Mark-to-Market, Loan Retention, and Loan Origination*

Alexander Bleck  Pingyang Gao

UBC  Chicago Booth

This version: August 9, 2018

Abstract

We study the effects of mark-to-market accounting (MTM) for banks following the originate-to-distribute lending model. Banks have expertise in originating loans but it is costly for them to retain the loans on their books. We study how the accounting measurement of the retained loans affects the banks’ origination and retention decisions. We show that, relative to historic cost accounting (HC), MTM has three consequences. First, it improves the accuracy of loan measurement ex-post. Second, it forces banks to retain more risk exposure on their own books. Finally, it can reduce ex-ante origination efforts and lower the average quality of loans in the economy.

Keywords: Mark-to-market accounting, historic cost accounting, risk-taking, loan quality, financial crisis.

JEL codes: G01, G21, G30, M41.

*We thank Anne Beatty, Sel Becker, Jeremy Bertomeu, Qi Chen, Doug Diamond, Richard Frankel, Andrei Kovrijnykh, Eva Labro, Christian Laux, Christian Leuz, Brian Mittendorf, Raghu Rajan, Korok Ray, Stephen Ryan, Haresh Sapra, Katherine Schipper, Cathy Schrand, Amit Seru, Doug Skinner, Phil Stocken, Lars Stole and participants at the NBER-Sloan Project on Market Institutions and Financial Market Risk, the Carnegie Mellon Accounting Theory Conference, the SUERF and Bank of Spain Conference on Disclosure and Market Discipline, the EIASM Workshop on Accounting and Economics, and workshops at the Bank for International Settlements, the Federal Reserve Banks of Chicago and Philadelphia, UBC, UNC, Wharton, Washington University, Duke University, Chicago Booth, Tilburg, CUHK, UST and Ohio State University for valuable discussions and acknowledge financial support from Chicago Booth and UBC.
1 Introduction

Mark-to-market accounting (hereafter MTM) is the practice of marking the book value of an asset to market prices of the same or comparable assets. In contrast, historical cost accounting (hereafter HC) records the value of an asset at its prior book value. The economic consequences of accounting measurement rules have long been debated in the literature (e.g., Paton and Littleton (1940); Edwards and Bell (1965); Chambers (1966); Ijiri (1975, 1980); Lim and Sunder (1991)). Since the recent financial crisis, the debate among policy-makers and academics has shifted towards the role MTM plays specifically in the banking industry (e.g., Laux and Leuz (2009, 2010); Bushman (2014, Forthcoming)). In this paper we study the economic consequences of measuring banks’ loans under different measurement rules.

We emphasize the point that the reason why a bank holds a loan on its balance sheet is relevant for understanding the economic consequences of different measurement rules of the loan. In a benchmark case, in which the bank’s loan retention decision is treated as exogenous, we show that MTM increases the loan’s measurement accuracy by marking its book value to the loan price that is informative about the loan quality. This improvement in measurement accuracy in turn improves the bank’s ex-ante origination decision, consistent with the conventional wisdom about MTM. The key in our model is to endogenize the bank’s decision to hold a loan on its balance sheet. To this end, we adopt the well-established “skin in the game” model (e.g., Gorton and Pennacchi (1995); DeMarzo and Duffie (1999)). In the model banks follow the originate-to-distribute lending model (hereafter OTD model): they have expertise in originating loans but seek to sell their loans after origination to avoid the retention’s regulatory cost. In distributing (selling) their loans, however, banks face a “lemons” market problem due to their natural information advantage from origination activities. The good bank (the bank with a good loan) overcomes this friction by keeping “skin in the game”: the good bank retains a portion of its loan to convince the market of its high quality. Since

---

the expected net cash flow of the loan is higher for the good bank, retention is less costly for the good bank making separation possible. In the resulting separating equilibrium, the bad bank sells its entire loan at a low price, while the good bank endogenously retains a portion of the loan. This baseline model is widely used in the theoretical banking literature and validated empirically.

The endogenous loan retention decisions change the evaluation of accounting measurement rules. The good bank retains a critical fraction of the loan to deter the bad bank from mimicking. As we switch from HC to MTM, any bank that retains the critical portion of the loan can mark its retention to the market price. This implies that the bad bank would receive this re-measurement benefit if it were to deviate by holding the critical portion of the loan. In other words, switching from HC to MTM increases the bad bank’s payoff from retention off the equilibrium path. Consequently, the good bank raises its level of costly retention to restore the separating equilibrium.

Compared with HC, MTM creates a trade-off: it enhances the ex-post measurement accuracy of retention but raises the costly equilibrium retention. In particular, we demonstrate three consequences of MTM. First, for any given loan retention, MTM improves its measurement accuracy. Since the loan price fully reveals the loan quality in a separating equilibrium, the book value of the retained loan under MTM accurately measures the quality of the loan on the bank’s balance sheet. Second, the higher level of retention under MTM (relative to HC) means that banks retain more exposure to the risk of the loans they originate. Finally, MTM can reduce the value of originating good loans, resulting in banks’ lower ex-ante incentive to originate good loans. Banks’ ex-ante origination incentive is increasing in the ex-post measurement accuracy of retention but decreasing in the level of the equilibrium retention. When the regulatory cost is sufficiently high, the latter effect dominates the former and MTM impedes overall ex-ante incentives to generate good loans.

Our paper’s contribution to the literature is to highlight a conceptual problem with
MTM. The appeal of MTM is a straightforward corollary of the triumph of the efficient market hypothesis: market prices reflect all relevant information and thus serve as the best measure of asset values. By exploiting the price informativeness, MTM improves measurement accuracy and leads to better decisions. We show that MTM not only exploits but also affects the price informativeness. Taking to account this endogenous nature of the price informativeness, MTM could be less efficient than HC.

Our approach responds to Demski’s calls for providing micro-foundations of equilibrium expectations in evaluating accounting policies (Demski (2004)). He argues that “the FASB has [...] a penchant for focusing on a type of transaction and then determining the proper accounting treatment of that transaction. It does not [...] overly concern itself with the supply of transactions if it proscribes one particular accounting treatment. [...] The FASB’s Conceptual Framework strikes me as [...] being built upon a foundation that sidesteps micro foundations of the underlying choices, and largely inadequate for scholarly purpose.”2 In our model, the price informativeness is sustained by banks’ retention decisions. Treating the retention as given, MTM unambiguously improves efficiency by enhancing measurement accuracy. However, the banks’ retention decisions are endogenous to accounting rules. Switching to MTM to exploit the price informativeness affects the very retention decision (“the supply of the loan transaction”) that sustains the price informativeness. Thus, MTM improves the ex-post measurement accuracy but at the same time increases the cost of sustaining the price informativeness, resulting in a non-trivial trade-off.

Opponents to MTM often accept the conceptual merit of MTM of providing more information, but challenge its practical implementability. They point out that market prices are often noisy or biased in reflecting the asset’s fundamental values in the presence of market illiquidity, and/or that more information may not be efficient in certain settings. Neither channel arises in our model by design. First, the market price of the sold loan perfectly

---

2 The astute reader will recognize that this discussion is reminiscent of the Lucas Critique that policies designed to exploit the observed empirical relation could change the underlying relation. Demski (2004) explicitly draws the connection to the Lucas Critique.
reveals the quality of the retained loan in our model. Second, exogenous information about
the retained loan (measurement accuracy) would have improved the ex-ante origination effort
in our model. Yet, we show that MTM could be less efficient than HC due to the endogenous
nature of price informativeness. We thus complement the MTM literature by identifying a
novel problem of MTM.

**Related literature.** The most closely related papers to ours are those that endogenize
the information in prices. *Reis and Stocken (2007)* are among the earliest efforts towards
this direction. They endogenize the pricing of inventory by examining a duopoly setting with
production. They show that it is difficult to implement fair value measurements because
they are endogenous to the strategic interactions between firms. *Bleck and Liu (2007)* study
a firm’s asset sale decision and show that the accounting rule distorts the decision and
thus the rule’s information content. *Marinovic (Forthcoming)* studies an auction model in
which the measurement of an asset on the acquirer’s books affects the acquirer’s bidding
strategies. He compares the bidding outcomes under three accounting measurement rules,
the purchase method, the exit value method, and the perceived value-in-use method. *Plantin
and Tirole (Forthcoming)* consider an agency model in which two performance measures, the
public market prices of a similar asset and the asset’s actual sale price, are available. They
endogenize market prices from a bidding process and show an interesting externality of using
market prices. However, the inefficiency of MTM in their paper comes from the imperfection
(noise) of the market prices as a measure of the asset value.

Most models of MTM, however, do not endogenize price informativeness. *Cifuentes,
Shin, and Ferrucci (2005); Allen and Carletti (2008); Plantin, Shin, and Sapra (2008) and
Shin (2008)* fall into this category, as they assume exogenous illiquidity in the asset market.
*Burkhardt and Strausz (2009) and Acharya and Ryan (2016)* show that MTM inefficiently
increases the firm’s risk-shifting incentive (see also *Heaton, Lucas, and McDonald (2010)).
*Caskey and Hughes (2012)* show that the use of MTM reduces the risk-shifting incentive and
improves investment decisions. *Lu, Sapra, and Subramanian (2012)* demonstrate that MTM
induces a tension between the risk-shifting and the debt-overhang problem with investments. Lin and Lu (2014) also find that MTM induces a tension in the socially optimal investment decision. Corona, Nan, and Zhang (2013) study banks’ voluntary choices of MTM, present an interesting possibility of multiple equilibria, and link the multiplicity to the recent financial crisis. In Otto and Volpin (Forthcoming), MTM reduces the use of other relevant information, while in Gigler, Kanodia, Sapra, and Venugopolan (2013) MTM leads to an overuse of information, with negative consequences for investment.

The rest of the paper is organized as follows. Section 2 describes the model, section 3 presents the equilibria, section 4 states our main results, section 5 considers various extensions to the basic model, and section 6 concludes.

2 Model

2.1 The overview

The model starts with a standard “skin in the game” component whereby the bank endogenously holds some risky loans on its balance sheet. We then augment this model with accounting measurement of the retained loan, and compare the retention and origination decisions under two different accounting measurement regimes.

The timing of the model is as follows. There are three dates: \( t = 0, 1, 2 \). At \( t = 0 \), the bank originates a loan (loan origination). At \( t = 1 \), the bank learns about the loan quality, chooses what fraction of the loan to retain and sells the rest to the loan market (loan distribution). At \( t = 2 \), the loan pays off. The risk free rate is zero and all parties are risk neutral.

There is a continuum of ex-ante identical commercial banks. The representative bank finances risky loans with insured deposits and equity. The bank makes decisions to maximize the market value of its equity. The bank’s equity holders have limited liability. If the bank’s
cash flow is insufficient to cover the deposits, the depositors are paid off by the deposit insurance fund. It is well-known that deposit insurance induces the bank to retain excessive risk. To counter this asset substitution incentive, the bank is subject to a capital ratio requirement $\gamma$ and pays a risk assessment $c$ for each unit of risky asset it retains.\(^3\) Each $1$ risky loan the bank retains on the balance sheet has to be financed at least by $\gamma$ equity and at most by $(1 - \gamma)$ deposits.\(^4\) Later we also assume that the risk assessment $c$ is so large that the bank has no incentive to retain risky loans in the absence of informational frictions. The bank adjusts its deposit and dividend policies to rebalance its capital structure.

In sum, we take the bank’s capital structure arrangement discussed above as given, as is common in the literature (e.g., Allen and Carletti (2008), Lu, Sapra, and Subramanian (2012) and Corona, Nan, and Zhang (2015)). We endogenize the bank’s capital structure in section 5.2. The representative bank follows the OTD model: it has expertise in originating loans but a disadvantage in retaining loans on the balance sheet. We operationalize the OTD business model as follows.

### 2.2 Loan origination

The first component of the OTD model is that the bank has expertise in originating loans. At $t = 0$, the bank originates a risky loan that matures at $t = 2$. The loan principal $B_0$ is recorded as the loan’s book value at $t = 0$. The loan carries an interest rate $R - B_0 > 0$. Thus, the loan’s face value is $R$.\(^5\) For simplicity, we assume that at $t = 2$ the risky loan either

---

\(^3\) Various interpretations of exogenous cost $c$ exist. For a regulated financial institution, cost $c$ could represent the marginal cost to meet its capital requirement when it takes on one more unit of a risky asset. More generally, cost $c$ could capture any differential in investment opportunities, liquidity preference or funding cost for the distributing institution and investors (e.g., DeMarzo and Duffie (1999); DeMarzo (2005)). We will stick to the interpretation of $c$ as the risk assessment by the FDIC for ease of reference in the rest of the paper.

\(^4\) We take the capital requirement $\gamma$, as well as any connection in practice between $\gamma$ and $c$, as exogenous to focus on the effects of accounting measurement. Later we endogenize the capital requirement choice by the regulator in section 5.5.

\(^5\) The interest rate on the loan satisfies $R = B_0 \cdot \left(1 + \frac{R - B_0}{B_0}\right)$. 
pays off $R$ in full or defaults with zero recovery. Denote the loan’s random cash flow by $	ilde{x} \in \{R, 0\}$. The probability of $x = R$ is $\theta \in \{g, b\}$, with $1 > g > b > 0$. We call $\theta$ the quality (type) of the loan, or interchangeably, the quality (type) of the bank. A good loan has a lower default probability than a bad loan.

The loan quality could be improved by the bank’s origination effort at $t = 0$. The bank with origination effort $m$ receives a good loan ($\theta = g$) with probability $m$ and a bad loan ($\theta = b$) with probability $1 - m$, that is $\Pr(\tilde{\theta}(m) = g) = m$. The origination effort $m$ comes at a private cost $s(m)$ to the bank. $s(m)$ satisfies the standard properties: $s(0) = s'(0) = 0$, $s'(m) > 0$ for $m > 0$, $s'(1) = S$, $s'' > 0$, where $S$ is a sufficiently large positive number to ensure that the choice of $m$ is interior. As will become clear later, whether origination effort $m$ is observable to the loan market or not does not affect any result in our baseline model. With the risk-free rate normalized to zero, we assume that a good loan yields a positive net present value (NPV) while a bad loan generates a negative NPV, that is $gR > B_0 > bR$.

Throughout the paper we refer to a single loan for ease of reference. However, the single loan should be understood as a stand-in for a large portfolio of loans, each with cash flow $\tilde{x} + \tilde{\varepsilon}_n$, where $\tilde{x}$ and $\tilde{\varepsilon}_n$ are uncorrelated and represent the systematic and the idiosyncratic components, respectively. $\tilde{\varepsilon}_n$ has mean zero. Thus, the average cash flow of the loan portfolio is $\bar{x} = \lim_{N \to \infty} \frac{1}{N} \sum_{n=1}^{N} (\tilde{x} + \tilde{\varepsilon}_n)$. Moreover, since we refer to a representative bank, the results could be interpreted as the aggregate results for the economy. For example, the representative bank’s origination effort $m$ determines the expected quality of the bank’s loan, but it also measures the average quality of loans in the economy by the law of large numbers.
2.3 Loan distribution

At $t = 1$, the bank privately observes its loan quality $\theta$ and makes the retention decision.\(^6\) Retention is costly in that the bank pays a risk assessment $c$ to the regulator for every unit of the risky loan it carries on its books from $t = 1$ to $t = 2$.\(^7\) This assumption operationalizes the second component of the OTD model that it is costly for the bank to retain risky loans on its books.

What complicates the retention decision is the fact that the bank faces the lemons problem in the loan market as a result of its private knowledge of its loan quality $\theta$, which in turn results from its expertise in loan origination (the first part of the OTD model). To overcome the lemons problem, the bank adopts a standard “skin in the game” solution. It retains $k$ homogeneous portion of the loan on its own books and sells the $1 - k$ portion to the loan’s market.\(^8\) The loan market responds with a per-unit price $p(k)$ for the sold portion. As a result, the bank endogenously holds a non-cash asset, i.e., the retained loan, on its balance sheet.

2.4 Accounting measurement

The key issue of interest is how the retained loan is valued on the bank’s balance sheet at $t = 1$. Accounting measurement of the retained loan matters because we assume that the capital ratio requirement $\gamma$ is based on accounting measures of assets, liabilities and capital.

We consider two polar accounting regimes: historical cost (HC) and mark-to-market

---

\(^6\) The bank’s information advantage over loan quality is a classic building block in banking theory. Significant delays between the asset generation and the sale, for instance in shelf registrations, explain the information advantage accumulated by the bank (DeMarzo and Duffie (1999)). Specific direct evidence comes from stock market reactions at the time of loan sales in the secondary market (e.g., Berndt and Gupta (2009); Gande and Saunders (2012)).

\(^7\) We assume away the risk assessment for holding the loan from $t = 0$ to $t = 1$. Adding such a cost does not affect the results qualitatively because the bank does not learn the loan quality until $t = 1$.

\(^8\) An alternative interpretation is the securitization of the loan. The bank places the whole loan in a special-purpose vehicle (SPV) and retains a proportional claim in the SPV.
(MTM). Under HC, the retained loan is recorded at its initial book value $B_0$ (possibly with pre-determined adjustments). Under MTM, the retained loan is marked to the market price of the sold portion of the loan. Denote by $B_1^A$ the per-unit measurement of the retained loan at $t = 1$ under accounting measurement regime $A \in \{H, M\}$. $A = H$ indicates HC and $A = M$ indicates MTM. Since we will compare the equilibria under HC and MTM, all endogenous valuables should be indexed by accounting regime $A$. To ease exposition, we omit the index $A$ unless we need to compare the two regimes.

3 The equilibrium

An equilibrium strategy profile consists of the triplet $\{m^*, k^*, p^*(k)\}$. Since $m$ is observable, the origination decision is subgame perfect. However, since the loan quality $\theta$ is the bank’s private information, we use Perfect Bayesian Equilibrium (PBE) as the solution concept for the retention decision.

3.1 Preliminary: the bank’s equity value

The bank makes decisions to maximize the market value of its equity. In the remainder of the paper, we use “equity value” to refer to the bank’s market value of equity, and highlight the distinction with “book equity” where necessary to avoid confusion. Before we solve for the retention decision at $t = 1$, we analyze the bank’s equity value at $t = 1$ and explain how it is affected by accounting measurement. Towards this purpose we treat the bank’s retention decision $k$ and origination decision $m$ as fixed in this subsection. In the next subsections, we examine these two decisions.

The equity value of the bank of type $\theta$ at $t = 1$, denoted by $V_{1\theta}$, is the sum of expected dividends at $t = 1$ and $t = 2$

$$V_{1\theta} = d_1 + E_{1\theta}[d_2(\bar{x})].$$  \hspace{1cm} (1)

Dividends $d_1$ and $d_2$ are plugs from the bank’s capital structure choices. Given the deposit insurance assumed in our model, the bank always retains the minimum required capital and distributes any excess capital as dividends. Accordingly, the dividends $d_1$ and $d_2$ are such that the capital requirement binds.\(^9\)

<table>
<thead>
<tr>
<th>Row</th>
<th>Events</th>
<th>Cash</th>
<th>Loan</th>
<th>Deposits</th>
<th>Book equity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$t = 0$</td>
<td>0</td>
<td>$B_0$</td>
<td>$(1 - \gamma) B_0$</td>
<td>$\gamma B_0$</td>
</tr>
<tr>
<td>2</td>
<td>$t = 1$ after sale before $d_1$</td>
<td>$CASH$</td>
<td>$kB_1$</td>
<td>$(1 - \gamma) kB_1$</td>
<td>$EQUITY$</td>
</tr>
<tr>
<td>3</td>
<td>$t = 1$ after $d_1$</td>
<td>0</td>
<td>$kB_1$</td>
<td>$(1 - \gamma) kB_1$</td>
<td>$\gamma kB_1$</td>
</tr>
<tr>
<td>4</td>
<td>$t = 2$ before $d_2$</td>
<td>$k\bar{x}$</td>
<td>0</td>
<td>$(1 - \gamma) kB_1$</td>
<td>$k [\bar{x} - (1 - \gamma) B_1]$</td>
</tr>
<tr>
<td>5</td>
<td>$t = 2$ after $d_2$</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Notes: \(CASH \triangleq (1 - k) p - kc + (1 - \gamma) (kB_1 - B_0) + e^0\) and \(EQUITY \triangleq (1 - k) (p - B_0) + k (B_1 - B_0) - kc + e^0 + \gamma B_0\).

Table 1: The bank’s balance sheets.

We describe the bank’s balance sheets working backward from $t = 2$. After the distribution of dividend $d_1$ at $t = 1$ but before the loan payout, the bank’s balance sheet can be read from row 3 in Table 1. The bank holds risky loan with book value $kB_1$ and finances it with $\gamma kB_1$ book equity and $(1 - \gamma) kB_1$ deposits. If the loan pays out $x = R$ per unit, the bank receives $kR$ from the retained loan. After paying off the deposits $k (1 - \gamma) B_1$, the bank distributes the remainder as dividend $d_2 = k [R - (1 - \gamma) B_1]$. If the loan defaults and pays out 0, then the bank equity holders receive $d_2 = 0$ (and the depositors are paid off by the FDIC). Thus, the dividend $d_2$ is a function of the loan payoff $\bar{x}$

$$d_2 (\bar{x}) = k \max \{\bar{x} - (1 - \gamma) B_1, 0\}. \quad (2)$$

Equation (2) shows that the bank effectively has a call option on the retained loan with a strike price equal to the deposits $(1 - \gamma) B_1$ (per unit of the retained loan). The loan has a risky payoff of $\bar{x}$. If the loan pays out $R$, which is greater than the deposits, the bank

---

\(^9\) The bank’s underlying optimization program and the proof of the optimality of the bank’s dividend decisions are available upon request.
exercises the call option by paying off the deposits and pockets the remainder. If the loan defaults, the bank does not exercise the call option and receives 0.

We perform a change of variable here to facilitate the subsequent analysis. According to the call-put parity, the call option could be replicated by the underlying loan $\bar{x}$ plus a put option with the same strike price plus cash. Define the put option as

$$A_\theta \triangleq E_{1\theta} \left[ \max \left\{ (1 - \gamma) B_1^A - \bar{x}, 0 \right\} \right] = (1 - \theta) (1 - \gamma) B_1^A.$$  \hfill (3)

We have indexed the notation by accounting regime $A$ for clarity. By the call-put parity, we can rewrite $d_2 (\bar{x})$ in equation (2) as

$$d_2 (\bar{x}) = k (E_{1\theta} [\bar{x}] + A_\theta - (1 - \gamma) B_1).$$

Now we compute dividend $d_1$. At $t = 1$, the bank starts with a risky loan $B_0$. After selling $1 - k$ fraction of the loan at price $p$ and marking the retained loan from $B_0$ per unit to $B_1$ per unit, the bank’s balance sheet is summarized in row 2 in Table 1. The two quantities, $CASH$ and $EQUITY$, are defined at the bottom of Table 1. With risky loan $kB_1$, the bank needs $(1 - \gamma) kB_1$ deposits and $\gamma kB_1$ book equity, and distributes the excess cash as dividend $d_1 = CASH$. The amount of $CASH$ results from the following transactions. First, the bank receives $(1 - k) p$ proceeds from the loan sale. Second, the bank pays risk assessment $kc$. Third, it raises cash by adjusting the deposit base by $k (1 - \gamma) (B_1 - B_0)$. Finally, it receives cash earnings $e^0$ from other sources. We make this assumption so that the bank would not violate the capital requirement at $t = 1$, and thus to avoid the uninteresting case in which the game ends at $t = 1$.

By the double-entry bookkeeping system, dividend $d_1$ can also be computed from the bank’s book equity side. The bank’s book equity changes as follows. First, the bank recognizes earnings $(1 - k) (p - B_0)$ from the loan sale. Second, the risk assessment cost $kc$ reduces its earnings. Third, the bank recognizes the re-measurement of the retained loan, $k (B_1 - B_0)$,
if any, in earnings. Finally, it records the earnings $e^0$ from other sources. Dividend $d_1$ is then equal to the beginning balance plus changes minus the ending balance of the book equity, that is

$$d_1 = \gamma B_0 + (1 - k) (p - B_0) - kc + k (B_1 - B_0) + e^0 - \gamma kB_1.$$  

(4)

$d_1$ can be verified to be the same as quantity $CASH$ defined in Table 1.

Plugging in $d_1$ and $d_2$ into equation (1), the bank’s equity value of type $\theta$ at $t = 1$ can be rewritten as

$$V_{1\theta} (k) = (1 - k) p + k (-c + E_{1\theta} [\bar{x}] + A_{\theta}) - (1 - \gamma) B_0 + e^0.$$ 

(5)

$V_{1\theta} (k)$ in equation (5) is the key quantity in the model. It describes the bank’s equity value as a function of the retention $k$. For the sold portion of the loan, the bank receives proceeds $(1 - k) p$. For each unit of the retained loan, the bank pays risk assessment $c$, receives the expected cash flow $E_{1\theta} [\bar{x}]$, and enjoys a put option $A_{\theta}$. In addition, the bank receives $e^0$ from other sources and needs to pay off the deposits $(1 - \gamma) B_0$ at $t = 1$.

Now we explain how accounting measurement affects the bank’s equity value $V_{1\theta} (k)$. Accounting measurement rules (MTM vs. HC) affect the book value of the retained loan $B_1$. Thus, the effect of accounting measurement on the bank’s equity value is captured by

$$\frac{\partial V_{1\theta}}{\partial B_1} = \frac{\partial d_1}{\partial B_1} + \frac{\partial E_{1\theta} [d_2(\bar{x})]}{\partial B_1} = k \left(1 - \gamma - \left(1 - \gamma - \frac{\partial A_{\theta}}{\partial B_1}\right)\right) = k \frac{\partial A_{\theta}}{\partial B_1} = k (1 - \theta) (1 - \gamma).$$ 

(6)

One dollar (accounting) re-measurement profit of the retention increases dividend $d_1$ at $t = 1$ by $\frac{\partial d_1}{\partial B_1} = 1 - \gamma$ dollars but reduces the expected dividend $d_2$ at $t = 2$ only by $\frac{\partial E_{1\theta} [d_2]}{\partial B_1} = (1 - \gamma) - \frac{\partial A_{\theta}}{\partial B_1}$ dollars. The net benefit of accounting re-measurement is thus $\frac{\partial A_{\theta}}{\partial B_1} = (1 - \theta) (1 - \gamma)$, which is strictly positive if $\theta < 1$ and $\gamma < 1$. In other words, as long as the bank has default risk ($\theta < 1$) and uses some deposits ($\gamma < 1$), the early recognition of earnings is valuable. Moreover, the put option value from the retention fully summarizes
the impact of accounting measurement on the bank’s equity value. We summarize the put option’s properties in the following lemma.

**Lemma 1.** *The put option value $A_\theta$ is increasing in the book value of the retained loan $B_1$, but decreasing in capital ratio requirement $\gamma$ and loan quality $\theta$.*

These results can be explained from the drivers of the value of a put option. The value of a put option is increasing in its strike price and in its volatility. From its definition in equation (3), the put option on the retained loan has a strike price of $(1 - \gamma)B_1$, which is equal to the deposit funding for per-unit retained loan. A higher loan value $B_1$ and a lower capital ratio requirement $\gamma$ increase the value of the put option because they allow the bank to increase its deposit funding for a given loan. In addition, the bad bank is more likely to exploit the deposit insurance because of its higher default risk. Hence, we have explained the intuition for Lemma 1.

We have created a setting in which accounting measurement has economic consequences. MTM allows the early recognition of the expected economic profit in current earnings, which allows the bank to pay out more dividends earlier. The early payout is valuable to the bank because it transfers the risk of the loan partially from the bank equity holders to the deposit insurer. Specifically, the bank benefits from the early recognition of earnings because it is protected by limited liability (as reflected in the put option) from having to “pay back” these earnings should the bank default in future. For the bank with limited liability, a bird in the hand (one more dollar of current earnings) is worth more than one in the bush (one more dollar of future earnings). The combination of insured deposits and a less than full capital requirement ($\gamma < 1$) creates the bank’s put option from loan retention. A higher capital requirement restricts the early dividend distribution and thus reduces the bank’s put option value. Accounting measurement becomes relevant when it is used in the implementation of the capital requirement.
3.2 The retention decision

Having characterized the bank equity value at \( t = 1 \) in equation (5), we are ready to solve for the bank’s retention \( k_g^* \). We focus on separating equilibria whenever possible because loan prices are most informative and thus the motivation for using MTM is the strongest in separating equilibria.

From here on, we explicitly index the endogenous variables with accounting regime \( A \in \{ H, M \} \). \( A = H \) indicates HC and \( A = M \) means MTM.

In a separating equilibrium, the bank of type \( \theta \) retains \( k_g^{A*} \) and the market perfectly infers the bank’s type \( \theta \) from the retention. Denote the market’s belief conditional on observing retention \( k \) by \( \pi (k) \triangleq \Pr (\theta = g | k) \). Thus, \( \pi (k_g^{HA*}) = 1 \) and \( \pi (k_g^{BA*}) = 0 \). Accordingly, \( p (k_g^{HA*}) = gR \) and \( p (k_g^{BA*}) = bR \). It is also convenient to define notations for the book value when the bank of type \( \theta \in \{ g, b \} \) holds \( k_g^{A*} \) under accounting regime \( A \in \{ H, M \} \), that is

\[
B_1^{A*} = \begin{cases} 
  p (k_g^{MA*}) = gR & \text{if } A = M \\
  B_0 & \text{if } A = H 
\end{cases}.
\]

(7)

The bank’s equity value, defined in equation (5), reveals that there are two components of the equity value that vary with bank type \( \theta \), the expected cash flow \( E_1^{\theta} [\bar{x}] = \theta R \) and the put option \( E_1^{\theta} [\max \{ (1 - \gamma) B_1^{A} - \bar{x}, 0 \}] = (1 - \theta) (1 - \gamma) B_1^{A} \). First, the good bank expects to receive \( gR \) per unit from the retention while the bad bank expects only \( bR \). Second, the put option is more valuable to the bad bank than to the good bank because the bad bank’s loan is more likely to default. Overall, the following lemma shows that the cash-flow term dominates the put option. As a result, the net cost of retention \( c - \theta R - (1 - \theta) (1 - \gamma) B_1^{A} \) is higher for the bad bank than for the good bank, thus making separation possible.

**Lemma 2.** *Retention is more costly for the bad bank than for the good bank.*

With these preliminaries, the retention decision can now be characterized as follows.
Proposition 1. For \( c \geq c_A \), under accounting regime \( A \in \{H,M\} \), the unique separating equilibrium is the least-cost one in which

- the retention decisions are \( k_{\theta}^{A*} = \begin{cases} \frac{(g-b)R}{(g-b)R + c - A_b} & \text{if } \theta = g \\ 0 & \text{if } \theta = b \end{cases} \);

- the per-unit loan prices conditional on retention are \( p^* (k) = \begin{cases} gR & \text{if } k \geq k_{g}^{A*} \\ bR & \text{otherwise} \end{cases} \).

Proposition 1 identifies the unique separating equilibrium under each accounting regime \( A \in \{H,M\} \). We discuss several features of the equilibrium. First, the separating equilibria arise only when the risk assessment \( c \) exceeds the value of the put option the bad bank receives off equilibrium \( A_b \). Otherwise, the retention would always be beneficial to the banks and could not serve as a credible signal of loan quality. The resulting equilibrium would be trivial in that both banks would hold the entire loan.

Second, the bad bank does not retain any loan in equilibrium under either accounting regime, that is \( k_{b}^{A*} = 0 \) for \( A \in \{H,M\} \). In any separating equilibrium, the bad bank receives \( p \left( k_{b}^{A*} \right) = bR \), the worst possible price. Holding any \( k_{b}^{A} > 0 \) does not improve the price the bad bank fetches for the sold portion of the loan but incurs a net retention cost \( c - A_b \). Thus, the bad bank sells the entire loan in any separating equilibrium. The bad bank’s equilibrium equity value is thus

\[
V_{1b}^{A*} \triangleq V_{1b}^{A} \left( k_{b}^{A*} \right) = bR - (1 - \gamma) B_0 + e^0, \ A \in \{H,M\}.
\] (8)

Third, the good bank has to retain enough loan in order to discourage the bad bank from mimicking. To see this, we check the bad bank’s incentive to deviate from \( k_{b}^{A*} = 0 \) to \( k_{g}^{A} \geq k_{g}^{A*} \). The incremental equity value is

\[
V_{1b}^{A} \left( k_{g}^{A} \right) - V_{1b}^{A} (0) = \left( 1 - k_{g}^{A} \right) \left( g - b \right) R - k_{g}^{A} \left( c - A_b \right).
\]
Retaining $k^A_g$ portion of the loan allows the bad bank to fetch a price premium $(g - b) R$ for the sold portion of the loan, but incurs a net cost of $c - A_g$ for each unit of the retention. As $k^A_g$ increases, the benefit becomes smaller (selling a smaller portion) while the cost becomes higher (retaining a larger portion). When $k^A_g > k^{A*}_g \triangleq \frac{(g-b) R}{(g-b) R + c - A_g}$, the bad bank does not find it optimal any longer to mimic the good bank. The bad bank’s off-equilibrium payoff thus determines the good bank’s equilibrium retention $k^{A*}_g$.

Finally, it can be verified (in the proof) that the good bank has an incentive to retain $k^{A*}_g$, and that the least-cost separating equilibrium $(k^{A*}_g, 0)$ is the unique equilibrium under the Intuitive Criterion. Moreover, the good bank’s equilibrium equity value is

$$V^{A*}_{1g} \triangleq V^{A}_{1g} (k^{A*}_g) = (1 - k^{A*}_g) g R + k^{A*}_g (g R - c + A_g) - (1 - \gamma) B_0 + e_0, \quad A \in \{H, M\}. \quad (9)$$

Having explained the separating equilibrium in Proposition 1, we now discuss its two implications. First, in the separating equilibrium, the loan prices of the sold portion are perfectly informative about the quality of the retained portion of the loan on the banks’ books because they are identical loans. Therefore, there is no illiquidity issue associated with the market price and the implementation of MTM is perfect. Second, the informativeness of the loan prices is not free. It is sustained by the good bank’s costly, inefficient retention.

We now quantify the cost of sustaining the price informativeness. To do this, we need a benchmark in which there is no information asymmetry about loan quality. In this case, $p(k) = \theta R$ for any $k$.

**Lemma 3.** For $c > c_A$, when loan quality $\theta$ is public information, under both accounting regimes $A \in \{H, M\}$,

1. both banks sell the entire loan at $t = 1$, that is $k^{BM*}_g = 0$;
2. the bank’s equilibrium equity value is $V^{BM*}_{1g} = \theta R - (1 - \gamma) B_0 + e_0$;
3. the bank’s ex-ante origination effort $m^{BM*}$ is the solution to the first-order condition
\( s' \left( m^{BM*} \right) = (g - b) R. \)

In the absence of information asymmetry in the loan market, the bank follows the OTD model. The bank sells the entire loan it originates and there are no risky loans retained on bank balance sheets.

Now we can examine the cost for the banks to sustain the informativeness of the loan price. The bad bank’s equilibrium equity value, computed in equation (8), is the same as that in the benchmark, that is \( V_{1b}^{BM*} = V_{1b}^{A*} \). This is because in equilibrium the bad bank sells the entire loan at the expected value \( bR \). On the other hand, the good bank’s equilibrium equity value, computed in equation (9), is lower than that in the benchmark. Specifically, the difference is

\[
V_{1g}^{BM*} - V_{1g}^{A*} = k_g^{A*} (c - A_g).
\]

The cost for the good bank to sustain the price informativeness is \( k_g^{A*} (c - A_g) \), the product of the equilibrium retention level and the effective per-unit retention cost. This cost of price discovery is consequential for the bank’s ex-ante origination decision, to which we turn now.

### 3.3 The origination decision

Anticipating that a loan of type \( \theta \) will receive an equity value of \( V_{1\theta}^{A*} \) at \( t = 1 \), the bank chooses origination effort \( m \) at \( t = 0 \) to maximize the expected equity value at \( t = 0 \)

\[
V_0^A (m) = m V_{1g}^{A*} + (1 - m) V_{1b}^{A*} - s (m).
\]  

The optimal origination effort \( m^{A*} \) is the solution to the first-order condition

\[
s' \left( m^{A*} \right) = V_{1g}^{A*} - V_{1b}^{A*} = (g - b) R - k_g^{A*} (c - A_g). \]
Origination effort \( m \) costs \( s(m) \), but increases the probability of receiving a good loan \( m \). The left-hand side is the marginal cost of origination effort. The right-hand side is the marginal benefit of effort, which is determined by the difference of the equity values of a good and a bad loan at \( t = 1 \). The greater the equity value differential at \( t = 1 \), the stronger the incentive the bank has to originate a good loan at \( t = 0 \). Therefore, the price discovery in the loan market at \( t = 1 \) provides incentives for the loan origination at \( t = 0 \).\(^{10}\)

The cost of price informativeness reduces \( V^{A^*}_{B^{-1}} \) and thus lowers the bank’s ex-ante incentive to originate good loans. Anticipating that the payoff of a good loan is lowered by the signaling cost, the bank exerts less effort to improve the loan quality in the first place. To see the last point more clearly, we could compare \( m^{A^*} \) with \( m^{BM^*} \)

\[
s'(m^{BM^*}) - s'(m^{A^*}) = k^{A^*}_{g}(c - A_g). \tag{12}
\]

The equilibrium origination effort is lower than the benchmark, that is \( m^{A^*} < m^{BM^*} \). Moreover, the shortfall is determined exactly by the signaling cost. MTM and HC affect this signaling cost differently and thus affect origination incentives differently.

The intuition highlights the novel feature of our model that information revealed through ex-post signaling (e.g., resolving the adverse selection problem) is useful for resolving the ex-ante moral hazard in the origination effort. Thus, the value of ex-post signaling is greater the more severe the moral hazard problem in the origination. As such, the severity of moral hazard in loan origination is an important predictor of the bank’s choice of distribution or securitization methods.

Finally, in making its origination and retention decisions, the bank should not lose money in expectation, that is, \( V^0(m^{A^*}) \geq 0 \). We verify that this participation constraint is satisfied.

\(^{10}\)The bank’s ex-ante effort to originate a good loan decreases in the amount of loan retained in our model. Alternatively, an often-heard argument is that banks must retain exposure to the risk of the loans they make so as to maintain incentives to originate good loans. This argument is valid if the bank commits to the retention before learning the quality of the loan. The proof is available upon request.
4 Analysis

In this section, we compare the economic consequences of MTM relative to HC for banks and the loan market. MTM creates a trade-off. On one hand, MTM marks the book value of the retained loan to the market price of the sold loan. Since the latter is informative about the loan quality, MTM improves the accuracy of the loan’s book value. On the other hand, in so doing, MTM also induces the good bank to retain more risky loans, which increases the cost of signaling. The net effect of MTM on the bank’s ex-ante is determined by this trade-off. We analyze each part of the trade-off in turn.

4.1 Benefits of MTM

A salient feature of the separating equilibrium under HC in Proposition 1 is that the price of the sold loan perfectly reveals the quality of the retention in equilibrium. Yet under HC, the retention is measured at $B_0$, the loan’s original cost. As such, the accounting system measures the retention in a systematically biased manner relative to its underlying quality, despite the fact that the relevant information is readily available. In contrast, MTM attempts to overcome this measurement deficiency. Under MTM, the retention is measured at $B_1^{MTM} = gR$, the equilibrium (per-unit) price of the sold portion of the loan. We define measurement accuracy as the (inverse) distance between the book value and the true quality of the loan. Thus, relative to HC, MTM improves measurement accuracy.

All else equal, this improvement in measurement accuracy increases the good bank’s equity value without affecting that of the bad bank. Therefore, it leads to a larger value differential between a good and bad bank, which increases the ex-ante origination effort.

**Proposition 2.** In equilibrium, the book value of the loan is lower than its true quality under HC, and is the same under MTM. All else equal, this improvement in measurement accuracy increases the good bank’s equity value and ex-ante origination efforts.
Proposition 2 highlights the conventional wisdom of the efficiency of MTM: MTM makes asset measurement more accurate by exploiting the information in asset prices. All else equal, the enhanced measurement accuracy mitigates the moral hazard problem in the loan origination efforts. However, all else is not equal. As we switch from HC to MTM, the bank’s equilibrium retention decisions change as well, the other part of the trade-off to which we turn next.

4.2 Cost of MTM: risk retention

As we switch to MTM, the book value of the retained loan is marked to the market price of the sold loan. While this improvement in measurement accuracy improves the good bank’s equity value on the equilibrium path, it also increases the bad bank’s equity value off the equilibrium path. As a result, the equilibrium retention decisions change, as stated below.

Proposition 3. The good bank retains more loans on the balance sheet under MTM than under HC, that is \( k_{gM}^* \geq k_{gH}^* \).

The intuition for Proposition 3 is simple. As the discussion following Proposition 1 suggests, the bad bank’s incentive to mimic the good bank on the off-equilibrium path drives the good bank’s equilibrium retention. When switching from HC to MTM, the only change to the bad bank’s off-equilibrium payoff is that the put option value changes from \( H_b \) to \( M_b \). By Lemma 1, we know that \( M_b > H_b \) because \( B_1^{M*} > B_1^{H*} \), that is, the measurement of the retention (when the bank retains \( k_{gA}^* \)) is higher under MTM than under HC. By marking the retention to the market price \( B_1^{M*} = gR \) under MTM, the bad bank could recognize an additional re-measurement benefit \( B_1^{M*} - B_1^{H*} \) for its retention if it were to mimic the good bank by holding \( k_{gM}^* \). This additional benefit would increase the strike price of the put option and make the bad bank’s deviation more profitable. To deter the bad bank from mimicking, the good bank has to send a stronger, more costly signal by retaining a larger position in the loan.
Proposition 3 demonstrates an important cost of using MTM to exploit the equilibrium informativeness of prices. Recall that the bank would ideally like to dispose of the entire loan. Information asymmetry in the loan market forces the good bank to retain some risky loans in equilibrium. MTM, however, forces the good bank to retain even more than HC. The attempt to exploit the information in price via MTM changes the (signaling) process by which the information is produced and makes the (signaling) process more costly. It is this adverse feedback to the banks’ retention decisions that could reduce the bank's origination efforts and the overall efficiency of MTM.

4.3 MTM and loan origination efforts

Having understood how MTM improves the ex-post measurement accuracy but increases the good bank’s costly retention, we turn to its overall effects on the bank’s ex-ante incentive to originate good loans.

**Proposition 4.** There exists a unique threshold of retention cost $c$, such that the bank’s origination efforts are lower under MTM than under HC if and only if $c > \bar{c}$.

Proposition 4 gives conditions under which MTM reduces the bank’s ex-ante incentives to originate good loans. The bank’s incentive to originate good loans at $t = 0$ is provided by the difference of the equity value of a good relative to a bad loan at $t = 1$, as we saw in the first-order condition for the origination decision (equation (11)). On the one hand, MTM allows the good bank to mark the retention up to its true value and reduces the effective per-unit retention cost. We call this the unit-cost effect. On the other hand, MTM also forces the good bank to retain more exposure. We term this as the level effect. As a result, the net impact of MTM on the signaling cost is a trade-off between a lower effective per-unit retention cost and a higher retention level.

This trade-off between the unit-cost effect and the level effect is complicated. For example, regulatory cost $c$ both reduces the retention level ($\frac{\partial}{\partial c} k^A < 0$) and increases the
unit retention cost \((c - A_g)\). Proposition 4 shows that when risk assessment \(c\) is sufficiently high, the level effect dominates the unit-cost effect. In that case, MTM increases the net signaling cost and reduces the bank’s ex-ante origination effort. The key driving force behind Proposition 4 is the following lemma.

**Lemma 4.** When switching to MTM, the put option value increases for both the good and the bad bank, but it increases more for the bad bank, that is \(M_b - H_b > M_g - H_g > 0\).

The signaling cost is determined by the good bank’s retention level and unit retention cost, but the former is determined by the bad bank’s retention cost. When we switch from HC to MTM, the re-measurement of retention reduces the good bank’s unit retention cost on the equilibrium path, but at the same time reduces the bad bank’s unit retention cost off the equilibrium path. Lemma 4 shows that the second effect is more important than the first effect. The reason is that, relative to the good loan, the bad loan is more likely to default at \(t = 2\) and thus yields a more valuable put option. To see the intuition better, we could derive

\[
m^{M*} - m^{H*} \propto k_g^{H*} (c - H_g) - k_g^{M*} (c - M_g) \\
\propto Y - [(M_b - H_b) - (M_g - H_g)] \cdot c,
\]

where \(\propto\) means “has the same sign as”, and \(Y\) is a positive constant whose expression is given in the Appendix. From relation (13) and Lemma 4, we know that the equilibrium origination effort under MTM relative to HC is decreasing in \(c\). It is then a short step to prove that when the risk assessment is sufficiently high, the equity value of a good loan is smaller, and thus the origination effort is lower, under MTM compared to HC.

Since our bank is a representative bank, the origination effort \(m^{A*}\) also represents the average efforts by all banks in the economy. Thus, it also measures the overall quality of loans in the economy by the law of large numbers.

In sum, in an attempt to exploit price informativeness, MTM makes it more costly to sustain price informativeness. MTM does not reveal the bank’s private information about
loan quality. If MTM could grant the mark-up only to the good bank and force the bad bank to mark its retention down, or equivalently if the information MTM exploits were exogenous, MTM would improve the measurement accuracy without affecting the retention decisions. However, the MTM rule stipulates that the retention be marked to the market price of the loan the bank has sold. To exploit the information in the loan price, MTM has to rely on the banks’ retention behavior to generate the information. Thus, the information in the loan price MTM exploits is endogenous to the banks’ retention decisions. Because the bad bank could also hold retention on the off-equilibrium path, the early recognition benefit under MTM is also available to the bad bank on the off-equilibrium path. This increase in the payoff for the bad bank on the off-equilibrium path, induced by MTM, increases the equilibrium retention by the good bank and makes signaling more costly. In this sense, the attempt to exploit the information in the loan price via MTM makes producing the information in the loan price more costly.

5 Extensions

The baseline model illustrates the point that the attempt to exploit the information in asset prices interferes with the market mechanism that sustains the price informativeness in the first place. It is this feedback effect that could compromise the efficiency of MTM. In this section, we discuss a few extensions of the model.

5.1 MTM could destroy price informativeness

The baseline model focuses on separating equilibria. Since the loan prices are informative about the loan quality in a separating equilibrium, the baseline model is stacked against HC. Yet, we still show that MTM could make it more costly to sustain price informativeness. In this extension, we study pooling equilibria in which MTM destroys the price informativeness
it attempts to exploit. As the risk assessment $c$ decreases, the good bank’s equilibrium retention increases. Ultimately, it could reach its natural ceiling of $k = 1$. Beyond this point, pooling equilibria arise.

We make two simplifying assumptions to characterize the pooling equilibria. First, we assume that at $t = 1$ banks can generate a bad loan at the cost of $bR$. That is, it is a zero NPV action to generate bad loans ex post. This assumption means that the supply of bad loans is potentially infinite, which helps pin down the price of the pooled loans. Second, we assume that $m$ is observable to the loan market at $t = 1$. This assumption circumvents the issue of the bank’s joint deviation of origination effort $m$ and retention $k$ and thus simplifies the analysis. Note that both assumptions are innocuous for the analysis in separating equilibria in the baseline model.

**Proposition 5.** For $c_M > c \geq c_H$, there does not exist a separating equilibrium under MTM even though there is a unique separating equilibrium under HC. Instead, there exists a pooling equilibrium under MTM in which

- all the good banks retain $k_g^* = 1$; the mass of bad banks (per 1 good bank) retaining $k_b^* = 1$ is $q^* = \frac{(1-b)(1-\gamma)gR-c}{c-(1-b)(1-\gamma)bR}$; the rest, if any, retains nothing;

- the per-unit prices of the loans conditional on retention are

  $$p^*(k|q^*) = \begin{cases} 
  \frac{gR+q^*bR}{1+q^*} & \text{if } k = 1 \\
  bR & \text{otherwise} 
  \end{cases}$$

Proposition 5 complements the separating equilibria under HC and MTM in Proposition 1. We discuss its three features. First, $c_M > c_H$. It is easier to sustain separation under HC than under MTM. As regulatory cost $c$ falls, holding retention becomes more attractive. To deter the bad bank from mimicking and to sustain the separating equilibrium, the good bank has to raise its level of retention. When the equilibrium retention reaches its upper bound, there does not exist any pure-strategy separating equilibrium any longer. Because
by Proposition 3, the retention level under MTM \( k^M_g \) reaches the upper bound earlier than \( k^H_g \), its counterpart under HC. Thus, the separating equilibrium collapses sooner under MTM than under HC.

Second, when separation becomes impossible under MTM, the resulting equilibrium involves pooling: all good banks retain \( k^M_g = 1 \) and the mass of bad banks retaining \( k^M_b = 1 \) is \( q^* \). In equilibrium, a bad bank is indifferent between retaining 1 and 0, and the market price of the sold loan reflects the average quality of the loan pool \( p(k^*|q^*) = \frac{gR + q^* bR}{1 + q^*} \). Moreover, \( p(k^*|q^*) \) is decreasing in \( q^* \): the mimicking by bad banks reduces the average quality of the retained loans on the banks’ balance sheets.

Finally, when the separating equilibrium collapses, the loan price in any resulting non-separating equilibrium becomes less informative about the quality of the retained loan. In an attempt to “correct” the inefficiency of HC, MTM exploits the information in the loan price, only to destroy its informativeness in equilibrium. This paradoxical result highlights the endogenous nature of the informativeness of the loan price.

5.2 Excess equity as an additional signal

So far we have demonstrated a trade-off for MTM. In particular, we have highlighted a conceptual shortcoming of MTM: the attempt to exploit the information in equilibrium asset price affects the firm’s decision to hold the asset in the first place. Taking into account this endogenous nature of asset holding, MTM could be less efficient than HC.

To create a setting in which the bank endogenously holds an asset, we have assumed that the bank facing information asymmetry in the loan market uses loan retention as a signal of its loan quality. In practice, banks can potentially use other instruments as signals as well. One choice in our setting is the capital structure. In addition to loan retention, the good bank can also choose to finance the retained loan with more equity to deter the
bad bank from mimicking. In this extension, we explicitly analyze this possibility to better understand our main mechanism for the conceptual problem of MTM in the baseline model.

We aim to answer two sets of questions in this extension. First, for any given accounting regime, how does the bank use loan retention and excessive equity as signals of its loan quality? What is the equilibrium relation between these two signaling choices? Second, does our main mechanism survive with the availability of additional signaling devices? Is it still true that MTM can be less efficient than HC? In other words, is our mechanism driven by the exogenous capital structure in the baseline model?

We augment the baseline model as follows. For each unit of risky loan the bank decides to retain on its book, the bank also chooses to finance it with $\phi \geq \gamma$ fraction of equity and $1 - \phi$ fraction of deposits. Recall that $\gamma$ is the exogenous capital requirement in the baseline model. It is now interpreted as the minimum capital requirement. For ease of reference, we call $\phi$ excess equity or capital structure interchangeably. To make excess equity $\phi$ a possible signal, we assume that excess equity is costly relative to insured debt. Denote this cost by $q(\phi)$ with the following properties. First, $q(\gamma) = 0$. The cost of meeting the minimum capital requirement is normalized to 0. Second, $q'(\phi) > 0$ for $\phi > \gamma$, and $q'' > 0$. It is increasing and convex. Third, $q'(\gamma) = 0$. The marginal cost of using excess equity is 0. Finally, $q(1)$ is sufficiently large. It is prohibitively costly to finance the bank with all equity.

We then expand our definition of equilibrium to accommodate the pair of signals $(k, \phi)$, and re-solve the model by following a similar procedure as in the baseline model. To simplify the discussion, we focus only on the parameter region $c > (1 - b)(1 - \gamma)gR$. Recall that in the baseline model, in this region, separating equilibrium is possible under both HC and MTM. It is also sufficient to guarantee separating equilibria in this extension and thus we assume it throughout this extension. All the proofs are in the Appendix. Define $\bar{c} = \max\{(1 - g)R, (1 - b)(1 - \gamma)gR\}$.

**Proposition 6.** In a separating equilibrium,
1. The good bank always uses loan retention as a signal, \( k_g^* > 0 \);

2. Whether the good bank uses excess equity or not depends on \( c \):
   
   (a) if \( c < \bar{c} \), then the good bank chooses the minimum required equity \( \phi_g^* = \gamma \);

   (b) if \( c > \bar{c} \), then the good bank maintains excess equity \( \phi_g^* > \gamma \).

3. When both signals are used, they are substitutes.

Proposition 6 answers the first set of questions about the use of two signals for any given accounting regime. Part 1 is straightforward. A necessary condition for a separating equilibrium is that the good bank retains some loan, that is, \( k_g^* > 0 \). If the bank does not retain any loan, then the capital structure \( \phi \) becomes meaningless. Part 2 shows that, unlike loan retention \( k \), the signal of excess equity is not always deployed. It is deployed if and only if loan retention is sufficiently costly, that is, \( c > \bar{c} \). As we explain in the proof in the Appendix, from the perspective of existing equity holders, excess equity is costly in two ways. First, the first cost is \( q(\phi) \geq 0 \), the incremental cost of raising new equity capital relative to debt. Second, using more equity to finance the loan also reduces the put option value \( (\frac{\partial A_0}{\partial \phi} = \frac{\partial[(1-\theta)(1-\phi)B_1]}{\partial \phi} < 0) \). Therefore, despite the assumption that \( q'(\gamma) = q(\gamma) = 0 \), the good bank still chooses not to maintain excess equity if loan retention is not sufficiently expensive. Part 3 shows that when the good bank has access to both instruments and when both are viable, they are substitutes.

In sum, Proposition 6 confirms the intuition that both loan retention and excess equity can serve as credible signals of the bank’s loan quality. It also reveals the asymmetry in the relation between these two signals. Loan retention is necessary for excess equity to serve as a signal, but the converse is not true.

Now we turn to the answers to the second set of questions about the robustness of our main mechanism in this extension. For simplicity, we use the term “efficiency” to refer to the equilibrium origination effort \( m^* \) because the bank’s ex-ante value is monotonically
increasing in the equilibrium $m^*$. 

**Proposition 7.** The effects of MTM on loan retention, capital structure, and origination effort are such that

1. If $c < \bar{c}$, then $\phi_g^* = \gamma$; the switch to MTM increases the loan retention but improves the efficiency, that is, $k_g^{M*} > k_g^{H*}$ and $m^{M*} > m^{H*};$

2. If $c > \bar{c}$, then $\phi_g^* \in (\gamma, 1)$; the switch to MTM increases the excess equity and reduces the efficiency, that is, $\phi_g^{M*} > \phi_g^{H*}$ and $m^{M*} < m^{H*}.$

Proposition 7 is the counterpart of Propositions 3 and 4 in the baseline model. It confirms that the conceptual problem of MTM still arises when the bank can use excess equity as a signal.

Note that Proposition 7 overlaps with Proposition 6 about the choice of $\phi_g^*$. We repeat this part of the results in Proposition 7 so as to facilitate the discussion here. Specifically, if $c < \bar{c}$, then the good bank uses only loan retention as a signal. The model then reverts back to the baseline. By Proposition 4 in the baseline model, MTM is more efficient than HC in this case. If $c > \bar{c}$, the good bank uses both loan retention and excess equity as signals of its high loan quality. Like in the baseline model, the switch to MTM increases the bad bank’s off-equilibrium payoff from mimicking the good bank’s retention. All else equal, the switch generates a larger put option value for the bad bank than for the good bank. Thus, the good bank has to increase the cost of its signals to restore the equilibrium. Therefore, this same mechanism that led to the inefficiency of MTM in the baseline model works here as well. Part 2 shows that MTM is less efficient when $c > \bar{c}$.

How does the availability of excess equity as a signal affect the mechanism? It expands the set of instruments the good bank has to increase the total cost of signaling to deter the bad bank from mimicking. In the baseline model, the good bank raises loan retention $k$ in response to the switch to MTM (Proposition 3). In this extension, the good bank
coordinates the use of both loan retention $k$ and excess equity $\phi$. Since the two instruments are substitutes (part 3 of Proposition 6), it seems intuitive that the good bank would increase both loan retention $k$ and excess equity $\phi$, that is, $k^*_g > k^*_H$ and $\phi^*_g > \phi^*_H$. While we are able to prove the latter ($\phi^*_g > \phi^*_H$), we are unable to analytically prove or disprove the former, partly due to the fact that $k^*_g$ is determined only implicitly (see equation (28) in the Appendix). However, we have run numerical simulations and all results show $k^*_g > k^*_H$.

In sum, our main mechanism is robust to the possibility that banks use capital structure as a signal. In a separating equilibrium, the loan price perfectly reveals the quality of the retained loan. By allowing the bank to mark the retained loan up to the market price, MTM increases the bad bank’s payoff from retention off the equilibrium path. The good bank has to increase the cost of signaling to restore the separating equilibrium. This conceptual shortcoming of MTM is robust to the specific instruments the bank uses as signals of its loan quality.

5.3 Reputation

Another solution to the adverse selection problem in the OTD model in practice is through the bank’s reputation. Since our model is static in nature, it does not endogenously generate a reputation mechanism. In this extension, we augment the baseline model with a reduced-form bank reputation. Like in the previous extension of using the additional signal of capital structure, we also ask two questions. First, how does reputation affect the bank’s retention and origination decisions? Second, is the conceptual shortcoming of MTM robust to the use of reputation as an additional solution to the agency frictions?

Consider a setting in which reputation acts as an additional cost to the bank in case the loan advertised as good turns out to default. By deciding to retain some loan $k$ at $t = 1$, the bank intends to influence the market’s belief (“advertise”) of its higher loan quality. Should the loan nevertheless turn out to default at $t = 2$, which occurs with probability
$1 - \theta$, we assume that the bank incurs a cost $\eta$ for each unit of loan retained. The total expected reputational damage the bank suffers at $t = 1$ is then $-\eta k (1 - \theta)$. $\eta$ measures the importance of the bank’s reputation concern. Our baseline model is a special case with $\eta = 0$.

In this extension, two main results emerge. First, in both accounting regimes, as reputation becomes more important, the good bank retains fewer risky loans, but the ex-ante origination effort is higher if and only if the assessment cost $c$ is sufficiently large. On the one hand, reputation makes it more costly for the bad bank to mimic the good bank’s retention and thus leads to lower retention by the good bank on the equilibrium path. On the other hand, since the loan outcome is only a noisy signal of loan quality, the good bank may also see its loan default and thus suffers reputational damage. The lower risky retention increases the ex-ante origination effort while the additional reputational damage reduces the ex-ante origination effort.

Second, the comparison of MTM and HC is not affected by reputation. MTM is still dominated by HC when the risk assessment cost $c$ is sufficiently large. Since the reputation mechanism works under both accounting regimes but does not directly interact with accounting measurement, the presence of reputation does not alter the relative efficiency of MTM. In other words, the conceptual shortcoming of MTM is robust to the introduction of reputation as an additional solution to the adverse selection in the loan market.

In sum, given the adverse selection problem in the secondary loan markets, there exist many potential solutions. Signaling by capital structure and reputation are two examples of such solutions. Our analysis of these two solutions reveals a common pattern. These solutions directly mitigate the adverse selection problem, but their effects do not change the comparison of MTM and HC. Since we focus on the economic consequences of accounting measurement and use the adverse selection to create a demand for accounting measurement,

---

11 The proofs are available upon request.
the adverse selection problem in our model could be viewed as the residual friction after all other (imperfect) solutions have been exhausted.

5.4 Noisy prices

As we have discussed in the Introduction, the prior literature has emphasized the implementation difficulty of MTM that arises from noisy or biased prices. In contrast, we have focused on a conceptual problem of MTM that the attempt to exploit price informativeness makes it more costly to sustain the price informativeness. In this extension we explore the possible interaction of these two mechanisms.

Consider a setting in which with probability \(1 - \varepsilon\) the signaling game proceeds as in our baseline model. However, with probability \(\varepsilon\), both banks receive the same pooling price \(p \equiv (m^*g + (1 - m^*)b) R\), regardless of their retention strategy. The pooling price \(\bar{p}\) is noisy in that it obscures the difference between the good and bad loans. \(\varepsilon\) thus measures the noise in the price. We re-solve the model to examine the consequences of introducing exogenous noise into price.

We obtain two main results.\(^{12}\) First, the exogenous noise in price reduces the bad bank’s incentive to mimic the good bank’s retention and thus lowers the equilibrium retention by the good bank. Costly retention is used to influence the loan price in the market. Since the exogenous noise in price weakens the link between retention and loan price, the off-equilibrium benefit of retention is lower for the bad bank. As a result, the equilibrium retention by the good bank falls. This lowers the good bank’s signaling cost and improves efficiency.

However, the exogenous noise in price has another direct consequence that reduces the efficiency. As the first-order condition for the bank’s origination effort \(m\) (equation (11)) shows, the origination effort is increasing in the price informativeness. The exogenous noise

\(^{12}\) The proofs are available upon request.
in price reduces the price informativeness, which lowers the ex-ante origination effort. To illustrate, consider an extreme case in which the loan price is purely white noise (or the uninformative pooling price). While neither bank has incentives to retain any loan, neither has incentives to exert any origination effort either.

5.5 Coordination between regulation and the accounting regime

So far we have identified a conceptual shortcoming of MTM in the baseline model, and have demonstrated its robustness to additional signaling devices in the previous extensions. Given this conceptual shortcoming, how should the regulator adjust the capital requirement in response to a switch to MTM? We analyze this issue in this extension.

We augment the baseline model by introducing a regulator. Before the bank engages in origination efforts, the regulator chooses capital requirement $\gamma$ to maximize social welfare $U(\gamma)$, defined as

$$U(\gamma) = V^*_0(\gamma) - w(\gamma).$$

Recall that $V^*_0$ is the bank’s ex-ante equilibrium equity value. $w(\gamma)$ is the social cost of the capital requirement. We assume that $w(0) = w'(0) = 0$, $w' > 0$ for $\gamma > 0$, $w'' > 0$, and $w(1)$ be sufficiently large. We assume that the capital requirement $\gamma$ chosen by the regulator always binds (since we have already studied banks’ ex-post equity choices in Section 5.2). For simplicity, we choose a quadratic origination cost function $s(m) = \frac{Sm^2}{2}$ with $S$ being sufficiently large to ensure an interior optimal origination effort.

The equilibrium solution concept with respect to the regulatory choice $\gamma$ is subgame perfection. Thus, we re-solve the model in three steps. First, for any given $\gamma$, we solve the subgame by using exactly the same procedure as in the baseline model. This step yields the bank’s ex-ante equity value $V^*_0(\gamma)$. Second, we derive the regulator’s optimal choice $\gamma^*$ for a given accounting regime. The structure specified above leads to an interior $\gamma^* \in (0, 1)$,
making it convenient to analyze our main question in the final step. Finally, we compare the optimal capital requirement and social welfare under the two accounting regimes. To save space, we focus only on the last step, which is our main question in this extension. We have relegated the proof and many details to the Appendix. Again we focus only on the separating equilibria.

**Proposition 8.** The effects of MTM on the optimal capital requirement and social welfare are such that

1. If \( c < \bar{c} \), then the switch to MTM leads to a lower capital requirement and higher social welfare, that is, \( \gamma^M_* < \gamma^H_* \) and \( U^M_* > U^H_* \);

2. If \( c > \bar{c} \), then the switch to MTM leads to a higher capital requirement and lower social welfare, that is, \( \gamma^M_* > \gamma^H_* \) and \( U^M_* < U^H_* \).

Proposition 8 shows that the optimal capital requirement should respond to the prevailing accounting regime. When \( c \) is sufficiently low \( (c < \bar{c}) \), we know from Proposition 4 in the baseline model that the switch to MTM improves the efficiency \( (V^*_0) \). The regulator lowers the capital requirement further to enhance this efficiency improvement and overall social welfare increases. In contrast, when \( c \) is sufficiently high \( (c > \bar{c}) \), we know from Proposition 4 in the baseline model that the switch to MTM reduces the efficiency \( (V^*_0) \). The regulator then responds with a higher capital requirement to mitigate the shortcoming of MTM. Despite the counteraction by the regulator, social welfare is still lower.

6 Conclusion

In this paper, we propose a new mechanism by which MTM could impose inefficiency on banks following the OTD model. We show that, relative to HC, MTM could induce banks to retain excessive exposure to the risk of the loans they originated and reduce banks’ ex-ante incentive to originate good loans. In the presence of information asymmetry, the
informativeness of loan prices is fragile in that it is sustained by a costly signaling process. The attempt to extract information from loan prices makes the signaling process costlier and in the extreme destroys the price informativeness. It is this feedback effect that compromises the efficiency of MTM and causes damage to the real economy. Our paper underscores that information and liquidity in asset markets are not exogenous. Rather, they are determined by the incentives and ability of market participants to overcome market frictions.

The appeal of MTM to economists is a straightforward corollary of the triumph of the efficient market hypothesis: market prices reflect all relevant information and thus serve as the best measure of asset values. By exploiting the information in market prices, MTM values a bank’s assets more accurately. The enhanced measurement accuracy improves the banks’ decisions. Opponents of MTM often accept this conceptual merit of MTM, but challenge its practical implementation. In particular, they point out that the market price is often imperfect in reflecting an asset’s fundamental value in the presence of fire sales or illiquidity (Shleifer and Vishny (1992)), and that the rigid reliance on imperfect prices under MTM could lead to undesirable consequences. Since the loan market is perfectly liquid from investors’ perspective, the implementation difficulty associated with exogenous illiquidity does not arise in our model. Instead, our model highlights a conceptual difficulty with MTM. The attempt to exploit the equilibrium price informativeness compromises the informativeness.

This conceptual difficulty with MTM may be a more general feature of accounting measurement beyond our particular setting of the OTD model. In general, a firm’s business model is viable only if it has some competitive advantage over the market in conducting its activities. As a result, the core assets and liabilities on a firm’s balance sheet, dictated by its business model, are often subject to the same market frictions that sustain the business model. Market prices in these markets are thus endogenously linked to the firm’s activities that are guided partially by accounting measurement. The optimal design of an accounting measurement rule thus requires an understanding of the firm’s business model to efficiently
support the business model. The inefficiency of MTM in the OTD model, where retention serves as a costly signal to overcome the information asymmetry in the market, is that MTM treats the retention as if it was sold, directly contradicting the bank’s purpose (business model) of holding retention. Attempting to resolve accounting measurement problems via a market-based solution could lead to unintended and sometimes undesirable consequences.

Finally, our model may also have some implications for understanding financial crises. To the extent that lower loan quality and banks’ excessive risk exposure are two important ingredients for the recent financial crisis, our models suggests a link between MTM and the financial crisis. The model helps explain the puzzling observation that banks have maintained excessive exposure to the risk of the loans they originated, contrary to what the OTD business model would suggest. This concentration of risk in the banking sector has been alleged as one of the key factors that turned the subprime mortgage crisis into a full-fledged financial crisis. Banks retain skin in the game to overcome the information asymmetry problem in the loan market. MTM exacerbates the problem by forcing banks to put even more loans on their own balance sheets. This cost could then further dampen banks' incentives to originate good loans, worsening the overall quality of loans in the economy.

References


Accounting Research 45 (2), 229–256.


A Appendix

Proof of Lemma 2

From expression (5), we have $\frac{\partial}{\partial k} V_{1g}^A (k) = -c - p + E_{1g}[\bar{x}] + E_{1g} \left[ \max \left\{ (1 - \gamma) B_1^A - \bar{x}, 0 \right\} \right] = -c - p + \theta R + (1 - \theta) (1 - \gamma) B_1^A$. Since $R > B_1^A$, we have $\frac{\partial}{\partial k} V_{1g}^A (k) - \frac{\partial}{\partial k} V_{1b}^A (k) = (g - b) \left[ R - (1 - \gamma) B_1^A \right] > 0$. Thus, retention is more costly for the bad type.

Proof of Proposition 1

Denote investors’ belief about bank type conditional on the bank’s retention decision $k$ by $\pi (\theta | k)$. In a separating PBE, $k_g^A \neq k_b^A = 0$ and the equilibrium belief is $\pi (g | k_g^A) =$
\[ \pi(b|k^A_g) = 1. \] Given the equilibrium belief, \( p(k) = gR \) if \( k = k^A_g \) and \( p(k) = bR \) otherwise. With this pricing strategy, the complete set of separating PBE levels of retention \( (S^A_s) \) is determined by the incentive compatibility constraints of both types. These constraints dictate that neither type must have an incentive to deviate from their equilibrium levels of retention \( (k^A_g > 0, k^A_b = 0) \)

\[
V_{1b}^A(0) \geq V_{1b}^A(k^A_g) \implies k^A_g \geq \frac{p(k^A_g) - p(0)}{c + p(k^A_g) - E_{1b}[\bar{x}] - A_b}, \tag{14}
\]

\[
V_{1g}^A(k^A_g) \geq V_{1g}^A(0) \implies k^A_g \leq \frac{p(k^A_g) - p(0)}{c + p(k^A_g) - E_{1g}[\bar{x}] - A_g}, \tag{15}
\]

where \( E_{1g}[\bar{x}] = gR \) and \( E_{1b}[\bar{x}] = bR \). The resulting set of separating PBE levels of retention under accounting regime \( A \) is

\[
S^A_s \triangleq \left\{ (k^A_g, k^A_b) \mid k^A_g = 0, k^A_g \in \left[ \frac{(g - b)R}{c + (g - b)R - A_b}, \min \left[ 1, \frac{(g - b)R}{c - A_g} \right] \right]\right\}.
\]

\( S^A_s \) is nonempty because, using equation (3) with expressions (7), \( (g - b)R - A_b + A_g = (g - b) \left( R - (1 - \gamma) B_1^A \right) > 0. \)

We now apply the Intuitive Criterion to refine away all PBEs that involve \( k^A_g \in \left( \frac{(g - b)R}{c + (g - b)R - A_b}, \min \left[ 1, \frac{(g - b)R}{c - A_g} \right] \right) \). For any such \( k^A_g \), consider the deviation \( \hat{k}^A = \frac{(g - b)R}{c + (g - b)R - A_b} \).

The Intuitive Criterion requires that \( \pi(b|\hat{k}^A) = 0 \) because \( \hat{k}^A \) is an equilibrium-dominated action for type \( b \) by condition (14) (the most favorable belief of investors upon observing \( \hat{k}^A \) is \( g \)). This implies that \( \pi(g|\hat{k}^A) = 1. \) Given this belief, \( \hat{k}^A \) is a profitable deviation for type \( g \) by condition (15). Thus, any \( k^A_g \in \left( \frac{(g - b)R}{c + (g - b)R - A_b}, \min \left[ 1, \frac{(g - b)R}{c - A_g} \right] \right) \) does not survive. The only PBE that survives is \( (k^A_g = \frac{(g - b)R}{c + (g - b)R - A_b}, k^A_b = 0) \). Finally, for \( c \geq c_A \triangleq A_b = (1 - b)(1 - \gamma)B_1^A \), we have \( k^A_g \in (0, 1] \) for \( A \in \{ H, M \} \).
Proof of participation constraint

For simplicity, we choose a quadratic origination cost function $s(m) = \frac{S m^2}{2}$ with $S$ being sufficiently large to ensure an interior optimal origination effort. With this simplification, we obtain the bank’s ex-ante equity value

$$V_0^{A*} = m^{A*} V_{1g}^{A*} + (1 - m^{A*}) V_{1b}^{A*} - s(m^{A*})$$

$$= V_{1b}^{A*} + \frac{S}{2} m^{A*2}. \quad (16)$$

The last line follows from substitution of the first-order condition for $m^{A*}$

$$S m^{A*} = V_{1g}^{A*} - V_{1b}^{A*}, \quad (17)$$

$$= \Delta p - k_g^{A*} (c - A_g)$$

$$= \frac{\Delta p (g - b)(R - (1 - \gamma) B_1)}{c + \Delta p - A_b}, \quad (18)$$

where we used the equilibrium outcomes

$$V_{1g}^{A*} = g R - (1 - \gamma) B_0 + e^0 - k_g^{A*} (c - A_g),$$

$$V_{1b}^{A*} = b R - (1 - \gamma) B_0 + e^0,$$

$$k_g^{A*} = \frac{\Delta p}{c + \Delta p - A_b}.$$

Substituting condition (18) back into expression (16) and simplifying, we have

$$V_0^{A*} (m^{A*}) = \frac{1}{2S} \left[ \frac{(g - b) R (R - (1 - \gamma) B_1^{A*})}{c + (g - b) R - (1 - b)(1 - \gamma) B_1^{A*}} \right]^2 + b R - (1 - \gamma) B_0 + e^0.$$

Using the parameter values \{\(g = 0.6, b = 0.4, R = 3, B_0 = 1.5, \gamma = 0.5, c = 1.5, e^0 = 1, S = 2\}\}, we verify numerically that $V_0^{M*} = 1.613 > 0$ and $V_0^{H*} = 1.617 > 0$ as required. Also, $c > \bar{c} = 0.54$. 

40
Proof of Lemma 3

With full information, \( p(k) = \theta R \) and \( E_{1\theta} \max \{(1 - \gamma) B_1 - \bar{x}, 0\} = A_\theta \). From equation (5), a sufficient condition for \( \frac{\partial}{\partial k} V_{1\theta} (k) = -c + (1 - \theta) (1 - \gamma) B_1 < 0 \) for all \( \theta \in \{g, b\} \) is \( c > (1 - b) (1 - \gamma) B_1 = A_b \). Thus, \( k_{g}^{BM*} = 0 \), and \( V_{1\theta}^{BM*} \) and \( s'(m^{BM*}) \) follow immediately from equations (5) and (11), respectively.

Proof of Proposition 2

Fixing the retention strategy under HC \( k_{H}^{*} \), the bank values under accounting regime \( A \) are

\[
\hat{V}_{1\theta}^{A} = \begin{cases} 
  gR - (1 - \gamma) B_0 + e^0 - k_{g}^{H*} (c - A_g) & \text{for } \theta = g \\
  bR - (1 - \gamma) B_0 + e^0 & \text{for } \theta = b 
\end{cases}
\]

where \( k_{g}^{H*} \) is given by the expression in Proposition 1, \( A_g = (1 - g) (1 - \gamma) B_1^A, B_1^M = gR \) and \( B_1^H = B_0 \). Since the impact of accounting measurement is captured by \( B_1^A \) through the option value \( A_g \), and \( \hat{V}_{1\theta}^{A} \) is increasing in \( B_1^A \), the bank values are (weakly) larger under MTM, that is, \( \hat{V}_{1\theta}^{M} \geq \hat{V}_{1\theta}^{H} \) for \( \theta = g, b \) with strict inequality for \( \theta = g \).

Using condition (11), the optimal origination effort satisfies

\[
s' \left( \hat{m}^{A} \right) = \hat{V}_{1g}^{A} - \hat{V}_{1b}^{A} = (g - b) R - k_{g}^{H*} (c - A_g), \quad (19)
\]

which is larger under MTM thanks to measurement accuracy, that is, \( B_1^M > B_1^H \), which increases the option value from \( H_g \) to \( M_g \). From expression (10), the ex-ante bank value is also higher under MTM, that is, \( \hat{V}_{0}^{M} > \hat{V}_{0}^{H} \).

Proof of Proposition 3

For \( c \geq c_M \), we have \( k_{g}^{M*} - k_{g}^{H*} = \frac{(g-b)R(M_b-H_b)}{(c+(g-b)R-H_b)(c+(g-b)R-M_b)} = \frac{(g-b)(1-b)(1-\gamma)(gR-B_b)}{(c+(g-b)R-H_b)(c+(g-b)R-M_b)} > 0 \), where the last equality follows from equation (3) and expressions (7).
Proof of Lemma 4 and Proposition 4

From equation (3) with expressions (7), $M_\theta - H_\theta = (1 - \theta)(1 - \gamma)(gR - B_0) > 0$. Moreover, $(M_b - H_b) - (M_g - H_g) = (g - b)(1 - \gamma)(gR - B_0) > 0$. This proves Lemma 4.

The value differential of a good loan under MTM and HC is

$$
\Delta(c) \triangleq V_{1g}^{M\ast} - V_{1g}^{H\ast}
= k_g^{H}\ast(c - H_g) - k_g^{M\ast}(c - M_g)
= \frac{(g - b) R [(g - b) R (M_g - H_g) + M_b H_g - M_g H_b - c [(M_b - H_b) - (M_g - H_g)])]}{(c + (g - b) R - M_b) (c + (g - b) R - H_b)}
\propto Y - c [(M_b - H_b) - (M_g - H_g)]
$$

where $Y \triangleq (g - b) R (M_g - H_g) + M_b H_g - M_g H_b$. Using equation (3) with expressions (7), we have $Y = (g - b) R (1 - g)(1 - \gamma)(gR - B_0) > 0$. Lemma 4 shows $(M_b - H_b) - (M_g - H_g) > 0$. This proves the claim in expression (13).

Using equation (3) with expressions (7) in equation (20), we can rewrite $\Delta(c)$ as

$$
\Delta(c) = \frac{(1 - \gamma)(g - b)^2 R(gR - B_0) ((1 - g) R - c)}{(c + (g - b) R - M_b) (c + (g - b) R - H_b)}.
$$

It is clear that $\Delta(c) < 0$ if and only if $c > (1 - g) R$. Combined with the condition of $c > c_M$, under which the separating equilibrium exists in Proposition 1, we have proved that there exists $\bar{c} \triangleq \max \{(1 - g) R, c_M\}$ such that $\Delta(c) < 0$ if and only if $c > \bar{c}$.

The lower origination effort under MTM compared to HC follows from differencing conditions (11) for $A \in \{H, M\}$, that is $s'(m^{M\ast}) - s'(m^{H\ast}) = V_{1g}^{M\ast} - V_{1b}^{M\ast} - (V_{1g}^{H\ast} - V_{1b}^{H\ast}) = \Delta(c)$, where the last equality follows from $V_{1b}^{M\ast} = V_{1b}^{H\ast}$ (see equation (8)). Combining $s' > 0, s'' > 0$ and $V_{1g}^{M\ast} < V_{1g}^{H\ast}$ for $c > \bar{c}$ gives the desired result.

Proof of Proposition 5
We verify that the pooling PBE in the proposition is indeed an equilibrium. We express \( p(k|\pi(q^*)) = p(k|q^*) \) to highlight the price determination based on \( q^* \). Given the retention strategies and the equilibrium beliefs, that is, all good banks and mass \( q^* \) of bad banks retain \( k_g^M = k_b^M = 1 \) and the equilibrium belief is \( \pi(g|1) = \frac{1}{1+q^*} \), the prices reflect the average quality of the loan pool. Therefore, \( p(k|q^*) = p\left(1|\frac{1}{1+q^*}\right) = \frac{1}{1+q^*}gR + \left(1 - \frac{1}{1+q^*}\right)bR \) if \( k = 1 \) and \( p(k|q^*) = bR \) otherwise. Given these prices, we show that the retention strategies \((k_g^M = 1, k_b^M = 1)\) satisfy the IC constraints of both types

\[
\begin{align*}
V_{1b}^M(1) & \geq V_{1b}^M(0) \quad (21) \\
V_{1g}^M(1) & > V_{1g}^M(0) \quad (22)
\end{align*}
\]

Therefore, neither type has an incentive to deviate from their equilibrium strategies. Constraint (21) holds with equality at the equilibrium mass of bad banks \( q^* \) that are indifferent between retaining 1 and retaining 0, that is for \( q^* = \frac{(1-b)(1-\gamma)gR-c}{c-(1-b)(1-\gamma)bR} \). Constraint (22) holds because \( R > p\left(1|q^*\right) \).

**Proof of Proposition 6**

We first expand our definition of equilibrium to accommodate the pair of signals \((k, \phi)\). We focus only on the parameter region in which separating equilibrium is possible. The following condition, which is sufficient for the separating equilibrium in the baseline model, is still sufficient in this extension

\[ c > (1-b)(1-\gamma)gR. \]

In a separating equilibrium, the good bank chooses the pair \((k_g, \phi_g)\) and the bad bank chooses \((0, 0)\) such that

1. the pricing strategy is separating: \( p(k, \phi) = gR \) if \( k \geq k_g \) and \( \phi \geq \phi_g \), and \( p(k) = bR \) otherwise;
2. both the good and bad banks’ incentive compatibility (IC) constraints are satisfied

\[ V_{1b}(0,0) \geq V_{1b}(k_g, \phi_g), \quad (23) \]
\[ V_{1g}(k_g, \phi_g) \geq V_{1g}(0,0). \quad (24) \]

To ease exposition, we omit the accounting regime index \( A \) until we compare the two regimes. We re-solve the model by following a similar procedure in the baseline model. To save space, we highlight only the major steps, in particular those brought in by the additional choice \( \phi \). We use backward induction to solve the model. At \( t = 2 \), the bank is liquidated and distributes all remaining equity to the shareholders

\[ d_2(\bar{x}) = k \max\{\bar{x} - (1 - \phi)B_1, 0\}. \]

At \( t = 1 \), after the bank has chosen \( k \) and \( \phi \), we can re-compute dividend \( d_1 \). Using the same procedure as in the baseline model, we have,

\[ d_1 = d_{1\text{baseline}} - kB_1[q(\phi) + (\phi - \gamma)]. \]

\( d_{1\text{baseline}} \) is dividend \( d_1 \) in the baseline model (equation (4)). Relative to \( d_{1\text{baseline}} \), the dividend at \( t = 1 \) in this extension is reduced by two terms. For each unit of retention \( kB_1 \), the first term \( q(\phi) \) is the incremental cost of equity financing (relative to debt financing), and the second term \( (\phi - \gamma) \) is the excess retained earnings the bank commits not to distribute. Note that the second component reduces \( d_1 \) but increases the expected \( d_2 \).

Substituting \( d_1 \) and \( d_2 \) into equation (1) and utilizing a modified version of the call-put parity, the bank’s equity value of type \( \theta \) at \( t = 1 \) can be rewritten as

\[ V_{1\theta}(k, \phi) = (1 - k)p + k(-c + E_{1\theta}[\bar{x}] + A_\theta - q(\phi)B_1) - (1 - \gamma)B_0 + e^0, \quad (25) \]

where the per-unit put option value is \( A_\theta = (1 - \theta)(1 - \phi)B_1 \) and \( E_{1\theta}[\bar{x}] = \theta R \).
We first verify the single-crossing properties for \( \phi \)

\[
\frac{\partial V_{10}(k,\phi)}{\partial \phi} = -k \left( q'(\phi) B_1 - \frac{\partial A_g}{\partial \phi} \right) = -kB_1 \left( q'(\phi) + (1 - \theta) \right) \leq 0, \quad (26)
\]

\[
\frac{\partial^2 V_{10}(k,\phi)}{\partial \phi \partial \theta} = k \frac{\partial^2 A_g}{\partial \phi \partial \theta} = kB_1 \geq 0. \quad (27)
\]

If \( k = 0 \), then \( \frac{\partial V_{10}(k,\phi)}{\partial \phi} = \frac{\partial^2 V_{10}(k,\phi)}{\partial \phi \partial \theta} = 0 \). As a result, the choice of \( \phi \) is moot and \( \phi \) cannot be a credible signal. If \( k > 0 \), then the equity value is decreasing in the excess equity \( \phi \left( \frac{\partial V_{10}(k,\phi)}{\partial \phi} < 0 \right) \), and decreasing faster for the bad type \( \left( \frac{\partial^2 V_{10}(k,\phi)}{\partial \phi \partial \theta} > 0 \right) \). In particular, the two components in expression (26) show that the excess capital is costly for existing shareholders for two reasons. First, there is a direct cost of excess equity \( (q'(\phi) > 0) \). Second, the use excess equity is also costly because it reduces the put option value \( (\frac{\partial A_g}{\partial \phi} < 0) \).

Moreover, expression (27) shows that the excess equity \( \phi \) is more costly for the bad type because the put option value is more important for the bad bank. Therefore, like loan retention \( k \), the capital structure choice \( \phi \) can potentially be a credible signal.

We now solve the model with the two possible signals, \( k \) and \( \phi \). Following the same argument of the baseline model, the bad type's IC condition binds in equilibrium. Substituting the equilibrium choices \( \{(k_g, \phi_g), (0, 0)\} \) into equation (25) and setting the bad bank’s IC (inequality (23)) to equality, we can solve for \( k_g \) as a function of \( \phi_g \)

\[
k_g = \frac{\Delta p}{c + \Delta p + q(\phi_g) B_1 - A_b}, \quad (28)
\]

where \( \Delta p \equiv p(k_g, \phi_g) - p(0, 0) = (g - b)R \).

In the baseline model with exogenous capital structure \( \phi = \gamma \), equation (28) determines the unique equilibrium retention (for the good bank). However, when the bank can use both loan retention \( k \) and capital structure \( \phi \), the bad bank’s binding IC (equation (28)) only pins down the pair of \( (k_g, \phi_g) \). There could be multiple pairs \( (k_g, \phi_g) \) that satisfy equation (28) but generate different equity values \( V_{1g} \).
Therefore, the good bank chooses a pair \((k_g, \phi_g)\) to maximize its equity value \(V_{1g}\) subject to equation (28) and the boundary conditions \(k_g \in [0, 1]\) and \(\phi_g \in [\gamma, 1]\). Substituting equation (28) into equation (25) for \(\theta = g\), we obtain the good bank’s equity value as

\[
V_{1g}(\phi_g) = gR - (1 - \gamma)B_0 + c^0 - \frac{\Delta p (c + q(\phi_g)B_1 - A_g)}{c + \Delta p + q(\phi_g)B_1 - A_b}.
\] (29)

Equation (28) shows that \(k_g > 0\) (because \(\Delta p > 0\)). Moreover, since we focus only on the separating equilibrium here, \(k_g < 1\). Finally, our assumption that \(q(1)\) is sufficiently large excludes the possibility of \(\phi_g = 1\). Therefore, the only boundary constraint that may bind is \(\phi \geq \gamma\). Denote \(\mu\) as the Lagrangian multiplier for this inequality. We write the Lagrangian of the optimization problem as

\[
L(\phi_g, \lambda) = V_{1g}(\phi_g) - \lambda(\phi - \gamma).
\]

Using the Kuhn-Tucker theorem, the necessary and sufficient conditions for \(\phi_g\) to be an optimal solution are

\[
\frac{\partial L(\phi_g, \lambda)}{\partial \phi_g} = 0;
\]
\[
\frac{\partial L(\phi_g, \lambda)}{\partial \lambda} = 0.
\]

With some tedious algebra, which we omit here, we can prove the following results:

1. If \(c < \bar{c} \equiv \{(1 - g)R, (1 - b)(1 - \gamma)gR\}\), then \(\lambda > 0\) and \(\phi_g^* = \gamma\);

2. If \(c \geq \bar{c}\), then \(\lambda = 0\) and \(\phi_g^* > \gamma\); moreover, \(\phi_g^*\) is determined by \(\frac{\partial L(\phi_g, \lambda)}{\partial \phi_g}|_{\lambda=0}\); after some algebra, \(\phi_g^*\) can be solved as a solution to the following equation

\[
F(\phi_g) \equiv c(g - b) - \Delta p(1 - g) - q'(\phi_g)(\Delta p - (A_g - A_b)) + q(\phi_g)(g - b)B_1 = 0. \] (30)
The definition of $\bar{c} \equiv \{(1 - g) R, (1 - b) (1 - \gamma) gR\}$ takes into account the global condition $c > (1 - b) (1 - \gamma) gR$ that supports separating equilibria.

Moreover, we use the intermediate value theorem to prove that $F(\phi_g^*) = 0$ has a unique solution. To see this,

\[
\lim_{\phi_g \to \gamma} F(\phi_g) = c(g - b) - \Delta p(1 - g) = (g - b)(c - (1 - g) R) > 0,
\]

\[
\lim_{\phi_g \to 1} F(\phi_g) = c(g - b) - \Delta p(1 - g) - q'(1) (\Delta p - (A_g - A_b)) + q(1) (g - b)B_1 < 0,
\]

\[
\frac{\partial F(\phi_g)}{\partial \phi_g} = -q''(\phi_g) (\Delta p - (A_g - A_b)) - q'(\phi_g) (g - b)B_1 + q'(\phi_g) (g - b)B_1
\]

\[
= -q''(\phi_g) (\Delta p - (A_g - A_b)) < 0.
\]

The first inequality uses the condition $c \geq \bar{c}$, the second uses the assumption that $q'(1)$ is sufficiently large, and the final condition follows from the convexity of the cost function $q'' > 0$. Therefore, $\phi_g^*$ is unique. Substituting $\phi_g^*$ into equation (28), we also obtain $k_g^*$. Thus, we have solved for the equilibrium $(k_g^*, \phi_g^*)$. We thus have proved part 2 of Proposition 6.

Differentiating equation (28) with respect to $k_g$ and $\phi_g$, we have

\[
\frac{d\phi_g}{dk_g} = -\frac{c + \Delta p + q(\phi_g) B_1 - A_b}{k_g B_1(1 - b + q') < 0}.
\]

Therefore, $k_g$ and $\phi_g$ are substitutes, which proves part 3 of Proposition 6.

**Proof of Proposition 7**

Part 1 is the same as in the baseline model. We thus focus on part 2. Since the only difference between MTM and HC is that $B_1^M = gR > B_1^H = B_0$, one way to compare outcomes under the two regimes is to conduct comparative statics of the outcome variables with respect to $B_1$. By applying the implicit function theorem to the first-order condition for the interior $\phi_g^*$
(equation (30)), we have

\[ F(\phi_g; B_1) \equiv c(g - b) - \Delta p(1 - g) - q'(\phi_g) (\Delta p - (A_g - A_b)) + q(\phi_g)(g - b)B_1 = 0, \]

\[ \frac{d\phi^*_g}{dB_1} = \frac{\partial\phi^*_g}{\partial B_1} = \frac{\partial F/\partial B_1}{\partial F/\partial \phi_g} \propto \frac{\partial F/\partial B_1}{(g - b)(q + (1 - \phi_g)q')} > 0. \]

Therefore, we have proved that \( \phi^*_g > \phi^*_H \).

For loan retention \( k^*_g \), we differentiate equation (28) to obtain

\[ \frac{dk^*_g}{dB_1} = \Delta p\frac{(1 - b)(1 - \phi_g) - q - (q' + (1 - b))B_1 \frac{\partial\phi^*_g}{\partial B_1}}{(c + \Delta p + q(\phi_g)B_1 - A_b)^2} \]

\[ \times (1 - b)(1 - \phi_g) - \left(q + (q' + (1 - b))B_1 \frac{\partial\phi^*_g}{\partial B_1}\right). \]

In the baseline model without the choice of \( \phi \), we had \( \frac{dk^*_g}{dB_1} \propto (1 - b)(1 - \gamma) > 0 \). In contrast, in this extension, we have already proved that \( \frac{\partial\phi^*_g}{\partial B_1} > 0 \), and thus the last two terms in the big bracket are positive. As a result, the sign of \( \frac{dk^*_g}{dB_1} \) depends on the comparison of these terms. However, since \( \phi^*_g \) is only implicitly characterized by the first-order condition (equation (30)), the expression of \( \left(q + (q' + (1 - b))B_1 \frac{\partial\phi^*_g}{\partial B_1}\right) \) is extremely complicated. We have tried the quadratic function \( q(\phi) = \frac{y\phi^2}{2} \) with \( y \) properly constrained to satisfy all the properties, but still cannot prove the sign of \( \frac{dk^*_g}{dB_1} \). However, as we have explained in the text, it seems intuitive that \( k^{M*}_g > k^{H*}_g \). Moreover, all of our numerical simulation results show \( k^{M*}_g > k^{H*}_g \).

Finally, by the envelope theorem, we have

\[ \frac{dV_{1g}^*}{dB_1} = \frac{\partial L^*}{\partial B_1} = \frac{\partial V_{1g}^*}{\partial B_1} \]

\[ = -\frac{\Delta p(g - b)(qR + (1 - \phi_g)(c - (1 - g)R))}{(c + \Delta p + q(\phi_g)B_1 - A_b)^2} \]

\[ < 0. \]
Therefore, \( c > \bar{c} \) (recall that we have imposed the global condition \( c > (1 - b) (1 - \gamma) gR \) to guarantee separating equilibria) is sufficient (but not necessary) to lead to \( \frac{dV_{1g}^*}{dB_1} < 0 \). We thus have proved that \( V_{1g}^{M*} < V_{1g}^{H*} \). Therefore, we have proved part 2 of Proposition 7.

**Proof of Proposition 8**

We prove the Proposition in the three steps explained in the text. Again we focus only on separating equilibria. The sufficient condition \( c > (1 - b) (1 - \gamma) gR \) that sustains separating equilibrium in the baseline model (and in the previous extension) is a bit tricky because it involves an equilibrium variable \( \gamma \) now. Thus, we use a more stringent sufficient condition \( c > (1 - b) gR \) to avoid this issue. For convenience, we still use the same notation \( \bar{c} \equiv \max\{(1 - g) R, (1 - b) gR\} \) whenever no confusion arises.

Step 1: for any regulatory choice \( \gamma \), we solve the subgame by using exactly the same procedure as in the baseline model. We omit this step as it is the same as in the baseline model. As a result of this step and with the simplification of \( s(m) = \frac{S m^2}{2} \), we obtain the bank’s ex-ante equity value

\[
V_0^*(\gamma) = m^* V_{1g}^* + (1 - m^*) V_{1b}^* - s(m^*) \]
\[
= V_{1b}^* + \frac{S}{2} m^*^2.
\]

We also have other equilibrium outcomes

\[
V_{1g}^* = gR - (1 - \gamma) B_0 + e^0 - k^*_g (c - A_g), \quad (31)
\]
\[
V_{1b}^* = bR - (1 - \gamma) B_0 + e^0, \quad (32)
\]
\[
k^*_g = \frac{\Delta p}{c + \Delta p - A_b}. \quad (33)
\]

These are the same as in the baseline model (equations (8) and (9), and the expression in Proposition (1)) but reproduced here for convenience.
Recall that the bank’s effort choice $m$ at $t = 0$ is characterized by the first-order condition

$$Sm^* = \Delta p - k^*_g (c - A_g) = \Delta p \frac{(\Delta p - A_b + A_g)}{c + \Delta p - A_b} = \frac{\Delta p(g - b)(R - (1 - \gamma)B_1)}{c + \Delta p - A_b}. \quad (34)$$

Differentiating the first-order condition for $m^*$ (equation (34)) with respect to $\gamma$ and $B_1$, after some tedious algebra, we obtain

$$\frac{\partial m^*}{\partial B_1} = \frac{\Delta p(g - b)B_1}{S(c + \Delta p - A_b)^2} (c - (1 - g)R), \quad (35)$$

$$\frac{\partial m^*}{\partial \gamma} = \frac{\Delta p(g - b)(1 - \gamma)}{S(c + \Delta p - A_b)^2} (c - (1 - g)R), \quad (36)$$

$$\frac{\partial^2 m^*}{\partial \gamma \partial B_1} = \frac{\Delta p(g - b)(c - A_b + \Delta p)}{S(c + \Delta p - A_b)^3} (c - (1 - g)R). \quad (37)$$

Step 2: we solve for the regulator’s optimal choice of $\gamma$. Since

$$U(\gamma) = V^*_0(\gamma) - \psi(\gamma) = V^*_1b + \frac{S}{2}m^{*2} - \psi(\gamma),$$

the first-order condition for $\gamma$ is

$$F(\gamma; B_1) = \frac{dU}{d\gamma} = m^* \frac{\partial m^*}{\partial \gamma} S - \psi'(\gamma) = 0.$$

By the implicit function theorem, we have

$$\frac{d\gamma^*}{dB_1} = - \frac{\partial F/\partial B_1}{\partial F/\partial \gamma} \propto \frac{\partial F/\partial B_1}{\partial F/\partial \gamma} \approx \frac{\partial m^* \partial m^*}{\partial B_1 \partial \gamma} S + m^* \frac{\partial^2 m^*}{\partial \gamma \partial B_1} S \propto c - (1 - g)R \quad (38)$$

The first $\propto$ follows from $\partial F/\partial \gamma < 0$ (the second-order condition for $\gamma^*$). The second $\propto$ is obtained after substituting equations (18), (35), (36), and (37) and simplifying.
To see how social welfare changes, we use the Envelope Theorem to obtain

\[
\frac{dU^*}{dB_1} = \frac{\partial U^*}{\partial B_1} = \frac{\partial V_0^*}{\partial B_1} \propto c - (1 - g)R.
\]

The last step comes from the proof of Proposition 4 in the baseline model. Taking into account the global condition \( c > (1 - b)gR \) and defining \( \bar{c} \equiv \max\{ (1 - g)R, (1 - b)gR \} \), we have proved Proposition 8.

**Variable definitions**

<table>
<thead>
<tr>
<th>Variable ( c_A )</th>
<th>Expression ( (1 - b)(1 - \gamma)B_1^A^* )</th>
<th>Defined on page 39</th>
</tr>
</thead>
<tbody>
<tr>
<td>( c_H )</td>
<td>( (1 - b)(1 - \gamma)B_0 )</td>
<td>39</td>
</tr>
<tr>
<td>( c_M )</td>
<td>( (1 - b)(1 - \gamma)gR )</td>
<td>39</td>
</tr>
<tr>
<td>( \bar{c} )</td>
<td>( \max{ (1 - g)R, (1 - b)(1 - \gamma)gR } )</td>
<td>42</td>
</tr>
<tr>
<td>( A_\theta )</td>
<td>( (1 - \theta)(1 - \gamma)B_1^A^* )</td>
<td>11</td>
</tr>
<tr>
<td>( M_g )</td>
<td>( (1 - g)(1 - \gamma)gR )</td>
<td>11</td>
</tr>
<tr>
<td>( M_b )</td>
<td>( (1 - b)(1 - \gamma)gR )</td>
<td>11</td>
</tr>
<tr>
<td>( H_g )</td>
<td>( (1 - g)(1 - \gamma)B_0 )</td>
<td>11</td>
</tr>
<tr>
<td>( H_b )</td>
<td>( (1 - b)(1 - \gamma)B_0 )</td>
<td>11</td>
</tr>
</tbody>
</table>