Measuring Welfare Effects of "Unbundling" Financial Innovations: The Case of Collateralized Mortgage Obligations

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The proposition that market-extending financial innovations enhance welfare has strong theoretical support. However, quantification of these welfare benefits has previously been unavailable. In this paper, we demonstrate that such quantification is possible for market-extending innovations that "unbundle" an existing asset by selling its cash flows in two or more parts. We apply this approach to a prominent recent example of an unbundling innovation—collateralized mortgage obligations—and find the benefits to have been substantial.


1. INTRODUCTION

Financial innovation has significantly reshaped capital markets in recent years. Previously unimagined markets for new financial instruments such as options, financial futures, and securitized loans have come into existence. However, financial innovation is often controversial. Trade in these new instruments is often viewed in the popular press and by the general public as increasing market volatility. Financial economists, on the other hand, view innovations as a means of increasing available trading opportunities. As such, innovations potentially enhance welfare and cannot be harmful.

One element missing from this discussion is quantification of the putative benefits of innovation. In this paper we offer such quantification for one important financial innovation—collateralized mortgage obligations (CMOs).

First issued in June of 1983, the volume of CMO issuance in 1987 had become $59.9 billion. While the institutional structure of a CMO (or its successor the REMIC) can be complex, the basic nature of the instrument is simple. CMOs are mortgage-backed bonds with a sequential pay fea-

ture. The CMO derives cash inflows from pools of, typically, fixed-rate residential mortgages. The mortgage pools constitute the "collateral" for the CMO. The cash inflows from interest and principal prepayments are allocated into several classes of securities, referred to as "tranches," each with a different maturity. A typical CMO consists of about 4 tranches although some issues have contained as many as 10. Principal and interest payments in excess of the coupon payment obligations are diverted to the shortest-maturity tranche until it is retired. After this class of securities is retired, prepayments are used to retire the next earliest-maturity securities, and so forth. The process continues until the whole issue is retired. Thus, the effect is to divide the mortgage cash flows among the investors in the various tranches. This is done in such a way that the timing of the cash flows in the various tranches differs greatly.2

This innovation offers a particularly favorable opportunity to study the quantitative welfare effects of financial innovation. First, as the volume of issuance makes clear, it has had a significant effect on the way mortgages are sold. Second, it is an "unbundling" innovation, or one that splits the cash flows from an existing instrument into two or more pieces.3 Because they permit investors to purchase independently claims that previously were available only as parts of a single package, unbundling innovations are a subcategory of "market-extending" innovations, or those that increase the set of events upon which portfolio payments can depend. Unbundling innovations are particularly amenable to theoretical and empirical analysis because the price and welfare effects of the innovation are reflected in the price behavior of the original bundled asset. When the complete bundle (here, whole mortgages) continues to trade alongside the unbundling instruments (the CMO tranches) empirical examination of these effects becomes possible.

In Section 2 we briefly review the limited empirical literature that now exists on the welfare effects of financial innovation. Section 3 discusses the theory concerning our measure of the welfare effects of an unbundling innovation. In Section 4 we present the evidence on the welfare benefits surrounding the introduction of CMOs. The empirical results suggest that, for this particular case at least, the benefits of a market completing financial innovations have been substantial. In light of this evidence we conclude in Section 5 that there is empirical support for the proposition that financial innovations have significant positive welfare effects.

2 Other divisions of the mortgage cash flows are possible. For example "strips" have been issued such that one set of investors receives principal repayments and another receives interest payments.

3 Other examples of unbundling innovations include stripped bonds, and corporate recapitalizations involving new instruments.

2. PREVIOUS EVIDENCE ON THE WELFARE EFFECTS OF INNOVATIONS

Previous empirical work on financial innovation has been quite limited.4 Hirschleifer [4] and Litzenberger and Sossin [7, 8] outline the theoretical benefits of market extending innovations. Because these innovations expand trading opportunities, their first-order effect may be welfare increasing or welfare neutral; an innovation can never reduce welfare.5 If many agents find the new trading opportunity attractive (that is, welfare increasing) significant trade occurs in the new instrument, possibly associated with changes in asset prices. The presence of such trade and price changes provides qualitative evidence that the innovation increased welfare.

A few papers have examined recapitalization of a mutual fund or firm. This is a particularly convenient place to look for price changes because one can compare the value of the portfolio of all securities issued by the firm before and after recapitalization. Sossin [14] studies the case of the unbundling of the shares of Source Capital Inc., a closed end mutual fund, into two components. He reports that the value of the securities of the mutual fund increased relative to the new asset value of its portfolio. This result, with those of Litzenberger and Sossin [8], indicates that there is room for capital restructuring, including unbundling, to increase the value of individual firms within the limits to arbitrage imposed by transaction costs. This observed value change is qualitative evidence of a welfare improvement caused by the recapitalization (innovation).

However, markets offer many good substitutes for shares in a single corporation and the capitalization of the fund or corporation is generally small relative to that of the substitutes. As a result, arbitrage between the unbundled instrument and substitutes makes price changes beyond the arbitrage bounds unlikely to occur. Thus, these price changes do not measure the welfare improvement. Measurement requires an innovation that affects a large class of securities for which no close substitutes exist.

The introduction of CMOs offers an unusual opportunity to study an innovation satisfying these requirements. Unlike a recapitalization, which affects only a single firm, CMOs have become a widely used marketing

4 One branch of that literature seeks to understand the causes of financial innovation. This work emphasizes changes in external constraints such as regulations (Kane [6], Miller [9]), taxes (Miller [9]) and increasingly binding financial constraints (Silber [13]). However, it does not attempt to quantify the social benefit of innovations.

5 However, trading on the new market(s) generally changes existing asset prices. These price changes produce a second-order welfare effect that can be either positive or negative. One branch of the literature, see, for example, Dybvig and Ingersoll [2], Hakansson [3], and Schueter [12] investigates the conditions under which these second-order price effects do not occur. In this paper, we follow Sossin [14] and Litzenberger and Sossin [8] in assuming that these price effects are of second-order importance and can be disregarded.
technology that is available to many mortgage market participants. Furthermore the cash flow characteristics of mortgages and their component CMO tranches are unique in that construction of close substitutes is costly and difficult. Thus the impact of the innovation affects mortgages generally, but has little opportunity to spread beyond mortgages. The impact of the innovation on mortgage prices is likely to reflect the whole impact of the innovation.

3. ON MEASURING WELFARE EFFECTS OF FINANCIAL INNOVATIONS

In this section we formally establish the relation between the welfare improvement and the observed shift in demand caused by innovations such as the CMO. In particular, we assume that existing instruments are not close substitutes for the unbundled product or its components and that the sales of other assets to finance the increased mortgage purchases are spread widely enough over other goods and financial instruments that their impact on these markets is negligible. Under these assumptions the relative prices of all assets except mortgages are unchanged by the innovation.

The argument rests on the well-known equivalence of a competitive market outcome and a Pareto optimal allocation. Specifically, suppose a planner desires to allocate a product (whole mortgages) that is a bundle of $k$ units of one commodity (e.g., the fast-paying tranche) and one unit of another (the slow-paying tranche). The planner’s problem is

$$\text{Max}_{b_i} \sum_i \omega_i U^i(kb_i, b_i) - \mu_Z \left( \sum_i b_i - Z \right),$$  

where $b_i$ is the allocation to investor $i$, $U^i$ is $i$’s utility as a function of the amount of the fast and slow tranche purchased, and $\omega_i$ is the weight the planner assigns to $i$’s utility. $Z$ represents the total available quantity of mortgages, and $\mu_Z$ is the Lagrange multiplier associated with this constraint.

Let $W^c(Z) = \sum_i \omega_i U^i(kb_i, b_i)$ denote the welfare achieved by solving (1), and call this maximum “constrained welfare” (constrained by the bundling

6 Roll [11, p. 7] argues that the interaction of contractual payment rules and mortgage borrower prepayment behavior leads the individual tranches to exhibit a “combination of return and risk that is impossible to obtain by direct investment in other mortgage related securities and that is hard to replicate with any set of fixed income securities.”

5 Sosin [14] uses a similar partial equilibrium assumption to establish that a price increase can result from an unbundling corporate recapitalization. However, he does not pursue the notion of the demand curve for the unbundled commodity or its link to quantitative welfare effects.

nothing to allocate. This, with (4), implies that on average unconstrained demand lies above constrained demand

$$W^U(Z) \geq W^C(Z),$$

or

$$p^U(Z) \geq p^C(Z).$$

Thus the unbundling innovation manifests itself in an outward shift in demand leading to increased price and quantity of mortgages issued. More importantly, for unbundling innovations the increased area under the demand curve measures the increase in welfare.

4. EVIDENCE ON THE EFFECTS OF CMOs

We begin by considering qualitative evidence that the introduction of CMOs affected the demand for mortgages, and we then present estimates of the magnitude of the welfare improvement.

4.1. Qualitative Results

4.1.1. Previous CMO literature. There is some previous literature bearing on the hypotheses that (1) CMOs have traded in significant volume, and (2) the introduction of CMOs is associated with an increase in price (reduction in yield) of whole mortgages.

The evidence on volume of CMO issuance is undisputed. The instrument (or the REMIC) has sold well since its inception showing steadily increasing volume. Specifically, the volume of issuance in billions of dollars has been: 4.68 in 1983, 10.75 in 1984, 16.01 in 1985, 48.32 in 1986, and 59.94 in 1987. The volume of trade indicates an important innovation.

The evidence on the effect of the introduction of CMOs on mortgage yields has been limited. In order to control for overall movements in the level of interest rates, it is obviously desirable to consider some kind of yield spread rather than the level of mortgage yields. A number of authors have suggested that the introduction of CMOs is associated with a reduction

6 While this result does not necessarily imply that the unconstrained price lies everywhere above the constrained price, it does mean that the general effect of eliminating this constraint is to shift demand outward. The unconstrained demand curve lies everywhere above the constrained demand curve and only if $W^U(Z) - W^C(Z)$ increases monotonically in $Z$. While it is possible to construct examples in which this does not occur, it is more natural to expect that, as the quantity of bundles increases, trade in the bundles likewise increases producing correspondingly increases gains from trade. For example, if the $U^i(a,b)$ are homothetic for everyone, the welfare gain is monotonic in $Z$.

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restriction). By the usual property of Lagrange multipliers we have

\[ dW^C/dZ = \mu_Z. \]  

(2)

Furthermore, it can be shown\(^8\) that under the assumptions outlined above,

\[ dW^C/dZ = p^C(Z), \]  

(3)

where \( p^C(Z) \) denotes the inverse demand for bundled mortgages. This says that the area under the demand curve equals welfare.

In the absence of the bundling constraint, the allocation problem becomes

\[
\text{Max } \sum_{a_i, b_i} \omega_i U^i(a_i, b_i) - \mu_i \left( \sum_i b_i - Z \right) + \mu_a \left( \sum_i a_i - kZ \right).
\]

The constraint that the two commodities (tranches) occur in the ratio of \( k \) to one applies only at the aggregate, not at the individual level. Call the welfare resulting from this maximization \( W^U(Z) \), "unconstrained welfare." Analogously to the constrained case we have

\[ dW^U/dZ = p^U(Z), \]

where \( p^U(Z) \) denotes the (inverse) demand for mortgages under our assumptions when unbundling is possible. Because the individual bundling constraints have been removed, unconstrained welfare must be at least as great as constrained welfare, that is

\[ W^U(Z) \geq W^C(Z). \]  

(4)

Obviously \( W^U(0) = W^C(0) \); the constraint is irrelevant when there is

\[ \text{The assumption that relative prices of other goods are unaffected by the innovation requires that changes in consumption of these goods do not affect marginal utility. Letting } \omega_i \text{ denote consumption of "other goods" (measured in dollars), this implies that utility functions have the form} \]

\[ U^i(a_i, b_i) + \lambda b_i. \]

Substitute into this equation the constraints \( a_i = kb_i \) and the budget condition \( m_i = W_i - pb_i \) (where \( W_i \) is individual wealth and \( p \) the price of the bundle (whole mortgage)). Market equilibrium is determined by the familiar first-order condition for utility maximization, \( (dU/db_i)/\lambda = p \), and the market-clearing condition \( \sum b_i = Z \). These are the same conditions that emerge from solving (1) when we let \( \omega_i = 1/\lambda_i \) and note \( \mu_Z = p \). This, with (2) establishes \( Q \).

\[ \text{in spreads between mortgages or mortgage-backed securities and treasuries (see for example, Roll [1]). A quick look at these spreads substantiates these claims. Figure 1 plots spreads between 10-year treasury bonds and GNMA, and between treasuries and two mortgage interest rate series published by the Federal Home Loan Bank Board. The series all behave in a similar fashion. There is a significant drop in late 1983 shortly after the introduction of CMOs. Obviously the presence or absence of CMOs is not the only factor influencing these spreads. A few authors analyzing the spread between} \]
treasuries and GNMAEs have included a dummy variable for the introduction of CMOs. Although these authors differ somewhat in the variables used to control for other influences, their conclusions are consistent. All find that spreads are narrower in the CMO era, but the difference is not statistically significant. Choe [1] concludes CMO issuance-reduced spreads on the order of 5 to 10 basis points, while Nothaft et al. [10] report a reduction of 13 basis points.

Overall, the existing evidence provides strong support for the hypothesis that CMOs trade in significant volume, and somewhat weaker, less direct support for the proposition that their introduction affected mortgage pricing.

4.1.2. Empirical results. The existing evidence on the volume of CMO issuance is sufficiently strong that we see no need to consider it further. The evidence on yield spreads, on the other hand, deserves a closer look. Clearly, it is insufficient to look only at the time series of spread of mortgages over treasuries. On the other hand, those authors who have done a careful analysis of the factors affecting spreads have studied GNMA-treasury spreads rather than mortgage-treasury spreads. The theory makes clear that unbundling works on the mortgage market by increasing derived demand for mortgages. While a large part of this demand is channelled through GNMAEs, other instruments also account for a substantial portion of CMO collateral. Thus the increased demand generated by the innovation is distributed among these instruments in a complicated fashion dependent on their suitability as collateral for various types of CMOs. Regardless of the precise channels and their relative importance, all new derived demand from the introduction of CMOs ultimately manifests itself as demand for mortgages. This suggests that direct examination of mortgage-treasury spreads offers the best chance to accurately measure the total effect of this innovation.

Table 1 provides a brief explanation of the variables used in this study. The Appendix describes the data and variables more explicitly.

Table 2 reports the results of regressions of mortgage-treasury spreads in both absolute and percentage terms on various explanatory variables, including a dummy for the presence of CMOs. Several specifications were tried to examine the robustness of the estimates of the effects of CMOs. The effects of the other explanatory variables are significant, consistent with previous work and the explanations provided therein. Thus, we see no necessity to discuss them further.

The important variable is the dummy indicating the existence of CMOs. For the absolute yield spread model, the estimated impact is a 31 basis point reduction in spreads. For the percentage spread equation, the effect is a negative 2.8%. At the sample average mortgage rate of 12.4%, this translates to an effect of about 35 basis points. Using a one-tail test at the 10% level, the results indicate a significant negative effect on yield spreads due to the introduction of CMOs, as expected.

Thus, a more careful examination of the data strengthens the impression gained from previous work that the introduction of CMOs narrowed the mortgage-treasury spread as predicted by our theory. This result confirms the conventional wisdom expressed by Roll [11] and Kane [6] that the introduction of CMOs has narrowed these spreads.

4.2. Quantitative Welfare Estimates

What is the estimated welfare gain associated with the introduction of CMOs? Under the assumptions of Section 3, the change in the area under
TABLE 2

Determinants of the Spread between Fixed Rate Mortgages and Treasury Securities

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>Absolute yield spread$^{b}$</th>
<th>Relative yield spread$^{d}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONSTANT</td>
<td>218.74*</td>
<td>0.270*</td>
</tr>
<tr>
<td>DEFAULT</td>
<td>0.721*</td>
<td>0.883*</td>
</tr>
<tr>
<td>PREMIUM</td>
<td>-3.43</td>
<td>(6.19)</td>
</tr>
<tr>
<td>CMO</td>
<td>-31.302*</td>
<td>-0.028*</td>
</tr>
<tr>
<td>YIELD SLOPE</td>
<td>-0.467*</td>
<td>-0.675*</td>
</tr>
<tr>
<td>SHORT-TERM RATE</td>
<td>-0.617*</td>
<td>-0.00007*</td>
</tr>
<tr>
<td>MORT VOLUME</td>
<td>-0.0012*</td>
<td>-0.0000</td>
</tr>
<tr>
<td>SAMPLE SIZE</td>
<td>53</td>
<td>53</td>
</tr>
<tr>
<td>R²</td>
<td>0.74</td>
<td>0.85</td>
</tr>
<tr>
<td>DW</td>
<td>1.74</td>
<td>1.82</td>
</tr>
<tr>
<td>ρ</td>
<td>0.72</td>
<td>0.67</td>
</tr>
</tbody>
</table>

$^{a}$ t value are in parentheses; * indicates significant at the 10% level; default premiums and yield curve slope are in absolute terms in the absolute yield spread equation and relative terms in the relative yield spread equation.

$^{b}$ Dependent variable is the monthly spread between the standard FRM interest rate and a Treasury security of equivalent maturity over the period July 1982 through December 1986.

$^{c}$ Dependent variable is the monthly spread as defined in footnote $^{b}$ divided by the equivalent Treasury security yield.

ways in which the first assumption may lead this approach to underestimate the value of the innovation. First, to the extent that the quantity of mortgage borrowing (that is, the supply of mortgages) responds to interest rates, the observed price change understates the vertical shift of the demand curve. Second, the intermediaries producing the CMOs may well realize a spread in excess of economic cost between the price they receive for the CMOs and the price they pay for the underlying mortgages. When this occurs the price change observed in the mortgage market understates the value of the innovation by the amount of these abnormal profits.

In general, it is not possible to say what bias, if any, is introduced by the second assumption. For reasonable specifications of the utility function, the bias is likely to be small.$^{15}$ Considered together, the most probable net effect of these assumptions is to understate the magnitude of the welfare benefits.

To calculate the implied price change, assume first that we are dealing with a fixed-rate mortgage amortized for a 30-year period at a contractual interest rate of 12.4%, the average in our sample. For the marginal purchaser, the offer price is just its face value, that is, the present value of the mortgage at its stated rate. When financial innovation increases investors' valuation of the underlying security, borrowers are presumably still willing to supply the same payment stream for the original payment (loan amount). Conservatively assuming prepayment at the end of 8 years, it is straightforward to calculate that a 30 basis point decrease in the discount rate implies a 1.50% increase in value. With $195.3$ billion worth of mortgages issued in 1984, the first full year after the introduction of CMOs, that implies an annual welfare gain of $2.93$ billion.$^{16}$ Of course, if the market expects the mortgage to be held longer before prepayment, even higher welfare gains result.

Our welfare gain calculations are based on a point estimate of the spread reduction that falls toward the lower end of the range of those found in this study. Even if the true reduction in the spread resulting from the introduction of CMOs is even smaller, a substantial welfare gain still results from this innovation.$^{17}$

$^{15}$The simplest bias-free situation occurs when the innovation induces a parallel shift in the demand curve. This happens if and only if $dW(Z) = W(Z)$ is a constant. A sufficient condition for this is for everyone to have utilities of the form described in footnote 9.

$^{16}$The present value of $1$ a month for $30$ years at 12.4% is $94.38$. This loan has a remaining balance of $90.36 after $8$ years. The present value of this balance and $1$ a month for $8$ years at 12.1% is $95.80$. This figure, compared to the original $94.38 present value, is the 1.50% increase in value.

$^{17}$Assuming the true effect is as small as a single basis point, calculations like those reported above lead to an estimated annual welfare gain of $103$ million.
5. CONCLUSIONS
The theoretical proposition that market-completing financial innovations enhance welfare is well established in the academic literature. Nonacademic sources seem to view this proposition with skepticism. By focusing on a market-extending innovation of a particular type, an unbundling innovation, we are able to present the first quantitative estimates of the welfare benefits of one such financial innovation, the collateralized mortgage obligation.

We first show that the introduction of CMOs led to the price and allocational effects that have the qualitative characteristics of a welfare-improving, market-extending innovation. More importantly, we present quantitative estimates of these welfare benefits. These estimates demonstrate that the welfare benefits associated with the introduction of collateralized mortgage obligations have been substantial.

APPENDIX
The objective of this study is to estimate the effects of CMOs on the absolute and relative spreads between fixed-rate mortgage and equivalent treasury securities. Precise definitions of the dependent variables appear in the notes to Table 2. The various independent variables include a default premium (defined as the yield spread between AAA and BAA corporate bonds), a dummy variable taking the value one in the period during which CMOs were issued and zero otherwise, yield curve slope (defined as the yield spread between 30-year and 1-year treasuries), short-term interest rate (the yield on 1-year treasuries), and total volume of long-term mortgage loans. For the relative yield spread regression, the default premium and yield slope variables are expressed in relative terms by dividing by the equivalent maturity treasury security yield. The equivalent maturity treasury security yield was calculated by interpolating between reported treasuries yields to infer the yield on a treasury security having the same maturity as that reported for the mortgage data. Both regressions have undergone a Chocran-Orcutt transformation to mitigate serial correlation in the error terms.

Data for this study are taken from four sources, Federal Reserve Bulletin, Federal Home Loan Bank board (FHLBB) survey, Roll [11], and Mortgage Banking (various issues). The study period is from July 1982 to December 1986. Data for monthly yields on U.S. treasury notes and bonds for constant maturities of 1 year, 20 years, 30 years, and for corporate bonds of AAA and BAA ratings are taken from Federal Reserve Bulletin. The data for primary and secondary mortgage markets, e.g., maturity and yield on FHLBB series, are also taken from Federal Reserve Bulletin. The interest rate and effective maturity for fixed-rate mortgages is collected from FHLBB survey of interest rates.

REFERENCES