Structured Finance and Mark-to-Model Accounting: A Few Simple Illustrations

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SYNOPSIS: We review the development of structured financial products, discuss their accounting treatment, and illustrate their valuation using simple numerical examples. The crucial element we incorporate is the possibility that the underlying assets in structured financial products have correlated returns. The benefit of structured finance is it uses diversification to protect the senior tranches’ cash flows. However, when the underlying assets have correlated returns diversification is not as effective. Normally, structured financial products would be marked “to market,” obviating the need for analytical valuation techniques. Current accounting standards, however, have significant provisions for valuing structured financial products based on analytically derived expectations of future cash flows, especially when markets are illiquid. Therefore, it is important for both preparers and users of accounting information to understand how underlying economic fundamentals, such as the correlation in returns, affect expectations of future cash flows.

Keywords: fair value accounting; structured finance; systematic risk.

INTRODUCTION

During the recent financial crisis, banks, hedge funds, credit-rating agencies, and regulatory agencies have all come under greater scrutiny. We may add to this list accountants and accounting standards. The two most prominent questions that have arisen with respect to accounting are whether mark-to-market accounting helps spread financial contagion (Pozen 2009; SEC 2008; Westbury 2008) and whether the more opaque mark-to-model method is reliable (Kolev 2008; Song et al. 2010). Marking “to market” refers to valuing financial assets at the price found for identical assets traded in active markets, whereas marking “to model” refers to valuing financial assets based on analytically derived expectations of future cash flows. Both approaches come under the broader rubric of fair value accounting and stand in stark contrast to the more traditional
historical cost approach. Standard-setters have gradually been moving away from historical cost, especially for financial assets (SEC 2008).

There have been several theories that attempt to explain how mark-to-market accounting can spread financial crises (Allen and Carletti 2008; Cifuentes et al. 2005; Heaton et al. 2009; Plantin et al. 2008). Although the models vary in their assumptions, most feature as the transmission mechanism some sort of regulatory capital requirement, such as minimum capital ratios. Laux and Leuz (2010, 93), in generalizing the models, note, “The write-downs . . . deplete bank capital and set off a downward spiral, as banks are forced to sell assets at ‘fire sale’ prices, which in turn can lead to contagion as prices from asset fire sales of one bank become relevant for other banks.” Authors such as Ball (2008) and Ryan (2008b) remain skeptical, and claim that mark-to-market speeds the necessary process of adjustment and bolsters investor confidence. The issue continues to be debated in scholarly journals and the popular press.1

Despite the unsettled nature of the issue, intense political pressure from Congress, which itself has been receiving pressure from the financial services industry, caused the Financial Accounting Standards Board (FASB) to issue Staff Position FSP 157-3, which expands the potential use of mark-to-model accounting for assets whose markets have become illiquid (Karabell 2008). Despite this move, many in the financial community did not believe the FASB went far enough (Pozen 2009). Under continued political pressure, the FASB further expanded the circumstances under which mark-to-model accounting may be used, issuing FSP 157-4 in April of 2009. Pozen (2009, 89) notes, “Given the FASB’s two recent pronouncements . . . there is no question that banks will increasingly value illiquid securities by marking them to model.” The FASB’s move to expand mark-to-model accounting has its critics, many of whom have labeled the new accounting standards as “mark-to-myth.”

The goal of this paper is not to pass judgment on the merits of mark-to-model accounting. Instead, our goal is to use simple numerical examples to illustrate how models can be employed to value certain types of financial assets. We show that for the financial assets in question, valuation is critically dependent on how one assesses the potential for systematic risk, that is, risk that cannot be mitigated through diversification.2

The assets we focus on are structured financial products and related credit derivatives. We use as an illustrative example a collateralized mortgage obligation (CMO), although the principles we present apply to many structured financial products. Our choice is not arbitrary. The use of structured financial products has exploded in recent years.3 For example, a recent International Monetary Fund (IMF) publication estimates that global structured financial products grew from around $500 billion in 2000 to a peak of around $3,000 billion in 2006 (IMF 2008). The largest share of these issuances was mortgage-backed securities, of which a CMO is one type.

1 Laux and Leuz (2009) provide a review of the current debate. They argue that even if it is true that mark-to-market accounting helps spread financial crises, changes should be made not to accounting standards, but to prudential regulations, such as capital ratio requirements, that interact with the accounting standards.

2 Confusion may ensue between the terms systematic risk and systemic risk. Systematic risk, which is well defined in the finance literature, refers to that portion of risk that cannot be eliminated through diversification. Systemic risk is less well defined, but generally refers to the risk of an event with system-wide consequences. Therefore, one might say that the collapse of a major financial institution (such as Lehman Brothers) is a systemic risk, whereas correlation in mortgage defaults is a systematic risk. Even here we have simplified somewhat, because the risk that may not be diversified by holding different mortgages may be diversified by holding non-mortgage assets, such as treasury bonds or gold.

3 Bowden and Lorimer (2009) note the sharp growth in structured financial products and their derivatives by providing a partial list of newly introduced products that includes credit spread options, swaptions, variance swaps, credit-linked notes, collateralized debt obligation squareds, collateralized loan obligations, synthetic CDOs, basket products, tranched index trades, equity default swaps, credit contingent swaps, constant maturity swaps and constant proportion portfolio insurance.
The rest of this paper is organized as follows. The second section provides background information on structured finance and relevant accounting standards. The third section introduces the model and extensions. The fourth section concludes the paper.

BACKGROUND

In this section we discuss some of the important concepts related to structured finance and fair value accounting. Terms in this arena often are used inconsistently and loosely defined; for example, securitization and structured finance are sometimes used interchangeably. We will try to be clear in our use of these terms.

Securitization

Securitization refers to the general process of forming a pool of assets, usually some type of loan or other debt-like instrument that is not sold in a very liquid market (e.g., student loans or auto loans), removing them from the balance sheet of the originator, and issuing securities with claims against the cash flows of the assets. The first and still most important type of asset to be securitized is mortgages, upon which we shall focus.

Prior to the Great Depression, mortgages were difficult for most people to obtain. The reason was that commercial banks had mainly short-term liabilities (deposits) and did not want to grant long-term loans against those liabilities. They tended to invest in tradable bonds or the call money market.4 The largest public source of mortgages at the time was organizations known as building and loans, as seen in the movie It’s a Wonderful Life. Their supply of capital was limited, because they drew mainly on small deposits from the local community (Mason 2004). Further, the terms of such mortgages, such as a 40 percent down payment, were difficult for most people to meet (Peterson 2007). As a result, homeownership rates were much lower than they are today: 45 percent in 1920 versus 66.2 percent in 2000, as reported by the U.S. Census Bureau. These numbers underestimate how much more difficult it was to obtain a mortgage during that time period, as a greater percentage of families lived in rural farm areas (with cheaper land) in the 1920s.

During the banking crisis of 1930–1933, the incomplete but functioning mortgage market collapsed. In order to address the collapse, several new federal agencies were founded, the most important of which, with respect to securitization, was the Federal National Mortgage Association, or “Fannie Mae.” Its mission was to buy mortgages, provided the mortgages had already received a government guarantee from other federal agencies (such as the Veterans Administration). In time Fannie Mae became an important, though not overwhelming, participant in the mortgage market (Mason 2004).

In 1968, Fannie Mae became a privately owned corporation and in 1971 began purchasing mortgages not guaranteed by federal agencies (Bartke 1971). It also helped create a new type of financial instrument: securities directly backed by mortgages. Along with newcomer Federal Home Loan Mortgage Corporation, or “Freddie Mac,” and government-owned Government National Mortgage Association, or “Ginnie Mae,” Fannie Mae issued securities that directly “passed through” interest and principal to investors (Peterson 2007). These securities are similar to secured debt; however, pass-through securities pay investors based on the cash flow received, rather than using a fixed schedule. This new financing vehicle is known as a mortgage-backed security (MBS). Marketability of early MBSs was substantially enhanced by having government-owned or affiliated institutions guarantee principal payments—the only risks to investors are that interest rates might change over the life of the security or that loans would be paid off early.

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4 Call money gets its name from the fact that the lender can demand that the loan be repaid at any time.
Despite privatization, Fannie Mae and Freddie Mac were still prohibited from servicing several segments of the mortgage market, including loans that exceeded a certain size ("jumbo loans") or loans that otherwise did not meet underwriting standards of the government-affiliated agencies (Sivesend 1979). These markets were serviced by private lenders, but suffered from some of the same problems that afflicted the mortgage market before the Great Depression. Therefore, an unmet demand remained for "securitization" of nongovernmental agency mortgages. In 1977, the first securitization was underwritten by Salomon Brothers and was related to a pool of Bank of America loans.

The growth of private mortgage securitization has been truly impressive in the last thirty years. Starting at nothing in 1977, privately securitized mortgages reached $3 trillion in 2007, according to the Federal Reserve’s Flow of Funds Report. Tirole (2009) provides some economic rationale for why securitization has become so popular, noting three important benefits: (1) it provides enhanced liquidity, (2) it provides an investment outlet for emerging economies that have surplus savings, and (3) it allows for better diversification. Of course, securitization also introduces the potential for significant costs that are generally associated with information asymmetries (Bernanke and Lown 1991).

Structured Finance

Of particular note with early MBSs is that all shares were of the same class, so that the credit risk of any share was identical to the weighted-average credit risk of the underlying mortgages. However, many potential investors, such as university endowments and pension funds, are prohibited from investing in less than investment-grade debt (Cantor et al. 2007). Therefore, in order to increase liquidity for lower quality mortgages successfully, MBSs had to be transformed into higher-rated securities. This process—referred to as alchemy by some—is a key feature in what is known as structured finance. Dodd (2007) reports that through proper structuring, 80 percent of even subprime mortgages can be packaged into investment-grade debt.

Although the underlying legal structure is quite complex, the overarching principle of structured finance is very simple. Instead of issuing one class of securities, the MBS is broken up into "tranches." Each tranche is structured so as to have a targeted risk level, i.e., a particular rating from a credit-rating agency. To illustrate, a financial intermediary could create a tranche that incurred losses only if 70 percent of the mortgages defaulted. This tranche would probably be considered quite safe and hence rated AAA by the rating agencies, making it palatable to almost
any investor. The tranched MBS is generally referred to as a collateralized mortgage obligation (CMO).

By carving up MBSs in this way, the capital available for investment is greatly enhanced. In addition to overcoming restrictions on investments by pension funds, trust funds, and others, tranching mitigates the adverse selection problem in the mortgage market to a greater extent than simply securitizing. Mitchell (2004) provides a summary of the economic benefits of structured finance.

Ashcraft and Schuerman (2008, Table 17) provide data on the capital structure of a typical CMO. In their example there are 17 tranches. The top five tranches are all rated AAA and represent 79.35 percent of the CMO. The next nine tranches are rated from AA+ to BBB−, with the latter representing the lowest rating for investment grade securities. These nine tranches are usually referred to as "mezzanine tranches." Below BBB are two tranches rated BB+ and BB. Last, there is an unrated tranche, referred to as over-collateralization or equity tranche. In order to make the sale of the tranches more palatable to investors, the CMO has to hold in reserve more collateral than the face value of securities issued. If needed, the over-collateralization will go to pay the principal on the more senior tranches. However, if after a specified period of time the CMO is performing well, some of the over-collateralization is released to the equity holders.

The idea behind structured finance is to create as much AAA rated debt as possible; therefore, financial intermediaries developed methods to "recycle" the mezzanine tranches into new CMOs. A CMO consisting of other CMO tranches is commonly referred to as a CDO-squared (CDO²). The process of structuring and re-structuring these debt products causes a polarization of debt quality, wherein a pool of mid-level assets is manufactured into either AAA or speculative grade debt.

Credit Default Swaps

A credit default swap (CDS) is a type of credit derivative. As with all derivatives, a CDS derives its value from another security, in this case a reference debt security. Although a CDS is somewhat complex in its mechanics, it can be thought of as a type of insurance. The issuer of a CDS agrees to pay its holder a specified amount conditional on the default of a reference debt security. Typically this amount is the par value of the debt, less any value the debt has in default. In exchange, the holder pays the issuer quarterly premiums, very much like insurance premiums. Therefore, the value of a CDS to the holder increases as the probability of default on the reference debt security increases. The value to the issuer is the net of discounted premiums and discounted expected indemnity payments.

Although there had been a few primitive predecessors, the first real CDS was created by J. P. Morgan in the mid-1990s. Its goal was to offload credit risks it otherwise would have held on its balance sheet, specifically a large loan to Exxon in the wake of the Exxon Valdez oil spill. J. P. Morgan structured a deal wherein it agreed to pay the European Bank for Reconstruction a fixed periodic premium while the bank assumed the credit risk on the Exxon loan (Tett 2009). Since that time, the issuance of CDSs has exploded, helped particularly by the lack of regulation ensured with

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10 The basic idea is that when there are informed and uninformed investors, the issuer wants to split the security into a risk-free bond and a risky asset (Gorton and Pennacchi 1990). The risk-free bond is sold to the uninformed investors, and the risky asset is sold to the informed investors. Structured finance is a method of approximating this outcome.

11 We use the Standard & Poor’s rating system. The higher the letter the lower the default risk is. Also, repeated letters indicate a lower default risk. So, AAA has lower default risk than BBB and BBB has lower default risk than BB.

12 CDO is an acronym for Collateralized Debt Obligation, and as the name implies, it holds a wider variety of debt than just mortgages. Our example might be more accurately described as a CMO-squared, but that term is rarely used.
the passage of the Commodities Futures Modernization Act of 2000 and the standardization of contract terms by the International Swaps and Derivatives Association (ISDA) in 2003.\(^\text{13}\) Although estimates vary, by 2006 the notional value of CDSs outstanding was thought to be somewhere around $45 trillion (Mengle 2007). That is, the amount of debt “insured” was $45 trillion. It is important to note that the issuance of CDSs is not limited by the amount of underlying debt outstanding. For example, in one particular bankruptcy in 2005 there were $28 billion in CDSs on $2.2 billion of underlying debt (Mengle 2007). Although originally developed for bank loans to corporations, CDSs have evolved to cover sovereign debt, indices of debt instruments, and structured finance (Mengle 2007).\(^\text{14}\)

Fair Value Accounting

Fair value accounting, in theory, “seeks to capture and report the present value of future cash flows associated with an asset or a liability” (Campbell et al. 2008, 32). In practice, the FASB interprets fair value to be the amount an unrelated party would pay for an asset (or demand to assume a liability) in an orderly transaction on the measurement date (FASB 2007).\(^\text{15}\) The FASB’s definition is silent regarding any difficulties related to market frictions, including those resulting from imperfect and incomplete markets (Bignon et al. 2009; Christensen and Frimor 2007; Demski et al. 2008, 2009; Fellingham 2010, Chap. 5).\(^\text{16}\) We do not address these market frictions directly, although they are of first-order importance in determining “fair values” for many classes of assets.

We focus on three of the many accounting standards that relate to fair value accounting.\(^\text{17}\) The first, SFAS 115, issued in 1993, classified financial assets into three types (FASB 1993). Held-to-maturity securities are debt instruments, for which the holder has both the intention and ability to hold the instruments until the principal becomes due. They are accounted for using amortized historical cost. Other than amortization, their value is adjusted only for “other than temporary” declines in value, in which case the losses are charged against either earnings or other comprehensive income (OCI), depending on the reason for the loss.\(^\text{18}\) Trading securities, such as those used by Goldman Sachs for proprietary trading purposes, are recorded at fair value, and changes in fair value are passed directly through earnings. Available-for-sale securities are those securities that are neither held-to-maturity nor trading. These assets are recorded at fair value, and changes in fair value are initially passed through OCI; gains or losses do not impact earnings until the assets are sold, other than as explained above.

The second accounting standard we consider, SFAS 133 (FASB 1998), addresses financial derivatives. Prior to the issuance of SFAS 133, derivative instruments were subject to a variety of

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\(^\text{13}\) The documentary film *The Warning*, broadcast in the U.S. in 2009 on public television, is helpful in understanding the history of credit derivative regulation.

\(^\text{14}\) CDSs have even been used to create a structured financial product known as a synthetic collateralized debt obligation (synthetic CDO). In a synthetic CDO, CDSs are issued against assets held by others, such as mortgages or tranches of CMOs that hold mortgages. The CDO collects quarterly premiums in exchange for issuing the CDSs and must pay the holders of the CDSs in case the “insured” CMO tranche defaults. In a typical structure, only a small percent of the notional value of the debt insured by the CDSs is covered by funds received from outside investors. The unfunded portion, which represents the most senior positions in the structure, is held on the books of the issuer as “super-senior” risk (Tett 2009, 61–66). The collapse of AIG was largely caused by their writing CDSs on tens of billions of dollars of super-senior risk (Lewis 2009).

\(^\text{15}\) See SEC (2008) for a brief history of fair value accounting in the United States.

\(^\text{16}\) Also, Christensen and Demski (2003) and Demski (2004) discuss the difficulty in applying fair value accounting. They argue that to value assets correctly one must take into account the reason for the assets’ acquisition and use by the firm, which is of course endogenous.

\(^\text{17}\) Ryan (2008a) provides an extended discussion of fair value accounting and structured financial products.

\(^\text{18}\) As stated in staff position FSP 115-2 (FASB 2009b), credit losses (borrower’s inability to pay) are charged to earnings; all other losses are charged to OCI. This rule also applies to available-for-sale debt securities.
rules that were incomplete and allowed similar derivatives to be treated differently. The statement focuses on derivatives used for hedging, such as airlines buying jet fuel futures. In addition, SFAS 133 states that derivatives not held for hedging are to be reported at fair value, with changes in value run through earnings. This accounting standard would seemingly apply to the issuer of CDSs. However, there were very few CDSs when SFAS 133 was issued, and CDSs did not seem to have been contemplated in the original statement. In succeeding years, the FASB observed the explosion of CDS use and in 2008 clarified the application of SFAS 133 with FSP 133-1 (FASB 2008b). This statement of position requires the liability of CDS issuers to be stated at fair value, as well as the disclosure of significant issues regarding the CDS, such as notional value.

The third and most significant accounting standard related to our discussion is SFAS 157 (FASB 2007). SFAS 157 does not change the requirements for fair value accounting per se. Rather, it provides overarching guidance on how it is to be applied (Christian and O’Reilly 2009). SFAS 157 introduces a classification scheme for assets conditioned on the type of information available for their valuation. Level 1 assets are valued using current market prices for identical assets in well-functioning markets. Level 2 assets are valued using current market prices in illiquid markets or current market prices for similar but not identical assets, as well as analytical techniques. Level 3 assets are valued using nonmarket inputs, such as models estimating future cash flows associated with the assets. Ryan (2008a) characterizes the various levels as follows: Level 1 is pure mark-to-market accounting, Level 3 is pure mark-to-model accounting, and Level 2 is a hybrid.

Given the problems of illiquidity that have recently gripped many markets, the FASB has issued continuing guidance on when it would be appropriate to set aside current market prices because they are not indicative of fair value (FASB 2008a, 2009a). What is most interesting is the FASB did not add any guidance on acceptable nonmarket methods of evaluation, but simply clarified and expanded the situations where market inputs can be set aside (Christian and O’Reilly 2009). The existing high degree of discretion is likely to increase the use of models in fair value accounting.19

The use of models to value structured financial products should not be thought of as being confined to extreme, once-in-a-generation events. Structured financial products tend to be one-of-a-kind securities that are thinly traded, as a rule (Zuckerman 2009). Therefore, even under normal conditions some modeling would be necessary. Laux and Leuz (2010) observe that banks were using cash flow models to value structured assets in 2007, well before the worst of the financial crisis hit. Further, Zuckerman (2009) describes how difficult it was in 2007 and 2008 for holders of certain structured financial products and related derivatives to get meaningful price quotes from broker dealers, forcing the use of some modeling to value the securities or derivatives.

MODEL

Our model borrows the basic structure suggested by Coval et al. (2009). However, we simplify the analysis and allow the systematic risk to be more transparent. Therefore, unlike Coval et al. (2009), we have no need to utilize complex computer simulations. Instead, we supply more straightforward calculations that can be easily replicated.

No Systematic Risk

To begin the analysis, suppose a CMO is backed by three mortgages. We normalize the principal balance to one per mortgage. We assume there is no interest paid on the mortgages and no

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19 See Negus and Boyles (2009) for practical guidance on valuing illiquid securities under recent FASB pronouncements.
recovery in default. Therefore, at some point in the future each mortgage pays either 1 or 0. We also assume the discount rate is 0. These assumptions greatly simplify the analysis, without any significant loss of insight. Finally, we assume that the probability of default is 0.1 for each mortgage. We initially assume the probability of default is independent across mortgages. That is, there is no systematic risk.

Our CMO comprises three tranches. Tranche A pays 1 to the security holder if fewer than three mortgages default. Tranche B pays 1 if fewer than two mortgages default. Tranche C pays 1 if no mortgages default. Panel A of Table 1 provides valuation figures for each tranche. The panel shows that structured finance techniques have converted an MBS with an average probability of default of 0.1 into three tranches, with two of them having less than a 0.03 probability of default and one tranche having a 0.271 probability of default.

<table>
<thead>
<tr>
<th>Panel A: No Systematic Risk; Probability of Default = 0.1</th>
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</thead>
<tbody>
<tr>
<td><strong>Probability Does Not Pay Out</strong></td>
</tr>
<tr>
<td>Tranche A</td>
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<tr>
<td>Tranche B</td>
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<tr>
<td>Tranche C</td>
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</tbody>
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* (0.1)^3.
b (0.1)^3 + (3)(0.1)^2(0.9).
c (0.1)^3 + (3)(0.1)^2(0.9) + (3)(0.1)(0.9)^2.

Panel B: Probability of Bad Economy = 0.5; Conditional Probability of Default = 0.2

<table>
<thead>
<tr>
<th>Probability Does Not Pay Out</th>
<th>Probability Pays Out = Mark-To-Model Value</th>
<th>Issuer Liability of 1,000 CDSs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tranche A</td>
<td>0.004d</td>
<td>0.996</td>
</tr>
<tr>
<td>Tranche B</td>
<td>0.052e</td>
<td>0.948</td>
</tr>
<tr>
<td>Tranche C</td>
<td>0.244f</td>
<td>0.756</td>
</tr>
</tbody>
</table>

d (0.5)(0.2)^3.
e (0.5)(0.2)^3 + (0.5)(3)(0.2)^2(0.8).
f (0.5)(0.2)^3 + (0.5)(3)(0.2)^2(0.8) + (0.5)(3)(0.2)(0.8)^2.

Panel C: Probability of Bad Economy = 0.2; Conditional Probability of Default = 0.5

<table>
<thead>
<tr>
<th>Probability Does Not Pay Out</th>
<th>Probability Pays Out = Mark-to-Model Value</th>
<th>Issuer Liability of 1,000 CDSs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tranche A</td>
<td>0.025g</td>
<td>0.975</td>
</tr>
<tr>
<td>Tranche B</td>
<td>0.100h</td>
<td>0.900</td>
</tr>
<tr>
<td>Tranche C</td>
<td>0.175i</td>
<td>0.825</td>
</tr>
</tbody>
</table>

g (0.2)(0.5)^3.
h (0.2)(0.5)^3 + (0.2)(3)(0.5)^2(0.5).
i (0.2)(0.5)^3 + (0.2)(3)(0.5)^2(0.5) + (0.2)(3)(0.5)(0.5)^2.

In the probability calculations a–i, the first term is the probability of all three mortgages defaulting, the second term (if applicable) is the probability of two mortgages defaulting, and the third term (if applicable) is the probability of one mortgage defaulting.
having a probability of default equal to 0.271. This structuring would likely qualify both Tranche A and B for selection by many pensions and endowments for which they would not otherwise have qualified. For Tranche A, the risk is only slightly more than a U.S. Treasury Bill.

Even though the structured finance techniques have created securities with different risk levels than the underlying securities, certain features of the underlying securities remain intact. For example, the average default risk (probability of default) of the three tranches is \( (0.001 + 0.028 + 0.271)/3 = 0.1 \), which is the same as the overall risk of the underlying CMO. In addition, the payout promised by each tranche is supported by the underlying CMO. That is, if no mortgages default, the total received from the mortgages in the CMO is 3, which is exactly the amount needed to satisfy the requirement that each of the three tranches pays 1. If one mortgage defaults, the total received from the mortgages in the CMO is 2, which would allow Tranche A and Tranche B each to pay 1. The analysis is similar for two and three defaults.

**Systematic Risk**

The reason securitization works so well toward reducing risk in our first example is we assumed there was no systematic risk. Thus, the protection of the senior tranche, Tranche A, was achieved through diversification. Given the assumptions that the probability of any particular mortgage defaulting is 0.1 and statistical independence between mortgages, it is very unlikely that all three mortgages would default.

Prior to the financial crisis, it was thought that diversifying across borrowers, regions, and loan amounts would protect the holders of mortgage securities from any localized disruptions in property values, such as that resulting from the closure of a factory. The potential for systematic risk in the form of a nationwide decrease in home prices was downplayed. Zuckerman (2009) reports financial analysts in 2005 as saying, “Home prices have never gone negative” and “They won’t even go flat.” Joseph Cassano, who headed the AIG financial products unit that sold the CDSs, ultimately leading to the firm’s demise, said as late as August 2007 in a conference call, “It is hard for us, and without being flippant, to even see a scenario within any kind of realm of reason that would see us losing $1 in any of those transactions” (Cohan 2010).

Ryan (2008a) provides an explanation for how systematic risk can be present in the mortgage market, at least for the case of subprime mortgages. He points out subprime borrowers generally have a hard time paying their mortgage from current income. Therefore, their loans are paid off mainly through refinancing. This can be easily accomplished in a period of rising house prices. However, when prices level off or fall, refinancing is not a viable option. Ryan (2008a, 1608) states, “[I]nvestment performance of these [subprime] positions exhibits a binary quality that depends on subprime mortgagors’ ability to obtain cash-out refinancing.” That is, they tend to all perform well, or all perform poorly. Tett (2009) describes another type of systematic risk, in the form of a negative feedback loop. In the event that houses in an area become vacant or neglected, the values of neighboring houses decline, causing greater defaults on these neighboring houses and more neglect. Finally, Guiso et al. (2009) describe a type of social contagion. They find that most people continue to pay on their mortgage even if they owe more

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20 By valuing the tranches in this way, we are essentially using the present value technique described in SFAS 157 (FASB 2007, 37–43). However, SFAS 157 requires that the discount rate incorporate the risk associated with model error. For simplicity we assume the risk adjusted discount rate is zero.

21 Using the long-term default data provided by Coval et al. (2009), the lowest level of investment-grade debt has a default rate of 7.26 percent, whereas the highest level of junk debt has a default rate of 10.18 percent.

22 See Zuckerman (2009, 100–102) for further support of Ryan’s (2008a) assertions regarding the effect of home appreciation on the performance of subprime loans.
than their property is worth. However, if they begin to hear about others defaulting, they
themselves are more likely to default.

We now introduce systematic risk into the model. To capture the phenomenon described
previously, suppose mortgages will default only if the economy is bad. In notation, the probability
the economy is good or bad is \( \Pr(G) \) and \( \Pr(B) \), respectively. If the economy is bad, there is a
probability \( p \) that any individual mortgage will default, with default being independent events
(conditional on the economy being bad). That is, \( \Pr(\text{default}|G) = 0 \) and \( \Pr(\text{default}|B) = p \). We
begin by assuming \( \Pr(G) = \Pr(B) = 0.5 \) and \( p = 0.2 \). These assumptions are consistent with the
original assumption that the unconditional probability of any particular mortgage defaulting is 0.1,
calculated as: \( \Pr(G)\Pr(\text{default}|G) + \Pr(B)\Pr(\text{default}|B) = 0.5 \times 0 + 0.5 \times 0.2 = 0.1 \). Because the
common state (B) has a positive probability of default for each mortgage, it creates (an
unconditional) correlation in defaults across mortgages.\(^{23}\) We show the mark-to-model valuations
of the three tranches in Panel B of Table 1.

Introducing correlation among mortgage defaults while keeping the unconditional probability
of default constant does not change the overall quality of the CMO. It does, however, change the
value of the individual tranches, and in such a way that harms high-level tranches while
benefitting low-level tranches. Specifically, in our example, the probability of default in Tranche
A increases from 0.001 to 0.004, while the probability of default in Tranche C declines from
0.271 to 0.244. Tranche A suffers due to the greater likelihood of all three mortgages defaulting
while Tranche C benefits due to the greater likelihood of none of the mortgages defaulting.

Moving from Panel B to Panel C of Table 1, where \( \Pr(B) = 0.2 \) and \( \Pr(\text{default}|B) = p = 0.5 \), the
incidence of default is even more concentrated in the bad state. Tranche A now has a probability
of default of 0.025, a 25-fold increase over the no systematic risk case. The 2.5 percent default
rate is still low but it is hardly in the category of a U.S. Treasury security. Tranche C now has a
0.175 probability of default, which is close to the unconditional probability of default on a single
mortgage of 0.1.

Although the introduction of correlation has not changed the overall quality of the CMO, that
does not mean that erroneously omitting correlation from valuation models is not costly. The low-
level tranches that do better with correlation are generally held by hedge funds and others who
presumably are structured to bear greater risk, while the high-level tranches that do worse with
correlation tend to be held by more risk-averse entities. Therefore a misspecified model can cause
overall social welfare to decrease, quite dramatically perhaps, even if overall expected cash flow is
unaffected. A related friction is that not all tranche holders are likely to use the same valuation
assumptions. It may be that those tranche holders who benefit most from correlation assume more
of it than those tranche holders who benefit least.

In summary, a comparison of the three panels of Table 1 illustrates that in marking structured
financial assets to a model, an important characteristic to incorporate is the potential for correlated
asset returns. Although individuals generally may have a good appreciation of the unconditional
likelihood of a particular event, they tend to underestimate the potential for systematic risk. Taleb
(2001) points out such errors can have a profound impact on investor behavior. Further, Salmon
(2009) notes even seasoned financial professionals may underestimate the potential for catastrophic
failure brought on by correlated asset returns.

\(^{23}\) Other modeling attributes that must be considered besides simple correlation are pre-payment risks, depth of the
tranche (shallower tranches will be wiped out more quickly), recovery rates (including costs to repossess and
rehabilitate properties), correlation between default clustering and recovery rates (in times of recession there
tends to be a clustering of defaults coupled with poor recovery rates [Altman et al. 2005]) and agency conflicts
(Ashcraft and Schuermann [2008] cite six examples).
We now consider the effect of systematic risk on CDSs. As mentioned, a CDS can be thought of as a type of insurance. CDSs must be recorded at “fair value” (FASB 1998, 2008b). The protection issuers of CDSs have when issuing a CDS on a high-level tranche is many mortgages must default for the tranche to fail. For the CDS in our illustration, suppose an issuer pays 1 in the event a tranche does not pay out and 0 otherwise. Further, as a simplification, assume quarterly premiums are zero. Hence, the fair value liability of a single CDS is equal to the probability of default multiplied by the par value of the debt, which in our case is 1. The right-most column in Table 1 reports the liability for 1,000 CDSs for the various tranches.

If one does not consider systematic risk, the liability resulting from the CDS on a high-level tranche is relatively low. However, moving from no systematic risk to even a small amount of systematic risk can drastically increase the liability. In Table 2, we concentrate on CDSs and provide data on four levels of correlation between mortgage defaults. Comparing Column 1, where there is no systematic risk, to Column 2 with some systematic risk \( \text{Pr}(B) = 0.5 \) and \( p = 0.2 \), there is a sharp difference in the liability of CDS issuers on the most senior tranche relative to the difference in value for the actual holders of the tranche. While the value of Tranche A declines less than 1 percent, from 0.999 to 0.996, the expected liability of CDS issuers increases by 400 percent. Comparing Column 1 to Column 3 where there is greater systematic risk \( \text{Pr}(B) = 0.2 \) and \( p = 0.5 \), the expected liability of CDS issuers increases 2,500 percent. One of the truisms of derivative products is they tend to magnify both the upside and downside risks relative to the securities from

<table>
<thead>
<tr>
<th>Scenario</th>
<th>( \text{Pr}(B) = 0.1 )</th>
<th>( \text{Pr}(B) = 0.5 )</th>
<th>( \text{Pr}(B) = 0.2 )</th>
<th>( \text{Pr}(B) = 0.1 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correlation Coefficient</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>between Any Two Mortgages</td>
<td>0</td>
<td>0.111</td>
<td>0.444</td>
<td>1</td>
</tr>
<tr>
<td>Liability from Tranche A</td>
<td>1</td>
<td>4</td>
<td>25</td>
<td>100</td>
</tr>
<tr>
<td>Liability from Tranche B</td>
<td>28</td>
<td>52</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Liability from Tranche C</td>
<td>271</td>
<td>244</td>
<td>175</td>
<td>100</td>
</tr>
<tr>
<td>Liabilities from A, B, and C</td>
<td>300</td>
<td>300</td>
<td>300</td>
<td>300</td>
</tr>
</tbody>
</table>

\( \text{Pr}(B) \) = probability of bad economy.
\( p \) = probability of default, conditional on bad economy.
Correlation coefficients measure the degree of association between two mortgages defaulting.
Correlation coefficient of two random variables:

\[
\text{Correlation Coefficient} = \frac{\text{Covariance}(X,Y)}{\sigma(X)\sigma(Y)}.
\]

Example of the calculation of the Correlation Coefficient assuming \( \text{Pr}(B) = 0.2 \) and \( p = 0.5 \):

\[
\text{Covariance}(X,Y) = E(XY) - E(X)E(Y).
\]

Assume that the event of default = 1, the event of non-default = 0, and that \( X \) and \( Y \) are random variables of the outcome of any two mortgages. Then:

\[
E(XY) = 0.05 \text{ and } E(X) = E(Y) = 0.1 \text{ so that } E(X)E(Y) = 0.01; \text{ therefore } \text{Covariance}(X,Y) = 0.04.
\]

\[
\sigma(X) = \sigma(Y) = 0.3 \text{ so that } \sigma(X)\sigma(Y) = 0.09.
\]

Correlation Coefficient = 0.04/0.09 = 0.444.
which they derive their values. Table 2 clearly shows the potential for large losses accruing from
CDSs.\textsuperscript{24}

\textbf{CDO-Squareds}

We close our analysis with an illustration of a CDO-squared. As mentioned, a CDO-squared typically comprises the middle tranches of other structured financial products, such as CMOs. The idea is to take tranches that are not rated highly enough to gain the desired liquidity and to repackage them so that most will now be saleable to a broad range of investors. Using the structure we developed above, suppose there are many three-tranche CMOs identical to the one described earlier. Further, suppose a new CMO is formed using the middle tranches (Tranche B) of eight of our original three-tranche CMOs. The new CMO, denoted CMO\textsuperscript{0}, has eight tranches, labeled A\textsuperscript{0} through H\textsuperscript{0}. The CMO tranches will pay either 1 or 0, and, as before, there is no interest. Tranche A\textsuperscript{0} pays 1 if seven or fewer original tranches fail; Tranche B\textsuperscript{0} pays 1 if six or fewer original tranches fail, and so on.

In Table 3, Panel A, we present the expected default rates given a default rate on the original middle tranche of 0.028, derived from a 0.1 probability of default on mortgages with no systematic risk (see Panel A of Table 1). We focus on Tranche F\textsuperscript{0}. Assuming there is no systematic risk, the security has a very low probability of default (0.001). Using the ten-year default statistics found in Coval et al. (2009), the security would earn an AAA debt rating.

In Panel B of Table 3, we consider the same CMO\textsuperscript{0}, assuming instead that systematic risk is present: Pr(B) = 0.5 and p = 0.2. Therefore, the original middle tranche has a default probability of 0.052 instead of 0.028 (see Panel B of Table 1). Table 3 shows the probability of default on Tranche F\textsuperscript{0} has risen from 0.001 to 0.021, with the value of the tranche decreasing from 0.999 to 0.979. At first, this decline in value may not seem substantial; however, many of the financial institutions holding structured financial products are highly leveraged. An SEC rule change in 2004, putatively to help financial institutions remain competitive with their European counterparts, effectively eliminated leverage restrictions on the broker-dealers (Labaton 2008).\textsuperscript{25} Bear Stearns, for example, before its collapse, had issued $13.4 trillion of notional value derivatives against $80 billion in capital (Evans-Pritchard 2008). Even crisis survivor Goldman Sachs was reported to have a leverage ratio of 25 to 1 prior to 2008, which means that an asset decline of 4 percent would wipe out their entire capital (Kassenaar and Harper 2008). Given this extreme degree of leverage, even small errors in fair value accounting can have large consequences on how investors and regulators would view a firm.

Perhaps more important, the contingent liability of 1,000 CDSs has increased from 1 to 21. As described in Tett (2009), Patterson (2010), and Zuckerman (2009), by 2006 much of the issuance of structured financial products was of the synthetic variety (that is, CDOs that were created from CDSs). Further, with AIG pulling out of the market for insuring super-senior risk, these CDSs were issued by the organizers such as Lehman Brothers and Merrill Lynch (Tett 2009). For highly leveraged institutions, the rise in expected liabilities and collateral calls from CDS issuance can have catastrophic consequences.

\textsuperscript{24} CDS issuers need not wait for actual default to feel the pain of rising CDS liability. As part of the CDS contract, issuers must put up collateral if the value of the underlying security falls or if their credit rating declines. The demise of AIG was as much due to calls for additional collateral as actual defaults (Sorkin 2009).

\textsuperscript{25} Leverage limits are much stricter for depository institutions, such as commercial banks and thrifts. National agencies, such as the Federal Reserve and the FDIC, and international agencies, such as the Basel Committee on Banking Supervision, take a more proactive role in banking regulations. Many have blamed the financial crisis on the so-called shadow-banking system a system of near-banks that perform many of the functions of banks without the regulation or capital of depository institutions (Farhi and Cintra 2009).
### TABLE 3
CDO-Squared Formed from Eight Middle Tranches (Tranche B) of the Three-Tranche CMO

#### Panel A: CDO-Squared—No Systematic Risk; Risk-Default Probability = 0.028

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tranche A'</td>
<td>7</td>
<td>3.77802E-13</td>
<td>&gt;0.999999999</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Tranche B'</td>
<td>6</td>
<td>1.05299E-10</td>
<td>&gt;0.999999999</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Tranche C'</td>
<td>5</td>
<td>1.28532E-08</td>
<td>0.999999999</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Tranche D'</td>
<td>4</td>
<td>8.97922E-07</td>
<td>0.999999102</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Tranche E'</td>
<td>3</td>
<td>3.93036E-05</td>
<td>0.999960966</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Tranche F'</td>
<td>2</td>
<td>0.001105884</td>
<td>0.998894116</td>
<td>1</td>
</tr>
<tr>
<td>Tranche G'</td>
<td>1</td>
<td>0.019618665</td>
<td>0.980381335</td>
<td>20</td>
</tr>
<tr>
<td>Tranche H'</td>
<td>0</td>
<td>0.203235236</td>
<td>0.796746764</td>
<td>203</td>
</tr>
</tbody>
</table>

Based on Table 1, Panel A, where unconditional probability tranche B pays out = 0.972.

\[
\text{Column C: } \sum_{i=0}^{8} \frac{8!}{i!(8-i)!} * 0.028^i(1 - 0.028)^{8-i}.
\]

\[
\text{Column D: } 1 - \text{Column C.}
\]

\[
\text{Column E: } 1,000 \times \frac{1}{\text{Column D}}.
\]

#### Panel B: CDO-Squared—Systematic Risk; Risk-Default Probability = 0.052

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>Probability in Bad Economy</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tranche A'</td>
<td>7</td>
<td>1.36857E-08</td>
<td>6.84285E-09</td>
<td>0.999999999</td>
<td>&lt;1</td>
<td></td>
</tr>
<tr>
<td>Tranche B'</td>
<td>6</td>
<td>9.56946E-07</td>
<td>4.78473E-07</td>
<td>0.99999952</td>
<td>&lt;1</td>
<td></td>
</tr>
<tr>
<td>Tranche C'</td>
<td>5</td>
<td>2.93999E-05</td>
<td>1.46999E-05</td>
<td>0.9999853</td>
<td>&lt;1</td>
<td></td>
</tr>
<tr>
<td>Tranche D'</td>
<td>4</td>
<td>0.000519493</td>
<td>0.000259747</td>
<td>0.99974025</td>
<td>&lt;1</td>
<td></td>
</tr>
<tr>
<td>Tranche E'</td>
<td>3</td>
<td>0.005797421</td>
<td>0.00289871</td>
<td>0.99710129</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Tranche F'</td>
<td>2</td>
<td>0.042174522</td>
<td>0.021087261</td>
<td>0.97891274</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>Tranche G'</td>
<td>1</td>
<td>0.198875883</td>
<td>0.099437942</td>
<td>0.90056206</td>
<td>99</td>
<td></td>
</tr>
<tr>
<td>Tranche H'</td>
<td>0</td>
<td>0.58460231</td>
<td>0.292301155</td>
<td>0.70769885</td>
<td>292</td>
<td></td>
</tr>
</tbody>
</table>

Based on Table 1, Panel B, where unconditional probability tranche B pays out = 0.948.

\[
\text{Pr(B) = probability of bad economy = 0.5.}
\]

\[
p = \text{conditional probability of default given bad economy = 0.2.}
\]

\[
m = \text{maximum number of tranche Bs that can fail for tranche to pay out.}
\]

\[
\text{Pr(tranche B does not pay | } p = 0.2 \text{ and Economy = Bad) = } 0.2^3 + (3)(0.2)^2 (0.8) = 0.104.
\]

\[
\text{Column C: } \sum_{i=0}^{8} \frac{8!}{i!(8-i)!} * 0.104^i(1 - 0.104)^{8-i}.
\]

\[
\text{Column D: } \text{Pr(B) } * \text{ Column C } + \text{Pr(G)} * 0 = 0.5 * \text{ Column C.}
\]

\[
\text{Column E: } 1 - \text{Column D.}
\]

\[
\text{Column F: } 1,000 \times (1 - \text{Column E}).
\]
Models in Practice

As noted above, modeling in practice is a rather complex task. In order to give an overview of modeling techniques in practice, we focus on credit-rating agencies. We do so because it is their purpose to evaluate debt securities without the benefit of price discovery. Also, we know much more about their models than those used by investment banks or hedge funds. Finally, there are strong indications that their ratings were heavily relied upon by unsophisticated purchasers of structured financial products (Adelino 2009; Ammer and Clinton 2004).

The rating agencies use what is called a “through-the-cycle” default likelihood estimation approach (Löffler 2004). This means they make no attempt to estimate the timing of recessions per se. Instead, they evaluate the debt instrument across the entire business cycle. In formulating their rating, the agency considers the likelihood of a stressful event during the term of the debt and the consequences of plausible outcomes associated with the stressful event. As an example, there might be a 30 percent chance of a severe recession during the term of the debt in question, with a severe recession resulting in a 6 percent mortgage default rate. In this sense, the credit-rating agencies’ approach is similar to ours. However, in reality there is a continuum of states—and this is just the beginning of the analysis. Rating agencies must look at the specific type of mortgages held and their vulnerability to economic downturns, the potential for low recovery rates, and the effect of geographic diversification. We have previously mentioned that subprime mortgages tend to experience very high default rates when home prices stop increasing. Therefore, for an instrument primarily composed of subprime mortgages, the rating agencies must assess the likelihood that home prices will remain flat (or decline) over the term of the instrument being rated, whether the price stagnation will be localized or national, and whether the instrument is geographically diversified or concentrated. Historical data will be the main source of analysis, but care must be taken not to assign zero probability to events that have yet to be observed.

All of the credit-rating agencies use some form of the Gaussian copula to model correlation (Coval et al. 2009). Amato and Gyntelberg (2005, 80–81) provide a simplified illustration and explanation of Gaussian copula methods. These methods, especially the “single factor method” that became the dominant approach in the early part of the last decade, have drawn serious criticism (Donnelly and Embrechts 2010; Salmon 2009). For example, one criticism is the method does not take into consideration the negative correlation between default clusters and recovery rates. In response to both critics and obvious flaws, modeling of structured financial products has continued to evolve (Brigo et al. 2010). However, unlike the physical sciences, the phenomenon of interest responds to the model. If markets get too comfortable with a model, they can behave in ways that invalidate the underlying model assumptions. One could argue this should have been the lesson learned in the collapse of Long-Term Capital Management in 1998 (Clark 2000).

Although the rating agencies are mainly interested in the probability of default, the probability of default is a key input, along with term, coupon rate, and risk-free rate, in determining the value of the instrument. One note of caution, though, credit ratings have only a single parameter mapping into default probabilities (or more generally expected losses). However, as investors consider the use of ratings in valuing structured financial products, they should be aware that the variance (and higher order moments) of the returns of CMOs tends to be larger than a claim on an untranched portfolio of mortgages.26

26 Tranches tend to have all-or-nothing outcomes. Once enough losses have occurred to breach the lower boundary of the tranche, it will quickly become worthless. In contrast, a claim on an untranched portfolio of mortgages with positive recovery rates cannot have a zero outcome and, therefore, untranched claims tend to have a less variable payout (CGFS 2005). See CGFS (2008) for proposals to add a second parameter to credit ratings of structured financial products. We thank an anonymous reviewer for pointing out the importance of higher order moments of the outcome distribution.

Accounting Horizons September 2011
Of course, we are interested not only in how values are modeled, but whether modeled values have information content. The evidence so far is consistent with prior research on other accounting methods with considerable management discretion; the accounting valuations have information content but are subject to manipulation. Goh et al. (2009), Kolev (2008), and Song et al. (2010) all find that mark-to-model valuations have information content, but less information content than mark-to-market valuations. Also, the information content of mark-to-model is increasing in measures of good corporate governance. However, there is also evidence of mark-to-model being used as an earnings management tool, both to increase earnings if necessary (Huizinga and Laeven 2009) and to take an “earnings bath” so as to boost future reported income (Fiechter and Meyer 2010). Finally, there is evidence that the percentage of assets disclosed as Level 3 is informative, with higher percentages meaning lower liquidity (Lev and Zhou 2009).

CONCLUSION

Ryan (2008a, 1606) deems the recent financial crisis as “the signal researchable-teachable moment of [his] two-decade-plus career as an accounting academic focused on financial reporting by financial institutions for financial instruments and transactions.” We have taken advantage of some of the issues exposed by the crisis to illustrate the critical nature of systematic risk in modeling the value of structured financial products. It is obvious now that correlated returns on certain types of assets underlying structured financial products can affect their values far beyond historical norms. Yet the Bank for International Settlements (CGFS 2008) reports that credit-rating agencies and their customers were surprised by the degree of correlation and its effect on the value of some structured financial products. Similarly, Salmon (2009) reports that many in the financial community knew of correlation modeling inadequacies and yet continued to act as if the problems did not exist.

Our goal is to provide a brief overview of structured financial products and to explore the sensitivity of their valuation to systematic risk. One reason this is important is the FASB has greatly expanded the circumstances under which modeling is an appropriate valuation technique. Another reason is that many structured financial products are inherently unique and hence difficult to value without some modeling to augment market observables. Finally, as the accounting standards for fair value continue to come under attack and are likely to face further review, nonmarket data may have an even greater role in valuing financial assets.

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