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The Economics of financial Matching

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THE ECONOMICS OF FINANCIAL MATCHING

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Abstract. In this paper we try to place the phenomenon of financial matching in the broader context of financial economics. We explore the conceptual links with collateral, leverage, role of capital in financial intermediaries and non-financial corporations, the risk-shifting between the financial and the non-financial sectors, and public policy implications. A broader research agenda is outlined. Although this is a far cry from a survey, we summarized two paradigms of financial economics which can buttress this endeavor. Finally, we prepared a small analytical example to analyze financial matching in a corporate governance setting.

Sumario (español): Este documento intenta colocar el fenómeno de los calces y descalces en los balances en el contexto más amplio de la economía financiera. Se exploran sus vínculos conceptuales con las garantías, el apalancamiento, el rol del capital propio en los intermediarios financieros y las empresas no financieras, las transferencias de riesgos entre los sectores financieros y no financieros, y las implicaciones para las políticas públicas. De ahí una amplia agenda de investigación es esbozada. Sin intentar hacer una revisión exhaustiva de la literatura, se presentan dos paradigmas de la economía financiera que pueden respaldar dicha agenda. Finalmente, se expone un pequeño ejemplo analítico de los calces financieros en el marco de un modelo de gobierno corporativo.

Introduction

Financial matching is a widely used tool in asset-liability management (ALM) to coordinate characteristics such as denomination and maturity of both sides of a balance sheet so as to reduce illiquidity or insolvency risks[1]. It is a widespread practice mainly in thinly capitalized financial intermediaries like banks, insurance companies, and defined benefit pension funds. In case of bonds and loans portfolios matching fixed/float interest rates terms and optionality ingredients (prepayment, rollover, commitments, etc.) may become very crucial as well.

Financial mismatches have been at the heart of major financial crises in developed countries (e.g. Savings & Loans in the US 1980s) as

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[1]See de La Grandville [2001] and Elton-Gruber [1995].

well as in the stream of emerging market economies collapses since 1980s. Only more recent academic work on the latter episodes has given an important macro role to currency and debt maturity mismatches, e.g., Caballero-Krishnamurthy [2002], Céspedes-Chang-Velasco [2002], Chamon [2002], Hausmann[2001], Holmström-Tirole [2002], and Tirole [2002a, 2002b].

We attempt to place financial matching more explicitly and centrally on the broad canvas of financial economics, and to model it in line with the most recent formulation of corporate finance with its focus on governance issues: Holmström-Tirole [1996, 1997, 1998, 2001, 2002], and Tirole [2001, 2002a, 2002b]. The organization of the paper is as follows: in the first section, without attempting any survey, we lay the ground for the connections between matching and other related issues in finance, next we place exogenous constraints on the environment of a GE model of an incomplete market economy for a primary approach of the relation between collateral and matching, and last we end up with a exploratory corporate governance model of financial matching.

1. Financial matching: related issues

It seems to make sense that matching is more likely to take place in highly leveraged firms like financial intermediaries than in the less leveraged non-financial sector. As the practitioner Matten [2000] notes, capital in banks, unlike non-financial firms, fulfills a negligible role as a funding source. A bank loaning out a sizeable fraction of its capital would be rated as poor manager of its equity base. There is little question that prevalent and ever increasing regulatory capital adequacy ratios are a binding constraint reluctantly tolerated by the major international players of the banking industry. Bank equity is best viewed as a buffer or cushion against losses.

Although our understanding of firms and hence financial intermediaries is still limited to either a technology or an owner managed unit, modern corporate finance have made a well established inroad on the implications of informational or contractual imperfections for the workings of capital and credit markets and the governance of firms[2]. The central lesson is that entrepreneurs can *pledge* strictly less than the full surplus of any project; therefore, investment by non-financial firms and financial intermediaries is wealth constrained by collateral or equity, and credit is then rationed. A conjecture we will explore later on is matching as a device to economize equity.

[2]Amaro de Matos [2001] is a good general text; Holmström-Tirole [1997] and Tirole [2001] are our lead in this discussion.

Asset transformation is the oldest academic rationale, albeit not the most fashionable, for financial intermediation in the economy[3]. The intermediary is rewarded to bear the risks of some mismatches, which would be hard avoid or hedge for its customers on both sides of the balance sheet in a direct finance scheme. Notice that there is some tension, with public policy relevance, between intermediation vis a vis direct finance and the exploitation of matching strategies. We will come back to this.

Depositary institutions furnish the best known traditional examples of asset transformations: liquidity and maturity transformations. Banks lend long term and take funds short term. Depositors free themselves (to a large extent) from interest rate risk. Banks get compensation from bearing the systematic risk part of fluctuations of the term structure of interest rates in this maturity transformation. In this particular case banks claims on its debtors and depositors claims differ in liquidity, and thus liquidity transformation goes hand in hand with maturity transformation. The liquidity creation by banks hinges on the lack of loans secondary markets and the strong optionality of deposits redeemable on demand.

The stronger reliance floating rate loans, and the standardization credit risk transfers in credit derivative markets, diminish a great deal the effective liquidity and maturity transformation that intermediaries are undertaking. While in the credit derivative markets the depository institution's counterpart is a sophisticated well hedged financial operator, floating rate loans, as a sequence of short term loans, are likely to mismatch some balance sheets of non-financial firms. Thakor [1994] points out that the clear trend of intermediaries reduction mismatches is uncovering as their true function the accumulation of informational capital and monitoring on debtors. Volatile interest rates may o may not account for this, according to the perspective assumed: partial or general equilibrium. Maturity mismatches may have been discouraged from the first perspective, but the effect is ambiguous from the second one. Finally, observe that mismatches of this sort may play an incentive role to ensure that intermediaries do not shirk in its monitoring tasks.

What about matching and non-financial firms? A possible striking answer is Hessen [1994] intriguing and thought provoking remark that "corporations" are a special type of "informal" intermediary where shareholders and bondholders finance a managers and workers as a coalition of borrowers. Controversy aside, we think that heavier regulation on formal financial intermediaries set them meaningfully apart.

[3]We put aside here "brokers", agents who facilitates other people's transactions without altering tha nature of assets traded. See the very recent survey by Gorton [2002], the textbook Freixas-Rochet [1997], and Thakor [1994].

There is little question that a non-financial corporation may fulfill a role of intermediary as to the management of its employees' defined benefit pension funds. But what about in their most general line of business? The seminal paper of Myers [1977] on the problem of underinvestment, i.e., the loss of profitable real investment opportunities because of outstanding financial obligations, incidentally pointed out a role for maturity matching of real investment and debt funding to overcome it. We think, however, that a much lower leverage and the usual presence of "real assets in place" readily available for collateral often takes from non-financial corporate scene matching as a large scale balance sheet management principle.

In absence of "real assets in place", sometime part of a firm assets or a project generate highly predictable and stable cash flows which can collateralize the issue of carefully designed financial instruments[4]. That is an instance of smaller scale asset-liabilities matching known as a "structured finance". This is akin to the linear programming approach of cash flows matching in bond management. In occasions, the concern is only to immunize a positive net asset position, and the more flexible duration matching is used[5].

We think useful to go over the central points discussed here for the rest of the paper:

(1) Financial matching is related to the extent of leverage.
(2) Financial matching functions differently in financial intermediaries and in non-financial firms.
(3) The distribution of "matches" and "mismatches" in the financial and non financial sectors is bound to have public policy and regulatory implications.
(4) Availability and demand for collateral, liability and security design, and financial matching are all intertwined.

2. A quasi-security market economy

Here we review the bare bones of the simplest and most general model economy used as a foundation of the arbitrage free pricing in financial economics according to the textbook presentation of LeRoy-Werner [2001]. The intention here is to place financial matching in relation with tradeable and non-tradeable claims and collateral. Although the environment is not meant to introduce "imperfections" directly, it is relatively easy to include exogenous restrictions on the menu of tradeable assets and transaction costs such as short-sales constraints and bid-ask spreads.

The environment and important notation are as follows:

[4] Of course, central theories of security design in corporate finance have to do with many aspects from signaling private information (Flannery [1986]) to the exercise on investors' control rights (Tirole [2001])

[5] See de La Grandville [2001] and Elton-Gruber [1995].

(1) Population is finite, there is only one good, S public states of nature, and two periods $t = 0, 1$.
(2) There are J securities (publicly tradeable assets), whose payoff $J \times S$ matrix X. We assume $\text{rank}(X) = J$, i.e., there are no redundant assets. Examples of securities are bonds and shares. Bilateral and tailor made financial contracts such as bank loans, insurance contracts, and over the counter financial instruments are not securities. Without loss of much generality $x_j \geq 0$ for each row j[6], i.e., all securities are "limited liability". Only the seller party has obligations in date 1, and the buyer limits his or her losses to the date 0 investment.
(3) An asset j will be normally represented by row vector $x_j = [x_{js}] \in \mathcal{R}^S$. Asset trading takes place at prices p_j at $t = 0$, and delivery of x_{js} takes place in period $t = 1$ after state s unravels. Since the menu of assets is by assumption "limited liability", arbitrage free security prices can never be zero or negative ($p_j > 0$).
(4) A portfolio is a detail of J asset holdings represented by a vector $h \in \mathcal{R}^J$. The cost of a portfolio is the inner product ph, where $p \in \mathcal{R}^J$.
(5) The portfolio payoff is $\sum_j h_j x_j = hX \in \mathcal{R}^S$. The asset span of X, the set of all payoffs that can be achieve by trading, is denoted by the set

$$\mathcal{M} = \{z \in \mathcal{R}^S : z = hX \text{ for some } h \in \mathcal{R}^J\}$$

(6) Consumption at $t = 0$ is $c_0 \in \mathcal{R}_+$, and at $t = 1$ is $c_1 \in \mathcal{R}^S_+$. For dated endowment: $w_0 \in \mathcal{R}_{++}$ and $w_1 \in \mathcal{R}^S_{++}$
(7) For every agent i, we have a strictly increasing and quasi-concave utility function $u^i : \mathcal{R}^{S+1}_+ \to \mathcal{R}$, more often denoted by $u^i(c_0, c_1)$. Nothing very specific is said about either time preference, but risk aversion for a given date 0 consumption is implied quasi-concavity.
(8) An economy is the set $\mathcal{E} = \{(u^i, (w^i_0, w^i_1)) : i = 1, 2, \ldots, I\}$. We often drop the individual index when the context is clear enough.

The description encompasses both a complete asset market economy ($\text{rank}(X) = S$) and an incomplete one ($\text{rank}(X) \neq S$).

A competitive equilibrium for the economy $\mathcal{E}$ is a vector of asset prices p and consumption and portfolio allocation (c^i_0, c^i_1, h^i) such that every agent i optimizes

$$\max_{c_0, c_1, h} u^i(c_0, c_1)$$

[6]We follow the standard convention for vector inequalities $x_j \geq 0$ means $x_{js} \geq 0$ for all s with at least one inequality strict.

subject to

$$0 \le c_0 \le w_0 - ph \text{ and } 0 \le c_1 \le w_1 + hX,$$

and markets clear

$$\begin{aligned} \sum_i c_0^i &\le \sum_i w_0^i, \\ \sum_i c_1^i &\le \sum_i w_1^i, \\ \sum_i h^i &= 0. \end{aligned}$$

Existence of an equilibrium is not an issue under given the rather minimalist assumptions made, though determinancy of real allocation is a problem under incomplete markets[7]. Full Pareto optimality is achieved under complete asset markets, but it fails generally in the incomplete market case.

The notion of arbitrage free pricing is central in financial economics, and the previous model affords a natural habitat for its definition and foundation.

An arbitrage opportunity (a "free lunch") at asset prices p is a portfolio h for $ph \le 0$ and $hX \ge 0$ with at least one of the $S+1$ inequalities being strict. In other words, an arbitrage opportunity is a limited liability portfolio at zero or negative cost . The previously described equilibrium rules out arbitrage opportunities. Conversely, if p is arbitrage free, loosely speaking it is an equilibrium price vector of some economy $\mathcal{E}$.

If p is arbitrage free, every Arrow-Debreu s contingent claim, i.e., one which pays one unit of the good if Nature chooses s and nothing otherwise, has a positive value, called "state price" q_s. If asset markets are complete, q_s is unique and strictly positive. Otherwise, the state prices are only positive and no longer unique.

The most important implication of arbitrage free pricing is the existence of a positive linear valuation functional $q : \mathcal{R}^S \to \mathcal{R}$. If asset markets are complete, the functional is unique. In case of incompleteness, the market can be completed one step at a time and extend the linear valuation functional in a consistent fashion.

In the incomplete asset market case it is common to assume date 1 consumption endowments w_1^i are in the asset span of X (denoted here by $\mathcal{M}$). We would like to allow $w_1^i \notin \mathcal{M}$ for some agents, i.e., their endowment cannot be bundled as a tradeable portfolio. For this reason we took the freedom to speak of a "quasi-security market economy", otherwise we would do it without the "quasi".

[7]Equilibrium allocations under incomplete markets with an abstract unit of account has $S-1$ degree of freedom. One way of lifting the indeterminancy is setting the contingent quantity of money. See Geanakoplos [1990] and Magill-Quinzii [1996].

A feature of any equilibrium of this type of economy is that every agent honor his or her promises. A net debtor obtains date 0 funding through short-selling of some securities to the extent of holding a negative cost portfolio ($ph < 0$)[8]. Then it must be the case that, al least for some state of nature k, the portfolio must deliver net repayments $\sum_j h_j x_{jk} < 0$. Since consumption is naturally non-negative, for state k we have

$$\sum_j h_j x_{jk} + w_k \geq c_k \geq 0. \tag{2.1}$$

That is, the net commitments cannot exceed the contingent endowment w_k. Eventual state contingent portfolio liabilities are collateralized or matched by state contingent resources. In an alternative presentation, let us set the liability side with short position holdings $h_l = -h_j$ if $h_j < 0$, and the asset side with long position holdings $h_a = h_j$ is $h_j \geq 0$. Therefore, 2.1 takes the form

$$w_s + \sum_a h_a x_{as} \geq \sum_l h_l x_{ls} \text{ for all s.} \tag{2.2}$$

To wit, all contingent liabilities are matched by initial holdings w_s and asset portfolio payoffs.

In Geanakoplos [1996] and Dubey-Geanakoplos-Shubik [2000, 2002] version of this model with endogenous default, infinite punishment trivially enforce promises as in equations 2.1 and 2.2.

By assumption security trading is mired by neither informational asymmetries or enforcement problems. However, a possible explanation of asset incompleteness and non-tradeable contingent personal endowment bundles may lay in one or another imperfection assumed away.

Let p be a vector of arbitrage free prices, and pick a likely debtor because $w_0 = 0$ and $w_1 \geq 0$. Suppose the future endowment w_1 cannot be bundled in a portfolio of securities ($w_1 \notin \mathcal{M}$). How can we value w_1? First we can try to find matching portfolios h_ℓ and h_u such that

$$h_\ell X \leq w_1 \leq h_u X.$$

One or both portfolios may not exist. We will see how to handle this.

Second, we define a lower and an upper bound for the non-tradeable endowment as the result of two linear programming problems:

$$q_\ell(w_1) = \max_h \{ph : w_1 \geq hX\}, \tag{2.3}$$

$$q_u(w_1) = \min_h \{ph : w_1 \leq hX\}. \tag{2.4}$$

These bounds extends naturally to any payoff $z \in \mathcal{R}^S$. If the payoff profile is achievable by security trading ($z \in \mathcal{M}$), then $q_\ell(z) = q_u(z) = q(z)$. Otherwise, $q_\ell(z) < q_u(z)$. If feasible sets are empty, it is a convention to set $q_\ell(z) = -\infty$ and $q_u(z) = +\infty$.

[8]Recall we assumed limited liability securities.

A trivial example: There is only one available security, $X = (1, 1)$ with $p = 1$, and the non tradeable endowment is $w_1 = (w_{11}, w_{12})$ with $0 \leq w_{11} < w_{12}$. Hence

$$\begin{aligned} q_\ell(w_1) &= \max_h \{h : (w_{11}, w_{12}) \geq (h, h)\} = w_{11}, \\ q_u(w_1) &= \min_h \{h : (w_{11}, w_{12}) \leq (h, h)\} = w_{12}. \end{aligned}$$

When portfolios h_ℓ and h_u exist, we express their optimality with the notation $h_\ell \in \text{argmax}_h\{ph : w_1 \geq hX\}$ and $h_u \in \text{argmin}_h\{ph : w_1 \leq hX\}$.

Equations 2.3 and 2.4 define a meaningful metric to match portfolio to payoff profile: 2.4 says choose to purchase a minimum cost portfolio to ensure a liability profile w_1 could be met, and 2.3 says choose a maximum value portfolio committing payments fully collateralized by w_1. The answers would be the same if w_1 belongs to the asset span. The point is that these are instances of common procedures to cash flow matching portfolios in bond management[9].

LeRoy-Werner [2001] shows that equations 2.3 and 2.4 can be expressed more naturally in a dual form, closer a pure asset valuation perspective:

$$\begin{aligned} q_\ell(w_1) &= \min_{q \geq 0} \{q w_1 : p = Xq\}, \\ q_u(w_1) &= \max_{q \geq 0} \{q w_1 : p = Xq\}. \end{aligned}$$

The previous example is confirmed:

$$\begin{aligned} q_\ell(w_1) &= \min_{q \geq 0} \{q_1 w_{11} + q_2 w_{12} : 1 = q_1 + q_2\} = w_{11}, \\ q_u(w_1) &= \max_{q \geq 0} \{q_1 w_{11} + q_2 w_{12} : 1 = q_1 + q_2\} = w_{12}. \end{aligned}$$

It is clear here that matching non-tradeable assets with securities is here a methodological tool for valuation. In this vein, we pointed out the parallelism practical managerial techniques of cash flow matching. Collateralization of obligations is built in the equilibrium, but there is no explicit threat contract breach.

As expected, if we tilt the endowment profile towards lower current level and higher future ones in a balanced way as to keep the budget set or the optimal utility constant, "leverage" could rise but consumption allocation will change little, at least in the utility metric. It would be difficult here to replicate a relation between matching and and the perils of excessive leverage.

A model with no firms, financial intermediaries, bilateral contracts, etc. is not likely to be a good home to discuss some of the issues highlighted at the end of Section 1. With market incompleteness and

[9]See Elton-Gruber [1995].

idiosyncratic endowments there seems to be much room for personalized contracts, financial innovation, and intermediation. Interesting elaborations in such direction are Geanakoplos [1996] and Dubey-Geanakoplos-Shubik [2000, 2002] accommodating endogenous default and demand for collateral, and Pesendorfer [1995] on financial intermediation and innovation.

3. A corporate finance approach

Some of the central issues posited at the end of Section 1 are best dealt in a general equilibrium framework: risk shifting mismatches between the financial and non financial sectors, and the relation between asset transformation and financial innovation. However, informational and enforcement problems and incentives are at the heart of this financial policy issue, and for this bilateral contractual models of modern corporate finance are very appropriate.

We will follow especially Holmström-Tirole [1997], Tirole [2001], and their other related work. The first step is to reformulate the story of Siandra [2001] in a more complete framework. From this point we introduce financial intermediaries and try to draw some germane implications to the points raised in Section 1.

Siandra [2001] contains a moral hazard model of stylized risk neutral "firms" which make a choice between two projects: the bad one has lower expected return and riskier cash flow than the good one. But the former has a very large and unlikely cash flow if successful, whilst the latter has a small but more likely lower payoff if successful. A type of project has foreign denominated cash flows payoffs, and another domestically denominated ones. However, either project can be financed in any currency. There are foreign and domestic lenders, and the paper consider risk neutral and risk averse investors. There are two interesting outcomes:

(1) Funding currency choice may compound the moral hazard problem by mismatching.
(2) When lenders are risk averse, it may be possible that they do match their balance sheets, but firms do not. This has been often the case in emerging market crises since 1980s.

The term "currency" should not be interpreted too literally, since motivation of money in economic modelling is still in shaky grounds. The interpretation of production of traded and non-traded goods, and the relative price of them as real exchange rate will do the job perfectly well here.

3.1. **A minimalist model.**

Tirole [2001] presents the basic agency problem between investors and entrepreneur-manager (insiders) is a particularly simple moral hazard example. None of the conclusions however depends on choosing moral hazard as the basic incentive problem: adverse selection, non-verifiable project cash flows, or incomplete contracts yield similar implications.

An entrepreneur has a project which needs external finance. There is no intermediation, to wit, all finance is *direct*. The "game" has three stages:

Financing: The project requires an investment of I, entrepreneur's equity ("inside equity") is $A < I$, and external funding demanded is $I - A$.

Hidden action: The entrepreneur can exert high effort and make the project success probability high, $p_H > 0$, getting no private benefit, or low effort for a success probability $0 < p_L < p_H$ obtaining a private benefit of $B > 0$.

Outcome: There is a verifiable profit of $R > 0$ if successful or 0 otherwise.

The entrepreneur has limited liability, no party discounts the future, and all are risk neutral. To make things concrete, assume the project is socially worth funding, i.e., has positive NPV if the entrepreneur chooses high effort:

$$p_H R - I > 0 > p_L R + B - I.$$

The optimal compensation scheme for the entrepreneur-manager is a remuneration w in case of success making more advantageous choosing high effort:

$$(p_H - p_L)w \geq B.$$

We set the notation $\Delta p \equiv p_H - p_L$, and then $w\Delta p \geq B$. At most, investor can expect to get $R - B/\Delta p$ keeping the right incentives for insiders. The necessary and sufficient condition for the external funding to be channelled is that the *pledgeable income (PI)* has to be enough for the investors to disgorge their cash:

$$PI \equiv p_H \left(R - \frac{B}{\Delta p} \right) \geq I - A.$$

With perfectly competitive investors and equality should be achieved. Therefore, the project net surplus is equal the entrepreneur's net surplus: $p_H w - A = p_H R - I$.

Two main lessons are

Credit rationing: If equity $A = 0$, then it is possible that a positive NPV project cannot be financed

$$p_H R - I > 0 > p_H \left(R - \frac{B}{\Delta p} \right) - I.$$

Inside equity: Entrepreneurs' net worth matters for external funding, unlike Section 2.

Whilst the foregoing was about direct finance, financial intermediation can be accommodated here. It is well known that intermediated finance is more expensive than direct one. The new thinking on intermediation revolves around the idea of costly active monitoring[10]. With a fixed c it is possible for the intermediary to reduce the private benefit from B to b. In general the entrepreneur will no be very happy, for his or her payoff diminishes: $p_H R - I > p_H R - I - c > 0$. But if his or her inside equity A is insufficient

$$p_H \left(R - \frac{B}{\Delta p} \right) < I - A,$$

intermediated finance could be an answer if

$$p_H \left(R - \frac{b}{\Delta p} \right) - c \geq I - A.$$

In other words, pledgeable income could be higher with the participation of the intermediary. In turn, the latter is obviously subject to moral hazard *vis a vis* its last term investors, but we do not have here a generally neat solution. But below, we provide one in our application.

3.2. **Asset-liability denomination matching and inside equity.** Here we extend the model of the previous Subsection to get insights into the link between capitalization or inside equity and financial matching as a risk management strategy. In particular we want to make the private benefits endogenous in a meaningful way for our application.

The analysis of matching denomination of liabilities and project cash flows is easier, but highly empirically relevant, as the stream of emerging market economies crises illustrate.

There are two goods, which the reader can think as one tradeable T and another non-tradeable N, and thus take an international financial analogue.

There is a group of foreign and another of domestic risk neutral investors, both perfectly competitors. Each group has a perfect storage technology as an outside opportunity in its own "country", a tantamount of interest rate zero or no discounting. The finance supply is infinitely elastic at those rates.

The "real exchange rate" is defined as the relative price of tradeable goods in terms of non-tradeable ones. In the financing stage the exchange rate is one-to-one, and when the project outcome is learnt, the real exchange rate can be e_+ with probability π or e_- with probability $1 - \pi$. We assume

$$0 < e_- < 1 < e_+.$$

Generically, $\tilde{e}$ stands for the *ex ante* level of exchange rate. Further, each class of investors has access to other class' storage technology. Thus the uncover interest parity obtains: $E(\tilde{e}) = \pi e_+ + (1 - \pi) e_- =$

[10] See Freixas-Rochet [1997] and Gorton [2002].

1. In a world with currencies the event $\tilde{e} = e_+$ is a depreciation of domestic currency, and $\tilde{e} = e_-$ is an appreciation. Lastly, exchange rate variability is independent of project success probabilities.

The typical entrepreneur faces the following choice: the good project produces *jointly* one unit of T *and* one unit of N with a probability $p > 1/2$, and the bad project one unit of T *or* one unit of N. The latter furnish the opportunity to misrepresent the nature of the good produced and pocket the difference. Thus, he or she can always claim having the lower valued good: mismatching is just plain embezzlement. Although a bit extreme, Akerlof [1993] argues strongly its relevance.

Suppose in the bad technology the entrepreneur produces T, and the real exchange is up. Although he or she has $e_+ > 1$ worth of N, his or her claim is that Nature only gave one unit of N. Thus, he or she pockets a difference of $e_+ - 1$ with a probability $\pi/2$. A similar argument when producing N, leads to a gain of $1-e_-$ with a probability $(1-\pi)/2$. The total private expected private benefit is

$$\frac{(e_+ - 1)\pi + (1 - e_-)(1 - \pi)}{2} = (1 - e_-)(1 - \pi) = (e_+ - 1)\pi,$$

using the fact that the expected real exchange is one.

We assume that the good project is the only socially efficient

$$2p - I > 0 > 1 + (1 - e_-)(1 - \pi) - I.$$

Let w be the "bribe" for the entrepreneur to choose the good project, and to prevent the use of the excuse of mismatching to "go for broke":

$$(p - 1/2)w \geq (1 - e_-)(1 - \pi).$$

The pledgeable income is therefore

$$p\left(2 - \frac{(1 - e_-)(1 - \pi)}{p - 1/2}\right),$$

and the condition for a project to get external finance for an entrepreneur with inside equity of A is

$$p\left(2 - \frac{(1 - e_-)(1 - \pi)}{p - 1/2}\right) \geq I - A.$$

Notice that the extent of moral hazard is lower as $e_- \to 1^-$ and $\pi \to 1^-$. Taking the first limit implies $e_+ \to 1^+$, i.e., lower real exchange rate volatility. Keeping in mind that

$$e_+ = 1 + \frac{(1 - e_-)(1 - \pi)}{\pi},$$

$\pi \to 1^-$ results in $e_+ \to 1^+$ and lower volatility as well. The embezzlement is less profitable, and the inducement for the choice of the good project need not be as high.

Whoever investor backs the project (foreign or domestic), the "bribe" secure a partial denomination asset-liability matching and protects from outright fraud.

Let $\bar{A}$ be the threshold of inside equity level necessary for the project to gets off the ground:

$$\bar{A} = I - 2p + \frac{p(1-\pi)(1-e_-)}{p-1/2}.$$

The interesting case for us is $\bar{A} \geq 0$, which implies that the NPV of the good project is bounded above by the moral hazard avoiding payment

$$2p - I < \frac{p(1-\pi)(1-e_-)}{p-1/2}.$$

The lesson is immediate: the easier to get partial matching, or equivalently, the lower the risk of fraudulent mismatches, the lower the minimum capitalization required, a valid result even if obtained in an environment a bit extreme (not all mismatches are plain embezzlement).

3.3. **Intermediation, denomination matching, and inside equity.** Although a full fledged model of intermediation to tackle our issues is not trivial, its motivation is easy in this framework. We follow closely the lead of Holmström-Tirole [1997].

As the result of active monitoring at a cost of c, the "bribe" is reduced to a fraction q reflecting an undetected level of fraud. Thus the private benefit of the poor technology is

$$b = \frac{qp(1-\pi)(1-e_-)}{p-1/2}.$$

The intermediary also faces moral hazard, and it has to be paid to do the monitoring at least $c/(p-1/2)$. Then the pledgeable income is

$$p\left(2 - \frac{q(1-e_-)(1-\pi)+c}{p-1/2}\right).$$

We envision a financial intermediation sector competitive, where intermediaries contribute with their own capital, called "informed capital"[11] to their borrowers, to ameliorate their own moral hazard. To make a consistent story, their investment portfolio cannot be perfectly diversified, otherwise, capital would not be needed, and they would never go bust. Although an extreme assumption, it is assumed perfect positive correlation of all intermediary's investments.

Let I_m be the intermediary's capital and β its rate return. Since monitoring is costly, then $\beta > 1$, i.e., its return must be higher than

[11]While so far we have as a external finance $I - A$, also called "uninformed capital".

the one of uninformed capital. The connection between both is

$$\beta = \frac{pc}{(p-1/2)I_m}.$$

Alternatively, we can write $I_m(\beta) = pc/((p-1/2)\beta)$.

The condition to obtain uninformed capital is

$$p\left(2 - \frac{q(1-e_-)(1-\pi)+c}{p-1/2}\right) \geq I - A - I_m(\beta),$$

and the threshold level

$$\bar{A}(\beta) = I - I_m(\beta) - p\left(2 - \frac{q(1-e_-)(1-\pi)+c}{p-1/2}\right).$$

If the collateral of firm does not reach $\bar{A}(\beta)$, it cannot get uninformed capital[12]. As intuitive, the threshold is increasing in β.

What is the lowest possible equilibrium rate β? To pin down that we resort to the condition that the surplus of the intermediary must yield the rate of return of the storage technology available to the uniformed investors:

$$pc/(p-1/2) - c = I_m(\beta) = pc/((p-1/2)\beta),$$

hence, $\beta = 2p > 1$, which is also the case here. For intermediation to be socially useful, it has to improve the access of strongly net worth constrained to uninformed capital:

$$\bar{A}(2p) \leq \bar{A}) \Rightarrow c < 2p(1-\pi)(1-e_-)(1-q),$$

that is, for c small enough.

For firms with inside equity in the mid range, $\bar{A}(\beta) \leq A \leq \bar{A})$, has a mix of funding of informed and uninformed capital. One possible interpretation is that uninformed investors are "depositors" in the intermediary.

If the distribution of inside equity is given by probability distribution $G(A)$, the aggregate demand for informed capital is

$$D_m(\beta) = (G(\bar{A})) - G(\bar{A}(\beta)))I_m(\beta),$$

decreasing in β. The credit market equilibrium with exogenous supply is $K_m = D_m(\beta)$

Notice that the presence of financial intermediaries is associated with poorer endowed inside equity firms, i.e., higher leverages. In this very special analytical example, intermediaries made less costly for firms to keep the more matched position. Of course, it is possible, and worth exploring other possibilities.

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[12]Informed capital is too costly to make up for the lack of uninformed capital

Conclusion

In this short paper we try to place financial matching in a broader framework of financial economics and outline something akin to a preliminary agenda for future work.

We explore the links of matching with collateral, leverage, the role of capital in financial and non financial firms, contract and security design, financial innovation, risk shifting among sectors and other related concepts. We pointed out its relevance for financial regulation and public policy.

Without attempting any survey, we summarize in more detail two different frameworks germane to financial matching: the stylized GE models with incomplete markets and corporate finance incentive models. Both have strengths and weaknesses.

In a simple model corporate governance model we produce a simple analytical example of the relation between asset-liability denomination matching, leverage, and inside equity. We think this modelling has much potential to carry out this paper agenda.

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