8649	0.7375	0.5283	0.5177	0.9388	0.8348	0.6666	0.5270^	0.5209^
1.35	0.8115	0.653	0.5927	0.5789	0.5662	0.9069	0.8286	0.7063	0.5273	0.5164	0.888	0.7856	0.6217	0.5275^	0.5212^
1.4	0.755	0.6113	0.5967	0.5826	0.5696	0.879	0.8031	0.6857	0.5267	0.5156	0.8505	0.7499	0.5906	0.5279^	0.5216^
1.45	0.713	0.6155	0.6005	0.5862	0.5728	0.8583	0.7847	0.672	0.5262	0.515	0.822	0.7235	0.5715*	0.5283^	0.5219^
1.5	0.6811	0.6194	0.6042	0.5896	0.5783	0.8425	0.7712	0.663	0.5259	0.5146	0.8	0.7036	0.5736*	0.5287^	0.5222^
Panel 2: Equilibrium Prices															
						Price P_l (a_i = 0.48)					**Price P_a (a_i = 0.48 and $q_j = q_H$)**				
1.25						1.	1.001	1.002	1.003	1.044	1.25	1.25	1.25	1.205^	1.176^
1.3						1.001	1.002	1.003	1.007	1.051	1.3	1.3	1.3	1.207^	1.178^
1.35						1.002	1.003	1.004	1.011	1.057	1.35	1.35	1.35	1.209^	1.179^
1.4						1.004	1.004	1.005	1.014	1.061	1.4	1.4	1.4	1.211^	1.181^
1.45						1.005	1.005	1.006	1.015	1.064	1.45	1.45	1.445*	1.213^	1.182^
1.5						1.006	1.006	1.006	1.017	1.065	1.5	1.5	1.457*	1.215^	1.184^
						Price P_h (a_i = 0.53)					**Price P_c (a_i = 0.53 and $q_j = q_L$)**				
1.25						1.	0.9988	0.9976	0.997	0.9579	0.75	0.8	0.85	0.9^	0.95^
1.3						0.9987	0.9976	0.9967	0.9933	0.9517	0.75	0.8	0.85	0.9^	0.95^
1.35						0.9976	0.9965	0.9958	0.9894	0.9471	0.75	0.8	0.85	0.9^	0.95^
1.4						0.9964	0.9956	0.9951	0.9867	0.9438	0.75	0.8	0.85	0.9^	0.95^
1.45						0.9954	0.9947	0.9944	0.9849	0.9415	0.75	0.8	0.85*	0.9^	0.95^
1.5						0.9944	0.9939	0.9939	0.9839	0.94	0.75	0.8	0.85*	0.9^	0.95^
											Price P_b (a_i = 0.48 and $q_j = q_L$; a_i = 0.53 and $q_j = q_L$)				
1.25											1.00	0.995	0.9862	0.9861^	0.963^
1.3											0.99	0.987	0.9792	0.9881^	0.964^
1.35											0.99	0.979	0.9731	0.99^	0.965^
1.4											0.987	0.972	0.9679	0.9917^	0.967^
1.45											0.97	0.966	0.9639*	0.9933^	0.968^
1.5											0.96	0.961	0.9641*	0.9948^	0.97^

FOOTNOTES

*London School of Economics and Political Science and CEPR, and Università degli Studi di Torino respectively. We are grateful for financial support from the Ente Einaudi, the Italian MURST, and the International Centre for Economic Research (ICER), Torino. It is a pleasure to acknowledge the excellent research assistance of Giacomo Elena. Work on this paper was begun while Bhattacharya was a Visiting Fellow at ICER during the Summer of 1995. We wish to thank, without implicating in errors, Gabriella Chiesa and Jose Marin for advice and encouragement, and participants at seminars at the Universities of Brescia, Roma "Tor Vergata", Tilburg, Torino, the CEPR Conference on "Information, Financial Intermediation and the Macroeconomy" Alghero 1997, as well as an anonymous referee and the editor René Stulz for their very helpful comments and suggestions.

[1] This can be interpreted as a shock to their other incomes resulting in changed preferences over withdrawals from their savings, such as a disability shock leading to early retirement.

[2] The reason is, of course, the wealth-invariant demand function for the risky asset implied by their agents' intertemporally additively separable negative exponential utility preferences.

[3] Dow and Rahi (1996) have recently extended these results to a more complete welfare analysis, in which noise trading by outsiders is generated via shocks to their endowments - as in Diamond and Verrecchia (1981).

[4] This occurs when a small proportion of late-diers require a very high risk premium in the asset price to compensate for their adverse selection losses to the insider, in states in which she sells without fully revealing her information via the long-term asset price.

[5] Our insider is endowed with the risky asset, and can only sell it because any borrowing by her to buy at the interim date would reveal her identity. In general, both buying and selling by the insider would be inconsistent with non-revelation of her information via REE prices; see below.

[6] Qi (1996) works with risk-neutral outsiders, hence his model does not capture the impact of insider trading on risk-sharing among the outsider agents that our calibrations emphasise.

[7] She may obtain a profitable price when the outsiders are "confused" between the two states of nature in which (I) the aggregate liquidity shock is low and the insider is selling the long-term asset, and (ii) the aggregate liquidity shock is high but the insider is not selling, because she expects a high future return on the long-term asset.

[8] In Bhattacharya and Gale (1987) it is shown that with agents having these interim (and uninsured) preference

shocks as in equation (3) above, even when $\{\alpha,\theta\}$ are deterministic, the allocations arising from interim trading among the agents at t=1, coupled with interim value- maximizing investment choices at t=0, are ex ante Pareto inefficient unless U(C)=log(C).

[9] The equilibrium borrowing rate at t=1 is such that no late-dier wishes to borrow.

[10] The non-linear equation is quadratic with logarithmic utility and of degree 4 when $U(C)=-1/(2C^2)$, which we use in most of our calibrations. Only one of the four roots is admissible as an equilibrium price solution (two of the roots are complex, and a third exceeds θ_H.).

[11] The relevant MATHEMATICA® programs are available from the authors upon request.

[12] When both $[\theta_L, \theta_H]$ are high the individual borrowing (12c) and the aggregate liquidity (13) constraints are violated in state $[\alpha_l, \theta_H]$ in the insider trading case. We therefore compute the solution imposing $P_c = (1-\alpha_l)K/[\alpha_l *(1-K)]$. When the aggregate liquidity constraint binds in the partitions consisting of states $\{[\alpha_l, \theta_H], [\alpha_l, \theta_H]\}$ also, we further impose $P_b = (1-\alpha_h)K/[\alpha_h (1-K)]$.

[13] We carried out comparisons analogous to those in Table I for U(C)=log (C), with relative risk-aversion of unity, and $U(C)=-C^{-4}$, with relative risk-aversion of five. When $\{\alpha_l, \alpha_h\} = \{0.4, 0.6\}$, insider trading improves outsiders' welfare in three cells in the former case and in four cells in the latter; the insider does not trade in eight and in five cells, respectively.