Profitable Innovation Without Patent Protection: The Case of Derivatives.

Helios Herrera — ITAM

Enrique Schroth[1] — HEC Lausanne and FAME[2]

February 10, 2003

[1]Corresponding author. BFSH 1, 1015 Lausanne, Switzerland. Email: Enrique.Schroth@hec.unil.ch. Tel: +41 21 692 3352. Fax: +41 21 692 3435.

[2]We are grateful to Douglas Gale, William Baumol, Jean-Pierre Benoît, Boyan Jovanovic, Josh Lerner, Giuseppe Moscarini, David Silber and Peter Tufano for their advice. All errors in the paper are only ours.

Abstract

Investment banks find it profitable to invest in the development of innovative derivative securities even without being able to preclude early competition from other investment banks using patents. To explain this, we assume that the developer can learn from the first issues of the innovative financial product and is able to become the expert issuer by the time imitation enters the market. We show how this becomes an informational first-mover advantage that turns innovators into the market leader. It is this advantage, and not the typical temporary monopoly position awarded to a patent holder, that provides the incentive to pay the development costs. In the aftermath, the innovator ends up with the largest share of the underwriting market and makes positive profits. Our model's predictions are consistent with many stylized facts of financial innovations by investment banks.

JEL Classification: G24, L12, L89.

Keywords: Financial innovation, first-mover advantages, asymmetric information, learning-by-doing.

1 Introduction

1.1 The Motivation

Unlike many innovative products, innovations in financial products remain largely unpatentable.[1] Some developments in Industrial Organization Theory show that, for some industries, patents are the only mechanism that can make it optimal for firms to pay the research and development costs (R&D henceforth) if their invented product would otherwise be reverse-engineered, produced and marketed by competitors that free-ride R&D. In such type of models, the free entry eliminates profits and potential innovators will choose not to invest in R&D without legal protection against imitation.[2]

Nevertheless, some models of product innovation can generate equilibria with positive innovator profits even when they cannot patent their discoveries.[3] One possibility is to assume that the developer has a lead-time over his

[1] Only recently, in January of 1999, a patent for a "financial method or formula" was upheld by the United States Supreme Court. The State Street Bank of Boston sued to invalidate a patent for a valuation algorithm by the Signature Financial Group of Massachussetts, arguing that it violated the business method exemption in patent laws. The Supreme Court upheld the patent, setting an important precedent that may make most innovations in finance patentable. As Lerner [11] argues, the number of patent fillings and awards may sharply increase now that the *State Street Case* has been settled.

[2] See Tirole [24, Ch. 10] for a description of the reasons why imitation of discoveries produces incentives for maintaining low levels of R&D.

[3] Benoît [3] and Reinganum [19] provide some notable examples.

imitators. If this lead-time is long enough or, if R&D costs are small enough, innovators can earn sufficiently large monopolist rents prior to imitation so as to justify the initial R&D expenditures. In essence, this effect is qualitatively no different than the effect of a patent. Another possibility is to assume that clients have costs of switching from the first provider of the new service (the innovator) to the late comers (the imitators). In this case the pioneer can effectively build large market shares and earn rents.

The delayed imitation hypothesis cannot be reconciled with the most important pieces of evidence of product innovation in finance. Tufano [26] found that periods of "monopolistic" issuing of new financial services are relatively short.[4] This makes a strong case against the argument that only sufficiently long periods of temporary monopoly make innovations worthwhile. In the same study, Tufano [26] also found that, for the 58 innovations he studied between 1974 and 1986, the investment banks that created them could not charge monopolistic underwriting fees before imitation occurred. Further, although data on innovation costs is not available, anecdotal evidence suggests

[4] For all the 58 innovations he studied, the median number of underwriting deals completed by the innovating bank prior to entry by rival banks was of only one.

that these are not negligible.[5],[6]

As Bhattacharyya and Nanda [4] point out, banks and clients may develop valuable relationships, making it costly for a firm to switch bankers. Thus, switching costs can explain why early imitation may not erode an innovator's profits and therefore its incentives to innovate. Evidence gathered in interviews to bankers by Naslund [15] suggests that switching costs might not be significant, "the banks mentioned that if one came up with an idea the innovator became known as the expert and customers would turn to it even if they used another bank for other services".[7]

The clue to what are the advantages to inovators in finance, despite all the disadvantages mentioned above, seems to be the fact that investment banks are able to capture the largest share of underwriting deals using the product they created. This is found in Tufano's sample of 58 securities, where despite being imitated early, the innovators preserve the leadership

[5] The relevant innovation cost is not only R&D, but all the sunk payments required to discover and introduce an innovation. Mansfield [13] disaggregates them in R&D, the building of production facilities, and marketing. In the IO literature, these costs are usually referred to as R&D. In this paper we follow the IO convention and use the term R&D to refer to total innovation costs.

[6] Investment bankers interviewed by Tufano [26] reportedly spent between $50,000 and $5 million to develop each new security. In a study by Naslund[15], marketing costs for innovations by 20 financial institutions range between $1 million and $3 million.

[7] Krigman, Shaw and Womack [10] mention other reasons why firms switch underwriters, the most important being the tendency to gradually select more reputed bankers to benefit from the higher quality of their research analysts.

in the long run. Other evidence of innovators becoming market leaders is found in Reilly [18]: Drexel Burnham Lambert, the pioneer in underwriting junk bonds had at least a 40% of the market between 1985 and 1988. Also, according to Mason et. al. [12] First Boston, the innovator of asset-backed securities, underwrote a share that almost doubled that of the second largest underwriter in this market between 1985 and 1991. More recently, Schroth [22] found that for most of the innovative equity-linked securities between 1985 and 2001 the innovators also had the lead in the corporate underwriting market. For other classes of derivatives the evidence is scarce. In fact, as Gastineau and Margolis [9] argue, some derivatives markets are not easy to define and market shares difficult to compute or disaggregate. Nevertheless, they argue that market makers are likely to have the largest market shares, as observed in the underwriting markets for the securities already mentioned.

Thus, it seems innovation in securities differs qualitatively from other kinds of product innovation. Most of the research in financial innovation has examined extensively case studies and asked why there was a demand for some new securities at the time they were introduced.[8] In other words, the

[8] Miller [14], for example, argues that what spurred the latest innovation "wave" were loopholes in tax codes that provided incentives to design securities that circumvented regulation. Finnerty [8] describes different ways in which new securities add value and relates them to corporate financial innovations since the 70s. A broader survey of the

focus has been, basically, on explaining what made each particular innovation attractive to investors. Not much research, though, has addressed the question of why an unpatentable innovation is worth its R&D expenditure if imitation is early and seemingly costless.[9] The question we try to answer here is why do investment banks find it privately profitable to be developers of marketable financial instruments.

1.2 The Agenda

The large variety of innovations observed in finance induces us to pursue a theory of innovation specific to some kind of financial products. Our model will focus on privately negotiated financial contracts that are designed to transfer the credit exposure of an underlying asset between two parties. As we will argue later, this type of contracts include several types of private deals made between competitive investment banks and the holders of claims to some asset with random payoffs. These holders may want to issue a new

history financial innovation can be found in Tufano [27].

[9] In a general setting, Boldrin and Levine [6] show how the natural monopoly position of the innovator as a provider of the original prototype can make the innovative process worthwhile despite imitation. In the case of financial innovation, Black and Silber [5] present a model in which the innovator is a futures exchange that develops and advantage for creating a new contract by providing liquidity for investors earlier than the competing exchanges in order to attract future trades.

security whose payoff is backed by the cashflow of the underlying asset or may just wan to swap away part of the risky component of the cashflow. A particular characteristic of the market where these deals are made is that the transactions made, for example, a credit swap or the purchase of a portfolio of credit card collectibles, are not observable for free. Confidentiality agreements in these markets are effective mechanisms that allow the banker (e.g., an innovator of a derivative) to conceal crucial information from potential competitors.

It is clear from our motivation that the innovator must have an advantage over its imitators. Since for financial innovations the lead-time is on average short and the development cost is substantial, the innovator must make supra-normal profits during the imitation stage. After revising some case studies in innovation in credit derivatives or asset securitization we can identify a common feature: bankers choose not to disclose the history of deals they have made but rather disclose only the aggregate dollar amount of the transactions made in a given period. Presumably, the knowledge of the history of their deals made is valuable and they are keen not to make it public. Therefore, the model we present here explains why the innovator extracts private information from early deals and uses it to compete with its imitators once they enter the market. As William Toy, Managing Director at CDC Capital Inc. puts it, "There is at least a perception that the first mover is more familiar with the product he issues than the imitator".[25]

In the model, the advantage enjoyed by the first-mover will be based on an information asymmetry: innovators will have had one previous period of deal making and will acquire finer information on the distribution of cash flows held by different types of clients. When imitators enter the market, this endogenously generated information advantage will make them the "expert" banker. The expert banker will be able to offer better deals to institutions than the competition and realize a positive profit. In short, this paper is a particular application of Bayesian learning to corporate finance: investment banks learn about the uncertainty in the market of corporate underwriting from past deals, and they are differentiated by the time at which they start the learning process. Thus, moving first puts them ahead in the learning curve.

In another testimony by a practitioner, we can find additional evidence that bankers learn from the deals made in the early issues of a new financial product: "Financial Innovations such as Credit Derivatives, are not like producing a new car, where you just sell it once manufactured. In every deal the Innovation changes: it is perfected to better suited the client's needs. By the fifth or sixth deal you are able to sell a much better product," (Tom Nobile, Managing Director, Bank of NY).[16] To this date, we know of very few applications of Bayesian learning in corporate finance (perhaps most notable being that one of Diamond [7]). We believe that this paper shows that modeling the dynamics of learning is promising to understand better the nature and the facts of product innovation in finance more generally.

In the next section we describe briefly some case studies in innovation of financial products with the objective of illustrating better the type of asymmetry that our model exhibits. Then, we continue by modeling the profit maximizing behavior of investment banks that either create a new financial product or imitate it and their counterparts in the deal. We characterize a generic contract that can resemble a part of a credit derivative transaction (e.g. a credit risk swap) or the securitization of an asset (e.g., a mortgage or a loan) and specify the profits that accrue to each of the parties in the contract. The third section presents the general set-up in which innovators develop an information advantage over imitators by moving first in the earliest stage of the game. The learning process is formalized in the general case and then a simple case is used to solve for the equilibrium in the subsequent section.

There we show how it is optimal for an investment bank to innovate in the first stage when it chooses between developing and marketing an innovation or not. The final section summarizes our results.

2 Some Cases of Product Innovation in Finance

In this paper we argue that the innovator of a financial product derives the advantage that ultimately makes it profitable to move first rather than free-ride from the fact that he positions ahead of his competitors in a learning curve. Below we discuss some well document cases in the literature in which we can see that the innovators had private information about their products and were keen not to disclose more information than they were legally required. This will fix our ideas for the theory presented afterwards.

2.1 The Securitization of Charge-Card Receivables

The securitization of the American Express charge-card receivables by Lehman Brothers in 1992 is a case that matches very well the model of innovation we suggest. By February 1992, the portfolio of outstanding charge-card collectibles was not was not traded as a security. Mason et. al. [12] suggest that "... Lehman saw the American Express charge-card deal as an important demonstration of its structuring abilities and as a means by which it could further establish itself as an innovative and leading underwriter of asset-backed securities".[10] Thus, the possibility of underwriting a large share of charge-card receivables motivated Lehman Brothers to come up with a new security, different to the existing credit-card-backed or fixed-asset-backed securities. It consisted on issuing debt collateralized by a portfolio of charge-card receivables. Interest payments to the holders of the security were financed by an additional discount on the purchase of the receivables, which was declared as the yield and used to provide a liquidity cushion against the risk of default. Note that asset-backed securities traded before the charge-card-backed products used financing charges to pay interest, but charge-cards do not collect finance charges.

In the first deal, 6'995,152 accounts were selected at random from American Express's portfolio and bundled in a master trust. These accounts amounted to $2.4 billion, while the total value of outstanding charge card receivables was $6.9 billion. Later, the underwriter and the issuer had the

[10] By that time, a large share of Credit-Card receivables had already been securitized by Citibank and First Boston and where publicly traded.

faculty to add or remove accounts from the trust. As documented by Mason et. al. [12], the securitization process allowed them to isolate accounts and have information on the trust performance on a monthly basis. For the sale prospectus though, it was not required to disclose individual account information, just aggregate statistics.

2.2 Nikkei 225 Put Warrants

The Nikkei 225 Put Warrant was a complicated transaction by which investment banks underwrote the issue of a put option on the performance of the Nikkei 225 index. Issuers were generally sovereign firms and the security was traded in the United States (American Stock Exchange). Goldman, Sachs, Inc. was the first investment banker to underwrite such issues. The first deal was completed in January of 1990.

This innovation was attractive to American investors because they were able to hold a security that would allow them to bet against the Nikkei 225 Index by buying the put option (expectations then were that the Nikkei 225 would soon revert its upward trend, and it did). Sovereign issuers could use this security as a cheaper source of finance, given the expectations in the US market about the Nikkei 225. Since the probability that the holders would exercise their option was high, Goldman, Sachs swapped with the issuers the risk of conversion and hedged this risk itself in its investment portfolio.

Since then, Goldman pioneered this type of deal in the 1990s and was, for a decade, the only investment bank to underwrite such a deal for issuers that were not the bank itself (the investment banking departments of Salomon Inc., Bankers Trust and Paine Webber underwrote these products but their own investment divisions were the issuers). In fact, Goldman started engineering put warrants type of deals but using different indexes, like France's CAC-40.

It is also worth noting that Goldman's hedging positions for each one of these deals were not disclosed (see Ryan and Granovsky [21])

2.3 Other Cases

Some anecdotal evidence also exhibits similar factures as the ones described in the cases above. Thackray [23], for example, documents how Drexel, Brunham, Lambert did not disclose its "junk-bond" prospectuses to Wall Street insiders because of fears that competitor's imitations may challenge their lead in the market for underwriting high-yield debt. J.P. Morgan's lead in underwriting asset-backed securities using its so called BISTRO variety of a collateralized loan obligation arguably hinges on the discretion with which it manages the pool of assets used as collateral (Roper [20]). Salomon dominated the market of ELKS (equity-linked securities), its own creation, and also managed the pool of backing assets at its discretion.

3 The Structure of the Model

In the subsections that follow we introduce the information structure which is general to the class of financial innovations discussed throughout the paper.

3.1 Asset Holders and their Types

We define a set of relevant states of the world $\mathcal{Z} = \{1, 2, ..., \overline{Z}\}$, which represents the set of all possible contingencies of the cash flows of the assets that different firms or institutional investors have full claim to. Henceforth, we shall refer to these agents as issuers. Essentially, as we shall see this cashflow is used to back the issue of a new security, hence the use of that notation. The true state, Z, will be a random draw from of a prior distribution $G(Z)$ over the set $\mathcal{Z}$. The knowledge of this distribution is common to all investment banks. The actual realization of Z is unknown and will not be observed ex-post either.

There is a finite set of types of issuers, i.e., potential clients of the banks, $\mathcal{F} = \{1, 2, ..., \overline{F}\}$. For each type there are many identical issuers and the cash flow of any one of type f is itself a random variable whose distribution is conditional on the state of the world. Let each unit of this cash flow be denoted by X_f, and let $H_f(x|Z)$ be its distribution conditional on the state of the world that is realized. As we will see below, from the knowledge of this distribution and the observations of X something can be learned about the true realization of Z.

The notion of a type in this context, can be understood more intuitively by relating it to the examples mentioned above. When Lehman Brothers updated the selection of accounts in the pool of American Express charge-card collectibles they used information of the credit profiles of the holders. Similarly, Salomon Brothers had to form a pool of stocks to back the repayment of the issue of equity-linked securities dubbed ELKS. The types of stocks selected would be the types we refer to here, and would be those that are particularly related to the dividend stream stipulated by the security issued. In the case of mortgage-backed securities, the types can correspond also to the risk profiles of the borrowers, which is effectively approximated by the geographical distribution of the loans.[11]

3.2 The Contract

Here we model a private contract between a potential issuer with claims to X_f and a banker. In this contract the issuer agrees to sell the payment stream it owns to the investment bank in exchange for another cash flow with different characteristics. In general, these two cash flows may have different credit risk, different types of indexation (currencies, commodity prices, interest rates), and different degrees of association with other random variables.

Formally, the type f will sell α_f units of its payment stream, which has a certain dependence on the realization of the unknown state of the world. In exchange for each unit X_f, she gets one unit of the payoff stream Y, which has a different dependence on z.[12] For each unit exchanged, the banker charges a transaction fee, s.[13]

[11] Coincidentally, Fannie Mae, the largest issuer of mortage-backed securities and collateralized mortgage obligations started reporting publicly the disaggregation of the pool of securiticized mortgages in its 2001 Information Statement. The first mortgage-backed securities were introduced in the early 1980s.

[12] In general, Y can be made contingent on many observable random variables. Credit derivatives will often provide insurance to financial institutions by swaping their uncertain cash flow for one which is tied to a more popular and less volatile index, e.g., tied to LIBOR. Y can also be a payment in cash if the banker is just buying outstanding loans to pool them.

[13] This fee would be equivalente to the unit underwriting spread.

It is important to stress the fact that the market for these private contracts differs from a generic product market in which there are many potential buyers of a product and where every seller cannot monitor each transaction made by their competitors. The market for private financial contracts described here is a market where the bank's counterparts (the issuers) are institutional investors or big corporations, so each transaction can be monitored. In effect, however, many details of such contracts are generally kept private for some time, and the very fact that they can be monitored makes it easier to detect any infringement of the confidentiality agreements on the part of the clients. Thus, the adverse effect on the reputation of the clients constitutes a strong incentive to honor the agreement.

3.3 The Innovation

Investment banks pool different types of payment streams and form a portfolio which is suited to the objectives of the bank. For example, the pool may be used as collateral for the newly issued security (which is sold to outside investors), or it may be used to hedge the current positions that the bank itself has. In the case of mortgage-banked securities, the pool of outstanding mortgages was used to back the payment of interest of the different tranches of securities issued. In the case of the Nikkei 225 Put Warrants, the bankers insured the issuer of the put on the Nikkei index by swapping away from them the risk of investors exercising the put option and hedging the risk themselves in their own investment portfolio. A wide array of credit derivatives also falls in this category. Some examples are Interest Rate Swaps, Collateralized Debt Obligations, and other highly structured debt instruments in which investment banks swap with the issuers the default risk of a pool of assets.

The innovation here is essentially the development of the payment function Y that issuers would trade for their own income stream. However, an important part of doing deals using this new contract is making them with the right types of issuers, i.e., getting right the types of cash flows more suitable for the pool. More specifically, the innovation will be fully determined by Y and the tuple $\boldsymbol{\alpha} \in \Re^F$ of the proportions of each type of investment cash flows that form the bundle. We will call this vector $\boldsymbol{\alpha}$ the *bundle specification.* In other words, the innovation consists of a new way to swap the cash flow of issuers, and a clever way of bundling them together.

We take as given the fact that the deal is attractive to the issuer because the new income stream Y is more convenient than their current stream X_f :

it may have a lower credit risk or be negatively correlated with some other income streams they have.

We will assume that in every deal, the component Y is the same regardless of the issuer's type that the investment bank deals with. Given this, a generic contract with a type f institution can be fully characterized by the two variables (α_f, s). α_f denotes the amount of cash flow owned by institution f that will be swapped for an equivalent amount of Y and s denotes the per unit fee charged by the investment bank for this transaction.

We assume that every banker has a bound on the number of units of cash flows it can swap. Without loss of generality we can normalize this upper bound to one and have:

$$
\begin{aligned}
0 &\leq \alpha_f \leq 1 \quad \forall f \in \mathcal{F}, \\
\sum_{f \in \mathcal{F}} \alpha_f &= 1,
\end{aligned} \tag{1}
$$

that is, $\boldsymbol{\alpha}$ belongs to the unit simplex in $\overline{F}$.

3.4 Profits from the Deal

In general, if a banker purchases an amount $\alpha_f X_f$ from a type f issuer, it will give in exchange $\alpha_f Y$. In addition, it will charge a fee $\alpha_f s$. The revenue for a type f issuer, net of the underwriting fee would be:

$$\alpha_f (Y - s). \tag{2}$$

On the other hand, the revenue of the investment bank for that one deal would be:

$$\alpha_f (X_f + s).$$

On aggregate, from all the deals signed, an investment bank would make a net revenue of:

$$\sum_{f \in \mathcal{F}} (\alpha_f X_f + \alpha_f s - \alpha_f Y) = \varphi(z) + s - Y, \tag{3}$$

where we have introduced the following notation:

$$\varphi(z) \equiv \sum_{f \in \mathcal{F}} \alpha_f X_f(z) \quad \forall z \in \mathcal{Z}.$$

3.5 Description of the Game

We model financial innovation as a three stage game of a finite number of investment bankers, indexed by $i = 1, 2, ..., I$.

Each stage is a time period $t = 0, 1$ and 2.

At $t = 0$ one of the banker decides whether or not to invest in the innovation, paying an R&D cost C to develop a new type of private financial contract (e.g., a credit derivative or an asset-backed security). The probability that this innovation is successful, i.e., that it will attract institutions and induce them to sign deals with the banker will be $\theta \in (0, 1)$. Two bankers developing the same instrument simultaneously is a zero probability event.

At $t = 1$ only the banker that paid C moves. We call this investment bank the innovator. It will sign underwriting contracts with a set of issuers.

At $t = 2$ the design of the new financial product is revealed to the investment banks that did not innovate (the imitators). They can implement this new design without paying C and be certain that it was a success. The business of this innovative deal making becomes competitive: all investment banks now engage in Bertrand Competition in underwriting

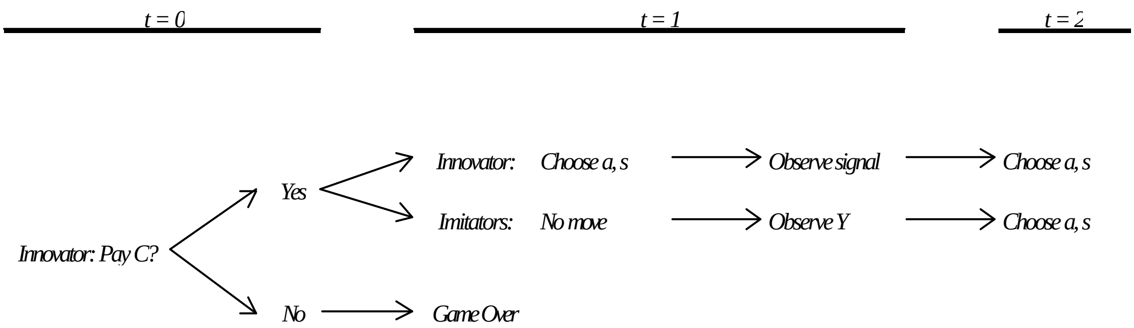

Figure 1: An illustration of the timing of the game. There are three periods, and only the banker that pays the R&D cost in period 0 moves in period 1. In period 2, the innovator and its imitators compete for market share. The innovator has had one previous period of making deals, that allowed him to extract a private signal.

fees.

See Figure 1 for an illustration of the timing described above.

3.6 Interpretation of the Game

At the start, an investment bank has to decide whether to develop or not a financial product. This product has a development cost C, and it is designed to attract issuers that hold claims to certain types of random cash flows. Once developed, the innovator makes the first underwriting deals, being the only underwriter of the issues using such a contract. Immediately after the first contracts are signed, some information about them always filters out to other investment banks that become able to imitate the product.[14] The market for this type of underwriting becomes competitive then. By the time imitation comes in, though, the innovator has already concluded some deals and has been able to gain some expertise. This will allow him to perfect the deal and, in particular, to improve the underlying money making scheme. This idea is summarized by the following testimony: "In Credit Derivatives, imitators can fully understand our new product but they don't know how to make money with it," (Andrei Paracivescu, Credit Derivatives Trader, J.P. Morgan.)[17]

The result of learning-by-doing is an information advantage of the developer over the imitators. In our framework, the innovator will have learned to match more appropriately the different types of institutions' payment streams creating a better portfolio of deals, i.e., enhancing his money-making scheme. Since the innovator's benchmark contract or terms-sheet is revealed (in this model what is revealed is Y, or what to swap X for), the imitators can make their own deals, offering the same contract but they will not have the same skill and expertise as innovators in creating the portfolio of deals. Again, as

[14] Although these kinds of private contracts are strictly confidential, information is leaked in various ways: the client may go to other investment banks to seek a better fee, or people that develop these products may be hired away to competing banks.

a Wall Street practitioner puts it, "everybody can see the laid-out contract but what I am careful not to disclose are the positions in my book. With this information you could track down the logic and see where I make money," (Andrei Paracivescu, Credit Derivatives Trader, J.P. Morgan.)[17]

4 The Innovator's Learning Process

In this section we explain the mechanism through which this learning-by-doing occurs, and illustrate what is the private signal that allows the innovator to have asymmetric information which is advantageous over its imitators.

4.1 The General Set-up

To fix ideas, let $\overline{F} = \overline{Z}$ so that there are as many types of issuers as states of the world. Issuers of any type can have either a high cash flow, H, or a low one, L. "Good" states for different types will be those states where the probability of having a high cash flow is greater than having a low one; "bad" states will be those in which the latter is not true. To simplify, we assume that for each type there is only one good state. Further, we will assume that this state is only good for that type of firm. Without loss of generality, let the good state for any arbitrary type $f \in \mathcal{F}$ be such that $z = f$. Thus, we can summarize $H_f(x|z)$ by:

$$\begin{aligned} \Pr(X_f &= H|z = f) = 1 - \varepsilon, \\ \Pr(X_f &= H|z \neq f) = \gamma, \forall f \in \mathcal{F}, z \in \mathcal{Z}, \end{aligned} \tag{4}$$

where ε and γ are small enough (all we need is for them to be smaller than $\frac{1}{2}$). Figure 2 illustrates these conditional distributions, for the case of Type 1 issuers.

Consider the case of an investment bank that has no information about the true state of the world. The bank knows the prior probability distribution $G(Z)$ over the states that, to keep things simple, we assume to be the uniform. An innovator gets a signal in the first stage. This signal, $\widetilde{\mathbf{x}}$, gives him a more accurate knowledge of the realized state of the world. It is an $\overline{F}$-dimensional vector of the cash flows of each institution from each type realized in the first stage, formally, $\widetilde{\mathbf{x}} \in \{H, L\}^{\overline{F}}$. Conditional on this signal, and the distributions given by (4), the innovator updates his prior beliefs on the actual realization of the state of the world. Notice that the signal can be mapped in two subsets of types: one containing those types that had high cash flows (the

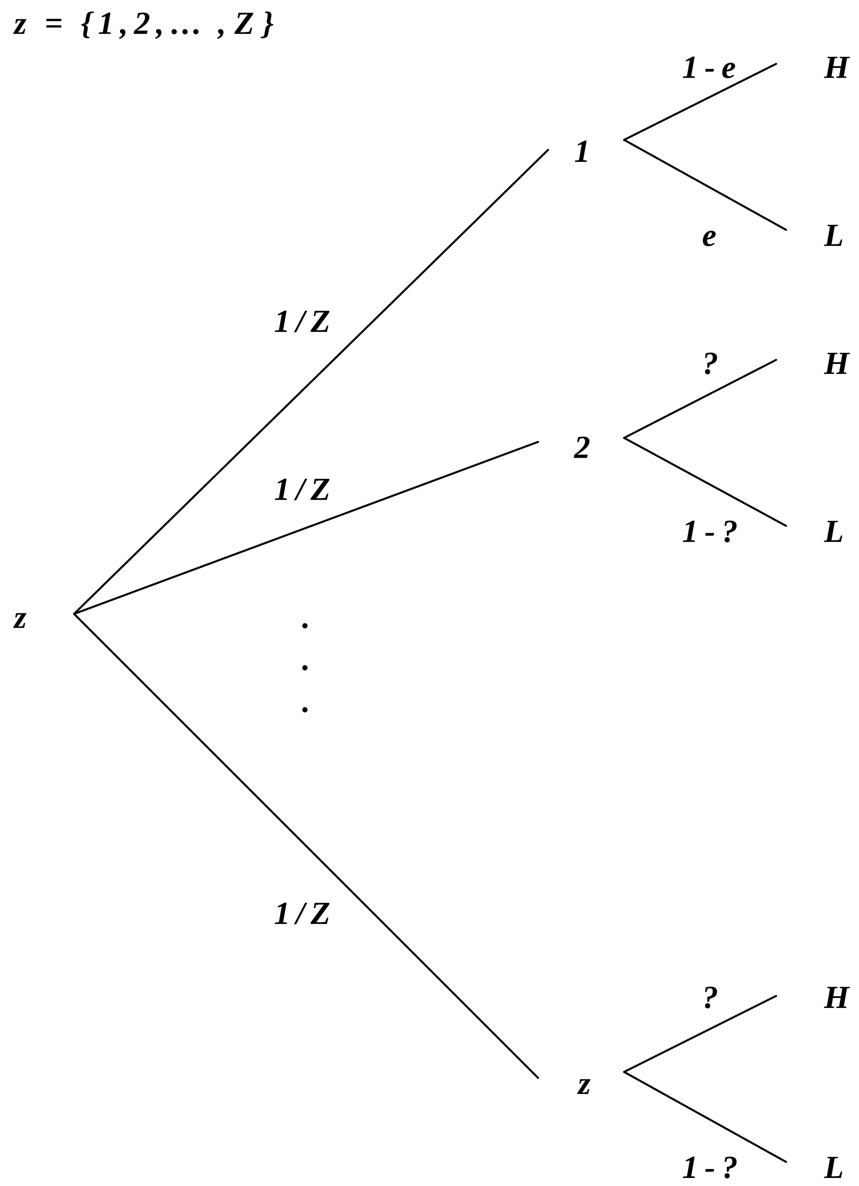

Figure 2: Conditional probability distribution function of the cash flow that an issuer of Type 1 has claims to. z is the underlying random variable that introduces uncertainty in the cash flow, and there are Z possible states of nature, one being the "good state" for each type. Note that $H > L$.

"high types") and the other containing those that did not (the "low types").

4.2 Bayesian Updating

For a uniform prior we have that $\forall z, \Pr(Z = z) = \frac{1}{Z}$. The generic signal will be a sequence of H and L. Now, we can define the sets

$$\mathcal{H} = \{f \in \mathcal{F} | X_f = H\} \text{ and } \mathcal{L} = \{f \in \mathcal{F} | X_f = L\},$$

and let $\#(\mathcal{H}) = h$ and $\#(\mathcal{L}) = l$, so that $h + l = \overline{Z}$.

Then for any state $j \in \mathcal{H}$, the posterior probability that this was the realized state would be given by:

$$\begin{aligned} \Pr(z &= j|\widetilde{\mathbf{x}}) = \\ &= \frac{(1-\varepsilon)\gamma^{h-1}(1-\gamma)^l}{h\left[(1-\varepsilon)\gamma^{h-1}(1-\gamma)^l\right] + l\left[\varepsilon(1-\gamma)^{l-1}\gamma^h\right]} \\ &= \frac{1}{h + l\left[\frac{\varepsilon}{1-\epsilon}\frac{\gamma}{1-\gamma}\right]} = \frac{\lambda}{\overline{Z} + h[\lambda - 1]}, \end{aligned}$$

where $\lambda \equiv \left[\frac{1-\varepsilon}{\epsilon}\frac{1-\gamma}{\gamma}\right] > 1$ for ε and γ small enough. For states $k \in \mathcal{L}$,

$$\begin{aligned}
\Pr(z &= k|\widetilde{\mathbf{x}}) = \\
&= \frac{\varepsilon\left(1-\gamma\right)^{l-1}\gamma^{h}}{h\left[\left(1-\varepsilon\right)\gamma^{h-1}\left(1-\gamma\right)^{l}\right]+l\left[\varepsilon\left(1-\gamma\right)^{l-1}\gamma^{h}\right]} = \\
&= \frac{1}{h\left[\frac{1-\varepsilon}{\epsilon}\frac{1-\gamma}{\gamma}\right]+l} = \frac{1}{\overline{Z}+h\left[\lambda-1\right]}.
\end{aligned}$$

Then, for most signals, i.e., for $h = 1, 2, ..., \overline{Z}-1$, there will be updating, i.e.:

$$\Pr(z = j|\widetilde{\mathbf{x}}) > \frac{1}{\overline{Z}} > \Pr(z = k|\widetilde{\mathbf{x}}).$$

Notice that the difference between the probabilities above is $\frac{\lambda-1}{\overline{Z}+h[\lambda-1]}$, which is decreasing in the observed number h of high types. Intuitively, the set of states of the world is partitioned in one with those more likely states and another with the less likely. The smaller h, the smaller the set of more likely states and the larger its complement. Thus, each state within the smaller set has more probability of being the realized one.

Note that the signals $(H, H, ..., H)$ and $(L, L, ..., L)$ don't allow any updating of the prior distribution $G(Z)$. The probability that the innovator gets a signal which allows updating, and in consequence, the probability of having superior information for the next issues of the new instrument is:

$$\xi = 1 - (1-\varepsilon)\gamma^{\overline{Z}-1} - \varepsilon(1-\gamma)^{\overline{Z}-1}. \tag{5}$$

4.3 Portfolio Choice for Innovators at $t = 2$

In this model investment banks choose a contract $(\boldsymbol{\alpha}, s)$ to maximize the net revenues given by (3) and taking as given the maximizing behavior of the issuers that they deal with. Since the fee s does not affect the value of the bankers portfolio, $\varphi(z)$, we can break down the optimization problem in two parts. First, banks solve the following problem:

$$\begin{gathered}\text{choose } \boldsymbol{\alpha} = (\alpha_1, \alpha_2, ..., \alpha_{\overline{F}}) \text{ to maximize } E\left[\varphi\left(z\right)\right] \\ \text{subject to } \boldsymbol{\alpha} \in \Delta^{\overline{F}}, \\ \text{and } Var[\varphi\left(z\right)] \leq V.\end{gathered} \tag{P1}$$

Investment banks are maximizing the expected value of their portfolio subject to the constraint that they cannot afford a limited volatility of returns in their portfolio.[15] We assume that V is small enough so that the constraint

[15] This volatitlity restrictions are common practice in portfolio management. Besides, this constraint also allows to solve the indeterminacy on the weights $\boldsymbol{\alpha}$ of all the H types

is binding. This will imply that the problem has an interior solution: $\boldsymbol{\alpha}^* \in (0,1)^{\overline{F}}$. Moreover,

Lemma 1 *The Lagrangian for (P1), Λ, is symmetric with respect all α_f such that $f \in \mathcal{H}$ and all α_g such that $g \in \mathcal{L}$:*

$$\begin{aligned}\Lambda(...,\alpha_i,...,\alpha_j,...) &= \Lambda(...,\alpha_j,...,\alpha_i,...) \quad \forall i,j \in \mathcal{H}, \\ \Lambda(...,\alpha_g,...,\alpha_h,...) &= \Lambda(...,\alpha_g,...,\alpha_h,...) \quad \forall g,h \in \mathcal{L}.\end{aligned}$$

Proof. See appendix. ■

This will imply that the solution arising from the first-order condition is also symmetric:

$$\begin{aligned}\alpha_i &= \alpha^H \quad \forall i \in \mathcal{H}, \qquad (6) \\ \alpha_i &= \alpha^L \quad \forall i \in \mathcal{L}.\end{aligned}$$

With updated beliefs on the states of the world, an informed banker will now form bundles that put more weight on the high types. That is, $\alpha^H > \alpha^L$.

---

and all the L types. Alternatively, a problem in which bankers have mean-variance utility would produce the same result.

4.4 Portfolio Choice of Uninformed Bankers

Imitators, or innovators at $t = 1$, know only a prior distribution of the true state of the world. That is, they have not had the chance to observe the signal $\widetilde{\mathbf{x}}$ and update their beliefs. Given this information, and given the symmetry of (P1), an uninformed banker can only form bundles with all the types of firms weighted symmetrically. That is, $\alpha_f = \frac{1}{F} \quad \forall f$.

The confidentiality agreements guarantee that imitating banks are prevented from gathering crucial information, such as the bundle specification, from the innovator's clients. In reality, it is observed that bankers make sure that their bundle specification is not disclosed early enough. For example, in the American Express Charge-Card securitization case, only the aggregate value of the accounts pooled was publicly reported, and not the active management of the portfolio. Similarly, as we mentioned before, Drexel, Brunham, Lambert were careful to keep private the order-flow of their "junk-bond" deals. In more recent cases, it has been well documented that due to discretionary management of the pools backing collateralized loan obligations it is impossible to observe the positions and to be rated by Standard & Poor (See Roper [20]).

Perhaps this fact is best summarized by a recent statement in the Recommendations for Disclosure of Trading and Derivatives Activities of Banks and Securities Firms, by the Basle Committee on Banking Supervision, on February 1999: "institutions should disclose information produced by their internal risk measurement and management systems on their risk exposures and their actual performance in managing these exposures. Linking public disclosure to internal risk management processes helps ensure that disclosure keeps pace with innovations in risk measurement and management techniques."[2].

4.5 A Simple Case of Learning: Two types, Two states

The discussion above argues that first-movers are able to assign higher probability of occurrence to those states that are good for the institutions that had high cash flows at the first stage of the game (and lower probability to the other states). Next, we develop the model for a simpler case where firms can be of one of two types only.

In the first stage, the first-mover develops the bundle with equal weights for each type, i.e., $\alpha_1 = \alpha_2 = \frac{1}{2}$. Imitators in the second stage have the same information as innovators had in the previous period. Thus, they can only form the $(\frac{1}{2}, \frac{1}{2})$ bundle.

Signals are drawn out of the set $\{(H, H), (H, L), (L, H), (L, L)\}$ conditional on the realized state of the world. Notice that, in this symmetric case, the signals $(H, H), (L, L)$ do not allow any updating. From (5), this probability equals $\varepsilon + \gamma - 2\varepsilon\gamma$.

If the first mover observes any of the two signals that allow him to update his prior beliefs $G(Z)$ then he will form a bundle in the second stage with larger weight on high types. Let this weight be α^H. Then, it is clear that $\alpha^H > \frac{1}{2} > \alpha^L = 1 - \alpha^H$.

An event in this world is characterized by the triple (Z, X_1, X_2). Four of the eight possible events involve non-informative signals and in two of them the realized state is not the most likely one, given the signal. In the latter cases, the future cash flows of the firm with more weight in the bundle would be low with a large probability.

Based on this information structure we compute the expected payoffs of imitators' and innovators' portfolios using the Lemma below.

Lemma 2 *In the case where Innovators can update their beliefs on the realization of the state of the world, i.e., when the signal is informative, we* *have:*

$$E(\varphi^{In}) = \{\alpha^H \frac{(1-\gamma)(1-\varepsilon)}{(1-\gamma)(1-\varepsilon)+\gamma\varepsilon} + \alpha^L \frac{\gamma\varepsilon}{(1-\gamma)(1-\varepsilon)+\gamma\varepsilon}\}[(1-\varepsilon)H+\varepsilon L] + \{\alpha^H \frac{\gamma\varepsilon}{(1-\gamma)(1-\varepsilon)+\gamma\varepsilon} + \alpha^L \frac{(1-\gamma)(1-\varepsilon)}{(1-\gamma)(1-\varepsilon)+\gamma\varepsilon}\}[\gamma H+(1-\gamma)L], \quad (7)$$

$$E(\varphi^{\text{Im}}) = \frac{1}{2}[(1-\varepsilon)H+\varepsilon L] + \frac{1}{2}[\gamma H+(1-\gamma)L]. \quad (8)$$

Proof. See appendix. ■

Lemma 3 *In the case where Innovators receive uninformative signals, the portfolio of innovators is equal to the imitators' and so are their corresponding expected returns, which equal:*

$$E(\varphi^{In}) = E(\varphi^{\text{Im}}) = \frac{1}{2}[(1-\varepsilon)H+\varepsilon L] + \frac{1}{2}[\gamma H+(1-\gamma)L]. \quad (9)$$

Proof. See appendix. ■

Our goal now is to show that, when learning occurs, the innovator will have a better portfolio of deals than the imitator. The reason for this is straight forward: the innovator's bundle has more units of cash flows of institutions of the high types and these are ex-ante more likely to have high returns in $t = 2$.

Proposition 4 *Whenever Innovators get an informative signal,* $E(\varphi^{In}) > E(\varphi^{\mathrm{Im}})$.

Proof. See appendix. ∎

Note that even though in some nodes of the last stage innovators will be no different than imitators, the probability of reaching these nodes is small. The event that there is no learning from the innovator becomes less likely as the number of types increases: the number of uninformative signals is always only two, while the total number of possible signals is $2^{\overline{F}}$. This is seen formally in equation (5), as $\frac{\partial \xi}{\partial F} > 0$. This is intuitive: the more deals across different types an innovator makes, the more likely it is he will learn to improve his portfolio and the higher the profit margin he will have with respect to imitators, as we will see below.

4.6 Issuers's Choice

All issuers that sign this underwriting contract are willing to swap all their units of X for the new payment stream Y. Since all investment bankers offer the same per unit cash flow Y, the institutions will be attracted to the banker that charges the lowest underwriting fee, s. That is, they choose $i \in \{1, 2, ..., I\}$ to maximize $Y - s^i$.

5 The Equilibrium

5.1 Bertrand Competition

We assume that investment banks will compete à la Bertrand in fees by undercutting each other. The undercutting process will reach a halt when imitators make zero profits. As a result, the equilibrium fee will be given by the imitators' zero profit condition:

$$s^* = Y - E(\varphi^{\mathrm{Im}}). \tag{10}$$

This will be the equilibrium underwriting fee charged to issuers. Indeed, for that fee, the innovator makes the profit :

$$E(\varphi^{In}) - Y + s^* = E(\varphi^{In}) - E(\varphi^{\mathrm{Im}}). \tag{11}$$

If the profits in (11) are positive, the pioneer will be able to marginally lower his fee further to attract more institutions, as we will show later.

Proposition 5 *At $t = 2$, imitators make zero profit in equilibrium and the innovator makes profit $E(\varphi^{In}) - E(\varphi^{\mathrm{Im}})$.*

Note that the higher the wedge between the expected returns of the portfolio of innovator over the imitators', the larger the developer's profits. The innovator's profits are determined by the extent of the learning-by-doing in the first stage, that is, by how much he learnt how to improve the money-making scheme in the second round of underwriting with respect to the first. Of course, in the unlikely event that there is no learning (no improving of the portfolio of deals), competition by imitators will drive innovator's second stage profits to zero.

5.2 Market Shares

If there is learning the developer's profit will be positive and it will allow him to undercut the fee s^* further by, say, an epsilon, and swap as many units of Y for X until his capacity constraint is reached. This will leave imitators to share the rest of the underwriting market. If we assume that issuers represent the short side of this market, the underwriting contracts will be rationed across imitators. Even though all investment banks have the same capacity, the equilibrium market shares of innovator and imitators are not the same. Since the innovator has the information advantage, he chooses a lower fee that allows him to underwrite deals at full capacity.

As in standard Bertrand competition, in this model each imitator's share of the new product's market is really undetermined because they make zero profits. Since the imitators are identical we can assume that the contracts that remain to be underwritten after the innovator has taken his share are equally rationed among them, following the general convention for Bertrand allocations. This will leave the innovator being the market leader, i.e., having the biggest market share.

Notice that it is not important that the innovator has a larger market share. Just because he is better informed about the state of the world, he is the only bank that can work at full capacity for any size of the market of potential issuers, and he is the only banker making profits with free-entry. Here we illustrate that this model can have as a prediction the market-shares leadership fact by assuming that imitators ration the proportion not underwritten by the innovator.

5.3 Optimality of Innovating

The final step is to find the optimal choice of the potential innovator and the equilibrium allocations resulting from this choice. At $t = 0$ this bank must decide whether or not to pay the development cost C. The potential developer will have to take into account that the innovation is risky: if he develops and pays C, there is a probability θ that the new product attracts institutions, but with probability $1-\theta$ the innovation will not be marketable, and the developer will make a loss.

If the innovative product proves to be successful, the developer will have to face competition from imitators. Imitators will enter the market after they see the first innovative deals. The developer's profits from these first deals, i.e., in the learning stage, are zero. This is because in this stage the newly established innovator has the same information and expertise as an imitator in the next stage. So, since the time lapse between the introduction of a new financial product and the appearance of imitations is typically very short, an innovator in the first stage effectively competes in fees with the imitators. With no time discounting, if an innovator charges a higher underwriting fee institutions will prefer to wait for the next period and make a more convenient deal with an imitator.[16] As a consequence, for the investment in the development of a new product to be worthwhile, the developer will have to make positive profits in the last stage, when competition from imitators drives profit margins down.[17] The developer will have on his side additional expertise and information over is competitors. In our model, this will happen if and only if some learning occurs in the first stage, that is, with probability ξ. With probability $1-\xi$, the innovator will have no comparative advantage with respect to his imitators and will make zero profit.

To summarize, at $t=0$, the expected profits for a bank that decides to invest to develop the innovation are:

$$\theta[\xi(E(\varphi^{In}) - E(\varphi^{\mathrm{Im}})) + (1-\xi)(0)] + (1-\theta)(0) - C.$$

That is, at the start of the game, a potential developer will pay the develop-

[16] Indeed, when offered an innovative deal by its developer at a given price, institutions often search around to see if other bankers can offer them a cheaper deal. As we mentioned, this is one channel through which some strictly confidential information about the innovation is transmited to potential imitators. In reality, as we mentioned, what is rather disclosed is the new swap technology, Y.

[17] This result is consistent with the evidence that Tufano [26] found: when they are the sole underwriters, innovators do nto charge fees larger than when they compete with imitators.

ment cost C if and only if:

$$\theta\xi[E(\varphi^{In}) - E(\varphi^{\mathrm{Im}})] \geq C. \tag{12}$$

Note that ξ increases in $\overline{F}$. That is, the more deals a pioneer is able to make prior to imitation, the higher the likelihood that he will gain expertise over his competitors from his first issues and that he will perfect the way to make money using this new way financial product. This constitutes his first-mover advantage.

Despite the absence of patents and the possibility of cost-less and early imitation, investment in R&D is still profitable for the investment banks. The monopolistic advantage derived from the first stage learning guarantees positive profits for innovators in the second period. Imitation may look attractive because it is cost-less but, for this same reason, has the disadvantage of being undertaken by almost all other banks: competition is fierce and generates low (zero in our model) profits.

6 Summary

Using a simplified 2-by-2 version of our model we have concluded that investment banks have the incentive to pursue in the discovery and marketing of a new financial product even in the absence of a patent that guarantees a profitable period of monopoly for the issuer. Innovation takes place through an investment bank's underwriting business: it makes an innovative exchange of outstanding payment streams owned by financial institutions for newly designed payment schedule. The incentive to innovate despite costless imitation is given by the supra-normal profits earned when exploiting the information asymmetry generated by the learning from the first private deals.

Our financial product is an innovation in the sense that the developer has to pay a development cost to try to discover a new payoff function which will attract institutions by providing improved hedging to their own cash flows. Like many other innovations, once one agent pays this development cost and the innovation proves successful, there is no need for competitors to pay it in order to market the imitation.

As innovators update their beliefs on the likelihood of different types having higher earning streams they can pick the right institutions to sign the deals with in order to match them more effectively in a portfolio. It is important to stress that what makes innovation profitable in this model is that the innovator exploits an information advantage in the competitive stage. Also, it is worth pointing out that the short lead time of the innovator merely provides him an informational advantage and *not* a temporary monopoly profit that could justify on its own the development stage expenditures. The supra-normal profits here are realized only during the imitation stage.

In this paper we have also explained why an innovator might end up having the largest market share of the market for underwriting.

References

[1] Allen, F. and D. Gale (1994): *Financial Innovation and Risk Sharing,* MIT Press, Cambridge, MA.

[2] Basle Committee on Banking Supervision and the Technical Committee of the International Organization of Securities Commissions, 1999: "Recommendations for Public Disclosure of Trading and Derivatives Activities of Banks and Securities Firms", Basle, February 1999.

[3] Benoit, J-P. (1985): "Innovation and Imitation in a Duopoly," *Review of Economic Studies,* 52, 99-106.

[4] Bhattacharyya, S. and V. Nanda (2000): "Client Discretion, Switching Costs, and Financial Innovation," *Review of Financial Studies,* 13(4), 1101-1127.

[5] Black, D and Silber, W. (1986): "Pioneering Products: Some Empirical Evidence from Futures Markets," Salomon Brothers Center for the Study of Financial Institutions Working Paper Series # 395.

[6] Boldrin, M. and J. Levine. (2002): "Perfectly Competitive Innovation," University of Minnesota, mimeo.

[7] DIAMOND, D. (1991): "Debt Maturity Structure and Liquidity Risk," *Quarterly Journal of Economics*, 106, 709-37.

[8] FINNERTY, J. (1992): "An Overview of Corporate Securities Innovation," *Journal of Applied Corporate Finance,* 4, 23-39.

[9] GASTINEAU, G. and L. MARGOLIS (2000): "What Lies Ahead?," in *The Handbook of Equity Derivatives*, J. Francis, W. Toy and J.G. Whittaker, eds. Wiley & Sons Press, New York.

[10] KRIGMAN, L., W. SHAW and K. WOMACK (2000): "Why Do Firms Switch Underwriters?," forthcoming *Journal of Financial Economics.*

[11] LERNER, J. (2000): "Where Does State Street Lead? A First Look at Finance Patents, 1971-2000, " mimeo, Harvard Business School.

[12] MASON, R., R. MERTON, A. PEROLD and P. TUFANO (1995): *Cases in Financial Engineering: Applied Studies of Financial Innovation.* Prentice Hall, New Jersey.

[13] MANSFIELD, E. (1971): *Research and Innovation in the Modern Corporation.* Norton, New York.

[14] Miller, M. (1986): "Financial Innovation: The Last Twenty Years and the Next," *Journal of Financial and Quantitative Analysis, 21, 459-471.*

[15] Naslund, B. (1986): "Financial Innovations: A Comparison with R&D in Physical Products," Salomon Brothers Center for the Study of Financial Institutions Working Paper Series # 391.

[16] Nobile, T. Personal Interview. New York City, March 2001.

[17] Paracivescu, A. Personal Interview. New York City, February 2001.

[18] Reilly, F.V. (1992): *Investments*, 3rd Edition. Dryden Press, New York.

[19] Reinganum, J. (1983): "Uncertain Innovation and the Persistence of Monopoly", *American Economic Review,* 73, 741-748.

[20] Roper, A. S. (1999): "CBO/CLO Ratings, Risk On Radar, S&P Says," *Private Placement Letter*, (December 6th Issue), New York.

[21] Ryan, M. and R. Granovsky (2000): "Nikkei 225 Put Warrants," in *The Handbook of Equity Derivatives*, J. Francis, W. Toy and J.G. Whittaker, eds. Wiley & Sons Press, New York.

[22] Schroth, E. (2002): "Innovation and First-Move Advantages in Corporate Underwriting: Evidence from Equity-Linked Securities," mimeo, FAME Research Paper Series.

[23] Thackray, J. (1985): "Corporate Finance in the Golden Age of Innovation," *Forbes,* 136 (April).

[24] Tirole, J. (1988): *The Theory of Industrial Organization,* MIT Press, Cambridge, MA.

[25] Toy, W. Personal Interview. New York City, February 2001.

[26] Tufano, P. (1989): "Financial Innovation and First-Mover Advantages," *Journal of Financial Economics*, 25, 213-240.

[27] Tufano, P. (1995): "Securities Innovations: A Historical and Functional Perspective," *Journal of Applied Corporate Finance*, 7(4), 90-104.

Appendix

Proof to Lemma 1. We ommit a proof, since we believe it is verified only by inspection. ■

Proof to Lemmas 2 & 3. In any state, one of the two firms in the bundle will have high cash flows with a probability $1-\varepsilon$ and the other with probability γ. When innovators receive an informative signal and form up the bundle with larger weight for the good type, the true state could be indeed the one suggested by the high signal, in which case the expected payoffs of the bundle would be

$$\alpha^H[(1-\varepsilon)H+\varepsilon L]+\alpha^L[\gamma H+(1-\gamma)L]. \tag{13}$$

In case the true state is not the most likely one, given the signal, the expected payoff of the same bundle would be

$$\alpha^L[(1-\varepsilon)H+\varepsilon L]+\alpha^H[\gamma H+(1-\gamma)L]. \tag{14}$$

Now then, the probability of receiving a "correct " informative signal, i.e., the one where the good type has a payoff of H, is $\frac{(1-\varepsilon)(1-\gamma)}{(1-\varepsilon)(1-\gamma)+\varepsilon\gamma}$ while the probability of getting incorrect signals is $\frac{\varepsilon\gamma}{(1-\varepsilon)(1-\gamma)+\varepsilon\gamma}$.

The expected payoff to the innovators' bundle at any node of the game where the signal was informative is then nothing but the weighted average of equations (13) and (14):

$$\begin{aligned}
E(\varphi^{In}) &= \frac{(1-\varepsilon)(1-\gamma)}{(1-\varepsilon)(1-\gamma)+\varepsilon\gamma}\{\alpha^H[(1-\varepsilon)H+\varepsilon L]+\alpha^L[\gamma H+(1-\gamma)L]+ \\
&\quad \frac{\varepsilon\gamma}{(1-\varepsilon)(1-\gamma)+\varepsilon\gamma}\{\alpha^L[(1-\varepsilon)H+\varepsilon L]+\alpha^H[\gamma H+(1-\gamma)L]\} \\
&= \{\alpha^H\frac{(1-\varepsilon)(1-\gamma)}{(1-\varepsilon)(1-\gamma)+\varepsilon\gamma}+\alpha^L\frac{\varepsilon\gamma}{(1-\varepsilon)(1-\gamma)+\varepsilon\gamma}\}[(1-\varepsilon)H+\varepsilon L]+ \\
&\quad \{\alpha^L\frac{(1-\varepsilon)(1-\gamma)}{(1-\varepsilon)(1-\gamma)+\varepsilon\gamma}+\alpha^H\frac{\varepsilon\gamma}{(1-\varepsilon)(1-\gamma)+\varepsilon\gamma}\}[\gamma H+(1-\gamma)L].
\end{aligned}$$

For any uninformative signal, innovators choose equal weights for each type of institution. Thus, in any event the expected payoff of the portfolio is:

$$E(\varphi^{In}) = \frac{1}{2}[(1-\varepsilon)H+\varepsilon L]+\frac{1}{2}[\gamma H+(1-\gamma)L]. \tag{15}$$

Imitators behave just like innovators who have received signals that allow no updating. They assign equal weights to each type in the bundle, thus the expected payoff of their portfolio is given by:

$$
\begin{aligned}
\mathrm{E}\left[\varphi^{\mathrm{Im}}\right] &= \mathrm{E}\left[\varphi|z=1\right]\Pr\left[z=1\right]+\mathrm{E}\left[\varphi|z=2\right]\Pr\left[z=2\right] \qquad (16)\\
\mathrm{E}\left[\varphi|z=1\right] &= \mathrm{E}\left[\varphi|z=2\right]=\frac{1}{2}[(1-\varepsilon)H+\varepsilon L]+\frac{1}{2}[\gamma H+(1-\gamma)L],
\end{aligned}
$$

which yields:

$$
\begin{aligned}
\mathrm{E}\left[\varphi^{\mathrm{Im}}\right] &= \mathrm{E}\left[\varphi|z=1\right](\Pr\left[z=1\right]+\Pr\left[z=2\right])= \\
&= \frac{1}{2}[(1-\varepsilon)H+\varepsilon L]+\frac{1}{2}[\gamma H+(1-\gamma)L].
\end{aligned}
$$

It is important to notice that this last result does not depend on the probability distribution. Imitators believe that $\Pr[z=1]$ $=\Pr[z=2]$ $=\frac{1}{2}$, the common prior. Once Innovators have updated their beliefs they will in general find new *different* values for this probabilities. Therefore, it could be argued that imitators are "wrong", i.e., less accurate than the one made by innovators that have learned more about the state of the world. However, given the symmetry of this setup this is not an issue here: $\mathrm{E}\left[\varphi^{\mathrm{Im}}\right]$ does not depend on the probability distribution. Probabilities add up to one and cancel out, since they multiply a common symmetric factor.

By assumption, $H > L$, $0 < \varepsilon, \gamma < \frac{1}{2}$ and $\alpha^H > \frac{1}{2}$. Now,

$$\begin{aligned} E(\varphi^{In} - \varphi^{\mathrm{Im}}) &= \{\alpha^H \frac{(1-\varepsilon)(1-\gamma)}{(1-\varepsilon)(1-\gamma)+\varepsilon\gamma} + \alpha^L \frac{\varepsilon\gamma}{(1-\varepsilon)(1-\gamma)+\varepsilon\gamma} - \frac{1}{2}\}[(1-\varepsilon)H + \varepsilon L] + \\ & \{\alpha^L \frac{\varepsilon\gamma}{(1-\varepsilon)(1-\gamma)+\varepsilon\gamma} + \alpha^H \frac{(1-\varepsilon)(1-\gamma)}{(1-\varepsilon)(1-\gamma)+\varepsilon\gamma} - \frac{1}{2}\}[\gamma H + (1-\gamma)L]. \end{aligned}$$

Substituting for $\alpha^L = 1 - \alpha^H$,

$$\begin{aligned} E(\varphi^{In} - \varphi^{\mathrm{Im}}) &= (\alpha^H - \frac{1}{2})[(1-\varepsilon)H + \varepsilon L] - \\ & (\alpha^H - \frac{1}{2})[\gamma H + (1-\gamma)L] \\ &= (\alpha^H - \frac{1}{2})(1-\gamma-\varepsilon)(H-L), \end{aligned}$$

which is clearly positive by the assumptions above. ■