Marking-to-Market: Panacea or Pandora's Box?[1]

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Abstract

Financial institutions have been at the forefront of the debate on the controversial shift in international standards from historical cost accounting to mark-to-market accounting. We show that the tradeoffs at stake in this debate are far from one-sided. While the excessive conservatism in the historical cost regime leads to some inefficiencies, marking to market may lead to other types of inefficiencies by injecting artificial volatility that degrades the information value of prices, and induces sub-optimal real decisions. We construct a framework that can weigh the pros and cons. We find that the damage done by marking to market is greatest when claims are (i) long-lived, (ii) illiquid, and (iii) senior. These are precisely the attributes of the key balance sheet items of banks and insurance companies. Our results therefore shed light on why banks and insurance companies have been the most vocal opponents of the shift to marking to market.

1 Introduction

One of the most important public policy debates in recent years has been the reform of accounting standards toward "fair value" accounting. Financial institutions, especially banks and insurance companies, have been at the forefront of this debate and have been the most vocal opponents of this reform. Judging from the intensity of the arguments and the controversy that this reform has generated, there is clearly much more at stake than what may appear to be esoteric measurement issues. Our paper is an attempt to shed light on this debate, and to provide a framework of analysis that can weigh up the arguments on both sides. Indeed, as we will show, far from being an esoteric debate, issues of measurement have a far reaching influence on the behavior of financial institutions, and determine to a large extent the efficiency of the price mechanism in guiding real decisions.

The immediate cause of the recent fierce debate has been the initiative of the International Accounting Standards Board (IASB) and the U. S. Financial Accounting Standards Board (FASB) toward convergence of accounting standards to a global one based on the information that is provided by prevailing market prices - sometimes known as a "fair value" or "mark-to-market" reporting system (Hansen (2004)). This is in contrast to measurement systems based on historical cost which require firms to record their assets and liabilities at their original prices with no adjustments for subsequent changes in the market values of those items.

The reform toward greater marking to market has had many influential champions. In testimony to U.S. House of Representatives, Paul Volcker, chairman of the Board of Trustees of the International Accounting Standards Committee, has stated that one of the fundamental conceptual issues facing accounting regulators worldwide is the "extent to which standards should move away from traditional cost-based accounting to marking assets and liabilities to market....." (Volcker (2001)). Robert Herz, chairman of the Financial

Accounting Standards Board has argued that "for accounting to better reflect true economic substance, fair value, rather than historical cost, would generally seem to be the better measure." (Herz (2003)). Others have called the move to a fair value measurement system "the biggest shift in accounting and financial reporting since standard setting was set up" (Williams (2002)). Some in the popular press have gone further. One commentator writes

> "Maybe, if companies in the United States and Asia had measured all financial instruments at fair value, regulators, depositors, and investors could have achieved greater regulatory and market discipline and avoided some of the losses that investors and taxpayers have had to pay during previous downturns in the economy" (Day (2000)).

However, arrayed against this formidable line-up has been an equally formidable group of banks and insurance companies drawn from the major industrialized countries, with the support of their prudential regulators and/or central banks. This group has waged an unprecedented joint lobbying campaign to limit the application of the FASB and IASB reform to their industries. For example, a joint international working group of banking associations (the banking associations of the United States, Australia, Canada, Japan, and the European Union) has issued a paper stating that "users of banks' financial statements do not support a change to a full fair value accounting system because a full fair value system does not provide a sound basis for providing banking book net cash flows and lacks relevance" (JWGBA (1999)). Similarly, a recent survey released by the Geneva Association indicates that there is a broad consensus in the insurance profession for the view that "a full fair value reporting system would have an adverse impact on the risk transfer role that the insurance industry plays within the wider economic system" (Geneva Association (2004)).

Banks and insurance companies accept that marking to market is desirable for *some* items on the balance sheet -in particular for transactions entered into with the objective of making a profit from short-term price variations. Their opposition is to a *full* fair value reporting system in which mark-to-market accounting should be applied uniformly to *all* assets and liabilities. In particular, they are strongly opposed to marking to market items such as long term loans and outstanding insurance claims that represent the major proportion of their balance sheets.

The arguments used by both sides raise a number of fundamental questions concerning allocative efficiency and the information conveyed by financial statements. Proponents of marking to market argue that the market value of an asset is more relevant than historical cost because it reflects the amount at which that asset could be bought or sold in a current transaction between willing parties. Similarly, the market value of a liability is more relevant than historical cost because it reflects the amount at which that liability could be incurred or settled in a current transaction between willing parties. A measurement system that reflects the market values of assets and liabilities would therefore lead to better insights into the risk profile of firms currently in place so that investors could exercise better market discipline and corrective action on firm's decisions.

Such an argument would be overwhelming in the context of completely frictionless markets where market prices fully reflect the fundamental values of all assets and liabilities. The benchmark efficiency properties of competitive equilibria could then be invoked, and no further argument would be necessary. However, when there are imperfections in the market, the superiority of a mark-to-market regime is no longer so immediate. The relevant analogy here is with the theory of the second best from welfare economics. When there is more than one imperfection in a competitive economy, removing just one of these imperfections need not be welfare-improving. It is possible that the removal of one of the imperfections magnifies the negative effects of the other imperfections to the detriment of overall welfare. Thus, simply moving to a mark-to-market regime without addressing the other imperfections in the financial system need not guarantee a welfare improvement. In some cases, the market price may not be the "true and fair" value of the asset.

Practitioners who have opposed marking to market have used three types of arguments. First, they argue that the very definition of market value by the FASB and the IASB assumes the existence of deep and liquid secondary markets for their assets and liabilities. They note, however, that many of the assets and liabilities of financial intermediaries do not trade in liquid secondary markets. Furthermore, much of the relevant information possessed by banks who originate a loan or insurers who underwrite a policy is "soft", and would never be priced in a market. Marking to market would thus decrease rather than increase the reliability of a bank's financial statements (European Central Bank (2004)).

Second, banks and insurance companies point out that mark-to-market accounting does not properly reflect the way in which they manage their core businesses of granting long term loans and underwriting insurance policies. For instance, the essence of banking lies in making long-term decisions about credit quality and concentration and fostering customer relationships over the life of the contracts. It is less concerned with short-term variations. Mark-to-market accounting could therefore have adverse real effects on banks and insurance companies' core businesses by shortening their planning horizons (Geneva Association (2004), JWGBA (1999)).

Finally, the opponents of marking to market argue that reliance on market values for assets and liabilities runs the risk that the information disclosed will embody excess volatility driven by short-term fluctuations in financial markets, in addition to the volatility driven by the riskiness of long-term cash flows. Marking to market will therefore result in *artificial* volatility in financial reports (The Economist (2004), JWGBA (1999)).

It is important here to distinguish volatility of market prices that merely reflects the volatility of fundamentals from volatility that cannot be justified by these fundamentals. If the fundamentals themselves are volatile, then market prices reflect genuine risk. However, the “artificial” nature of volatility mentioned by the opponents of the reform refers to something more pernicious. Market prices play a double-edged role. Not only are they a reflection of the underlying fundamentals, but they also *affect* the market outcome through their influence on the actions of market participants. When the decision horizon of market participants are shortened, for instance due to agency problems or other market imperfections, then short-term price fluctuations affect the payoffs of these players in a mark-to-market regime, and hence will influence their actions. There is then the possibility of a feedback loop where anticipation of short-term price movements will induce market participants to act in such as a way as to amplify these price movements. When such feedback effects are strong, then firms’ decisions are based on the second-guessing of others’ decisions rather than on the basis of perceived fundamentals. In this sense, there is the danger of the emergence of an additional, endogenous source of volatility that is purely a consequence of the accounting norm, rather than something that reflects the underlying fundamentals. Understanding the nature and severity of such effects will be one of the key tasks in our paper.

In spite of the practical importance of the issue, there has been surprisingly little theoretical work on the economic trade-offs of mark-to-market versus historical cost measurement policies.[1] Our paper is an attempt to redress this balance. We develop a parsimonious model that compares the real effects of a historical cost and mark-to-market measurement regime.

[1]There are some notable exceptions. O’Hara (1993) investigates the effect of market value accounting on loan maturity and finds that mark-to-market results in a preference for short-term loans over long-term loans. In contemporaneous work, Strausz (2004) posits that marking to market should mitigate information asymmetry, and derives its impact on banks’ liquidity. Freixas and Tsomocos (2004) notes that the inferior intertemporal smoothing properties of marking to market should be detrimental to banks. Our analysis builds upon quite different premises, and is therefore unrelated to these contributions.

The fundamental trade-off can be described as follows. The historical cost regime relies on past prices, and so accounting values are insensitive to price signals under this regime. This leads to one type of inefficiency arising from excessive conservatism. Marking to market overcomes this conservatism by extracting the information conveyed by market prices, but it also *distorts* this information. When the decision horizons are shortened due to agency problems, the anticipation of future prices affects firms' decisions which, in turn, injects artificial volatility into prices. Knowing all this, the firms become even more sensitive to short-term price movements. These effects are broadly in line with the informal arguments of practitioners, and lead to clear economic trade-offs between the two measurement regimes.

Our model generates the following three main implications:

1. The longer the duration of the asset, the more vulnerable the asset is to artificial volatility. In particular, for sufficiently long-lived assets, a historical cost regime is superior to a mark-to-market regime. Conversely, for shorter-lived assets, a mark-to-market regime dominates a historical cost regime.

2. The more illiquid the market for the asset, the more vulnerable the asset is to artificial volatility. For those assets whose markets have a limited absorption capacity for sales, a historical cost regime is superior to a mark–to–market regime. Conversely, for those assets with sufficiently deep and liquid markets, mark–to–market is preferable.

3. The more senior the asset, the more vulnerable the asset is to artificial volatility. Senior claims that have limited upside but a large possible downside risk are the most susceptible to artificial volatility in the mark-to-market regime. Junior claims with a large potential upside but limited downside are more plagued by the conservatism of the historical cost regime.

We believe that our results shed some light on why the opposition to marking to market has been led by the banking and insurance industries. For these financial institutions a large proportion of their balance sheets consists precisely of items that are long duration, illiquid and senior. For banks, these items appear on the asset side of their balance sheets. Loans, typically, are senior, long-term and very illiquid. For insurance companies, the focus is on the liabilities side of their balance sheet. Insurance liabilities are long-term, illiquid and have limited upside from the point of view of the insurance company.

Our modelling approach is to keep the details to a bare minimum, but with just enough richness to capture these effects. Our model studies financial institutions that have acquired an asset in a primary market and face the decision whether to hold it until maturity or off-load it in a secondary market, such as the securitization market or the reinsurance market. There are three ingredients that make such a decision problematic. First, the horizon of firms does not match the duration of their assets. Second, the true value of the asset cannot be contracted upon. Instead, the value of the firm can be measured only with the prices of its assets, either the past price (historical cost regime) or the current price (mark-to-market regime). Third, the secondary market for the asset is illiquid. There is limited absorption capacity for sales. The limited capacity of the market to absorb sales of assets has figured prominently in the literature on banking and financial crises (see for example Allen and Gale (2001) and Gorton and Huang (2003)). Also, the buyers in the secondary market are not able to extract the same full value as the originators—the specific skills of financial intermediaries are an important ingredient, as in Diamond and Rajan (2000).

Under the historical cost regime, short-horizon firms find it optimal to sell assets that have recently appreciated in value, since booking them at historical cost understates their worth. Despite a discount in the secondary market, the inertia in accounting values gives these short horizon firms the incentives to sell. Thus, the historical cost regime leads to excess conservatism—firms have no incentives to exert their skills when it is the most valuable.

A natural remedy to this excess conservatism would be to shift to a mark-to-market regime. This is only an imperfect solution, however. The illiquidity of the secondary market causes another type of inefficiency. A bad outcome for the asset will depress fundamental values somewhat, but the more pernicious effect comes from the negative externalities generated by other firms selling. When others sell, short-term prices are depressed more than is justified by the fundamentals, and exerts a negative effect on all others, but especially on those who have chosen to hold on to the asset. Anticipating this negative outcome, a short-horizon firm will be tempted to preempt the fall in price by selling the asset itself. However, such preemptive action will merely serve to amplify the price fall. In this way, the mark-to-market regime generates endogenous volatility of prices that impede the resource allocation role of prices. Using global game techniques, we can characterize such artificial volatility as a function of the underlying fundamentals. In general, marking to market tends to amplify the movements in asset prices relative to their fundamental values in bad states of the world. The mark-to-market regime leads to inefficient sales in bad times, but the historical cost regime turns out to be particularly inefficient in good times. This is why the seniority of the asset's payoff (which determines the concavity of the payoff function) and the skewness of the distribution of the future cash flows have an important impact on the choice of the optimal regime.

As the duration of assets increase, both regimes become more inefficient. However, the historical cost regime exhibits less inefficiency relative to the mark-to-market regime. This is because the negative externality exerted by other sellers becomes more severe when the duration of the asset increases, and the firms' actions are influenced more by the second-guessing of other firms' decisions.

Our model highlights some key factors in the strategic interactions between firms in the secondary market. Under the historical cost regime, actions of the firms are strategic substitutes. Sales by the other firms drive the market price down, which makes holding the asset booked at the acquisition cost more desirable. Conversely, in the mark-to-market regime, firms' actions are strategic complements. The expectation of sales by the other firms makes holding the asset *less* desirable because of an expected low market value at the reporting date. Strategic substitutability has a stabilizing effect, so that the market price is "artificially smooth" as compared to the true value of the asset under the historical cost measurement regime. Strategic complementarity adds endogenous volatility, so that the market prices are "artificially volatile" as compared to the fundamental values in a marked-to-market economy. In extreme cases, the endogenously generated market distress can lead to "liquidity black holes" (Morris and Shin (2004)).

These strategic effects give a pivotal role to the liquidity of the secondary market. In more illiquid markets, strategic concerns become more important. As the market becomes more illiquid, strategic complementarity increases in the mark-to-market regime, leading to greater incidence of sales and more volatile prices. In the historical cost regime, increasing illiquidity has a disciplining effect on firms because of increased strategic substitutability, and may therefore be Pareto improving for some values of the parameters.

The rest of the paper is organized as follows. Section 2 presents a simple model in which we show that the choice of an accounting measurement policy—mark–to–market *versus* historical cost—is not neutral. We find that both measurement regimes have important real effects in line with those conjectured by practitioners. Section 3 introduces global game techniques to reduce the number of equilibria in this simple model. Section 4 studies the impact of asset duration and liquidity on asset prices in each measurement regime. Section 5 carries out a welfare analysis. Section 6 concludes. Section 7 contains proofs of the major propositions.

2 The Basic Model

Our model is built around the decision of a financial institution, such as a commercial bank, that is contemplating the sale of assets by securitizing a portfolio of loans or notes, either in a cash deal or in a synthetic transaction with credit derivatives. The main friction in the story that make the decision of the bank non-trivial is that the "true and fair" value of the bank's assets that would hold in perfect, frictionless markets cannot be contracted upon. Instead, there are two imperfect estimates of this true and fair value that can be used for contracting purposes. The first is the *market price* of the asset, and the second is the *historical cost* of the asset.

The market price may diverge from the true and fair value of the asset that would hold in frictionless markets due to agency costs and liquidity effects. Agency costs are associated with the feature that the value extracted from an asset depends on who holds the asset and what kind of informational advantage that party may have with respect to the asset. Bank loans are a prime example of an asset that is sensitive to such factors. Liquidity effects arise due to the limited capacity of the market to absorb the sale of assets due, in part, to the differential abilities of other market participants to manage the assets that may be sold.

The objective of the bank's management is to maximize the short-term accounting value of the firm, where this accounting value is the contractible estimate of the true and fair value. The accounting value will, of course, depend sensitively on what accounting regime is in place. Commercial banks have good reason for their focus on accounting values. Not only are balance sheets informative of the values of long-lived and illiquid assets, but also the public, certifiable nature of the numbers serve important contractual purposes, such as the determination of the managers' remuneration or the determination of prudential ratios and the threshold values for regulatory intervention. For these reasons, it is the short term accounting value of the bank that is at the center of the bank management's decisions.

An alternative interpretation of the model is that the financial institution is an insurance company contemplating ceding outstanding liabilities in the over-the-counter reinsurance market. The fact that the reinsurance market has important capacity constraints is well-documented. There is also empirical evidence that reinsurance transactions suffer from moral hazard problems (see for example, Doherty and Smetters (2002)).

Building on the themes laid out above, we describe our model is more detail. There are three dates in our model, indexed by $t \in \{0, 1, 2\}$. There is a continuum of *ex ante* identical financial institutions (FIs) with unit mass. At date 0, each FI holds a long–lived asset generating a single future cash flow. This asset has been acquired in the past at a cost v_0 determined outside the model. At date 0, the future cash flow generated by each asset, or asset fundamental, is known to all the FIs and equal to v. However, there is uncertainty about the date at which each asset pays off. An asset may pay off either at date 1, with probability $1 - d$, or at date 2, with probability d. We interpret d as a measure of the duration of the asset.

The FIs are run by risk neutral managers whose horizon is shorter than the duration of the long–lived asset: each manager aims at maximizing the expected date 1 accounting value of the asset. This valuation depends on the prevailing accounting regime. As outlined above, the main friction of this economy is that the "true and fair" value v is non-contractible, and cannot be used in arriving at the accounting value. Instead, there are two contractible estimates of v - the market price p, or the historical cost v_0. In the case of a historical cost measurement regime, the estimate of v is given by its acquisition cost v_0. Under a mark–to–market regime, the estimate of v is its market price at the date of the valuation. The market price p is given by

$$p = \delta v - \gamma s$$

where δ is a positive constant less than 1, s is the proportion of financial institutions who sell the asset, and γ is a positive constant. The secondary market price p may diverge from v for two reasons. First, there is the discount factor δ that arises due to agency costs. The counterparties of the FIs that purchase the asset have less skills in extracting the cash flows generated by the asset than the FIs, and an agency problem prevents the FIs to exert their skills once they have off-loaded the risk. Second, the price p depends on how many of the financial institutions sell the asset. The parameter γ is interpreted as a measure of the illiquidity of the asset. When $\gamma = 0$, the market for the asset is infinitely deep so that the price of the asset does not depend on aggregate sale s. When $\gamma > 0$, the market price is sensitive to aggregate sales. The larger γ is, the more illiquid the market for the asset, and the more sensitive is the price p to the fraction s of FIs selling the asset.

By means of our two parameters δ and γ, we capture the feature that when banks securitize their outstanding claims, they place them in a decentralized over-the-counter market, with institutional investors such as life insurance companies or pension funds. These institutional investors have a limited absorption capacity (captured by $\gamma > 0$) because they are subject to diversification and asset-liability management constraints, and have lower monitoring skills (captured by $\delta < 1$) because they do not enter into a banking relationship with the originator of the claim. The limited liquidity of the secondary market has also figured recently in the literature on financial market runs (see, e.g., Bernardo and Welch (2004), or Morris and Shin (2004)).

At date 0, the FIs must decide whether to sell their asset in the secondary market or hold it until date 1. If they hold the asset, its value is booked in accordance with the prevailing accounting regime. Under the historical cost regime, the asset is booked at historical cost v_0. Under the mark-to-market regime, it is booked at market price p.

If a financial institution sells the asset, then its payoff depends on how many other FIs have also chosen to sell the asset. The FIs who have decided to sell are matched in random order with a buyer in the order book. The place of a given FI in the queue is uniformly distributed over $[0, s]$, where s is the fraction of FIs having opted for a sale. Execution randomness captures the following feature of the asset: the market for the asset is an over-the-counter, decentralized market, and thus there is uncertainty about which FIs will match first with the potential buyers. Conditional on a fraction s of FIs opting for a sale, the expected proceeds from the sale are

$$\delta v - \gamma \frac{s}{2}$$

We have set up the model in such a way that selling the asset occurs for window-dressing reasons only and asset sales are therefore always inefficient in our environment. Such inefficient sales reduce the surplus of FIs. We, of course, do not want to imply that securitization or reinsurance is not desirable in general. We do not model efficient sales for genuine risk-management purposes only because such sales do not depend on the accounting measurement regime by definition, and would therefore be immaterial for the purpose of this paper. Focusing on inefficient sales allows us to obtain sharper insights on the real effects of imperfect measurement regimes.

Each measurement regime induces significant real effects by affecting the decisions of the FIs to hold or off-load the asset at date 0. We carry out this analysis under the assumption that $d \geq \frac{1}{2}$ and $d + \delta > 1$, namely when assets are sufficiently long-lived and not too specific.

Let Δ_{HC} denote the differential expected value of carrying the asset *versus* selling it for a given FI under the historical–cost regime. Conditional on expecting that a fraction s of other FIs will liquidate the asset,

$$\Delta_{HC} > 0 \longleftrightarrow \underbrace{(1-d)v + dv_0}_{\text{Expected valuation if hold}} > \underbrace{\delta v - \frac{\gamma}{2} s}_{\text{Expected price if sell}}, \text{ or}$$

$$\Delta_{HC} > 0 \longleftrightarrow (d + \delta - 1)v < dv_0 + \frac{\gamma}{2} s.$$

Similarly, denoting Δ_{MM} the same differential expected value under a mark–to–market measurement,

$$\begin{aligned}\Delta_{MM} &> 0 \longleftrightarrow (1-d)v + d\left(\delta v - \gamma s\right) > \delta v - \frac{\gamma}{2}s, \text{ or} \\ \Delta_{MM} &> 0 \longleftrightarrow (1-d)\left(1-\delta\right)v > \left(d - \frac{1}{2}\right)\gamma s\end{aligned}$$

The following proposition is a straightforward consequence of these inequalities:

Proposition 1 *Under the historical–cost measurement regime, there is a unique equilibrium in which:*

- *FIs hold their assets if* $v < \frac{dv_0}{d+\delta-1}$;
- *FIs sell their assets if* $v > \frac{dv_0 + \frac{\gamma}{2}}{d+\delta-1}$;
- *Otherwise, they sell with a probability* $\pi = \frac{2}{\gamma}((d+\delta-1)v - dv_0)$.

  Under the mark–to–market measurement regime:

- *If* $v < 0$, *there is a unique equilibrium in which FIs sell their assets.*
- *If* $v > \gamma\frac{d-\frac{1}{2}}{(1-d)(1-\delta)}$, *there is a unique equilibrium in which FIs hold their assets.*
- *Otherwise, there are two pure-strategy equilibria, one in which all FIs sell their assets, one in which all FIs hold their assets.*

Historical–cost measurement has the unfortunate consequence that FIs are too conservative, because their books do not reflect sufficiently quickly the appreciated value of their assets. This accounting norm prevents a smooth transfer of wealth across dates because it does not make use of price signals. As a result, FIs do not carry out the most profitable projects whose horizons exceed their tenure. Instead, they find it preferable to realize a lower gain in the short run by selling their assets. Unfortunately, switching to a mark–to–market system is only an imperfect remedy to this myopia. By trying to extract the informational content of prices, the mark–to–market regime actually distorts this content. Marking to market may create "beauty contests" in which FIs become concerned to off-load their assets due to the concern that they expect that others will do so.

Under the historical cost measurement regime, sales are strategic substitutes. If a FI believes that other FIs will sell, she finds holding the asset more valuable. This strategic substitutability is a stabilizing phenomenon leading to a unique price. Conversely, under the mark–to–market regime, sales are strategic complements: sales by other FIs make the sale of the asset more appealing. This strategic complementarity adds a source of *endogenous* risk in the economy. This endogenous risk has nothing to do with the fundamental volatility of the asset and is an unfortunate consequence of the mark–to–market regime. Thus, a social planner who has to opt for one of these two measurement regimes is caught between the horns of a dilemma. On the one hand, historical cost makes too little use of the information contained in the prices on the asset market and relies too heavily on the out-dated historical cost, v_0. On the other hand, in trying to extract the informational content of prices, marking to market distorts this information by adding endogenous risk.

An immediate implication of Proposition 1 is that the mark–to–market regime creates this additional endogenous risk only if the asset is sufficiently long-lived ($d > \frac{1}{2}$). If the horizon of the FIs is not too different from the duration of the assets ($d \leq \frac{1}{2}$), the mark–to–market regime implements the first-best allocation under which none of the FIs sell their assets. This is because the negative externality that the FIs that sell their assets create for the FIs that hold their assets is $d\gamma s$ which is smaller than $\gamma\frac{s}{2}$, the negative externality that the selling FIs create for themselves. In this case, "runs" do not occur in equilibrium for nonnegative values of v. Thus, at this stage, our model already suggests that absent an important mismatch between the horizon of firms and the duration of assets, a mark–to–market measurement regime is unambiguously preferable to a historical cost measurement regime.

Note also that marking to market at the average price observed between dates 0 and 1 (namely, $\delta v-\gamma\frac{s}{2}$) instead of the actual price that the marginal seller gets at date 1 (namely $\delta v-s$) removes this risk of self-fulfilling "runs". This result is in line with the fact that some practitioners view the valuation of assets at the average price observed during the reporting period as a good compromise between the current historical cost regime and regulatory proposals of valuing the asset at its price at the end of the reporting period. However, it is still not clear whether this solution would be robust in a more dynamic model. If information about the fundamental v arrived dynamically between dates 0 and 1, this solution would create the perverse incentives of the historical cost regime whereby a FI would be tempted to sell her asset in order to realize quick gains in case of good news.

Further comparison between the regimes requires that the endogenous risk under the mark-to-market regime be quantified. The multiplicity of equilibria makes this difficult. In the next section, we assume that FIs do not observe v perfectly at date 0. Rather, when deciding whether to sell or hold the asset, each FI observes a noisy version of the fundamental v. Using global games techniques, we obtain unique equilibrium outcomes.

3 The Global Game

We will now apply the techniques from the theory of global games to arrive at unique equilibrium outcomes.[2] The only modification to the game outlined so far is to introduce some idiosyncratic, possibly arbitrarily small noise in the information set of FIs so that common knowledge of fundamentals no longer holds. More precisely, suppose that the payoff of the asset v admits a *prior* density $f(.)$, which is continuous and has a connected

[2]The theory of global games has been introduced by Carlsson and van Damme (1993), and Morris and Shin (1998) popularized its applications.

support. We also let $F(.)$ denote the c.d.f. of v.

The financial institutions do not observe v immediately when realized at date 0, but only later on when the market clears. Instead, at date 0, when facing the decision to hold or off-load the asset, each FI i observes the noisy signal $x_i = v+\varepsilon_i$. The noise term ε_i is distributed uniformly on the interval $[-\eta, \eta]$, and these noise terms are independent across FIs. We will be particularly interested in the limiting case of our framework in which $\eta \to 0$ so that the noise becomes negligible in the limit. In this framework, a (symmetric) equilibrium is characterized by a strategy $s(x)$ mapping a signal x into a probability $s(x)$ to sell the asset. We will characterize the equilibrium outcomes in this limiting case in the two accounting regimes–mark–to–market and historical cost. We begin with the mark–to–market case.

3.1 Equilibrium in the Mark–to–Market Regime

In the mark–to–market regime, our setup is a particular case of the global game solved in Frankel, Morris, and Pauzner (2003) or Morris and Shin (2003), in which the payoff is a linear function of the fundamental v. Thus, their results can be readily applied:

Proposition 2 *In the limit as $\eta \to 0$, there is a unique dominance solvable equilibrium under the mark–to–market regime. In this equilibrium,*

$$\begin{aligned} s(x) &= 0 \quad if \quad x > \tfrac{\gamma}{2}\tfrac{d-\frac{1}{2}}{(1-d)(1-\delta)} \\ s(x) &= 1 \qquad\qquad otherwise. \end{aligned}$$

In words, in the limit, FIs sell their assets if and only if their signal is below the cutoff value $\frac{\gamma}{2}\frac{d-\frac{1}{2}}{(1-d)(1-\delta)}$.

To offer some intuition for this result, we will show with a simple argument that there is a unique equilibrium in threshold strategies as $\eta \to 0$. A threshold strategy consists in selling the asset if and only if the signal is below some cutoff value $\widehat{x}$. To demonstrate this result, let us begin by showing that the strategic uncertainty—the uncertainty over the actions of other players—can be pinned down precisely in the limit as $\eta \to 0$.

Lemma 1 *Suppose that all FIs follow the threshold strategy around $\widehat{x}$. Then, conditional on receiving a signal equal to the threshold point, the density over the proportion of FIs that sell the asset is given by the uniform density in the limit as $\eta \to 0$.*

When v is the true state, each signal is distributed uniformly in the interval $[v - \eta, v + \eta]$. By the law of large numbers, when the threshold point $\widehat{x}$ lies in this interval, the proportion of firms that sell the asset is thus given by:

$$\frac{\widehat{x} - (v - \eta)}{2\eta}$$

This proportion is exactly equal to some constant z when $\frac{\widehat{x}-(v-\eta)}{2\eta} = z$. Denote the value of v that satisfies this relation as $\widehat{v}$. Thus,

$$\widehat{v} = \widehat{x} + \eta(1 - 2z) \tag{1}$$

Whenever the true state v is greater than or equal to $\widehat{v}$, then the proportion of firms that sell the asset is less than or equal to z. Thus, the probability that the proportion of firms that sell the asset is less than or equal to z is given by the probability that the true state v is greater than or equal to $\widehat{v}$. Thus, the cumulative distribution function $G(z)$ over the proportion of firms that sell the asset evaluated at the point z is given by the probability that the true state v is above $\widehat{v}$.

Consider the conditional density over the true state v conditional on a signal equal to $\widehat{x}$. Since the noise term ε_i has bounded support in $[-\eta, \eta]$, the *posterior* density over the true state v conditional on $\widehat{x}$ has support on the interval $[\widehat{x} - \eta, \widehat{x} + \eta]$. Since the *prior* density over v was assumed to be continuous, the *posterior* density reaches a minimum $m(\eta)$ and a maximum $M(\eta)$ on this interval, such that:

$$lim_{\eta\to 0}\left(2\eta \times m(\eta)\right) = lim_{\eta\to 0}\left(2\eta \times M(\eta)\right) = 1.$$

Conditional on being at the threshold point $\widehat{x}$, the probability that $v \geq \widehat{v}$ is given by the area under the *posterior* density over v to the right of $\widehat{v}$. This area will give us $G(z)$. From the definition of m and M, we thus have the pair of inequalities:

$$2\eta m(\eta)\left(\frac{\widehat{x}+\eta-\widehat{v}}{2\eta}\right) \leq G(z) \leq 2\eta M(\eta)\left(\frac{\widehat{x}+\eta-\widehat{v}}{2\eta}\right).$$

Thus, we conclude that in the limit:

$$\lim_{\eta\to 0} G(z) = z.$$

In other words, the cumulative distribution function over the proportion of firms that sell the asset tends to the identity function. In turn, this implies that the density function over the proportion of firms that sell tends to the uniform density. *QED*

The characterization of the threshold point in the mark–to–market regime is then obtained as the indifference point of a firm when it hypothesizes that the density over the proportion of firms that sell is given by the uniform density (so that the expected proportion of firms that sell is given by 1/2). This gives the cutoff value in proposition 2.

3.2 Equilibrium in the Historical-Cost Regime

In the historical-cost regime, the complete information game has a unique equilibrium. Thus, it is easy to see that the introduction of an arbitrarily small noise in the fundamentals has essentially no effect on the equilibrium of the complete information game. Formally, note that the distribution of v conditional on a signal x_i tends to a Dirac delta function in x_i as $\eta \to 0$. Thus, any equilibrium strategy of the incomplete information game, $s_\eta(.)$, must be such that $s_\eta(x_i)$ tends to an equilibrium strategy in the complete information game with payoff x_i as $\eta \to 0$. But since, unlike in the mark–to–market case, there is only one such strategy for each value x_i in the complete information game, it must be that $s_\eta(.)$ converges pointwise to this strategy:

Proposition 3 *Suppose that the firms are operating under the historical–cost regime. Then, there is a unique equilibrium in the limit as $\eta \to 0$. In this equilibrium,*

$$\begin{array}{rl} s(x) = 0 & if \quad x < \frac{dv_0}{d+\delta-1}, \\ s(x) = 1 & if \quad x > \frac{dv_0+\frac{\gamma}{2}}{d+\delta-1}, \\ s(x) = \frac{2}{\gamma}((d+\delta-1)x - dv_0) & \quad otherwise. \end{array}$$

In words, the equilibria of the incomplete information game converge to the unique equilibrium of the complete information game.

In the following sections, we will derive the implications of these equilibria on the price of the asset and on social welfare in each measurement regime.

4 Effect of Measurement Regime on Prices

The equilibria derived under each measurement regime have interesting implications for the impact of each regime on the distribution of the price of the asset in the secondary market. We first study $p(v)$, the average price at which the asset trades between $t = 0$ and $t = 1$ conditional on v. By substituting the (deterministic) equilibrium proportion, $s(v)$, of FIs off-loading the asset in the average market price of the asset:

$$p(v) = \delta v - \gamma \frac{s\,(v)}{2},$$

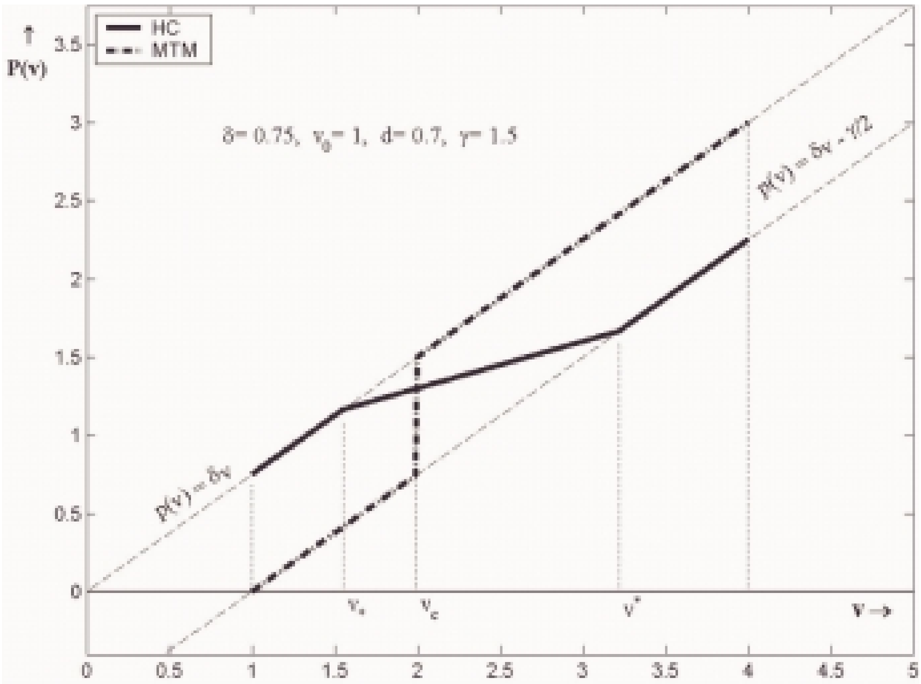

Figure 1: Price of the asset of as a function of the fundamental v.

it is straightforward to verify that under the historical cost accounting regime, the average market price of the asset, $p_{HC}(v)$, is:

$$\begin{aligned} p_{HC}(v) &= \delta v & if \quad & v < v_* \equiv \tfrac{dv_0}{d+\delta-1}, \\ p_{HC}(v) &= (1-d)\,v + dv_0 & if \quad & \tfrac{dv_0}{d+\delta-1} \leq v \leq \tfrac{dv_0+\frac{1}{2}\gamma}{d+\delta-1}, \\ p_{HC}(v) &= \delta v - \tfrac{1}{2}\gamma & if \quad & v > v^* \equiv \tfrac{dv_0+\frac{1}{2}\gamma}{d+\delta-1}. \end{aligned} \tag{2}$$

Similarly, under the mark–to–market accounting regime, the average market price of the asset, $p_{MM}(v)$, is:

$$\begin{aligned} p_{MM}(v) &= \delta v & if \quad & v > v_c \equiv \tfrac{\gamma}{2}\tfrac{d-\frac{1}{2}}{(1-d)(1-\delta)}, \\ p_{MM}(v) &= \delta v - \tfrac{1}{2}\gamma & if \quad & v \leq v_c \equiv \tfrac{\gamma}{2}\tfrac{d-\frac{1}{2}}{(1-d)(1-\delta)}. \end{aligned} \tag{3}$$

Figure 1 illustrates the behavior of the market price as a function of the fundamental v for given values of δ, d, γ, and v_0.

Figure 1 shows that under the historical cost accounting regime, the price is a continuous function of the fundamental v. Because $1 - d < \delta$, the price function $p_{HC}(v)$ in the intermediate region $v_* \leq v \leq v^*$ is less steep than the price function in the outer regions $v < v_*$ and $v > v^*$. Strategic substitutability stabilizes the price, namely it makes the price function smoother than δv in this intermediate region. In the mark–to–market regime, the price of the asset is a discontinuous function of the fundamental at $v = v_c \equiv \frac{\gamma}{2} \frac{d - \frac{1}{2}}{(1-d)(1-\delta)}$. The step function $-\frac{1}{2} 1_{\left\{ v \leq \frac{1}{2} \frac{d - \frac{1}{2}}{(1-d)(1-\delta)} \right\}}$ adds endogenous volatility to the price of the asset. This volatility is endogenous in the sense that it has nothing to do with the fundamental v of the asset but arises as an unfortunate consequence of the mark–to–market regime. This regime creates creates beauty contests in which FIs liquidate their assets when $v < v_c$ simply because they expect that everybody will do so, and this is a self-justifying belief. The single-crossing property of $p_{MM}(v)$ and $p_{HC}(v)$ illustrated in Figure 1 shows that $p_{MM}(v)$ is riskier in the sense that its distribution has more weight in the tails than the distribution of $p_{HC}(v)$.

As we had discussed in the Introduction, financial institutions have argued against marking to market on the grounds that a mark–to–market measurement regime would add undesirable artificial volatility to their reported numbers, while supporters of full fair value have argued that historical cost conceals volatility. Figure 1 does bolster both claims. Marking to market increases the volatility of prices and this excess volatility has indeed nothing to do with the fundamental volatility of the asset *per se*. Conversely, prices are artificially smoothed under the historical cost regime.

We will now investigate the effects of each measurement regime on the *ex ante* price of the asset, namely the expected market price $E(\widetilde{p})$ where the expectation is taken with respect to v. For all subsequent *ex ante* price and welfare analyses, we will assume, to fix ideas, that v has a continuous density $f(.)$ and cumulative density $F(.)$ on the positive support $[0, \infty)$

with mean μ.[3] However, we do not need to restrict the analysis to a particular specification for $F(.)$. Using the expressions for $p_{HC}(v)$ and $p_{MM}(v)$ derived in (2) and (3) respectively, the following expressions characterize the *ex ante* price of the asset under each measurement regime.

The *ex ante* price $E(\widetilde{p}_{MM})$ of the asset in the mark–to–market regime is:

$$E(\widetilde{p}_{MM}) = \delta\mu - \frac{\gamma}{2}F(v_c) \text{ where } v_c \equiv \frac{\gamma}{2}\frac{d-\frac{1}{2}}{(1-d)(1-\delta)} \tag{4}$$

while the *ex ante* price $E(\widetilde{p}_{HC})$ of the asset in the historical cost regime is:

$$E(\widetilde{p}_{HC}) = \delta\mu - \int_{v_*}^{v^*}[(\delta+d-1)v - dv_0]f(v)dv - \frac{\gamma}{2}[1-F(v^*)] \tag{5}$$

$$\text{where } v_* \equiv \frac{dv_0}{d+\delta-1} \text{ and } v^* \equiv \frac{dv_0 + \frac{1}{2}\gamma}{d+\delta-1}$$

As expected, for each measurement regime, the *ex ante* price of the asset is less than $\delta\mu$, the expected price that would prevail if the market for the asset were perfectly liquid. In the next sections, we study the comparative statics of the *ex ante* price in each measurement regime with respect to the duration of the asset, d, and its liquidity, γ .

4.1 Price and Duration

By differentiating (4) with respect to d, we obtain:

$$\frac{\partial E_{MM}(\widetilde{p})}{\partial d} = -\frac{\gamma}{2}f(v_c)\frac{\partial v_c}{\partial d} < 0.$$

Similarly, differentiating (5) with respect to d, we obtain:

$$\frac{\partial E_{HC}(\widetilde{p})}{\partial d} = \int_{v_*}^{v^*}(v_0 - v)f(v)dv < 0$$

[3] Note that in order to guarantee that the global game has a unique equilibrium, v should also take nonpositive values. In other words, v should lie in the interval $[-\varepsilon, \infty[$ where $\varepsilon > 0$. For analytical tractability we have taken ε to be arbitrarily close to zero by assuming a positive support.

Thus, in both measurement regimes, as the duration d of the asset increases, the *ex ante* price of the asset falls. The intuition is simple. In this economy, FIs sell when they believe that their assets will be misvalued by the imperfect measurement regime. As the cash flows generated by the asset shift towards the future, misvaluation is more likely, and this misvaluation, in turn, triggers more sales under both regimes.

While the *ex ante* price of the asset is decreasing in its duration d in both regimes, the next proposition shows that the mark–to–market regime yields higher market valuations for assets of relatively short durations, while the historical cost regime leads to higher expected prices for assets of relatively long durations.

Proposition 4 *All else equal, there exists* (d_*, d^*) *where* $1/2 < d_* \leq d^* < 1$ *such that:*

$$\begin{aligned} E(\widetilde{p}_{MM}) &> E(\widetilde{p}_{HC}) \textit{ for all } d < d_*, \\ \textit{and } E(\widetilde{p}_{MM}) &< E(\widetilde{p}_{HC}) \textit{ for all } d > d^*. \end{aligned}$$

Proof. See Appendix. ■

The intuition behind Proposition 4 is as follows: the *ex ante* price in the mark–to–market regime is low because of the beauty contest effect while the *ex ante* price in the historical cost regime is low because of the conservatism effect. Therefore, as duration changes the beauty contest effect in the mark–to–market regime has to be weighed against the conservative effect of the historical cost regime. In the mark-to-market regime, when the horizon of the FIs is not too different from the duration of the assets (d is small), the FIs coordinate on the Pareto-dominant equilibrium for most values of their signal, and runs become therefore unlikely. In the historical cost regime, even for arbitrarily small values of d, a FI is still willing to realize the value of the asset for large values of v by selling it. In other words, for relatively low values of duration, inefficient window-dressing persists in the historical cost regime while it vanishes in the marking-to-market regime. Conversely when

d is relatively large, the asset is very vulnerable to beauty contests in the mark–to–market regime. As $d \to 1$, FIs coordinate on off-loading the asset regardless of its value. In the historical cost regime, when $d = 1$, there is still an area to the left of $v_* > v_0$ in which FIs do not sell because the inertia inherent to this regime provides them with a "hedge". In other words, for large durations, inefficient window-dressing remains limited under the historical cost measurement regime, but not in the marking-to-market regime.

Figure 2 is a graphical illustration of the above proposition. It shows how, all else equal, the *ex ante* price of the asset behaves in each measurement regime as the duration d of the asset increases from 1/2 to 1. For assets of relatively short durations, the mark–to–market regime results in higher *ex ante* prices than the historical cost regime. Conversely, for assets with relatively long durations, the historical cost regime results in higher *ex ante* prices. Note that for the particular environment illustrated in Figure 2, $d_* = d^*$, so that the *ex ante* price functions under both regimes have a unique crossing point.

4.2 Price and Liquidity

The parameter γ captures the liquidity of the asset. The larger γ is, the less liquid the asset is because a large value of γ makes the price of the asset very sensitive to asset sales. We therefore expect the *ex ante* price of the asset to be decreasing in γ in both measurement regimes. We show that this is indeed the case below. However, the sensitivity of the price with respect to γ is very different across the two regimes.

Differentiating the *ex ante* price of the asset in the mark–to–market regime (4) with respect to γ, we get:

$$\frac{\partial E(\widetilde{p}_{MM})}{\partial \gamma} = -\underbrace{\frac{1}{2}F(v_c)}_{direct\ effect} - \underbrace{\frac{\gamma}{2}f(v_c)\frac{\partial v_c}{\partial \gamma}}_{indirect\ effect} < 0 \tag{6}$$

Thus, in the mark–to–market regime, an increase in γ lowers the *ex ante* price of the FI due

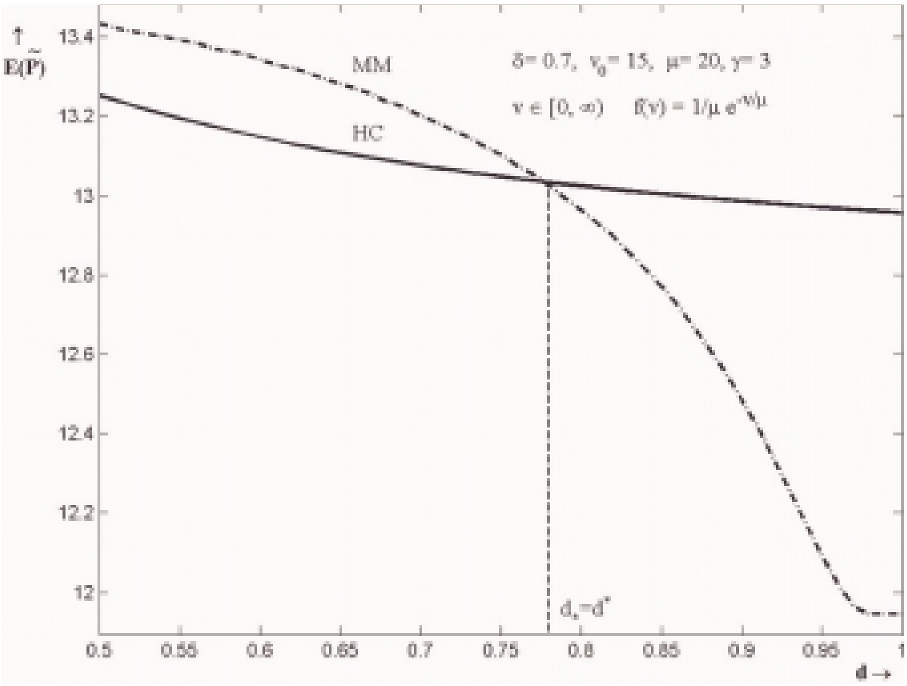

Figure 2: *Ex ante* price $E(\widetilde{p})$ of the asset as a function of its duration, d.

to two effects: the first term in (6) is negative and captures the direct effect of a reduction of liquidity on prices. A large γ implies that price falls more for the same amount of sales by FIs. The second effect is indirect and captures the strategic complementarity effect: as γ increases, FIs coordinate on a more "trigger-happy" strategy, so that the region of fundamentals over which FIs sell increases, leading prices to fall even more. These two effects reinforce each other in the mark–to–market regime so that prices are very sensitive to and decreasing in γ.

To see the effect of a change in liquidity on the historical cost regime, differentiating (5) with respect to γ yields:

$$\frac{\partial E(\widetilde{p}_{HC})}{\partial \gamma} = -\frac{1}{2}[1 - F(v^*)] < 0 \tag{7}$$

In the historical cost regime, for the region $v \leq v_*$, the price does not depend on γ because the dominant strategy is to hold. For the intermediate region, $v_* \leq v \leq v^*$, as γ increases, price becomes more sensitive to sales but the likelihood of sales is also lower so that the effect of γ is exactly offsetting: Strategic substitutability in the region implies that price does not depend on γ for $v_* \leq v \leq v^*$. Thus, γ has a direct effect on price only for values of $v > v^*$ where $p(v) = \delta v - \frac{\gamma}{2}$.

To sum up, an increase in γ has a direct negative impact on the price under each regime, but also an indirect effect because it makes each FI more dependent on the strategies followed by the others. This indirect effect reinforces the direct one in the mark-to-market regime because of strategic complementarity. Conversely, the indirect effect mitigates the direct effect in the historical cost regime because sales are strategic substitutes in this case. The following proposition shows that the impact of liquidity on prices parallels the effect of duration.

Proposition 5 *All else equal, there exists* (γ_*, γ^*) *where* $0 \leq \gamma_* \leq \gamma^*$ *such that:*

$$
\begin{aligned}
E(\widetilde{p}_{MM}) &> E(\widetilde{p}_{HC}) \text{ for all } \gamma < \gamma_*, \\
\text{and } E(\widetilde{p}_{MM}) &< E(\widetilde{p}_{HC}) \text{ for all } \gamma > \gamma^*.
\end{aligned}
$$

Proof. See Appendix. ■

Figure 3 illustrates this result for a specific environment. Note that in this particular case, $\gamma_* = \gamma^*$, so that the *ex ante* price functions under both regimes have a unique crossing point.

The analyses of duration and liquidity on *ex ante prices* lead to similar conclusions: for sufficiently long–lived and illiquid assets, *ex ante* prices are higher under a historical cost regime than under a mark–to–market regime. Conversely, for relatively short–lived and liquid assets, mark–to–market performs better than historical cost in terms of prices. Banks and insurance companies have relatively long–lived and illiquid claims in their asset–liability

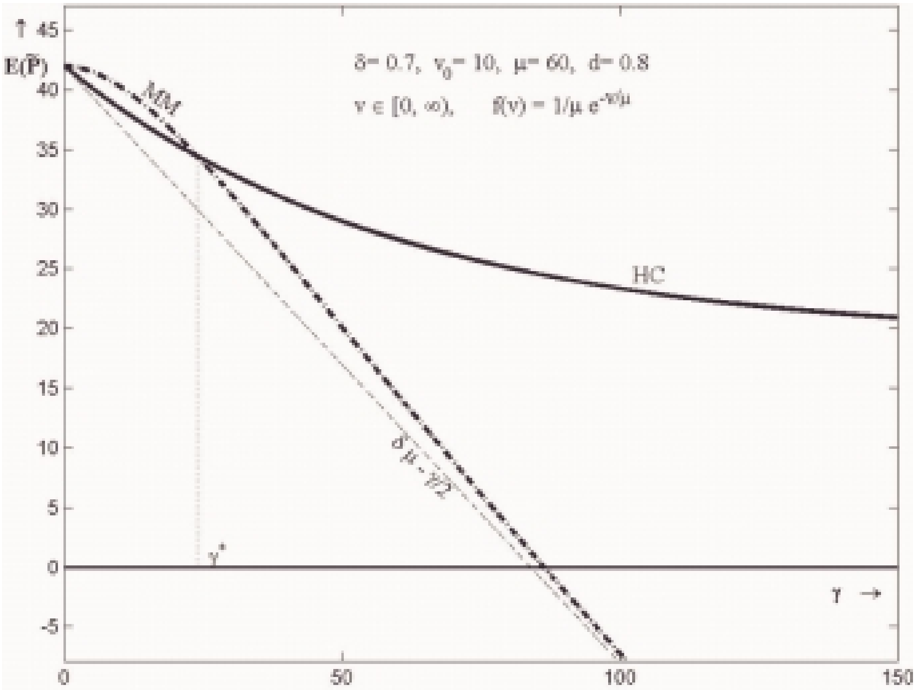

Figure 3: Effect of Asset Liquidity γ on *Ex ante* Prices.

portfolios and to the extent that they care about the market prices of their claims, these results explain their reluctance to marking to market.

We turn next to the analysis of the welfare consequences of each measurement regime.

5 Welfare Analysis

Sales of assets for window-dressing purposes reduce the surplus that FIs could create for their claimholders by holding the assets. In this section, we compare the welfare losses for the claimholders of the FIs under each regime. Formally, the welfare loss for a given value of v, $L(v)$, is given by the total value destroyed by assets sales:

$$L(v) = s(v)(v - p(v)),$$

where $s(v)$ is the (deterministic) proportion of FIs selling for a given payoff v and $p(v)$ is the price of the asset for each realized value of v derived in the former section. This simple form stems from the linearity of the demand curve.

Let $L_{HC}(v)$ and $L_{MM}(v)$ denote the respective welfare loss functions for a realization v of the expected payoff under the historical cost and mark–to–market regimes respectively. Using the expressions for $p(v)$ and $s(v)$ derived above, it is straightforward to show that:

$$\begin{array}{rlll} L_{HC}(v) & = 0 & if & v < v_* \\ L_{HC}(v) & = \frac{2d}{\gamma}(v - v_0)\left[d(v - v_0) - (1-\delta)v\right] & if & v_* \leq v \leq v^* \\ L_{HC}(v) & = (1-\delta)\, v + \frac{\gamma}{2} & if & v > v^* \end{array} \text{, and} \tag{8}$$

$$\begin{array}{rlll} L_{MM}(v) & = 0 & if & v > v_c \\ L_{MM}(v) & = (1-\delta)\, v + \frac{\gamma}{2} & if & v \leq v_c \end{array} . \tag{9}$$

Figure 4 illustrates the behavior of the loss function $L(v)$ in each measurement regime as v changes.

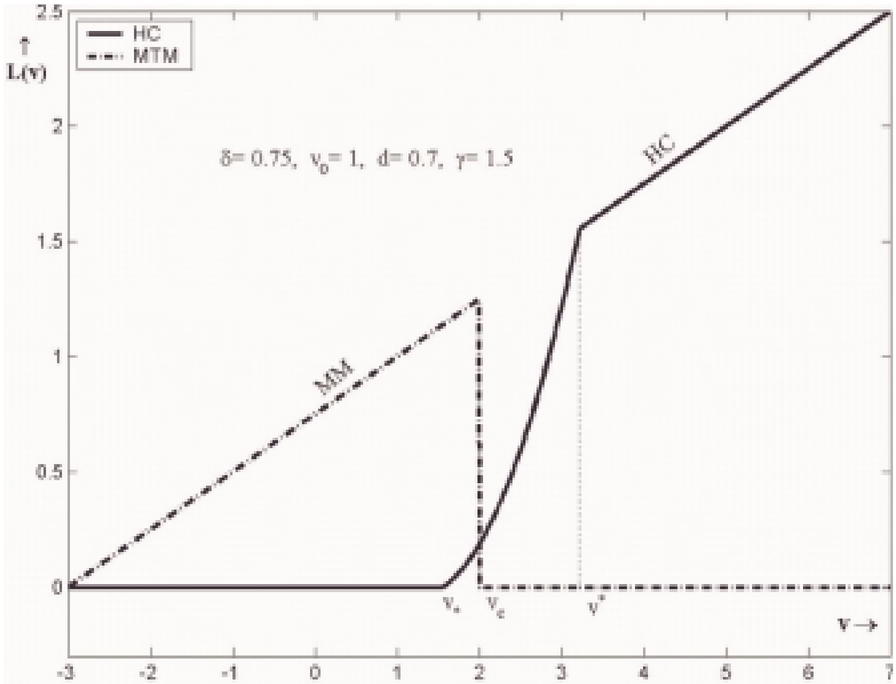

Figure 4: Welfare Loss as a function of the fundamental v.

Figure 4 is instructive because it illustrates the dramatic change in the shape of the loss function as we move across measurement regimes. Specifically, in the historical cost regime, there is no welfare loss for very low values of v, i.e., in the lower tail region $v < v_*$. There is a welfare loss in the intermediate and upper tail regions. On the other hand, in the mark–to–market regime, the opposite is true. There is a welfare loss in the lower tail region $v \leq v_c$ while there is no welfare loss in the upper tail region $v > v_c$.

5.1 Nature of Claim and Welfare

An inspection of Figure 4 delivers immediately the following Lemma:

Lemma 2 *Marking to market is preferable for assets whose payoff's distribution has a sufficiently fat right tail and a sufficiently thin left tail. Conversely, the historical cost* *regime is preferable for assets whose payoff's distribution has a sufficiently fat left tail and a sufficiently thin right tail.*

The risk profile of banks' assets—typically senior loans, and insurance liabilities involve a large potential downside and a more limited potential upside. Lemma 2 suggests that banks' assets and insurers' liabilities are typically the class of claims for which historical cost is likely to dominate mark–to–market in our environment. This result again explains why banks and insurance companies have been the most vocal opponents of marking-to-market: a large proportion of their claims are senior and thus face relatively large downside risks but limited upside risks.

Lemma 2 also sheds some light on the political economy of the FASB and IASB reform. Among participants in the heated debate about the applicability of mark-to-market accounting to financial institutions, auditing firms are the most fervent supporters of full fair value, while, at the other end of the spectrum, prudential regulators are the most reluctant. By nature, auditing firms act on behalf of shareholders, while prudential regulators are the representatives of depositors and policyholders. Shareholders hold the most junior claims on the assets of financial institutions while depositors and policy holders hold the senior claims and therefore their respective upside and downside risks may explain their respective lobbying strategies.

Using the welfare functions (8) and (9), we will now investigate how *ex ante* welfare losses $E(\widetilde{L}_{HC})$ and $E(\widetilde{L}_{MM})$ in the historical cost and mark–to–market measurement regimes vary with d, the asset's duration and γ, the asset's liquidity.

5.2 Duration and Welfare

The impact of duration on welfare does not differ qualitatively from its impact on price studied in the former section. Since measurement problems are more severe for long-lived assets, incentives to sell are stronger for such assets, therefore duration has a negative impact on welfare regardless of the regime. An inspection of Figure 4 suggests this result. In the mark-to-market regime, the region of nonnegative welfare loss lies on the left of v_c, while this region lies on the right of v_* for the historical cost regime. v_c increases with respect to d, while v_* and v^* decrease with respect to d. Thus the welfare loss regions expand in both regimes.

Furthermore, v_c tends to zero, while v^* remains bounded as d gets close to $\frac{1}{2}$. Thus the mark-to-market regime should be preferable for short-lived assets. Similarly, v_c tends to infinity, while v_* remains bounded away from 0 as d gets close to 1, suggesting that the historical cost regime entails a smaller welfare loss than the mark-to-market regime for long-lived assets. The next proposition formalizes these intuitions.

Proposition 6 *The ex ante welfare functions $E(\widetilde{L}_{MM})$ and $E(\widetilde{L}_{HC})$ in the mark–to–market and historical cost regimes both increase in d, the asset duration. Furthermore, all else equal, there exists a unique $\left(\underline{d}, \overline{d}\right)$ where $\frac{1}{2} < \underline{d} \leq \overline{d} < 1$ such that:*

$$
\begin{aligned}
E(\widetilde{L}_{MM}) &< E(\widetilde{L}_{HC}) \text{ for all } d < \underline{d}, \text{ and} \\
E(\widetilde{L}_{MM}) &> E(\widetilde{L}_{HC}) \text{ for all } d > \overline{d}.
\end{aligned}
$$

Proof. See Appendix. ■

Figure 5 illustrates the implications of proposition (6) for a specific environment where $\underline{d} = \overline{d}$.

Once again, these results support banks' and insurance companies' arguments against marking their assets to market. The above analyses of duration on welfare and prices have shown that long–lived claims are very vulnerable to beauty contest effects in the mark–to–market regime and these beauty contest effects overwhelm the conservatism effects of the

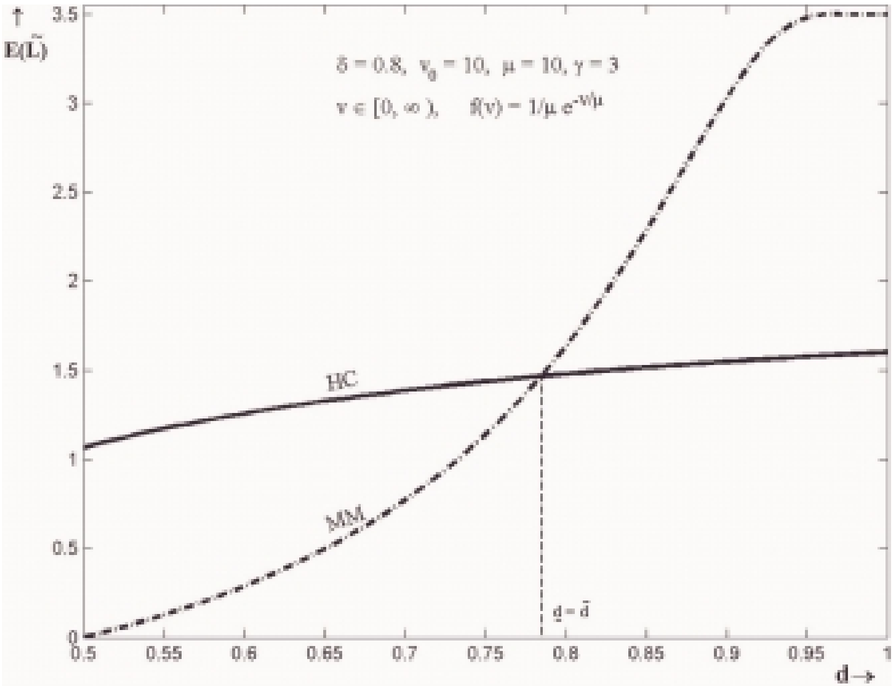

Figure 5: Impact of Duration on ex ante Welfare loss, $E(\widetilde{L})$.

historical cost regime. Both regimes are inefficient, but for long–lived assets, the relative inefficiency of the mark–to–market is more severe.

Interestingly, this result is consistent with the current U.S. generally accepted accounting principles (GAAP) reporting requirements for assets: short–lived assets such as short term investments and inventories are marked to market on the balance sheets while long–lived assets such as property, plant and equipment and long term investments are not marked to market but measured at historical cost.

5.3 Liquidity and Welfare

The following proposition shows that the measurement regimes can be Pareto-ranked unambiguously for relatively liquid or relatively illiquid secondary markets:

Proposition 7 *There exists* $(\underline{\gamma}, \overline{\gamma})$ *where* $0 < \underline{\gamma} \leq \overline{\gamma}$ *such that:*

$$\begin{aligned} E(\widetilde{L}_{MM}) &< E(\widetilde{L}_{HC}) \textit{ for all } \gamma < \underline{\gamma}, \textit{ and} \\ E(\widetilde{L}_{MM}) &> E(\widetilde{L}_{HC}) \textit{ for all } \gamma > \overline{\gamma}. \end{aligned}$$

Proof. Similar to proof of Proposition 6. ■

The impact of liquidity on welfare bears similarities with the impact of liquidity on price analyzed in the former section. An increase in γ has direct negative effects on welfare in both regimes because, all else equal, prices are lower. However, the indirect strategic consequences of illiquidity are much more important on welfare than on price, because welfare is a strictly convex (quadratic) function of the fraction of selling FIs, while the price is a linear one. As the market becomes more illiquid, strategic complementarity increases in the mark-to-market regime, leading to a greater likelihood of "runs". The indirect strategic effect thus reduces welfare. In the historical cost regime, increasing illiquidity has a disciplining effect on firms because of increased strategic substitutability, and may therefore be Pareto improving for some values of the parameters. In other words, in the historical cost regime, the indirect positive strategic effect may even overcome the direct negative effect so that welfare increases as the market becomes less liquid.

To see this more formally, notice that the *ex ante* welfare loss in the mark–to–market regime is given by:

$$E(\widetilde{L}_{MM}) = \int_0^{v_c(\gamma)} [(1-\delta)v + \frac{\gamma}{2}] f(v) dv, \tag{10}$$

and the *ex ante* welfare loss in the historical cost regime is given by:

$$E(\widetilde{L}_{HC}) = \int_{v_*}^{v^*(\gamma)} \frac{2d}{\gamma} [d(v - v_0) - (1-\delta)v](v - v_0)] f(v) dv + \int_{v^*(\gamma)}^{\infty} [(1-\delta)v + \frac{\gamma}{2}] f(v) dv, \tag{11}$$

where we have written the cutoff points v_c and v^*as functions of γ to show their explicit dependence on the liquidity parameter γ.

Differentiating (10) with respect to γ, yields:

$$\begin{aligned}\frac{\partial E(\widetilde{L}_{MM})}{\partial\gamma} &= \underbrace{\frac{1}{2}F(v_c(\gamma))}_{direct\ effect} + \underbrace{\frac{\partial v_c}{\partial\gamma}[(1-\delta)v_c(\gamma)+\frac{\gamma}{2}]f(v_c(\gamma))}_{indirect\ effect} > 0 \qquad (12)\\ &= -\frac{\partial E(\widetilde{p}_{MM})}{\partial\gamma} + \frac{\partial v_c}{\partial\gamma}(1-\delta)v_c(\gamma)\end{aligned}$$

Thus, the *ex ante* welfare loss in the mark–to–market regime increases unambiguously as the liquidity of the asset decreases. Expression (12) shows that the indirect effect of liquidity is more important on welfare than it is on price.

Differentiating (11) with respect to γ and substituting for $v^*(\gamma) = \frac{dv_0+\frac{\gamma}{2}}{d+\delta-1}$ yields:

$$\begin{aligned}\frac{\partial E(\widetilde{L}_{HC})}{\partial\gamma} &= \underbrace{\frac{1}{2}[1-F(v^*(\gamma))]}_{\text{positive effect}} + \underbrace{\int_{v_*}^{v^*(\gamma)} -\frac{2d}{\gamma^2}[(d+\delta-1)v-dv_0](v-v_0)]f(v)dv}_{\text{negative effect}} \qquad (13)\\ &= -\frac{\partial E(\widetilde{p}_{HC})}{\partial\gamma} - \int_{v_*}^{v^*(\gamma)} \frac{2d}{\gamma^2}[(d+\delta-1)v-dv_0](v-v_0)]f(v)dv\end{aligned}$$

Expression (13) shows that the effects of liquidity on the historical cost measurement regime can also be decomposed into the sum of its effect on price and an additional term. However, this term is nonpositive, and therefore it cannot be ruled out that illiquidity *enhances* welfare for some values of the parameters. This is because even though a larger γ makes prices more sensitive to asset sales, a larger γ also reduces the quantities sold when $v \in [v_*, v^*]$ because $s(v) = \frac{2}{\gamma}((d+\delta-1)v - dv_0)$. This strategic substitutability effect implies that γ has no effect on the expected price in this region. However, the welfare loss is given by $s(v)[(v-p(v)]$. Because $s(v)$ is decreasing in γ, increases in γ therefore reduces the expected welfare loss over the interval $v_* \le v \le v^*$. In other words, for $v_* \le v \le v^*$, illiquidity is a disciplining device reducing sales, so much so that a decrease in illiquidity *enhances* welfare conditional on v in this region.

However, as liquidity decreases, unconditional welfare may increase or decrease depending on the relative magnitudes of the two terms described in (13). The net effect of liquidity

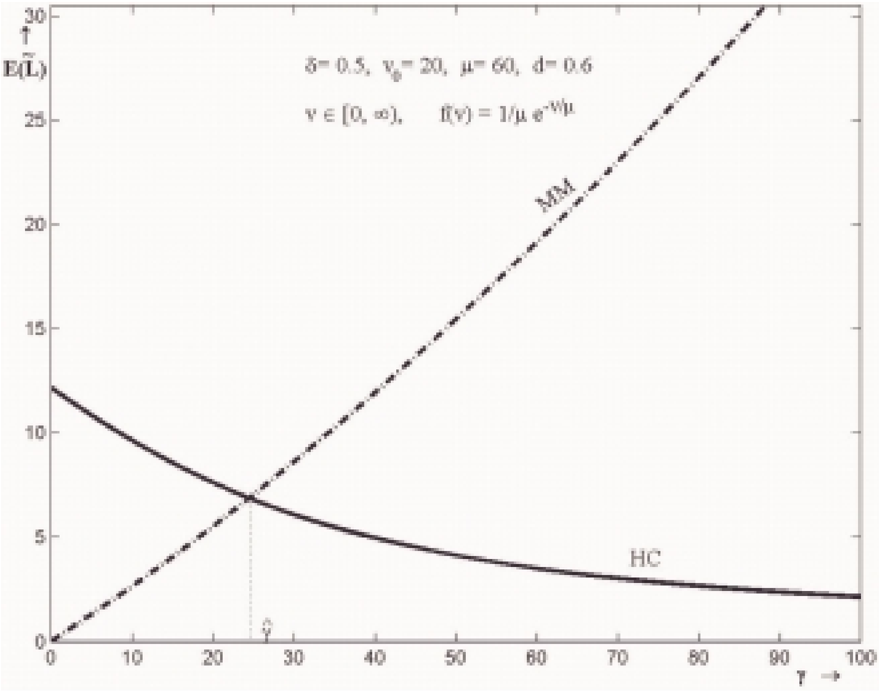

Figure 6: Impact of Asset Liquidity on Ex ante Welfare Loss, $E(\widetilde{L})$.

in the historical cost regime is therefore ambiguous. Can the negative effect overwhelm the positive effect so that welfare in the historical cost regime improves as liquidity decreases? Figure 6 shows this is indeed feasible for a specific environment.

Figure 6 confirms the result derived above that liquidity unambiguously reduces welfare in the mark–to–market regime so that $E(\widetilde{L}_{MM})$ is increasing in γ. However, $E(\widetilde{L}_{HC})$ is decreasing in γ so that for the specific environment graphed in Figure 6, welfare in the historical cost regime increases as liquidity decreases.

These results are again consistent with the arguments made by the opponents of mark–to–market accounting such as banks and insurance companies that hold claims that are relatively illiquid.

6 Concluding Remarks

The choice of a measurement regime for financial intermediaries is one of the most important and contentious current policy issues in the financial services industry. We have developed an economic analysis of this issue. We have modelled an environment in which the only contractible valuations of assets are their prices in an illiquid market. In this environment, measurement policies affect firms' actions, and these actions, in turn, affect prices. Thus, prices drive measurements, but measurements also have a feedback effect on prices. We compare a measurement regime based on past price—historical cost—with a regime based upon current price—mark-to-market. The historical cost regime is inefficient because it ignores price signals. This leads to excess conservatism. However, in trying to extract the informational content of current prices, the mark-to-market regime damages this content by adding a purely speculative component to price fluctuations. As a result, the choice between these measurement regimes boils down to a dilemma between ignoring price signals, or relying on their degraded versions. We show that the historical cost regime may dominate the mark-to-market regime when assets have a long duration, trade in a very illiquid market, or feature an important downside risk. These results help explain why the application of the regulatory mark-to-market reforms to financial institutions is so contentious. A large proportion of the balance sheets of financial institutions consists precisely of items that are of long duration, illiquid and senior.

Our results also suggest that a careless, rapid shift to a full mark-to-market regime may be detrimental to financial intermediation and therefore to economic growth. This is not to deny that such a transition is a desirable long-run aim. In the long run, large mispricings in relatively illiquid secondary markets would likely trigger financial innovations in order to attract new classes of investors. This enlarged participation would in turn enhance liquidity, a situation in which our analysis shows that marking to market becomes more efficient. A natural route for future research is to endogenize market participation and thus liquidity in our setup, so as to analyze how a careful transition towards market-based measurements could trade off the costs we have emphasized with the long-run benefits from a higher reliance on price signals.

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7 Appendix

Proof of Proposition 4. $E(\widetilde{p}_{MM})$ and $E(\widetilde{p}_{HC})$ are continuous functions. Thus, it is sufficient to show that $E(\widetilde{p}_{MM}) > E(\widetilde{p}_{HC})$ when $d = \frac{1}{2}$ while $E(\widetilde{p}_{MM}) < E(\widetilde{p}_{HC})$ when $d = 1$.When $d = \frac{1}{2}$, $v_c = 0$ so that $E(\widetilde{p}_{MM}) = \delta\mu - \frac{\gamma}{2}F(0) = \delta\mu$. When $d = \frac{1}{2}, v_* = \frac{v_0}{2\delta-1}$ and $v^* = \frac{v_0+\gamma}{2\delta-1}$ so that:

$$E(\widetilde{p}_{HC}) = \delta\mu - \frac{1}{2}\int_{\frac{v_0}{2\delta-1}}^{\frac{v_0+\gamma}{2\delta-1}} [(2\delta-1)v - v_0]f(v)dv - \frac{\gamma}{2}\left[1 - F(\frac{v_0+\gamma}{2\delta-1})\right] < \delta\mu = E(\widetilde{p}_{MM})$$

When $d = 1$, $v_c = \infty$ so that $E(\widetilde{p}_{MM}) = \delta\mu - \frac{\gamma}{2}F(\infty) = \delta\mu - \frac{\gamma}{2}$. When $d = 1, v_* = \frac{v_0}{\delta}$ and $v^* = \frac{v_0+\frac{1}{2}\gamma}{\delta}$ so that:

$$\begin{aligned}
E(\widetilde{p}_{HC}) &= \delta\mu - \int_{\frac{v_0}{\delta}}^{\frac{v_0+\frac{1}{2}\gamma}{\delta}} (\delta v - v_0)f(v)dv - \frac{\gamma}{2}\left[1 - F(\frac{v_0+\frac{1}{2}\gamma}{\delta})\right] \\
&> \delta\mu - \int_{\frac{v_0}{\delta}}^{\frac{v_0+\frac{1}{2}\gamma}{\delta}} (\delta(\frac{v_0+\frac{1}{2}\gamma}{\delta}) - v_0)f(v)dv - \frac{\gamma}{2}\left[1 - F(\frac{v_0+\frac{1}{2}\gamma}{\delta})\right] \\
&= \delta\mu - \frac{\gamma}{2}\int_{\frac{v_0}{\delta}}^{\frac{v_0+\frac{1}{2}\gamma}{\delta}} f(v)dv - \frac{\gamma}{2}\left[1 - F(\frac{v_0+\frac{1}{2}\gamma}{\delta})\right] \\
&= \delta\mu - \frac{\gamma}{2}[F(\frac{v_0+\frac{1}{2}\gamma}{\delta}) - F(\frac{v_0}{\delta})] - \frac{\gamma}{2}\left[1 - F(\frac{v_0+\frac{1}{2}\gamma}{\delta})\right] \\
&= \delta\mu - \frac{\gamma}{2} + \frac{\gamma}{2}F(\frac{v_0}{\delta}) > \delta\mu - \frac{\gamma}{2} = E(\widetilde{p}_{MM})
\end{aligned}$$

■

Proof of Proposition 5. We have

$$E(\widetilde{p}_{HC}) - E(\widetilde{p}_{MM}) = \frac{\gamma}{2}\left(F(v_c) + F(v^*) - 1\right) - \int_{v_*}^{v^*} \left((d+\delta-1)\,v - dv_0\right) f(v)dv,$$

and

$$0 \le \int_{v_*}^{v^*} \left((d+\delta-1)\,v - dv_0\right) f(v)dv \le \frac{\gamma}{2}\left(F(v^*) - F(v_*)\right).$$

Thus,

$$\frac{\gamma}{2}\left(F(v_c)+F(v_*)-1\right) \leq E(\widetilde{p}_{HC}) - E(\widetilde{p}_{MM}) \leq \frac{\gamma}{2}\left(F(v_c)+F(v^*)-1\right).$$

It is easy to see that the lower bound is nonnegative for γ sufficiently large (because $v_c \to \infty$ in this case) while the upper bound is nonpositive for γ sufficiently small (because $v_c \to 0$ in this case). ■

Proof of Proposition 6. We will first show that the *ex ante* welfare loss in both regimes increase with the duration of the asset.

The *ex ante* welfare loss in the historical cost regime is given by the following expression:

$$E(\widetilde{L}_{HC}) = \int_{v_*(d)}^{v^*(d)} \frac{2d}{\gamma}[d(v-v_0)-(1-\delta)v](v-v_0)]f(v)dv + \int_{v^*(d)}^{\infty}[(1-\delta)v+\frac{\gamma}{2}]f(v)dv$$

Differentiating the above expression with respect to d, we get:

$$\begin{aligned}\frac{\partial E(\widetilde{L}_{HC})}{\partial d} &= \frac{\partial v^*}{\partial d}[\frac{2d}{\gamma}[d(v^*(d)-v_0)-(1-\delta)v^*(d)](v^*(d)-v_0)]f(v^*(d))] - \\ &-\frac{\partial v_*}{\partial d}[\frac{2d}{\gamma}[d(v_*(d)-v_0)-(1-\delta)v_*(d)](v_*(d)-v_0)]f(v_*(d))] + \\ &\int_{v_*(d)}^{v^*(d)}\frac{2(v-v_0)}{\gamma}[(2d+\delta-1)v-2dv_0]f(v)dv - \frac{\partial v^*}{\partial d}[(1-\delta)v^*(d)+\frac{\gamma}{2}]f(v^*(d))\end{aligned}$$

Substituting for $v^*(d) = \frac{dv_0+\frac{\gamma}{2}}{d+\delta-1}$ and $v_*(d) = \frac{dv_0}{d+\delta-1}$ in the above expression and simplifying, we get:

$$\int_{v_*(d)}^{v^*(d)}\frac{2(v-v_0)}{\gamma}[(2d+\delta-1)v-2dv_0]f(v)dv \text{ which is clearly positive.}$$

The *ex ante* welfare loss in the mark–to–market regime is given by:

$$E(\widetilde{L}_{MM}) = \int_0^{v_c(d)}[(1-\delta)v+\frac{\gamma}{2}]f(v)dv$$

Differentiating the above expression with respect to d yields:

$$\frac{\partial E(\widetilde{L}_{MM})}{\partial d} = \frac{\partial v_c}{\partial d}[(1-\delta)v_c(d)+\frac{\gamma}{2}]f(v_c(d)) \text{ which is obviously positive.}$$

We have thus established that the *ex ante* welfare loss is increasing in the asset duration d for both regimes.

To show the second part of the Proposition, note that as $d- > \frac{1}{2}, v_c \longrightarrow 0$ so that the *ex ante* welfare loss in the mark–to–market regime tends to 0. In the historical cost region, as $d- > \frac{1}{2}$, v_* and v^* tend to $\frac{v_0}{2\delta-1}$ and $\frac{v_0+\gamma}{2\delta-1}$ so that the *ex ante* welfare loss is strictly larger than zero. This implies that for relatively small values of d:

$$E(\widetilde{L}_{MM}) < E(\widetilde{L}_{HC}).$$

Similarly, when $d- > 1, v_c \rightarrow \infty$ so that the *ex ante* welfare loss in the mark–to–market regime approaches the following expression:

$$\lim_{d->1} E(\widetilde{L}_{MM}) = \int_0^\infty [(1-\delta)v + \frac{\gamma}{2}]f(v)dv$$

In the historical cost regime, as $d- > 1$, the *ex ante* welfare loss in the historical cost regime tends to:

$$\lim_{d->1} E(\widetilde{L}_{HC}) = \int_{\frac{v_0}{\delta}}^{\frac{v_0+\frac{\gamma}{2}}{\delta}} \frac{2}{\gamma}[(v-v_0)-(1-\delta)v](v-v_0)]f(v)dv + \int_{\frac{v_0+\frac{\gamma}{2}}{\delta}}^\infty [(1-\delta)v + \frac{\gamma}{2}]f(v)dv$$

Note that because $\frac{2}{\gamma}[(v-v_0)-(1-\delta)v](v-v_0) \leq (1-\delta)v + \frac{\gamma}{2}$ when $\frac{v_0}{\delta} \leq v \leq \frac{v_0+\frac{\gamma}{2}}{\delta}$, it follows that for relatively large values of d :

$$E(\widetilde{L}_{MM}) > E(\widetilde{L}_{HC}).$$

■