Resource Allocation Effects of Price Reactions to Disclosures*

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Abstract

Capital market participants collectively may possess information about the valuation implications of a firm's change in strategy not known by the management of the firm proposing the change. We ask whether a firm's management can exploit the capital market's information in deciding either whether to proceed with a contemplated strategy change or whether to continue with a previously initiated strategy change. In the case of a proposed strategy change, we show that managers can extract the capital market's information by announcing a potential new strategy, and then conditioning the decision to implement the new strategy on the size of the market's price reaction to the announcement. Under this arrangement, we show that a necessary condition to implement all and only positive net present value strategy changes is that managers proceed to implement some strategies that garner negative price reactions upon their announcement. In the case of deciding whether to continue with a previously implemented strategy change, we show that it may be optimal for the firm to predicate its abandonment/continuation decision on the magnitude of the costs it has already incurred. Thus, what looks like "sunk-cost" behavior may in fact be optimal.

Both demonstrations show that, in addition to performing their usual role of *anticipating* future cash flows generated by a manager's actions, capital market prices can also be used to *direct* a manager's actions. It follows that, in contrast to the usual depiction of the information flows between capital markets and firms as being one way — from firms to the capital markets — information also flows from capital markets to firms.

Keywords Disclosures; Information; Market prices; Resource allocation

Condensé

Dans les travaux réalisés jusqu'à maintenant sur la communication d'information, l'on considère que l'information circule à sens unique entre les sociétés et les marchés de capitaux. Les auteurs adoptent ici l'hypothèse selon laquelle l'information circule également dans l'autre sens, entre les marchés de capitaux et les entreprises. Ils considèrent, en effet, que les cours fixés sur les marchés de capitaux indiquent aux dirigeants de sociétés quelles sont les

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décisions qui recueillent la faveur des actionnaires, ce qui, au fil du temps, oriente leurs choix stratégiques quant aux projets à maintenir ou à abandonner. Les conséquences de la circulation bidirectionnelle de l'information semblent se manifester aussi bien à l'échelon de l'entreprise qu'à l'échelon du secteur. À l'échelon de l'entreprise, l'on peut penser à United Airlines qui a été incapable de susciter une réaction positive du cours des titres au projet de former une société combinant des activités de transport aérien, d'hébergement et de location de voitures par l'intermédiaire du conglomérat « Allegis ». L'on croit que la réaction défavorable des investisseurs a incité la haute direction de United à renverser la vapeur et à recentrer sa stratégie sur les activités de base que constitue le transport aérien. À l'échelon du secteur, un exemple probant est celui de la hausse démesurée du cours des titres des sociétés Internet : les primes considérables dont ces titres ont fait l'objet avant le printemps 2000 ont amené maintes entreprises à créer leurs propres filiales de cybercommerce. L'effondrement des cours dans le secteur technologique a par la suite amené de nombreux investisseurs à retirer leur mise dans les cybersociétés.

La circulation de l'information en sens inverse, soit des marchés de capitaux vers les entreprises, est susceptible de se produire pour plusieurs raisons. Le cours des titres sur les marchés de capitaux, comme les prix dans d'autres contextes, influe sur les décisions d'affectation des ressources. Par ailleurs, les participants aux marchés de capitaux se spécialisent dans l'évaluation, et leur longévité dépend de leur capacité à estimer les répercussions qu'auront les décisions passées et anticipées des sociétés sur la valeur de ces dernières. Au surplus, certains faits empiriques et certains résultats d'analyse corroborent les propriétés d'agrégation de l'information que possèdent les cours des marchés de capitaux. Ces cours devraient donc, du moins à l'occasion, contenir de l'information que les gestionnaires ne sauraient obtenir d'autres sources.

Il est souvent difficile de dire si les cours réagissent aux décisions des sociétés ou si les décisions des sociétés réagissent aux cours. Lorsqu'une société annonce une offre publique d'achat (OPA), par exemple, il semble que ce soit elle qui initie le mouvement et suscite la réaction, favorable ou non, des marchés de capitaux. Mais cette conclusion n'est pas aussi évidente si l'on songe que la décision de procéder à cette OPA peut avoir été influencée par l'anticipation de la réaction des marchés de capitaux. En situation d'équilibre, les cours des marchés de capitaux et les décisions des sociétés doivent être déterminés conjointement, voire même simultanément.

Les auteurs élargissent la portée des recherches existantes sur la communication d'information en se demandant si la détermination conjointe des cours des marchés de capitaux et des décisions des sociétés peut permettre aux entreprises d'améliorer la qualité de leurs décisions stratégiques en communiquant aux marchés le changement stratégique ou le « projet » qu'elles envisagent et en n'opérant ce changement que si la réaction des cours à l'information communiquée est suffisamment positive. Dans la mesure où ce mécanisme d'« orientation stratégique par sondage » fonctionne, il est susceptible de réduire la fréquence des erreurs stratégiques. L'applicabilité dudit mécanisme dépend de la capacité des cours des marchés de capitaux de jouer à la fois leur rôle traditionnel d'évaluation des conséquences futures que peuvent avoir sur les flux de trésorerie les décisions *prévues* des dirigeants d'entreprise et leur rôle d'orientation des décisions des dirigeants vers les activités susceptibles de générer les flux de trésorerie les plus élevés. Dans leur analyse, les auteurs montrent que, de façon générale, les cours des marchés peuvent s'acquitter de ce double rôle.

Les politiques d'adoption de projets selon les cours des marchés de capitaux ne sont pas toutes aussi intéressantes. Les auteurs constatent qu'une société dont la politique consiste à mettre en œuvre les projets qu'elle envisage uniquement lorsque la réaction des cours à l'annonce de ces projets est favorable se voit ainsi contrainte à renoncer à de nombreux projets dont la valeur actualisée nette (VAN) espérée est positive, à moins que les marchés de capitaux n'ignorent totalement l'existence de ces projets. En gros, cela tient au fait que, si les cours en vigueur sur le marché anticipent la venue de projets futurs, seuls les projets qui entraînent une réaction positive des cours au moment où ils sont annoncés sont supérieurs à la moyenne. Par conséquent, si l'on veut que seuls les projets présentant une VAN positive soient entrepris mais qu'ils le soient tous, certains projets dont l'annonce provoque une réaction négative des cours devront néanmoins être réalisés. Compte tenu de cette observation, c'est avec prudence qu'il faut interpréter les réactions négatives des cours des titres à l'information livrée par les sociétés sur divers changements envisagés en matière d'exploitation, de financement ou de stratégie, en évitant de conclure invariablement qu'elles sont de mauvais augure pour la réalisation du projet. L'interprétation traditionnelle des émissions de titres ou du recours aux « pilules empoisonnées » comme étant un message négatif (voir, par exemple, Asquith et Mullins, 1986, dans le premier cas et Malastesta et Walkling, 1988, dans le second), ou l'attribution de connotations neutres ou négatives aux propositions de prise de contrôle pour l'acquéreur (voir, par exemple, Schwert, 1996 ; Weston, Chung et Siu, 2001) mériterait d'être réévaluée à la lumière de cette constatation.

Bien que leur étude porte essentiellement sur le cas où une société envisage un nouveau projet stratégique, les auteurs expliquent que l'analyse s'applique aussi bien à celui où une société a déjà amorcé un nouveau projet ou une réorientation stratégique et souhaite maintenant sonder les marchés de capitaux avant de décider de la poursuite ou de l'abandon de ce projet ou de cette stratégie. L'extension de l'analyse à ce genre de décisions relatives à la poursuite ou à l'abandon de projets fait intervenir dans l'étude un nouvel élément d'une importance primordiale : la prise en compte appropriée des coûts irrécupérables résultant de l'abandon du projet. Les auteurs font remarquer que les décisions optimales d'abandon ou de poursuite maximisant la VAN affichent un profil que l'on pourrait interpréter à tort comme une réaction au leurre des coûts irrécupérables — dans la mesure où l'ampleur des coûts irrécupérables paraît influer sur les décisions optimales d'abandon ou de poursuite. S'il faut se garder d'interpréter toute réaction négative du cours des titres à l'annonce d'un nouveau projet comme étant de mauvais augure pour la réalisation dudit projet, il faut donc également, comme l'indique l'analyse des décisions optimales d'abandon ou de poursuite, se garder d'interpréter la décision de poursuivre un projet existant motivée par l'importance des coûts irrécupérables qui y sont associés comme étant la preuve d'une erreur décisionnelle.

Dans une entreprise, la prise de décisions relatives à l'affectation des ressources en fonction du critère de la réaction des cours à l'annonce de ces décisions offre un maximum d'avantages, et est donc la méthode la plus susceptible d'être utilisée, dans les cas où les marchés de capitaux possèdent un avantage prépondérant sur le plan de l'information par rapport aux dirigeants de l'entreprise, par exemple lorsque la viabilité financière d'un projet est tributaire des tendances macroéconomiques ou sectorielles que les participants aux marchés de capitaux sont particulièrement aptes à prévoir. De façon plus générale, l'on devrait s'attendre à ce que les dirigeants optent pour ce genre de décisions d'adoption conditionnelles lorsqu'ils sont dans l'incertitude au sujet de la façon d'évaluer une nouvelle initiative stratégique.

Les résultats obtenus par les auteurs en ce qui a trait à l'abandon ou à la poursuite des projets donnent à penser que ce mode de décision donne son plein rendement lorsqu'une grande partie de l'investissement initial exigé par un nouveau projet peut être récupérée à l'abandon dudit projet. Les auteurs formulent l'hypothèse selon laquelle ce mode de décision est moins prisé lorsque la révélation précoce de la réorientation stratégique proposée par l'entreprise risque de livrer aux concurrents de l'information privilégiée, lorsque la direction de la société est inflexible, lorsqu'un revirement pourrait nuire grandement à la réputation de la direction ou lorsque le rendement d'un nouveau projet est à tel point élevé que la confirmation externe de la viabilité financière du projet par le marché des capitaux est inutile.

Les recherches théoriques en comptabilité qui se rapprochent le plus de la présente étude sont celles de Sunder (1989) et d'Amershi et Sunder (1987). Sunder (1989) s'interroge sur l'orientation potentielle pouvant être fournie par les cours des marchés de capitaux dans la perspective de l'amélioration de la prise de décisions par les autorités de réglementation. Plus précisément, Sunder avance, dans un contexte assez différent de celui de la présente étude, que la technique implicite dans les précédents débats sur les politiques --- technique qui consistait à ne mettre en application que les normes comptables dont l'annonce suscitait une réaction positive des cours des titres - n'est peut-être pas opérationnelle. Amershi et Sunder (1987) se demandent, quant à eux, si un dirigeant peut résoudre son incertitude quant aux facteurs déterminant la valeur de marché d'une société en observant la relation entre les décisions de la direction et les réactions du cours des titres à l'annonce de ces décisions. Du côté des ouvrages financiers, Dow et Gorton (1997) proposent un modèle théorique représentant la façon dont les dirigeants peuvent utiliser l'information « prospective » intégrée aux cours des marchés de capitaux pour améliorer leurs décisions d'investissement par rapport à celles que permet un modèle simple où le rendement résultant de l'investissement est binaire.

Il existe une foule de travaux empiriques étayant l'hypothèse fondamentale sur laquelle repose la présente étude, soit que les cours des marchés de capitaux ont une grande capacité d'agrégation de l'information que possèdent les investisseurs. Fama (1976) synthétise bien certains des premiers travaux sur le sujet. Roll (1984) propose un exemple innovateur de cette capacité d'agrégation des cours des marchés de capitaux. Dans le cas qu'il décrit, l'information privilégiée que possèdent les négociateurs de contrats à terme sur les agrumes en ce qui a trait aux prévisions du temps dans la région des principales plantations d'agrumes, en Floride, se trouve suffisamment intégrée aux cours des contrats à terme sur les agrumes pour que ces cours puissent servir à améliorer la qualité des prévisions météorologiques officielles pour la région. La recherche de Roll débouche naturellement sur les questions suivantes : les producteurs d'agrumes peuvent-ils, à leur tour, utiliser ces prévisions météorologiques de meilleure qualité pour atténuer les conséquences néfastes des gels prévus sur leurs récoltes d'agrumes en adoptant diverses mesures visant à en contrer les effets (par exemple, en améliorant le déploiement des chaufferettes) ? Si tel est le cas et que ces mesures sont d'une grande efficacité dans la réduction des dommages causés par le gel, l'anticipation des réactions des producteurs par les participants aux marchés de capitaux pourra-t-elle atténuer la réaction des cours à l'annonce de gels éventuels au point d'éliminer le contenu en information météorologique des cours des contrats à terme sur les agrumes ? Bien que le modèle proposé par les auteurs de la présente étude soit conçu pour résoudre les questions relatives à la mise en œuvre de projets stratégiques dans un contexte beaucoup plus large que celui de l'exemple des contrats à terme sur les agrumes évoqué par Roll, leur modèle de base peut être adapté à l'analyse de telles situations.

La thèse de Y. Luo (2001) est venue récemment attester empiriquement les conclusions des auteurs. Luo fournit des preuves que les dirigeants d'entreprises tirent de l'information des cours des marchés de capitaux, en situation de prise de contrôle. Il fait la démonstration empirique que l'information *exclusive* que possèdent les marchés de capitaux quant aux effets de synergie d'une fusion proposée influe sur la probabilité que cette fusion se réalise, et il conclut donc à l'existence d'un apprentissage résultant de l'annonce de fusions avant qu'un accord définitif ne soit signé par les sociétés en cause et lorsque les sociétés en cause n'appartiennent pas au secteur de la haute technologie. Ces travaux, lorsqu'on les associe à ceux de Schipper et Thompson (1983) qui en viennent à la conclusion que les cours des marchés de capitaux réagissent lorsque les sociétés annoncent des décisions stratégiques, soutiennent l'hypothèse initiale des auteurs selon laquelle l'information circule à double sens entre les sociétés et les marchés de capitaux réagissent en tirer parti pour améliorer la qualité de leurs décisions stratégiques.

1. Introduction

The existing literature on disclosure primarily views the information flows between firms and the capital market as one way — from firms to the capital market. This paper is premised on information flows also occurring from capital markets to firms: the prices set in the capital market reveal what actions shareholders value and, over time, firms can employ this information when deciding what strategies to pursue or abandon. The effects of the reverse information flows appear at both firm-specific and sector-wide levels. As a firm-specific example, consider the failure of United Airlines to get a positive price reaction to its formation of a combined airline, hotel, and rental car business through the "Allegis" conglomerate. The unfavorable reaction is believed to have caused United's senior management to reverse course and return to concentrate on their core airline operations (Salpukas 1987). As a sector-wide example, consider the Internet price bubble: the extraordinary premiums placed on Internet firms before spring 2000 induced many firms to establish e-commerce subsidiaries. The subsequent collapse of prices in the technology sector caused retrenchments in Internet-based investments.

The reverse information flows from capital markets to firms should be expected to occur for several reasons. Prices in capital markets, like prices elsewhere, affect resource allocation decisions. Also, capital market participants specialize in valuation, and their livelihoods depend on their ability to estimate the valuation implications of firms' past and anticipated decisions. Moreover, there is both empirical and analytical support for the information-aggregating properties of capital market prices. So capital market prices, at least occasionally, should be expected to contain information not otherwise known to managers.

Whether prices in capital markets respond to firms' actions or firms' actions respond to capital market prices is often unclear. When a firm announces a takeover bid, for example, it seems that firms go "first", and then capital markets respond either favorably or unfavorably. This conclusion is not so obvious, however, when one considers the possibility that a firm's anticipation of the capital market's reaction to the takeover bid may have influenced the decision to proceed with the bid in the first place. In equilibrium, we expect capital market prices and firms' decisions to be jointly, if not simultaneously, determined.

This paper extends the disclosure literature by asking whether the joint determination of capital market prices and firms' actions allows firms to improve their strategic decision making by disclosing a proposed strategy change or "project", and then implementing the strategy change only if the price reaction to the disclosure is sufficiently favorable. To the extent that such strategy-directing disclosures work, it may reduce the frequency of implementing undesirable strategy changes. The question whether strategy-directing disclosures are feasible depends on whether capital market prices can perform simultaneously their conventional role of assessing the future cash flow implications of managers' *anticipated* actions, while at the same time serving to *direct* the firm's manager's actions toward the highest cash flow-generating activities. In the subsequent analysis, we show that, quite generally, market prices can perform both roles.

Not all price-dependent project adoption policies are equally attractive. We show that a policy of implementing projects only if the price reaction to the projects' announcement is favorable leaves many positive expected net present value (NPV) projects unimplemented, unless the availability of the projects was completely unanticipated by the capital market. The reason for this is that - to the extent that current market prices anticipate the arrival of future projects - the only projects that receive positive price reactions upon their announcement are aboveaverage projects. Thus, to get all and only positive NPV projects implemented, some projects must be implemented that garner a negative price reaction upon announcement. As a consequence of this finding, one must be cautious when interpreting negative stock price reactions to firms' announcements of various operating, financing, and/or strategic changes as being invariably bad news about the firm's impending decisions. In particular, the conventional interpretations of equity issuances or the adoption of poison pills as bad news (see, e.g., Asquith and Mullins 1986 for the former and Malatesta and Walkling 1988 for the latter), or the neutral to negative connotations attached to takeover proposals for the acquirer (see, e.g., Schwert 1996; Weston, Chung, and Siu 2001) may require re-evaluation in view of this finding.¹

While the presentation in much of the paper is couched in terms of a firm considering whether to initiate a new strategy proposal, we show that the analysis applies equally well to those instances in which a firm has previously initiated a new project/strategy and is now looking to the capital markets for guidance in deciding whether to continue or abandon the project/strategy. The primary new feature introduced by extending the analysis to include such project abandonment/ continuation decisions involves proper accounting for the sunk costs of project abandonment. We show that optimal, NPV-maximizing abandonment/continuation decisions exhibit behavior that could be misinterpreted as acting in accordance with the sunk-cost fallacy — in so far as the magnitude of the sunk costs appears to influence optimal abandonment/continuation decisions. So, just as one must be cautious in not interpreting all negative price reactions to the announcement of a new project as bad news about the desirability of implementing the project, the analysis of optimal project abandonment/continuation decisions establishes that one must be cautious in interpreting the decision to continue with a pre-existing project based on the size of the sunk costs associated with the project as evidence of flawed decision making.

Making a firm's resource allocation decisions contingent on the price reactions to its disclosures is most beneficial, and hence most likely to occur, in situations where capital markets have the greatest informational advantage over the firm's managers - for example, in situations where the financial viability of a project is sensitive to macroeconomic or industry-wide trends that capital market participants are especially good at assessing.² More generally, we expect to see such contingent adoption decisions employed when managers are most uncertain about how to value a new strategic initiative. Our results on project abandonment/continuation suggest that such strategies are most valuable when much of the initial investment in a new project is recoverable upon a project's abandonment. We conjecture that these strategies are less likely to be employed where the early revelation of a firm's proposed strategy change might reveal proprietary information to competitors, where the firm's management is entrenched,³ where managers' reputations might be significantly damaged by reversing previously announced strategic initiatives,⁴ or where the returns to a new project are so high that external confirmation of the financial viability of the project by the capital market is unnecessary.

The theoretical research in accounting most closely related to this paper is that of Sunder 1989 and Amershi and Sunder 1987. Sunder (1989) asks what potential guidance can be supplied by market prices for improving regulators' decision making. Specifically, Sunder argues, in a setup quite different from ours, that a scheme implicit in past policy debates of implementing only those accounting standards that generate a positive price reaction to their announcement may not be operational. Amershi and Sunder (1987) ask whether a manager can resolve his or her uncertainty about what determines a firm's market value by observing the relationship between the manager's actions and the stock price reactions to those actions. In the finance literature, Dow and Gorton (1997) supply a theoretical model that illustrates how managers can use "prospective" information impounded in market prices to improve upon investment decisions in a simple model where the investment's realized return is binary.

There is a plethora of empirical work supporting the fundamental supposition underlying this paper that capital market prices are good aggregators of investors' information. Fama (1976) presents a good summary of some of the early literature in this area. Roll (1984) provides an innovative illustration of this aggregation capability of capital market prices. He shows that the private information of citrus futures traders with regard to future weather conditions in the vicinity of major Florida citrus groves gets sufficiently impounded into citrus futures' prices so that these prices can be used to improve public predictions of the weather in the vicinity of these groves. Roll's 1984 paper naturally leads to the following questions: can citrus growers use these improved weather predictions to compensate for the effects of forecasted frosts on their citrus crops by adopting various countermeasures (for example, by improving their deployment of smudge pots)? If they can, and

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these countermeasures have a first-order effect on reducing the damage done by frosts, will capital market participants' anticipation of these growers' responses so substantially dampen the price reactions to the arrival of information about impending frosts so as to eliminate the weather-related information content of these citrus futures' prices? Although our model is designed to address strategic implementation issues in a much broader context than that of Roll's citrus futures example, extensions of our basic model can be used to address such questions.

Recently, our research has received empirical support in Luo's 2001 thesis. Luo provides evidence that shows managers do learn from capital market prices in a takeover context. He demonstrates empirically that the capital market's unique information about the synergies associated with a proposed merger significantly affect the probability that the merger will be consummated, and thus concludes that "learning occurs in deals that are announced before firms have signed definitive merger agreements and in deals that happened in non-high technology industries" (Luo 2001, abstract). This work, when combined with Schipper and Thompson's 1983 finding that capital market prices respond when firms announce strategy changes, buttresses our initial claim that information flows occur bidirection-ally between firms and the capital market, and that managers can exploit these bidirectional flows to improve their strategic decision making.

This paper proceeds as follows. The next section presents the basic model setup. Section 3 contains the formal analysis of how managers can learn from observing the capital market's price reaction to proposed strategy changes. Section 4 discusses various extensions of the analysis, and section 5 contains a summary of the paper's principal conclusions.

2. Model setup

The value of a firm derives from the value of the businesses it already operates in conjunction with the value of the options on those businesses it may enter in the future. To present the results as starkly as possible, we begin by assuming that the firm under examination consists of nothing but an option on some future business opportunity. (After introducing the base model, we will show how the analysis can be extended to instances in which the firm has a pre-existing line of business.) Thus, as of some initial date 0, the market price of the firm, P₀, is the capital market's assessment of the expected present value of the cash flows from a project/business that the firm has yet to identify or operate. To avoid inessential notational clutter, we ignore discounting in the following and we posit risk-neutral pricing. At some later date 1, with probability $q \in [0, 1]$, the manager of the firm identifies a new business opportunity/project that it may, but need not, implement. Capital market participants collectively react to the manager's announcement of the availability of the new project by producing an estimate $v = v(\tilde{y})$ of the new project's expected discounted value if implemented.⁵ Here, \tilde{y} has density h(y) and support $[y, \bar{y}]$, where $v(y) < 0 < v(\bar{y})$, and $v(\bar{y})$ is a differentiable, strictly increasing function of \tilde{y} that determines the date 1 price of the firm, $P_1(\tilde{y})$.

Capital market participants' collective assessment $v(\tilde{y})$ of the new project's value is an aggregation of individual investors' assessments. For example, if the

"true" value of the project is the realization of some (unknown) normally distributed random variable \tilde{u} , there are *n* investors, and investor *i*'s assessment of the project's value is $\tilde{y}_i = \tilde{u} + \tilde{\varepsilon}_i$, where $\{\tilde{\varepsilon}_i | i = 1, ..., n\}$ is a set of independent, normally distributed, mean zero error terms, then the collective assessment $v(\tilde{y})$ is given by $v(\tilde{y}) = \tilde{y} \equiv 1/n \sum_{i=1}^{n} \tilde{y}_i$, because this is a sufficient statistic for the information collectively possessed by investors with regard to the new project's value. As another example, if investor *i*'s information \tilde{y}_i is uniformly distributed on $[0, \tilde{u}]$, where \tilde{y}_i and \tilde{y}_j are independent conditional on \tilde{u} , then the collective assessment of the market is some function $v(\tilde{y})$ of the sufficient statistic $\tilde{y} \equiv \max\{\tilde{y}_1, ..., \tilde{y}_n\}$. As these examples illustrate, we posit that information about the value of the new project is widely dispersed — no individual possesses this information. Thus, the only way for the manager to obtain the market's collective assessment \tilde{y} about the project's value is to infer it from the price reaction to the manager's announcement of the project's availability.

We take the process by which the capital market aggregates the information \tilde{y} as exogenous. For the initial display of our results, we also suppose that the manager has no private assessment of the new project's value. Later, we extend the model by supposing that the manager has his or her own private assessment of the new project's value.

The manager looks to the capital market to obtain guidance about the desirability of implementing the new project. Since \tilde{y} — the information capital market participants collectively learn about the new project — is dispersed across investors, the only way the firm's manager can hope to learn \tilde{y} is by making inferences from the market's price reaction $P_1(\tilde{y}) - P_0$ to the new project's announcement. We focus on investigating whether, and how, this price reaction conveys enough information to improve the manager's strategic decision making with regard to project implementation.

A "project adoption rule" specifies when the manager will implement the project as a function of information the manager either observes directly or can infer from observing the price reaction to the project's announcement; such rules must be measurable with respect to the manager's information set. An equilibrium relative to a project adoption rule specifies the firm's market price at each date, along with the manager's project implementation decision, so that

- there is enough information in the price reaction to the new project's announcement for the manager to implement the project adoption rule; and
- the price of the firm at each date equals the market's perception of the firm's expected cash flows at that date, assuming that the manager acts in accordance with the project adoption rule.

In equilibrium, we posit that the manager is willing to implement whatever project adoption policy investors instruct him or her to, as long as there is enough information in market prices for him to adhere to the specified policy.⁶

3. Analysis

What is a good project adoption rule? We start by studying an intuitive rule: have the manager implement all those new projects and only those new projects that garner a strictly positive price reaction upon announcement. Formally:

DEFINITION 1. The "positive price reaction rule": The manager implements the new project when it arrives if and only if the price reaction to the new project's arrival, $P_1(y) - P_0$, is positive.

This rule impounds the seemingly sound idea that "good" projects are those for which the price reaction attending their arrival is positive, and, therefore, "good" projects should be implemented. Inversely, "bad" projects are those for which the price reaction attending their arrival is negative, and, therefore, such projects should be avoided.

In general, equilibrium pricing dictates that the date 0 price P_0 impound the option value of proceeding with the new project based on the manager's anticipated adoption of a specific project adoption rule. Under the positive price reaction rule, the price P_0 is recursively linked to the price(s) $P_1(y)$ through the following equation:

$$P_0 = q \times \int_{y': P_1(y') - P_0 > 0} v(y') h(y') dy'$$
(1).

That is, because the market is assumed to engage in risk-neutral pricing, the price of the firm at date 0 is the product of the probability that a project will arrive at the firm at date 1 and the expected value of those projects that the market expects the manager to implement. Under the positive price reaction rule, the date 1 price of the firm is further linked to the date 0 price through:

$$P_{1}(y) = \begin{cases} v(y), \text{ if a new project arrives and } P_{1}(y) - P_{0} > 0\\ 0, \text{ if a new project arrives and } P_{1}(y) - P_{0} \le 0\\ 0, \text{ if no new project arrives} \end{cases}$$
(2).

With ϑ denoting the set of realizations of \tilde{y} for which the market believes the manager will implement the new project when $\tilde{y} = y$, it follows that, under the positive price reaction rule,

$$\vartheta = \{y | P_1(y) - P_0 > 0\}$$

= $\{y | v(y) - q \int_{y': P_1(y') - P_0 > 0} v(y') h(y') dy' > 0\}$
= $\{y | v(y) > q \int_{y' \in \vartheta} v(y') h(y') dy'\}$ (3).

This demonstration suggests that if $y \in \vartheta$ and y'' > y, then $y'' \in \vartheta$ also — that is, that ϑ is an interval of the form $(y_{inf}, \overline{y}]$ for some lower bound y_{inf} . In this paper, we confine our study to equilibria for which ϑ is such an interval, and we call such equilibria "natural".⁷ Since v(y) is strictly, continuously increasing in y, in any natural equilibrium in which ϑ is neither an empty set nor all of $(y, \overline{y}]$, we have:

$$\mathbf{v}(y_{\text{inf}}) = q \times \int_{y' \in \mathcal{D}} \mathbf{v}(y') \mathbf{h}(y') dy'$$

$$= q \times \int_{y' > y_{\text{inf}}} \mathbf{v}(y') \mathbf{h}(y') dy' \qquad (4).$$

Notice that the recursion in prices depicted in (1) and (2) generates the recursion defining y_{inf} . An equilibrium exists if and only if the latter recursion is well-defined. The following theorem characterizes several features of the equilibria that arise under the positive price reaction rule.

- THEOREM 1. There are two natural equilibria corresponding to the positive price reaction rule. In one equilibrium, ϑ is empty and no new project is ever adopted. In the other equilibrium:
 - (a) ϑ is the interval (yinf, \overline{y}] where yinf is the unique fixed point of the function $\Psi(y) \equiv v^{-1}[q \times \int_{y'>y} v(y')h(y')dy']$.
 - (b) As long as q > 0, v(yinf) is positive, and all positive net present value projects with values v(y) ∈ (0, v(yinf)) are forgone.
 - (c) The performance of the positive price reaction rule worsens as q increases. That is:
 - (i) $y_{inf}(q)$ increases in q;
 - (ii) conditional on a new project arriving, each of: the probability that positive NPV projects will be forgone, the fraction of positive NPV projects forgone, and the expected value of the positive NPV projects forgone, is increasing in q;
 - (iii) as q approaches zero, virtually all positive NPV projects are implemented under this rule.

Proof of Theorem 1

First, suppose the market believes that the manager will never implement the new project — that is, the set ϑ is empty. Then, the market price P_1 will be identically 0, as will be the price P_0 . Thus, there will never be a (positive) price reaction to a new project's arrival. So, if the manager implements the new project only upon observing a positive price reaction to the new project's arrival, the manager will never implement the project. Thus, the set ϑ is empty constitutes an equilibrium.

Next, suppose that the set ϑ is not empty. By the observations preceding the statement of Theorem 1 above, if a natural equilibrium exists, then ϑ is an interval of the form $\vartheta = (y_{inf}, \bar{y}]$ that satisfies the recursion (4). Clearly, the existence of a y_{inf} satisfying (4) is equivalent to the existence of a fixed point of $\psi(\bullet)$. We now show that $\psi(\bullet)$ has a unique fixed point y_{inf} , and this fixed point belongs to the interval (y_0, \bar{y}) , where y_0 is defined by $v(y_0) \equiv 0.^8$ This will complete the proof of parts (a) and (b) of the theorem, since demonstrating $y_{inf} > y_0$ will establish that $v(y_{inf}) > 0$.

Note that y_{inf} is a fixed point of $\psi(\bullet)$ if and only if y_{inf} is a root of the function $\chi(y) \equiv v(y) - q \int_y^{\overline{y}} v(y')h(y')dy'$. Since $0 < q \le 1$, $\int_y^{\overline{y}} h(y')dy' \le 1$, and $v(\bullet)$ is strictly increasing, it follows that, for $y \le y_0$, that is, for $v(y) \le 0$,

$$\mathbf{v}(y) \le q \mathbf{v}(y) \int_{y}^{\bar{y}} \mathbf{h}(y') dy' < q \int_{y}^{\bar{y}} \mathbf{v}(y') \mathbf{h}(y') dy'.$$

This proves that $\chi(y) < 0$ whenever $y \le y_0$, and hence that $\chi(y)$ has no root in the interval $[\underline{y}, y_0]$. Observe next that $0 < v(\overline{y}) = \chi(\overline{y})$. These facts, combined with the continuity of $\chi(\bullet)$ (which follows by the fundamental theorem of calculus), establish that $\chi(y)$ has at least one root in (y_0, \overline{y}) and no roots anywhere else. Since $(d/dy)\chi(y) = v'(y) + qv(y)h(y)$ is positive for $y > y_0, \chi(y)$ has only one root in (y_0, \overline{y}) , and hence only one root in all of $[\underline{y}, \overline{y}]$. This proves parts (a) and (b) of the theorem.

For fixed q, let $y_{inf} = y_{inf}(q)$ be this root — that is,

$$v(y_{\inf}(q)) = q \int_{y_{\inf}(q)}^{\bar{y}} v(y') h(y') dy'$$
(5).

It is clear that $y_{inf}(q)$ increases in q, because assuming the contrary leads to a contradiction: were it to decrease in q, then the left-hand side of (5) decreases in q while the right-hand side of (5) increases in q (the latter fact follows from the previously demonstrated fact that $v(y_{inf}(q)) > 0$, so $\int_{y_{inf}(q)}^{\bar{y}} v(y')h(y')dy'$ gets larger as $y_{inf}(q)$ falls). This proves (c)(i). Part (c)(ii) follows immediately, since each of $\int_{y_0}^{y_{inf}(q)} h(y')dy'$, $\int_{y_0}^{y_{inf}(q)} h(y')dy'/\int_{y_0}^{\bar{y}} h(y')dy'$, and $\int_{y_0}^{y_{inf}(q)} v(y')h(y')dy'$ obviously increases in q. To prove (c)(iii), note that $\lim_{q\to 0}q \int_{y_{inf}(q)}^{\bar{y}} v(y')h(y')dy' = 0$, hence $\lim_{q\to 0} v(y_{inf}(q)) = 0$.

There are three noteworthy features of the theorem. First, notwithstanding the extraordinarily recursive specification of prices associated with the positive price reaction rule depicted in (1) and (2), the rule is internally consistent — it leads to well-defined market prices and an equilibrium in which the firm's market price at all times correctly anticipates that the manager will adopt only projects that yield

positive price reactions. Second, except for the case where q = 0, the positive price reaction rule is deficient in so far as it leaves many positive NPV projects unadopted. The intuition for this is clear: under the positive price reaction rule, only projects that are, in some sense, "better than average" are implemented, because the reference point in deciding whether or not a project is adopted is whether the date 1 price is above the date 0 price.⁹ Third, the set of positive NPV projects forgone under the positive price reaction rule contracts as q declines, and shrinks to the empty set as q approaches zero. Thus, when the arrival of the new project is "completely" unexpected (that is, q = 0), the positive price reaction rule gets all positive NPV projects implemented. The intuitively appealing nature of the positive price reaction rule derives from the attention we implicitly attach to instances in which the market is completely surprised by the arrival of a new project.

We next present two applications of the theorem. In the first application, we take v(y) = y and \tilde{y} uniformly distributed on $[\underline{y}, \overline{y}]$, with $\underline{y} < 0 < \overline{y}$. In this case, (5) specializes to:

$$y_{\text{inf}} = q \int_{y_{\text{inf}}}^{\overline{y}} y' h(y') dy'$$
$$= q \Pr(\overline{y} > y_{\text{inf}}) \mathbb{E}[\overline{y} | \overline{y} > y_{\text{inf}}]$$
$$= q \frac{\overline{y} - y_{\text{inf}}}{\overline{y} - y} \frac{\overline{y} + y_{\text{inf}}}{2}.$$

This equation defines a quadratic in y_{inf} . The pertinent solution of this quadratic equation — that is, the positive solution — is given by¹⁰

$$y_{\text{inf}} = \frac{(\overline{y} - \underline{y})}{q} \left[-1 + \sqrt{1 + \left(\frac{q\overline{y}}{\overline{y} - \underline{y}}\right)^2} \right].$$

By rewriting y_{inf} in terms of the mean $(\mu = (\bar{y} + y)/2)$ and variance $(\sigma^2 = (\bar{y} - y)^2/12)$ of this uniform distribution, we obtain the following results. The claims made in Examples 1 and 2 below are proven in the appendix.

Example 1

When \tilde{y} is uniformly distributed with mean μ and variance σ^2 with $\mu - \sigma\sqrt{3} = y \le 0 \le \bar{y} = \mu + \sigma\sqrt{3}$, the positive price reaction rule is in effect, and $\vartheta \neq \phi$:

(i) Conditional on a new project arriving, the probability that a positive NPV project is not adopted is given by

$$\frac{1}{q}\left\{-1+\sqrt{1+\left[\frac{q(\mu+\sqrt{3}\sigma)}{2\sqrt{3}\sigma}\right]^2}\right\}$$
(6).

This probability increases in μ and q and decreases in σ , and (for $\mu \le \sigma \sqrt{3}$ and q = 1) can be as high as 41.4 percent. In the case $\mu = 0$ and q = 1, approximately 23.6 percent of the available positive NPV projects are forgone.

(ii) The expected value of the positive NPV projects forgone is given by

$$\frac{\sqrt{3}\sigma}{q} \left\{ -1 + \sqrt{1 + \left[\frac{q(\mu + \sqrt{3}\sigma)}{2\sqrt{3}\sigma}\right]^2} \right\}^2$$
(7).

This last expected value is not monotonic in σ , but is monotonically increasing in μ and achieves a maximum (for $\mu \le \sigma \sqrt{3}$ and q = 1) of 0.297 σ . At $\mu = \sigma \sqrt{3}$ and q = 1, this constitutes approximately 17.2 percent of the expected value of all positive NPV projects. When $\mu = 0$ and q = 1, approximately 5.57 percent of the expected value of all positive NPV projects is lost.

As a second application of the theorem, take v(y) = y and \tilde{y} normally distributed with mean 0 and variance $\sigma^{2,11}$ In this case, y_{inf} solves:

$$y_{\text{inf}} = \frac{q}{\sigma\sqrt{2\pi}} \int_{y_{\text{inf}}}^{\infty} y' e^{-y'^2/2\sigma^2} dy'$$
$$= \frac{q\sigma}{\sqrt{2\pi}} e^{-y_{\text{inf}}^2/2\sigma^2}$$
(8).

Equation (8) is nonlinear in y_{inf} with parameters q and σ . From Theorem 1, we know that there exists a unique solution $y_{inf} = y_{inf}(q, \sigma)$, and this solution is positive (since $y_{inf} = v(y_{inf}, q) > 0$) and increasing in q. An inspection of (8) reveals that $y_{inf}(q, \sigma)$ is linear in σ — that is, $y_{inf}(q, \sigma) = k^*(q) \times \sigma$, where the constant $k^*(q)$ is independent of σ .¹² Clearly, k(0) = 0, and k(q) increases in q. Numerical analysis establishes that k(1) is approximately 0.372. In the following discussion, the numerical results are confined to q = 1, which (by Theorem 1) is the case for which the positive price reaction rule performs worst.

Example 2

When \tilde{y} is normally distributed with mean 0 and variance σ^2 , the positive price reaction rule is adopted, and ϑ is nonempty:

(i) Conditional on a new project arriving, the probability that a positive NPV project is not adopted is increasing in q and independent of σ , and (for q = 1) can be as high as 14.5 percent; in that case, approximately 29 percent of the available positive NPV projects are forgone.

(ii) The expected value of the positive NPV projects forgone is increasing in σ . When q = 1, the expected value of positive NPV projects forgone is 0.0267 σ ; this constitutes approximately 6.69 percent of the expected value of all positive NPV projects.

The examples demonstrate that the performance of the positive price reaction rule when $\mu = 0$ and q = 1 is similar for projects whose values are either uniformly or normally distributed random variables: in both cases, somewhat more than 20 percent of the positive NPV projects are forgone under this rule, which results in losing approximately 6 percent of the expected value of all positive NPV projects. The performance of the positive price reaction rule, as measured by the percentage of positive NPV projects not implemented under the rule, is worse than the performance of the rule, as measured by the the forgone expected value of unimplemented projects, because the positive NPV projects that the rule fails to implement are those with relatively low expected values.

We now show that, when q > 0, there is a much better rule for the manager to adopt than the positive price reaction rule. To state this better rule, we recall that y_0 is defined by $v(y_0) = 0$ — that is, y_0 is that critical threshold for the market's information at which the NPV of the new project is zero.

THEOREM 2. Among all project adoption rules that are functions of the price reaction $P_1 - P_0$ to the announcement of a new project, there is a uniquely optimal rule that implements all those and only those projects that have positive expected NPV, defined as follows: with $\Delta \equiv -q \times \int_{y_0}^{\bar{y}} v(y)h(y)dy$, the rule requires the manager to adopt all those projects and only those projects for which the price reaction $P_1(y) - P_0$ is strictly greater than Δ — that is, for which the firm's market price either rises by any positive amount or falls by strictly less than $-\Delta$.

Proof of Theorem 2

The first part of this proof will demonstrate the implementability of the stated policy. Given this demonstration, the rule's optimality is immediate (since it necessarily maximizes the firm's expected NPV by implementing all positive and no negative NPV projects). The second part will demonstrate the rule's uniqueness within the class stated in the theorem.

If the investors believe that the manager will implement all positive NPV projects, then the date 0 price of the firm will be

$$\mathbf{P}_0 = q \int_{y_0}^{\bar{y}} \mathbf{v}(y) \mathbf{h}(y) dy = -\Delta.$$

Now, suppose that at date 1 a new project arrives and the market learns $\tilde{y} = y$ where v(y) > 0. Then, investors — acting on their belief that the manager will implement all positive NPV projects — will price the firm at date 1 at: $P_1 = v(y)$. So, the price reaction $P_1(y) - P_0$ will be

$$\mathbf{v}(\mathbf{y}) - \mathbf{P}_0 = \mathbf{v}(\mathbf{y}) + \Delta > \Delta.$$

Thus, since this price reaction strictly exceeds Δ , the manager — upon observing this price reaction (and acting in conformity with the " Δ project adoption rule") — will implement the new project, thereby fulfilling investors' beliefs.

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Next, suppose that at date 1 a new project arrives and the market learns $\tilde{y} = y$ where $v(y) \le 0$. Investors in this instance believe the manager will not implement the new project, and so they price the firm at $P_1(y) = 0$. Consequently, in this case, the price reaction $P_1(y) - P_0$ is $-P_0 = \Delta$. Since the manager implements the new project only if the price reaction strictly exceeds Δ , the manager does not implement the project in this case, once again fulfilling investors' beliefs. This establishes that the Δ project adoption rule is both implementable and optimal.

We conclude by establishing that this policy is uniquely optimal.¹³ As above, let $\vartheta \equiv \{y | \text{the manager implements the project when } \tilde{y} = y\}$. ϑ can be described in two alternative ways. On the one hand, ϑ equals $\vartheta_1 \equiv \{y | v(y) > 0\}$ — that is, the set of implemented projects consists of just the positive NPV projects. On the other hand, ϑ equals $\vartheta_2 \equiv \{y | P_1(y) - P_0 > k\}$ for some k — that is, the set of projects implemented consists of those projects whose announcement yields a price reaction strictly greater than k. The set ϑ_2 can be rewritten as

$$\vartheta_2 = \{y | \mathbf{v}(y) - q \int_{y_0}^{\bar{y}} \mathbf{v}(y) \mathbf{h}(y) dy > \mathbf{k}\} = \{y | \mathbf{v}(y) > \mathbf{k} + q \int_{y_0}^{\bar{y}} \mathbf{v}(y) \mathbf{h}(y) dy\}.$$

For ϑ_1 and ϑ_2 to coincide, the right-hand sides of these two alternative specifications of ϑ must coincide. This requires $k = -q \int_{y_0}^{y} v(y)h(y)dy$ — that is, $k = \Delta$. This proves the uniqueness of the Δ project adoption rule.

The project adoption rule specified in Theorem 2 results in the best possible equilibrium, because all positive NPV projects, and no negative NPV projects, get implemented. These rules are easy to calculate once specific distributions for the NPV of the new project are determined. We illustrate this for the two examples previously presented. For Example 1, with a uniform distribution,

$$\Delta \equiv -q \int_0^{\bar{y}} y h(y) dy = -q \frac{\left(\mu + \sigma \sqrt{3}\right)^2}{4\sigma \sqrt{3}}$$
(9).

For Example 2, with a normal distribution,

$$\Delta \equiv -\frac{q}{\sigma\sqrt{2\pi}} \int_0^\infty y e^{-y^2/2\sigma^2} dy = -q \frac{\sigma}{\sqrt{2\pi}}.$$

By examining these two expressions, we deduce:

REMARK 1.

- (a) When v(y) = y and \tilde{y} is either uniformly or normally distributed, Δ decreases in σ .
- (b) When v(y) = y and \tilde{y} is uniformly distributed, Δ also decreases in μ for $\mu \sigma\sqrt{3} = y \le 0 \le \mu + \sigma\sqrt{3} = \bar{y}$.

The comparative statics detailed in Remark 1 are intuitive: in the uniform case, when the (unconditional) mean of the new project rises, the mean of the new project conditional on the new project having positive NPV also rises. So, when investors anticipate that all positive NPV projects will be implemented, the price of the firm before the manager's announcement of the availability of a new project will rise with the mean. Therefore, the range of negative price reactions associated with the new project's implementation must expand to ensure that no positive NPV project is discarded. The intuition underlying the comparative static for variance follows from the fact that the new project is, effectively, a call option with an exercise price of zero. As is well known, the value of a call option increases with the variance of the distribution of the asset on which the call option is based. Hence, increases in the variance of the new project's value also cause the price of the firm before the announcement of the new project to rise, and hence — just as in the case when the project's mean rises — requires that implementation of the new project be associated with a wider range of negative stock price reactions to the new project's announcement to ensure the implementation of all positive NPV projects.

4. Extensions

Privately informed managers

Suppose that, at date 0, the firm already operates in some line of business, and the market's assessment of the value of that business is \tilde{x} . Further suppose that, when the new project arrives, only the manager learns of its arrival and that, additionally, the manager receives a private assessment $\tilde{y}_m \in [y_m, \bar{y}_m]$ about the project's value. If the manager alerts the market to the existence of the project, then the market, as before, produces information \tilde{y} related to the project's expected value. The project's value, based on the combined assessment is not available directly to any single individual. We take $v(\bullet)$ to be continuous and strictly increasing in both arguments. We require there to be a differentiable function $y_m^*(y) \in (y_m, \bar{y}_m)$ such that $v(y, y_m^*(y)) \equiv 0$, and so $v(y, y_m)$ is positive or negative, depending on whether y_m is bigger or smaller than $y_m^*(y)$. We let $h(y_m|y)$ denote the conditional density of \tilde{y}_m given y. Finally, we assume that the manager's and market's information "move together". An increase in y increases (in the sense of strict first-order stochastic dominance) the conditional distribution of \tilde{y}_m given y.

We assume that the manager credibly announces the existence of the project to the capital market, but the manager cannot credibly announce the value \tilde{y}_m .¹⁴ In this case, shareholders cannot perfectly predict whether the new project will be adopted based solely on their own information. But, we will now show that this is inessential: prices and disclosures (about the new project's availability) can still serve a strategy-directing role.

If shareholders believe that the manager can infer the realization y of the market's information \tilde{y} from observing the price/price reaction following the manager's announcement of the new project's arrival and — following this inference — proceed to implement the project only when its NPV (calculated based on the combined

information (y, y_m) is positive, then the date 1 and date 0 prices of the firm will be given by, respectively,

$$P_1(x, y) = x + \int_{\underline{y}_m}^{\overline{y}_m} \max\{0, v(y, \, \widetilde{y}_m)\} h(\widetilde{y}_m | y) d\widetilde{y}_m = x + \int_{\underline{y}_m^*(y)}^{\overline{y}_m} v(y, \, \widetilde{y}_m) h(\widetilde{y}_m | y) d\widetilde{y}_m$$

and

$$P_0(x) = x + q \int_{\underline{y}} \int_{\underline{y}_m}^{\overline{y}_m} \max\{0, \mathbf{v}(y, \, \tilde{y}_m)\} \mathbf{h}(\tilde{y}_m | y) d\tilde{y}_m \mathbf{h}(y) dy.$$

The critical observation is that the date 1 price constructed in this way is strictly monotone increasing in y:¹⁵

$$\begin{aligned} \frac{\partial}{\partial y} \mathbf{P}_{1}(x, y) &= -\mathbf{v}(y, y_{m}^{*}(y))\mathbf{h}(y_{m}^{*}(y)|y)\frac{d}{dy}y_{m}^{*}(y) + \int_{y_{m}^{*}(y)}^{y_{m}}\mathbf{v}_{y}(y, \tilde{y}_{m})\mathbf{h}(\tilde{y}_{m}|y)d\tilde{y}_{m} \\ &+ \int_{y_{m}^{*}(y)}^{\bar{y}_{m}}\mathbf{v}(y, \tilde{y}_{m})\mathbf{h}_{y}(\tilde{y}_{m}|y)d\tilde{y}_{m} \\ &= \int_{y_{m}^{*}(y)}^{\bar{y}_{m}}\mathbf{v}_{y}(y, \tilde{y}_{m})\mathbf{h}(\tilde{y}_{m}|y)d\tilde{y}_{m} + \int_{y_{m}}^{\bar{y}_{m}}\max\{0, \mathbf{v}(y, \tilde{y}_{m})\}\mathbf{h}_{y}(\tilde{y}_{m}|y)d\tilde{y}_{m} > 0 \end{aligned}$$

That is, if the market believes that the manager can infer and exploit the information in the market price, then the market price will, in fact, have enough information in it for the manager to discern the realization of \tilde{y} by observing the market price. Moreover, if the probability q is equal to (or even sufficiently near) 1, then — as in the preceding section — there will be a positive probability that the manager will implement the project even though the price reaction to the project's announcement is negative. This follows since $\Pr(\tilde{y}_m > y_m^*(y)|y) > 0$ for each y (since $y_m^*(y) \in (\underline{y}_m, \overline{y}_m)$) and, for q = 1, $\Pr_0(x) = \mathbb{E}[\Pr_1(x, \overline{y})|x]$ for all x — so, since $\Pr_1(x, y)$ varies with y, we know that $\Pr(\Pr_1(x, \overline{y}) < \Pr_0(x)|x) > 0$. For q sufficiently near one, the same argument applies.

This proves the following:

LEMMA 1. Under the distributional assumptions of this subsection, when both the manager and the market have information pertinent to valuing the project, and the manager cannot disclose the value of his information, there is enough information in the price reaction to the project's announcement so as to permit the manager to make "first-best" project adoption decisions. For q sufficiently near 1, the project is implemented with positive probability even when the price reaction to the project's announcement is negative.

Managers facing project continuation/abandonment decisions

In this subsection, we apply the analysis to instances in which a firm is deciding whether to continue or abandon a previously initiated strategy. The principal new issue introduced by the abandonment/continuation decision is that, in the event of project abandonment, some of the original costs of investment in the project may be recouped. We now give a simple illustration of how the model of the preceding sections can be modified to accommodate this situation. Suppose that at date 0, the manager anticipates that by date 1, he will receive what appears to him to be an attractive (positive NPV) project with probability q. If such a project arrives, we assume the manager provisionally invests in it, expending k. After having some experience running the project, the manager announces the project to the market at date 2, at which time the market generates an estimate v(y) of the project's value. As before, the manager tries to extract the information v(y) from the market's price reaction $P_2 - P_0$ to the project's announcement in deciding whether to continue with the project. If the manager decides to abandon the project, the firm can recoup fraction α of its original investment in the project. That is, $(1 - \alpha)k$ represents the sunk cost associated with abandoning the project in midstream.

Clearly, an optimal project abandonment/continuation decision entails continuing with the project if and only if $v(y) > \alpha k$. If we presume that the manager can fully extract the market's information v(y) from observing the price reaction, and the manager adheres to an optimal abandonment/continuation policy, the date 2 price of the firm will be given by

$$P_2(y) = \begin{cases} v(y) \text{ for } v(y) > \alpha k \\ \alpha k \text{ for } v(y) \le \alpha k. \end{cases}$$

Anticipating this, the date 0 price of the firm will be

$$\mathbf{P}_0 = q\left(\int_{\underline{y}}^{\overline{y}} \max\{\alpha k, \mathbf{v}(y)\}\mathbf{h}(y)dy - k\right).$$

So, the price reaction $P_2(y) - P_0$ corresponding to an optimal abandonment/continuation decision is

$$\mathbf{v}(y) - \mathbf{P}_0 = \mathbf{v}(y) - q\left(\int_{\underline{y}}^{\overline{y}} \max\{\alpha k, \mathbf{v}(y)\}\mathbf{h}(y)dy - k\right) \text{ for } \mathbf{v}(y) > \alpha k,$$

and $\alpha k - q\left(\int_{\underline{y}}^{\overline{y}} \max\{\alpha k, v(y)\}h(y)dy - k\right)$ for $v(y) \le \alpha k$. This yields the following corollary:

COROLLARY 1. The price reaction that leads to the optimal project abandonment/continuation decision entails continuing with the project if and only if the price reaction strictly exceeds

$$\Delta_{\alpha} \equiv (\alpha + q)k - q \int_{\underline{y}}^{\overline{y}} \max\{\alpha k, v(y)\}h(y)dy.$$

As an example, if \tilde{y} is uniformly distributed on [-0.5, 0.5] — that is, $\bar{y} = 0.5 = -y$, $v(y) \equiv y$, and q = 1, then $\Delta_{\alpha} = k + 0.5[\alpha k - (\alpha k)^2 - 0.25]$, for $\alpha k \in [0, 0.5]$. At k = 0, $\Delta_{\alpha} = -0.125$ and at k = 0.5 and $\alpha = 1$, $\Delta_{\alpha} = 0.5$. Δ_{α} is easily shown to be strictly increasing in α for fixed k. That is, as α increases, the set of price reactions that lead a value-maximizing manager to continue with the project shrinks. Equivalently, as the sunk cost $(1 - \alpha)k$ increases, the project optimally is continued for an expanded set of price reactions. When phrased in this way, this result appears to indicate that the manager, in deciding whether to continue with the project, is exhibiting behavior consistent with the sunk-cost fallacy — in so far as the manager is more likely to continue with the project the larger the project's sunk costs. Since we know that the manager's strategy was constructed to be NPV-maximizing, this appearance must be illusory. The apparent paradox is resolved by noting that, here, increases in sunk costs are tantamount to reductions in the value of a project's abandonment.

The prospect of being able to reverse a previously adopted project/strategy based on the capital market's assessment of it also influences the circumstances under which a manager will initiate the project/strategy in the first place. It is easy to show that the "real option" component of the manager's initial project adoption decision — introduced by the opportunity to exploit the market's subsequent assessment of the value of continuing the project — will induce the manager to experiment by undertaking a wider array of projects than would be the case were the market's assessments of the project's continuation value ignored.¹⁶ Furthermore, the amount of this experimentation will increase the smaller the irreversible investment in the new project. Thus, to the extent that better-quality managers are more willing to "listen to the capital markets" by predicating their decision to continue with or abandon a project based on the market's evaluation of the project, or to the extent that better-quality managers are capable of structuring their investments in new projects so as to economize on the irreversible costs of those investments, it follows that firms that have a higher-than-average propensity to abandon past strategic initiatives may in fact be run by above-average-quality managers. Thus, decisions for reversals in strategic direction need not necessarily impugn the reputations of managers who make them.

Having the option to abandon or continue a previously adopted project based on information inferred from the firm's stock price is a special case of being able to change existing operations based on such information. While some operating changes are necessarily discrete, as in the abandonment/continuation decision, often they are continuous — as when a firm changes its output in anticipation of changes in supply or demand conditions. We conclude this subsection by showing that, very generally, managers may also be able to "read from the market" in those cases of continuous change. To illustrate this, suppose the value of a firm x in its existing line of business depends upon what operating actions a it takes and what random events occur. Summarize these random events by the realization ω of the random variable $\tilde{\omega}$, so $x = x(a, \omega)$. If the firm's manager knew ω , he would select a = $a(\omega)$ to maximize x — that is, $x(a(\omega), \omega) = \max_{\alpha} x(\alpha, \omega)$. Under many common regularity conditions, $x(a(\omega), \omega)$ is strictly monotone in ω .¹⁷ If the date 0 price of the firm P_0 is set before ω is known, and the market anticipates that the manager will act optimally based on his subsequent knowledge of ω , then the date 0 and date 1 prices of the firm will be given by $P_0 = E[x(a(\tilde{\omega}), \tilde{\omega})]$ and (presuming that the market knows $\tilde{\omega}$'s realization at date 1) $P_1(\omega) = x(a(\omega), \omega)$. Observe that, under the preceding assumptions, the price reaction $P_1(\omega) - P_0$ will be monotone in ω . So, even if — contrary to the preceding presumptions — only the capital market participants learn ω , the manager can infer the exact realization of ω by observing the price reaction $P_1 - P_0$, and so be guided to select the correct operating decision $a(\omega)$. Thus, there is a remarkably broad set of conditions under which a firm's operating decisions can be improved when the manager contemplates extracting information from price changes in the capital markets.

5. Conclusions

Disclosures by firms can serve many functions: they may reduce a firm's cost of capital (e.g., Botosan 1997), mitigate agency problems with management (Christensen and Feltham 2000), influence a rival's competitive strategy (e.g., Dye 1985; Feltham and Xie 1992), and affect product market competition (e.g., Clarke 1983; Darrough 1993; Feltham, Gigler, and Hughes 1992; Kirby 1988; Vives 1984). We have introduced yet another possible role for disclosures: disclosures of potential strategy changes may provoke the capital market's information machinery to go into operation, and the information implicit in the price reactions to such disclosures may allow managers to improve their strategic decision making.

Appendix

Proof for claims in Example 1

(i) Equation (6) is simply $y_{inf}/(\bar{y} - y)$ re-expressed in terms of μ and σ . Calculated at $\mu = \sigma \sqrt{3}$ and q = 1, this is 41.4 percent. When $\mu = 0$ and q = 1, 23.6 percent is the value of the ratio

$$\left(\frac{y_{\inf}-0}{\overline{y}-\underline{y}}\right) / \left(\frac{\overline{y}-0}{\overline{y}-\underline{y}}\right) = \frac{y_{\inf}}{\overline{y}},$$

evaluated at $\mu = 0$ and q = 1. (ii) Equation (7) is

$$\frac{q}{\bar{y}-\underline{y}}\int_0^{y_{\inf}} y dy = \frac{qy_{\inf}}{2(\bar{y}-\underline{y})},$$

expressed in terms of μ and σ . It achieves a maximum value of

$$0.297\sigma \approx \frac{\sqrt{3}\sigma}{q} \left\{ -1 + \sqrt{1 + \left[\frac{q(\mu + \sqrt{3}\sigma)}{2\sqrt{3}\sigma}\right]^2} \right\}^2$$

at q = 1 and $\mu = \sqrt{3}\sigma$.

When $\mu = 0$, the expected value of all positive NPV projects is

$$\frac{1}{\overline{y}-\underline{y}}\int_0^{\overline{y}} ydy = \frac{(\sigma\sqrt{3})^2}{4\sigma\sqrt{3}} = \frac{\sigma\sqrt{3}}{4}.$$

So, the expected value of projects lost under the positive price reaction rule as a fraction of the total expected value of positive NPV projects is

$$\frac{\sigma\sqrt{3} \times \left[-1 + \sqrt{1 + \left(\frac{\sigma\sqrt{3}}{2\sigma\sqrt{3}}\right)^2}\right]^2}{(\sigma\sqrt{3})/4} = 4\left(-1 + \sqrt{\frac{5}{4}}\right)^2 \approx 0.0557.$$

Proof for claims in Example 2

(i) It was demonstrated in the text that

$$y_{inf} = y_{inf}(q, \sigma) = k(q) \times \sigma.$$

So, conditional on a new project arriving, the probability that a positive NPV project is not adopted is

$$Pr(0 < \tilde{y} < y_{inf}(\sigma) | \sigma) = \frac{1}{\sigma \sqrt{2\pi}} \int_{0}^{y_{inf}} e^{-y'^{2}/2\sigma^{2}} dy'$$
$$= \frac{1}{\sigma \sqrt{2\pi}} \int_{0}^{k(q)\sigma} e^{-y'^{2}/2\sigma^{2}} dy'$$
$$= \frac{1}{\sqrt{2\pi}} \int_{0}^{k(q)} e^{-z^{2}/2} dz.$$

(The last equality follows by using the transformation of variables $z = y/\sigma$.) Because this probability is independent of and the same for all σ , it suffices to evaluate this probability at $\sigma = 1$ — that is, we can evaluate $(q/\sqrt{2\pi}) \int_0^k e^{-y^2/2} dy \approx$ 0.145q. Since, for any σ , the measure of all positive NPV projects is $(1/\sigma\sqrt{2\pi}) \times$ $\int_0^\infty e^{-y^2/2\sigma^2} dy = 0.5$, the positive NPV projects forgone as a consequence of adopting the positive price reaction rule constitute 0.145/(1/2) = 29 percent of all positive NPV projects.

(ii) The expected value of the positive NPV projects forgone is

$$\frac{1}{\sigma\sqrt{2\pi}} \int_0^{\mathbf{k}(q)\sigma} y' e^{-y'^2/2\sigma^2} dy = \frac{\sigma}{\sqrt{2\pi}} \int_0^{\mathbf{k}(q)} z e^{-z/2} dz$$
(10).

When q = 1, (10) equals 0.0267034σ . Since the expected value of all positive NPV projects is

$$\frac{1}{\sigma\sqrt{2\pi}}\int_0^\infty y e^{-y^2/2\sigma^2} dy = \frac{\sigma}{\sqrt{2\pi}},$$

the fraction of positive NPV projects forgone is $0.0267034\sigma/(\sigma/\sqrt{2\pi}) = \sqrt{2\pi} \times 0.0267034 = 0.0669355$.

Endnotes

- 1. We wish to thank Linda Vincent for assistance in identifying these references.
- Luo (2001) makes the related point that, in the context of takeovers, learning from the capital market is most likely to occur when the capital market has unique information about the merger not possessed by the potential acquirer.
- 3. Because entrenched management can better afford to disregard the capital market's assessments of their actions.
- 4. This is consistent with Kanodia et al. 1989.
- 5. The distinction between \tilde{y} and $v(\tilde{y})$ will become clear when we extend the model to situations in which the manager has his or her own independent assessment of the new project's value.

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- 6. Dye and Sridhar (2000) examine how and when agency considerations between the firm's manager and shareholders can interfere with the firm's project adoption decision. Other extensions examined by them include study of strategy-directing disclosures when there are technological interdependencies between the "base" project and the new project, and when there are potential proprietary costs associated with the manager's disclosure of the new project in advance of implementation of the project.
- 7. In principle, there could be non-natural equilibria in which investors, for whatever reason, believe the manager will implement a project with value v(y) at the same time they believe the manager will not implement a project with value v(y') > v(y). While it is possible to rule out these unnatural equilibria by undertaking a more detailed examination of the price formation process, we do not undertake this examination here, since this would distract from the focus of our paper, which is to study how managers extract information embedded in capital market prices.
- 8. By the assumptions previously made on $v(\bullet)$, y_0 exists and is unique.
- 9. Given this, it is somewhat surprising that anything other than just the very best (highest NPV) projects are implemented under this rule. Such a "race to the top" would occur in the case q = 1 if y_{inf} were (incorrectly) defined by $v(y_{inf}) = E[v(\tilde{y})|\tilde{y} > y_{inf}]$, rather than

correctly defined as
$$v(y_{inf}) = \int_{y_{inf}}^{\tilde{y}} v(y')h(y')dy' = E[v(\tilde{y})|\tilde{y} > y_{inf}] \times Pr(\tilde{y} > y_{inf}).$$

- 10. Note that, as q approaches 0, this expression for y_{inf} approaches zero by applying L'Hospital's rule, so the example illustrates, consistent with Theorem 1, how the performance of the positive price reaction rule converges to "first-best" as q approaches zero.
- 11. The case where \tilde{y} is normal with a nonzero mean is intractable.
- 12. To see this, observe that if k solves

$$k = \frac{\sigma q}{\sqrt{2\pi}} e^{-k^2/2}$$

then $k\sigma$ satisfies

$$k\sigma = \frac{\sigma q}{\sqrt{2\pi}} e^{-k^2/2} = \frac{\sigma q}{\sqrt{2\pi}} e^{-(k\sigma)^2/2\sigma^2}.$$

- 13. As the theorem states, this demonstration of uniqueness is within the class of project adoption rules that depend on the price reaction to the project's announcement. There may be other rules that are equivalent to this rule (in that they result in the same equilibrium prices and the same set of implemented projects) but that take a slightly different form for example, rules depending on the ratios of price P_1/P_0 , or the returns $(P_1 P_0)/P_0$ to investing in the shares of the firm, etc.
- 14. Two additional comments are warranted here. First, it is reasonable to suppose that the manager will announce truthfully the arrival of new projects for three reasons: (a) since there is no moral hazard problem between himself and the firm's shareholders, there is no reason for the manager not to be honest regarding the arrival of a project; (b) the manager can make better decisions with regard to whether the new project should be implemented by combining his private information with the information he can extract from observing the price reaction to the project's announcement; and (c) were the

manager to announce falsely the arrival of a new project, subsequent investigation by shareholders would soon establish the manager's duplicity.

Second, whether the manager in practice could disclose the realization of his information \tilde{y}_m to the capital market depends upon what the nature of that information is — for example, on its dimensionality, "hardness" (Ijiri 1975), etc. If that information could be disclosed, then the analysis is basically the same as that already performed in the previous section of the paper: to see this, just replace v(y) with $v(y, y_m)$, and redefine Δ to be equal to

$$-q\int_{\underline{y}}^{\overline{y}}\int_{\underline{y}_m}^{\overline{y}_m}\max\{0,\mathbf{v}(\overline{y},\ \overline{y}_m)\}\mathbf{h}(y_m|y)\mathbf{h}(y)dy_mdy.$$

With these replacements, the analysis of the text is unchanged.

Incidentally, it is not difficult to show that even if the manager's announcement, say \hat{y}_m , of y_m is not truthful, the date 1 market price $P_I(y, \hat{y}_m)$ will be monotonic in y, and so the market price will continue to contain useful information with regard to the desirability of implementing the new project.

15. The integral

 $\int_{y_m^*(y)}^{\bar{y}_m} v_y(y, \tilde{y}_m) h(\tilde{y}_m | y) d\tilde{y}_m$

below is positive since $v_y(\bullet)$ is positive. The integral

 $\int_{y_m}^{y_m} \max\{0, \mathbf{v}(y, \tilde{y}_m)\} \mathbf{h}_y(\tilde{y}_m|y) d\tilde{y}_m$

is positive since max $\{0, v(y, \tilde{y}_m)\}$ is strictly increasing in \tilde{y}_m over a set of positive probability and the distribution of \tilde{y}_m stochastically increases in y.

- 16. Details are available from the authors.
- 17. For example, if the envelope theorem applies and $x_{\omega}(a, \omega)$ is always positive, or if $x_{\omega}(a, \omega)$ is always negative, then $x(a(\omega), \omega)$ will be monotone.

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