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Financial Intermediation and Best Execution

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This working paper presents preliminary findings and is offered to interested readers to stimulate discussion and elicit comments. Content is subject to change.

Abstract

Intermediaries and securitization provide a bridge between households and capital investment in the economy. The existence of intermediaries and securitization is an indication that the underlying payoffs of assets may be valued differently by different investors, thus violating the Law of One Price. There is substantial evidence that households differ from the classical mean variance investor in that they greatly prefer risk-free assets over slightly risk-free assets and that they demand more return for low beta assets than required under the capital asset pricing model (CAPM).

A best-execution model that looks at the role of intermediaries, leverage and securitization provides an indication of how household required returns which are concave in standard deviation of risk and can explain the structure of the holdings of households and intermediaries. In a best execution model, assets are held by an intermediary or structured into securities to maximize value so that the value of the pieces or portfolio is greater than the value of the underlying asset. Institutional constraints on intermediaries can create gaps and inconsistencies in pricing.

Intermediation and securitization are a violation of the Law of One Price. The value of a claim depends on who owns the claim and how it is bundled with other claims. Markets are segmented between intermediaries and households, as well as among different types of intermediaries. Examples of intermediaries include mutual funds, money market funds, banks and insurance companies. Each type of intermediary performs a specific function, has a set of allowable investments, and in turn provides specific types of instruments for investors. Households may be willing to pay more for the instruments issued by the intermediaries than they would pay for the assets held by the intermediary.

Investors in securitized interests created from an underlying asset (sometimes called the collateral) are willing to pay more in total for those interests than investors in the underlying asset. Generally, the investors in securitized assets are intermediaries. Both the issuance of issuance of stocks and bonds by corporations or other entities and the pooling of retail assets, such as mortgage-backed securities are securitizations, in that they are (generally passive) transactions that create tradable claims that segment the cash flows of the underlying asset.

In stable markets, it may appear that there is a smooth universal pricing function or stochastic discount factor (SDF). Under the universal function, investments with similar payoffs and other features should have similar prices, that is, the pricing function should be continuous. However, from time to time these relationships imbedded in the pricing function appear to break down and small changes in asset characteristics lead to large disruptive (discontinuous) changes in asset values.

These disruptions arise because assets are not valued in a single unified market, but rather are priced by a mosaic of intermediaries. This mosaic viewed from a distance create the impression of a single unified market that provides consistent pricing for all assets. However, certain market conditions open gaps between the tiles and asset values collapse as they fall into the cracks. As with ice floes on a frozen sea, at cold enough temperatures you can cross with ease, but with greater turbulence, the ice floes separate, creating gaps so that traversing the sea becomes impossible.

Each intermediary operates under a set of constraints created by regulation, accounting, taxation and custom. During normal market conditions these constraints define the intermediary. In times of disruption, they provide limitations on the eligible investments, access to capital or leverage of the intermediary. When too many intermediaries facing similar constraints are no longer able or willing to invest in a set of assets, there is increased potential for discontinuous changes in prices and other market disruptions. Table 1 provides a list of major intermediaries based on the Federal Reserve Flow of Funds.

Table 1. Intermediaries and Securitization

Financial Intermediary	Financial Assets ($ trillions)
Private Pension Fund	22.4
Private Depository Institutions	19.2
Mutual Funds	15.9
State and Local Retirement	9.0
Life Insurance Companies	7.6
Federal Govt Retirement	4.0
Exchange Traded Funds	3.4
Broker-Dealers	3.4
Money Market	3.0
Property-Casualty Insurance	2.4
Finance Companies	1.5
REITs	0.8
Closed End Funds	0.3

Source: FOF, year-end 2018

There are many reasons why there are intermediaries in the economy and why there are limitations on their activities. (See, for example, Gorton & Winton, 2002). In this paper, intermediaries primarily serve to facilitate diversification and to facilitate the leverage. Households have limited ability to diversify without the benefits of intermediaries such as mutual funds and insurance companies. Moreover, as we shall show below, households generally do not hold debt instruments, other than risk-free assets, so intermediaries are an important component in creating leverage. Interestingly mutual funds are prohibited from using leverage, and insurance companies are limited in their use of external leverage, while banks are generally prohibited from owning stocks, thus the functions of leverage and diversification are segmented in the economy.

Not only does each intermediary have different constraints on their investment strategies, they also may have very different valuation criteria. The investment decisions, within the allowable class of investments, are generally determined by the incentive structure of the managers rather than the directly by the utility function of beneficial investors. These incentive structures for intermediaries can vary significantly, giving rise to a large range of potential decision criteria.

For example, some managers may have parallel equity stakes, while other managers may benefit from assets under management. Some managers may be paid incentive fees based upon short-term performance, while others may have compensation tied to long-term results. Some managers may be paid on transaction volume while others are paid based on cost reductions. Often more important than

the incentive structure, however, is the regulatory, accounting, and tax regime of each type of intermediary which directly affects what types of assets it can acquire and what types of liabilities it can issue.

Debt securities play a critical role in this process of allocating assets among intermediaries. We split debt securities into corporate bonds or corporate loans, which are obligations of a single entity, and securitization, which involves a pool of generally similar assets. Table 2 shows the volume of debt securities in the Flow of Funds.

Table 2. Non-Treasury Debt Securities

GSEs MBS	5.0
Ginnie Mae and CMOs	2.3
Asset-Backed Securities	1.2
Non-Financial (Corp and Muni)	6.3

Source: FOF, year-end 2018

The issuance of corporate debt securities transforms the risk and tax characteristics of a claims on corporate income. Corporations use a wide variety of debt instruments from short-term commercial paper, to bank loans, to long-term debt, to enhance their leverage.

Securitization offers two primary benefits to intermediaries. By pooling many loans with similar characteristics, it diversifies idiosyncratic risk. Securitization also allows for leverage. In addition, it offers the opportunity to transform financial claims into instruments that meet the unique constraints and incentives of a variety of financial intermediaries both as issuers and investors. Securitization achieves this by segmenting the cash flows of an asset to meet the investment goals as well as the regulatory, accounting, tax and other requirements of the intermediaries so as to produce a higher valuation on the asset than if it were introduced into the market in its raw form. Through this process, securitization enhances the value of assets and may lead to greater economic growth. Whether or not this process is beneficial to the economy ultimately depends on how the overall economy prices and allocates risk.

The securitization industry has developed numerous techniques to allocate payoffs between intermediaries. These include standardization of contract types, use of credit ratings, separation of interest rate risk from credit risk, establishing true sale, establishing mechanisms for resolution of default, minimization of prepayment risk, creation of floating rate securities from fixed rate securities, isolation of tax effects and many more.

Table 3 shows the variety of collateral that has been pooled and segmented using securitization. This table uses data from SIFMA and the totals do not match those from the Flow of Funds data due to different categorization of some of the transactions. This table also excludes corporate bonds, except those securitized in CDOs and CLOs.

Table 3. Securitization by Collateral Type

Securitization Balance Outstanding Year-end 2018 ($ billions)		
Asset Backed Securitization		
Automobile	223	
Credit Card	124	
Equipment	84	
Other	206	
Student Loans	171	
CDO/CLO	808	
Total		1,616
Mortgage Related Securitization		
Agency MBS	7,269	
Agency CMO	1,103	
Non-Agency CMBS	543	
Non-Agency RMBS	817	
		9,732
Total Securitization		11,348

Source: SIFMA

Ultimately, whether or not a financial claim is created and how it is valued, depends on the principle of best execution. Best execution represents the highest price (lowest required return), that will be paid for a claim by a household or intermediary directly or via securitization. As each participant in the market may have different investment requirements, that participant may or may not be able or willing to buy a claim and will have its own maximum price for that claim.

The best execution view reverses the usual view of investors who create a portfolio based upon analysis of the risk-return tradeoff and choose the highest-return, least-risk portfolio. Instead, each investor has a return cut-off for each investment based on its risk characteristics for any asset that meets their investment criteria. Assets that do not meet that return requirement for any investor must be repriced lower or not created in the first place. While assets with low expected returns may be created and owned by households or private investors, they do not exist in the capital markets.

The challenge, then, is to first determine the return requirements of households if there were no intermediaries, and the pricing mechanisms of the intermediaries and then to determine the required return of each claim based upon the highest price that any intermediary would pay. The combined mosaic of these pricing mechanisms produces the overall pricing function of the economy.

Market Disruption

The fundamental principle, the reason the securitization exists at all, is that there are investors with a lower required return (or higher valuation) than other investors for a particular pattern of payoffs, and that securitization creates the opportunity for those investors to participate in the payoffs of an asset that match their requirements and thereby increase the value of the asset. If the conditions that allowed those investors to participate are violated, the pricing of that component of the cash flow will fall, perhaps substantially. The extent of the drop and the impact on the value of the underlying asset will depend on the degree that there is a close substitute investor for the now orphaned bonds and the connectedness of the markets that depend on that bond or the underlying asset.

One can imagine a securitization as piling specific instruments on the edges of the ice floes in our mosaic, taking advantage of the unique constraints of that intermediary. When the cracks appear between the ice floes, the overloaded floes dump their holdings into the freezing water.

The mosaic of intermediaries is dynamic and subject to various constraints on profitability and performance. While additional capital could flow into new intermediaries to fill gaps, intermediaries can also produce pricing anomalies that last for long periods of time.

There have been numerous market disruptions arising from the instruments created by intermediation and securitization. While the recent sub-prime and financial crisis is still fresh in many people's minds, there have been disruptions caused by inverse floaters, Interest Only and Principle Only bonds, broken PAC (Planned Amortization Class) bonds, and support bonds, to name a few. Each of these securities was designed to meet the need of a specific type of investor. When market conditions changed there were forced sales and significant declines in value that were disproportional to the change in risk and expected payoffs of the instruments. These forced sales could result from firms purchasing assets that were never likely to achieve the intended investment objectives (and consequently led to underperformance and bankruptcy) or from regulatory, tax, and other operational constraints that lead to deleveraging or forced divestures of assets.

In either case, as one intermediary was no longer able or willing to own a given claim, the best execution price could change dramatically if there were no investors who were willing to pay the same or similar price for that investment. Through the process of risk segmentation and value creation, securitization sets the stage for disruptions when the securitized instrument can no longer be held by the institutions for which they were created.

Related Literature

In John Cochrane's Presidential Address to the American Finance Association in 2010 about discount rates, he distinguished "segmented markets" from "intermediated markets." He described segmentation as "limited risk sharing among a pool of investors who are active in a particular market" while intermediation refers to "vertical rather than horizontal, separation of investors from payoffs."

Both segmentation and intermediation have been documented in recent research. Each contributes to the role of securitization. Intermediation, by distancing household utility from the pricing function and segmentation, by creating the conditions that allow securitizes to create securities that meet the unique requirements of different intermediaries.

Intermediaries

There is also a growing literature associated with the role of financial intermediaries in pricing of assets. The work of He and Krishnamurthy (2013) show the role of intermediaries in market disruptions. They posit that households do not directly invest in risky assets, rather they invest through intermediaries. In the He and Krishnamurthy (H&K) model households invest primarily through risky equity investments in specialist intermediaries and riskless debt. Investors require side-by-side equity investment by the specialists, which creates an equity constraint on investment, so pricing is tied to specialist equity.

Adrian, Etula and Muir (2013) (AEM) in "Financial Intermediaries and the Cross Section of Asset Returns" also suggest a pricing model based upon intermediaries. They write: "This paper shifts attention from measuring the SDF [stochastic discount factor] of the average household to measuring a financial intermediary SDF. This approach takes us to a new place in the field of empirical asset pricing—rather than emphasizing average household behavior, the assumptions of frictionless markets and intertemporally optimizing behavior suggest [elevating] financial intermediaries to the center stage of asset pricing."

In contrast to H&K, the AEM model focuses on access to leverage as the pricing mechanism for the intermediaries. AEM develop a leverage measure for broker-dealers and show that the leverage measure provides a good measure of cross sectional and time series variations in asset prices.

Segmentation of Intermediaries

In our view, both the H&K and AEM could be correct descriptions of asset pricing (at least for some assets). Other structures are also possible. Intermediaries may have a variety of institutional structures that determine the reward structure for managers and thereby the valuation criteria for investment by that intermediary. A serious downside of a theory with a variety of institutional structures for intermediaries means that the mathematics that leads to a universal SDF becomes much more complex as the value of any one asset depends upon the best execution for that asset among multiple alternatives and can change in a discontinuous fashion across the borders between the best buyers.

There is a substantial literature of the limitations of the one price model, often under the concept of "limits of arbitrage." An oft-cited paper in this area, Gabaix, Krishnamurthy and Vigneron (2007), identifies a mortgage prepayment model uncertainty factor that is priced by mortgage investors but is paid for by borrowers. Since model uncertainty is a zero-sum game in the economy, it would not be a candidate for a priced risk factor without segmentation. In earlier work, Levin and Davidson (2005) show that prepayment risk in mortgage-backed securities arises from two factors, turnover risk and refinancing risk, so that a single option-adjusted spread cannot be used to price all mortgage-backed securities. The existence of such pricing anomalies in the mortgage-backed securities market has been explored by practitioners going back to at least the 1980s.

Another series of recent papers have addressed the market disruption of the 2007-2008 financial crisis by looking at failures of market mechanisms. Duffie's 2010 Presidential Address to the AFA discusses the implications of slow-moving capital for asset price dynamics. He shows how market prices can fall rapidly and recover slowly due to impediments to capital movement. Dow and Han's 2017 award-winning *Journal of Finance* publication combines a rational expectations and "lemons" model to explain fire sales.

The existence of multi-trillion-dollar securitization markets is further evidence of market segmentation. Securitization is an expensive process involving many parties and operational hurdles. If it were not possible to sell the products of securitization at a higher price than the raw material, securitization would not exist. In addition, most securitization involves not just the process of pooling loans or other claims into securities, but also involves a significant amount of cash flow structuring that allocates cash flows to different classes of investment. This introduces additional costs and complexity into the securitization process, further evidence of significant market segmentation.

Market Structure

The financial intermediation theories rely on assumptions that households cannot (or at least do not) invest directly in a range of risk assets. Instead, households invest primarily in risk free assets and equities.

Recent research also supports this characterization of household investment. While it is unlikely that there will be any absolute statements about the investment of all households, the work of Carlson et al (2016) and Greenwood et al (2015) demonstrate that households have a strong demand for the riskless short-term asset. They show that the risk-free asset, in particular, short-term government debt requires a lower yield than other short-term low-risk investments even adjusting for risk. They describe a variety of near substitutes that also have pricing advantages.

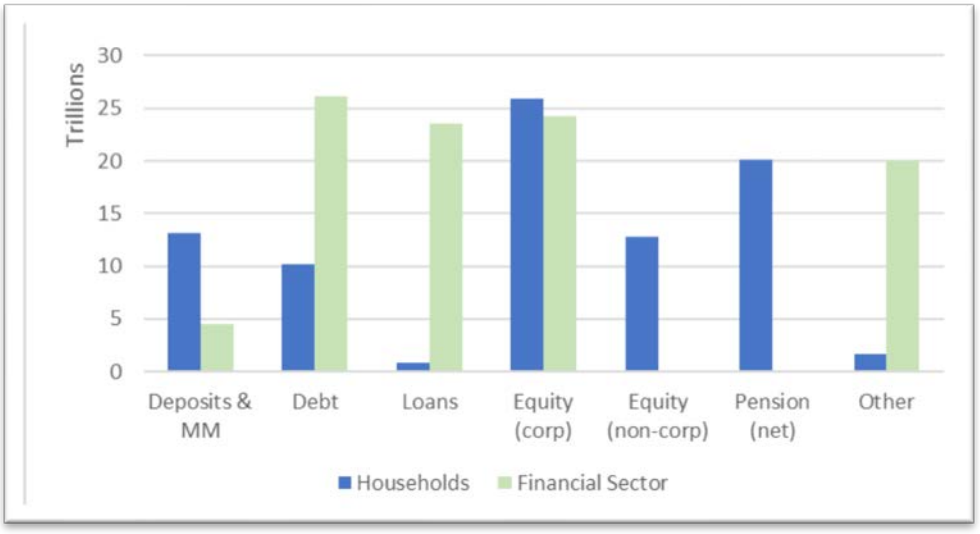
On the equity side, Frazzini and Pedersen (2014) demonstrate that investors prefer high beta assets to leveraged low beta assets. In the model of best execution, households will have a pricing function based upon the square root of the standard deviation of returns. This will have the effect of having low-beta investments having a required return well above the CAPM market line.

The portfolio holdings of households versus the portfolio holdings of the financial sector, shown in Figure 1, support the idea that households concentrate their investments in equities and risk-free assets. As compared with the financial sector, households have a much lower proportion of investments in debt securities and loans. Moreover, as seen in Figure 2, a large portion of the equity holdings of the households are through intermediaries as are most all of the risk-free (or near risk-free) assets, which consist primarily of bank deposits, savings accounts and money market funds.

The capital asset pricing model assumes, among other things, that there are no transaction costs and that investors can borrower or lend at the risk-free rate. However, when we look at household investment, we generally see that households have limited ability to diversify without using intermediaries such as ETFs and mutual funds. Likewise, households do not have the ability to borrower at the risk-free rate and instead invest in firms that utilize leverage through corporate borrowing and banks that utilize deposits and other borrowings. Thus, to the extent that CAPM is a good model of the market it must be a model of intermediation.

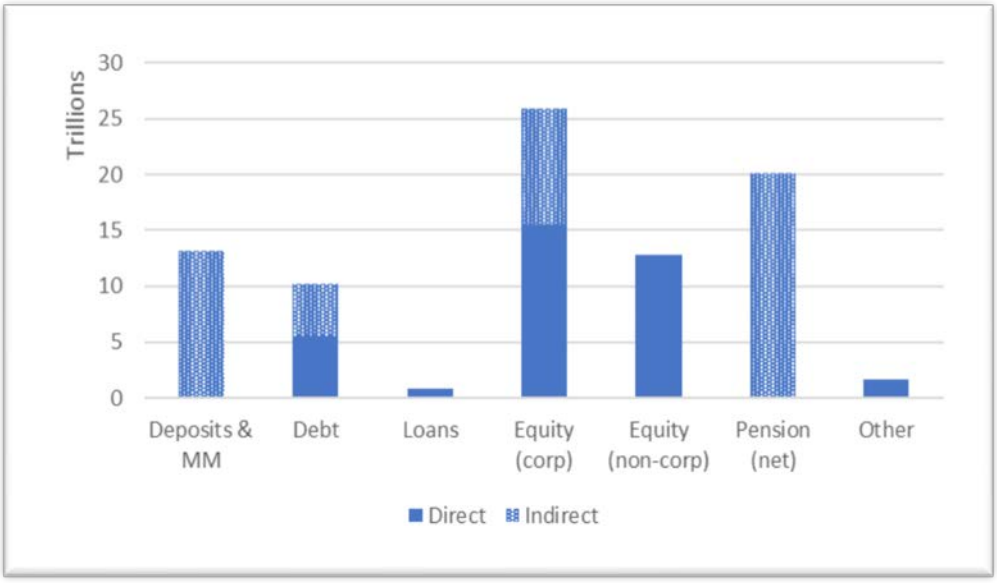
In addition, as we will show in the Best Execution Pricing Model below, the current allocation of assets in the financial sector as shown in Figures 1 and 2 is consistent with households having a pricing function for assets that is concave (negatively convex). That is, while the required return increases as risk increases, the rate of increase in required return decreases as risk increases.

Figure 1. The Financial Assets of the Household and Financial Sectors



Source: Federal Reserve Flow of Funds, Year-end 2018

Figure 2. Direct and Indirect Financial Assets of Households



Source: Federal Reserve Flow of Funds, Year-end 2018

Securitization

Recent research has also tied securitization to systemic risk. Chen, John, Liu, Zhou, in "Bank Securitization and Systemic Risk" (2017) document a link between securitization by banks and the risk of bank failure.

Tying these concepts together, in my book with Alex Levin, *Mortgage Valuation Models* (2014), we discussed the difference between intrinsic value and market value in the context of the post crisis pricing of non-agency residential mortgage backed securities. Table 4 below reproduces a portion of Table 18.2 from the book. The A2 and A3 classes fell in price dramatically and then recovered. Our view is that the cash flows of these bonds were never seriously impaired, but that the market price dynamics represented forced liquidations with few buyers.

Table 4. Market Prices of Tranches of SASC 2006-BC4

	Sep-07	Nov-08	Apr-10	Mar-11	Nov-12
A2	99.04	91.59	95.91	99.59	Paid off
A3	97.65	73.91	85.63	92.64	97.95

We document how the process of determining valuations associated with OTTI (other than temporary impairment) would lead to forced sales of these securities by regulated financial institutions. That is the change in value reflected a dramatic change in best execution, not in the expected cash flows of the instruments.

Other theories

In this paper, we argue that the risk of significant price declines is inherent in the securitization process coupled with the role of intermediation of segmentation. If the path that lead to an increase in value through best execution is inhibited, it is likely that there will be price declines in the instruments that benefited from the higher pricing. What goes up, might come down!

This contrasts with the view of Dow and Han and others that the price decline is an independent of the process that created the securities. Dow and Han write: "One explanation is given by Shleifer and Vishny (1997): if industry experts with higher private valuations do not have enough liquidity, assets are bought at a discount by non-experts who cannot use them efficiently. This argument applies naturally to real assets rather than financial securities. But since financial securities typically require the holder only to collect cash flows, not to operate the assets, there should not be significant differences in private valuations."

Cochrane also seems to be skeptical of the segmented market and intermediated market approaches saying, "[T]here are strong incentives to undo any price anomaly induced by segmentation or intermediation." He writes that "transaction costs, attention costs or limited expertise suggest that markets can be segmented until the 'deep pockets' arrive, but that they do arrive eventually."

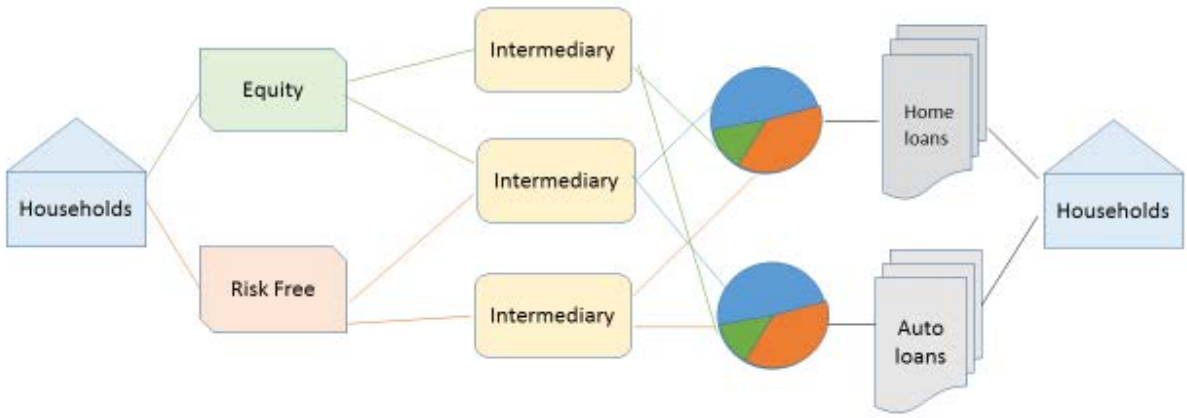
However, segmentation and intermediation can and do lead to market disruption. All that is required is practical or institutional constraints on various types of financial arrangements and obstacles to changes in those constraints. The US financial system is a complex web of intermediaries facing very different constraints. Banks have access to deposits and a degree of leverage not available to non-regulated entities. Mutual funds face limits on their ability to leverage. Money market funds face limits on allowable investments. While some less regulated entities may not face these constraints, they generally do not have access to the same liabilities (such as insured deposits) as regulated entities. The size and scope of regulated entities whose investment criteria are only indirectly tied to the aggregate household creates the landscape to allow significant segmentation.

Securitization takes advantage of intermediary constraints and finds pathways to deliver specialized investments. Disruption of those pathways can lead to severe declines in market valuations. If at any time the volume of assets that were purchased by one type of financial intermediary exceeds the demand from that type of intermediary, prices can drop. If there is no close substitute buyer due to the specific attributes of the securitized asset, then the price can drop substantially. Securitization magnifies both the gains in value and the potential for disruption by recognizing the mosaic of intermediaries and designing securities that meet the specific needs of those intermediaries. The resulting market declines can be magnified by policies, regulations and trading strategies that create discontinuities.

(An interesting feature of the market is that many of the obligations that have been securitized are the debt obligations of households. Households appear to desire the leverage but have little interest in

investing directly in the debt obligations of other households. See simplified chart of market structure Figure 3.)

Figure 3. Segmented Intermediation of Household Investments and Liabilities with Securitization



The Best Execution Pricing Model

Description

Here we develop a simple one-period model to demonstrate how intermediation and securitization produce differential valuation for assets.

Each asset can be classified by its risk characteristics. The risk has two dimensions, systematic risk, outcomes correlated to the market, and diversifiable risk, outcomes that are independent from the risk of the market and all other assets. To start, we assume a discrete set of assets in two dimensions running from zero risk in both dimensions to a maximum standard deviation in each dimension, divided into ten equal increments (for a total of 11 in each dimension). The standard deviation of the asset is determined assuming the two dimensions of risk are independent.

For purposes of exposition, we also assume that there is one unit of asset in each of the 121 combinations of systemic and diversifiable risk. The equal distribution of assets is not intended to reflect the actual distribution of risk in the economy. Rather, each cell should be viewed as providing insight on how assets of that type would be priced in the market. Initially, the amount of asset in each bucket is also independent of the required return, or best execution, but that assumption will be relaxed.

Households are generally risk-averse and have limited ability to diversify. As a result, households engage in two types of investments: risk-free (or nearly risk-free instruments) and high returning equities. For risk-free assets, households require the risk-free return, for equity assets, households require a return associated with risk (as measured by standard deviation). Households also have a

minimum return threshold for any risky investment. This final assumption drives many of the results of the model.

The model has two types of intermediation mutual funds and banks. And two types of leverage, corporate bonds and structured finance. The model does not reflect all intermediaries in the market.

- Mutual Funds can purchase portfolios of equities and diversify holdings but cannot utilize leverage.
- Banks can issue deposits as risk-free securities and equity. In exchange for deposit insurance there are leverage limits and limits on asset risk as well as a required fee.
- Corporations can issue (risky) bonds and equity. While they could create bonds of any risk, in the model, they limit the risk of the bonds to the maximum risk allowed for bank investment.
- Structured Finance has two functions. It can diversify assets and can issue claims with different risks: A risk-free claim, a mezzanine claim, and an equity claim. The risk-free claim can be bought by households, the mezzanine claim is bought by banks and the equity claim is bought by mutual funds. There is a cost associated with securitization.

Other intermediaries are possible, but not modeled to reduce the complexity of exposition. These include:

- Money Market Funds
- Retirement Funds
- Investment Grade Bond Funds
- Speculative Grade (Junk) Bond Funds
- Property and Causality Insurance
- Life Insurance
- Broker-Dealers
- Hedge Funds
- Private Equity

There may be some overlap between these intermediaries and those in the model. For example, like banks, bond funds could also purchase corporate bonds, and like securitization, insurance companies could also provide diversification. We also do not formally create money market funds in the model but recognize that much risk-free investing is via money market funds.

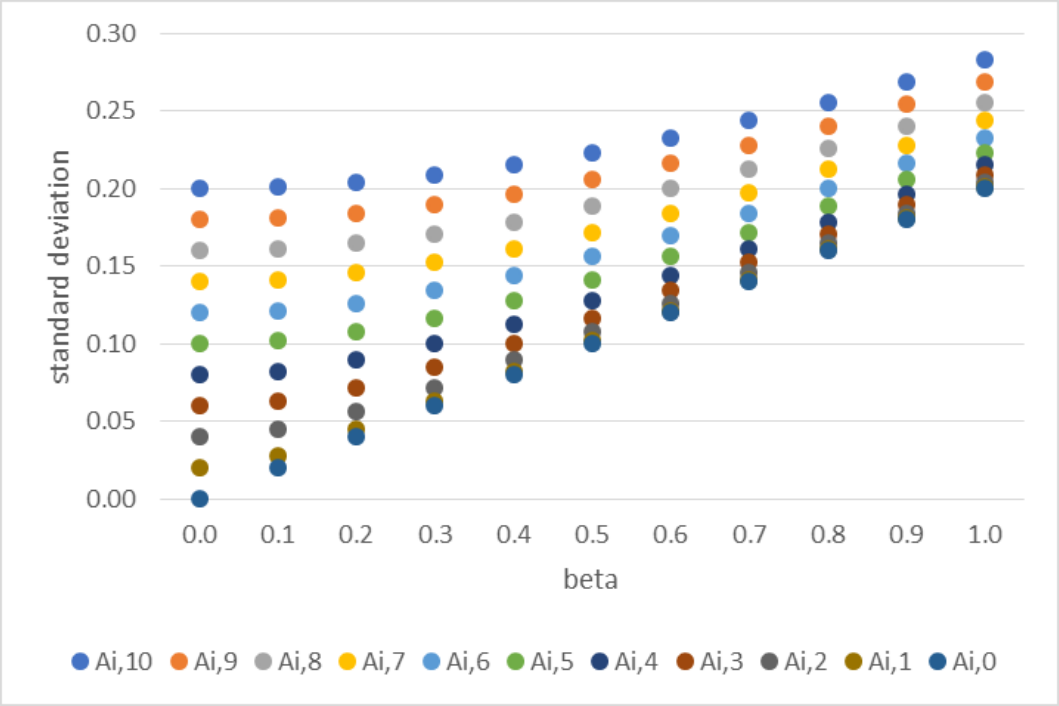
While there could be many requirements imposed upon intermediary purchases of assets, in the model asset standard deviation is the only basis for establishing intermediary investment. For example, banks may be constrained by rating or blocked from owning certain types of assets, such as real estate. Such additional dimensions would create further segmentation. We demonstrate segmentation, even without these added dimensions.

Assumptions

The Investment Universe, I, consists of 121 Assets, A_{ij} for i,j integers from 0 to 10.
The risk of A_{ij} is the ordered pair (σ_i^s, σ_j^d)
Where σ_i^s represents systematic risk, σ_j^d represents diversifiable risk
Asset $A_{i,j}$ has $\beta_i = i/10$, $\sigma_i^s = \beta_i \sigma_{s,}$ and $\sigma_j^d = (j/10)\sigma_{d,}$
We compute $\sigma_{ij} = ((\sigma_i^s)^2 + (\sigma_j^d)^2)^{1/2}$

With $\sigma_s = \sigma_d = 0.2$, σ_{ij} are shown in Figure 4.

Figure 4. Standard deviation of asset returns



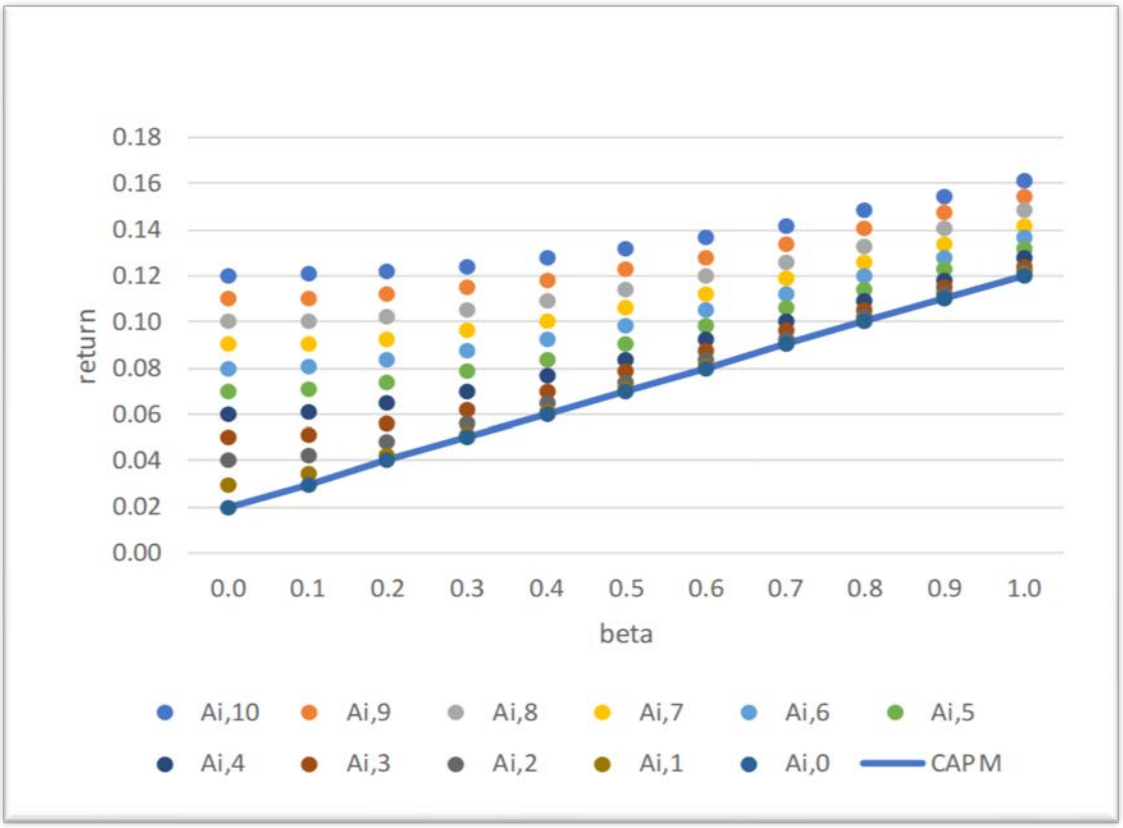
Each market player establishes its best price for A_{ij}, $1-r_{ij}$ where r_{ij} is the one period discount (return) for purchasing 1 unit of A_{ij}. To facilitate analysis, we measure the arithmetic discount to keep measures of value linear and to keep the focus on the minimizing the cost of acquisition of assets. We use the terms return and discount interchangeably.

Let's first consider the pricing function of a linear risk adverse investor with coefficient of risk aversion of k. The required discount or return is: $r_{ij} = R_f + k\,\sigma_{ij}$

With $R_f = .02$ and $k = .5$ the required return of the Investment Universe is shown in Figure 5.

For an investor who only prices systemic risk and has the same coefficient of risk aversion, we have the pricing equation: $r_{ij} = R_f + \beta_i (R_m - R_f)$, where $(R_m - R_f)$ is the Risk premium for $\beta_i = 1$. We shall call this line CAPM as it has the same form as the Capital Asset Pricing Model.

Figure 5. Return under Risk Aversion and CAPM



This is a good point to describe the principle of best execution. At this point each asset has a price under CAPM and under Risk Aversion. A seller of the asset will sell to the investor willing to pay the highest price. In this case, it would be the CAPM investor. Moreover, for high standard deviation assets it will make more economic sense to create assets under CAPM than under Risk Aversion as the cost of capital would be lower. However, for now we will assume that the amount of assets offered is the same under both models.

Assuming each asset has a value of 1 at the end of period, we can compute the total (average) discount. It costs 3.35 (2.77%) less to purchase the 121 assets under CAPM than under risk aversion as shown in Table 5.

Table 5. Comparison of Methods

Method	Total Discount	Average
Risk Aversion	-11.82	9.77%
CAPM	-8.47	7.00%
difference	3.35	2.77%

The CAPM pricing has a lower required return and a higher value. Keep in mind that this is a one period model and over longer time horizons the magnitude of the value differential will increase.

The Household/Retail Investor

The pricing models above are idealized models and do not represent any investor in the model. We now introduce the household investor and we can compare the pricing of households to the idealized models above.

The household pricing model is:
Risk aversion: $r_{ij} = R_f + k_r\sigma_{ij}^{1/2}$

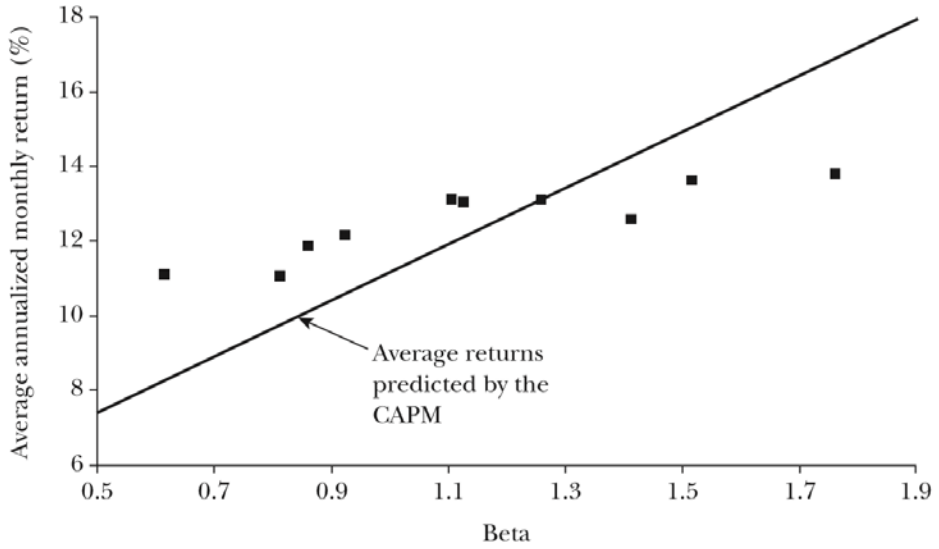
These conditions imply that the risk-free asset is priced at R_f and risky assets are priced based on the square root of the standard deviation with a minimum required return of R_r. As a result, households have a strong preference for the risk-free asset relative to slightly risky assets. In addition, as households price all risk, not just systematic risk, there is a significant gap between the household required returns and the CAPM required returns. That gap creates the opportunity for intermediation and securitization.

Note also that the curvature of the household required returns, shown in Figure 6, even for assets with only systemic risk means that households may prefer barbell holdings of mostly risk-free assets and mostly higher risk assets.

This form of required pricing could result from mechanics such is in the Black (1972) CAPM model with restricted borrowing or some variant of Kahneman and Tversky (1979) Prospect Theory that imposes a higher utility cost for small losses than utility gain for small gains. The essential feature for the exposition is that the required return function for households is upward sloping, and concave (i.e., has a positive first derivative and a negative second derivative.)

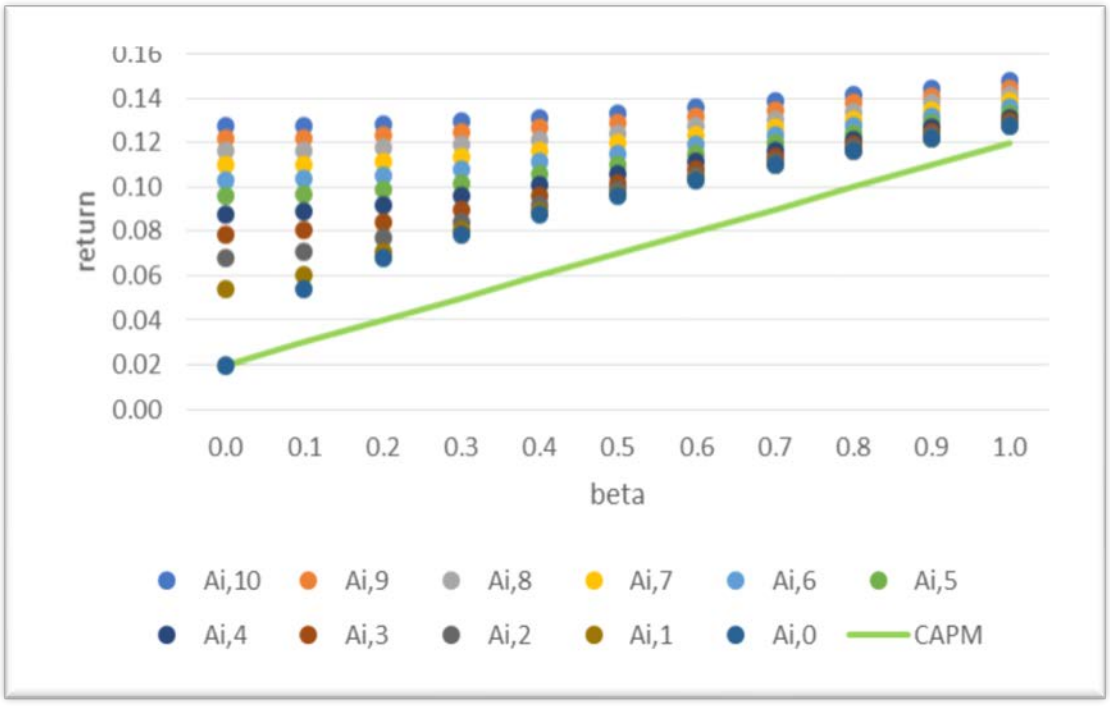
Note that this pricing function is also similar to the results in Figure 2 of Fama-French (2004), reproduced here.

Average Annualized Monthly Return versus Beta for Value Weight Portfolios Formed on Prior Beta, 1928–2003



Source: Fama-French (2004) Figure 2, p33.

Figure 6. Household Required Returns



The Intermediaries

The model includes two intermediaries. These intermediaries can purchase assets $A_{i,j}$ and transform them into claims for investment by households. Households will price these claims based upon the transformed risk characteristics.

Mutual Funds

Mutual funds are not permitted to utilize leverage, but they can diversify. We assume that the mutual funds almost fully eliminate diversifiable risk from their portfolios except they cannot create risk-free assets. They then offer broadly diversified portfolios to retail investors. As a result, the pricing function of the mutual fund is:

$r_{ij} = R_m + F_f$ where R_m represents the required return of investors for a diversified portfolio with beta equal to 0.9 and F_f represents the additional fee charged by the fund to cover expense and manager compensation. (Beta of 0.9 is used to reflect that the overall risk of the equity market must be a blend of the assets held by the mutual funds.)

In words: mutual funds deliver a diversified portfolio to investors and the investments of the fund must also cover the funds costs. While mutual funds can diversify, they are not able to create risk-free assets from risky assets. While we don't explicitly include money market funds in this model, money market funds can only hold risk-free or very nearly risk-free assets—a constraint that will be important for analysis of market disruption.

Banks

Banks are chartered by the government and have the power to issue risk-free securities as insured deposits. In exchange for this power, banks are limited in what assets they can purchase and the amount of leverage they can utilize.

For eligible assets the bank required return is:
$B_c = B_e * R_r + (1 - B_e) * (R_f + B_f)$, where B_e is the required equity percentage and B_f is the fee paid by the bank for deposit insurance. Note that B_c does not depend on σ_{ij} of the assets held by the banks.

The restriction on bank investments is given by:
$\sigma_{ij} \leq B_\sigma$, where B_σ is the bank risk cut-off.
So if($\sigma_{ij} \leq B_\sigma$), $r_{ij} = B_c$, otherwise undefined.

We will get back to this later, but under this rule, if the σ_{ij} increases above B_σ, the bank will be forced to sell the asset. In practice, banks have more complicated asset restrictions and many of their asset restrictions are based on probability of default. To simplify the exposition, rather than using specific probability of default (PD) metrics, the more general standard deviation limit used in the model reflects the spirit of constraints on bank investment.

Setting B_e to 10%, B_σ to 8% and B_f to 0.5%, results in B_c = 3.45%. If we also set F_f to 0.25%, we can see the results for the pricing function for I with the two intermediaries in Table 6. The pricing of the mutual funds is shown in blue and the pricing of the banks is shown in orange. The risk-free investment is shown in green.

Table 6. Required Returns with Banks

R10	0.124	0.124	0.124	0.124	0.124	0.124	0.124	0.124	0.124	0.124	0.124
R9	0.122	0.122	0.123	0.124	0.124	0.124	0.124	0.124	0.124	0.124	0.124
R8	0.116	0.116	0.117	0.119	0.122	0.124	0.124	0.124	0.124	0.124	0.124
R7	0.110	0.110	0.112	0.114	0.116	0.120	0.123	0.124	0.124	0.124	0.124
R6	0.103	0.104	0.105	0.108	0.111	0.115	0.119	0.123	0.124	0.124	0.124
R5	0.096	0.097	0.099	0.102	0.106	0.110	0.115	0.120	0.124	0.124	0.124
R4	0.035	0.089	0.092	0.096	0.101	0.106	0.111	0.116	0.122	0.124	0.124
R3	0.035	0.035	0.035	0.090	0.096	0.102	0.108	0.114	0.119	0.124	0.124
R2	0.035	0.035	0.035	0.035	0.092	0.099	0.105	0.112	0.117	0.123	0.124
R1	0.035	0.035	0.035	0.035	0.089	0.097	0.104	0.110	0.116	0.122	0.124
R0	0.020	0.035	0.035	0.035	0.035	0.096	0.103	0.110	0.116	0.122	0.124
beta	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0

While more assets are now priced closer to the CAPM line, there are still substantial areas where the conservative retail pricing dominates. Moreover, given the limitations on the activities of the two intermediaries they cannot participate in those sectors. Securitization is necessary to transfer the claims on those assets to forms that better fit the requirements of the intermediaries.

Leverage

Corporate Debt

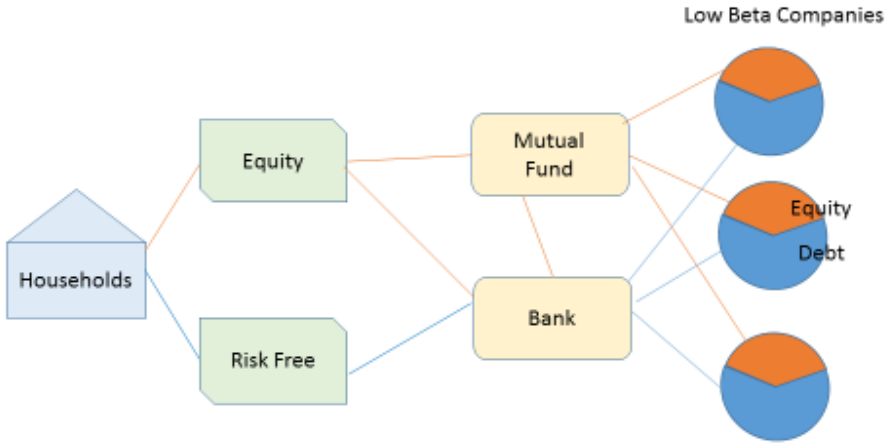
Corporate debt is created by splitting the risk of an asset into two components, debt and equity. As the debt needs to be sold to the banks and the banks have the same cost of capital for all eligible assets, we will create debt that has a standard deviation at the maximum allowable risk for banks of B_σ. In addition, we will limit the maximum standard deviation of the leveraged equity position, L_s and the maximum leveraged beta to 1. The leveraged equity is assumed to be sold to a mutual fund.

The required return on an asset that is transformed into corporate debt and equity is then given by:

$$r = x * B_c + (1-x) * R_e$$
$$R_e = R_r + R_f$$
$$x = \min((Std - Ls)/Br-Ls), 1/\beta-1)$$

Figure 7 is a schematic of how the risk and return requirements of low beta assets are distributed in the model. The claims are split between bonds which will be held by the banks and stocks that will be held by the mutual funds. In turn, those intermediaries are held by households.

Figure 7. Leverage and the Specialized Investment of Intermediaries



Securitization

While corporate debt, restructures a single asset, securitization restructures a pool of assets. As a result, securitization can be used to diversify risk as well as leverage risk and as a result of diversification and risk segmentation, securitization trusts can issue nearly-risk free debt as well. In the model we allow securitization to partially reduce diversifiable risk, and issue three claims (tranches): a risk-free investment, a bank investment and an equity investment. To approximate the ratings approach used in securitization we set limits on the multiples of standard deviation for each tranche to meet the investment requirements of the investors. It may help to think of a pool of auto loans or mortgage loans.

We assume, in our example, that there is minimum size of 65% of the asset for the risk-free or AAA-equivalent bond to make the transaction worthwhile. We assume that the pooling of assets can eliminate 70% of the idiosyncratic risk of the asset. The amount of credit enhancement for the AAA tranche is equal to 8.5x the standard deviation of asset after diversification and the credit enhancement for the bank-held bond is 1.9x the standard deviation of the asset after diversification. The remaining balance is an equity position. The required returns on each tranche are 2%, 3.45% and 12.3% respectively.

For example, if the asset standard deviation after diversification is 4% then the structure of the securitization is shown in Table 7.

Table 7. Securitization Structure

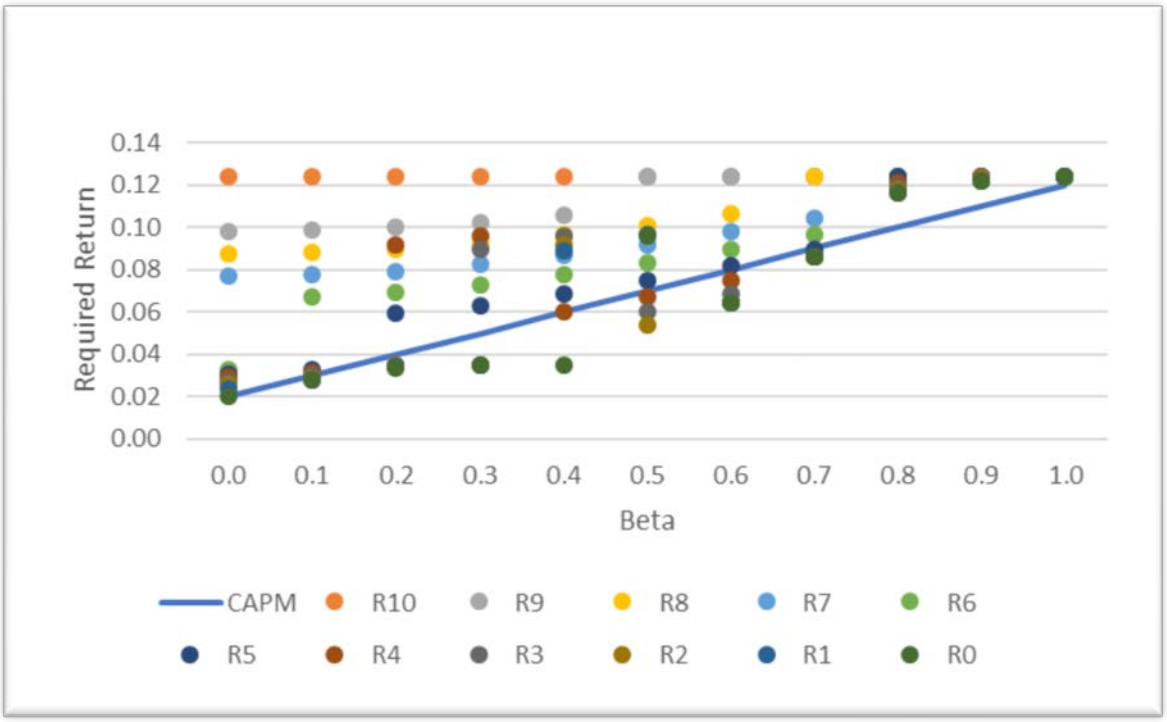
Asset std dev		4.00%		
Tranche		size	std dev	return
AAA		66.00%	0	0.02
Mezz		26.40%	8%	0.0347
First loss		7.60%	25%	0.1243
Combined			4.01%	3.18%

Table 8 shows the pricing of the assets with these two forms of securities in place. The yellow boxes represent corporate debt and the gray boxes represent asset securitization. Figure 8 shows the returns graphically. Many more assets are priced closer to the CAPM line, even though there is no investor or intermediary who prices to CAPM.

Table 8. Required Returns including Securitization and Corporate Debt

CAPM	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	0.10	0.11	0.12
R10	0.1243	0.1243	0.1243	0.1243	0.1243	0.1243	0.1243	0.1243	0.1243	0.1243	0.1243
R9	0.0980	0.0985	0.1000	0.1026	0.1061	0.1243	0.1243	0.1243	0.1243	0.1243	0.1243
R8	0.0874	0.0880	0.0897	0.0925	0.0964	0.1011	0.1066	0.1243	0.1243	0.1243	0.1243
R7	0.0769	0.0775	0.0795	0.0826	0.0868	0.0920	0.0980	0.1046	0.1243	0.1243	0.1243
R6	0.0326	0.0671	0.0693	0.0728	0.0775	0.0832	0.0897	0.0969	0.1243	0.1243	0.1243
R5	0.0309	0.0326	0.0592	0.0632	0.0685	0.0749	0.0820	0.0897	0.1242	0.1243	0.1243
R4	0.0291	0.0312	0.0918	0.0959	0.0600	0.0671	0.0749	0.0859	0.1215	0.1243	0.1243
R3	0.0273	0.0299	0.0347	0.0899	0.0959	0.0600	0.0685	0.0859	0.1192	0.1243	0.1243
R2	0.0255	0.0289	0.0347	0.0347	0.0918	0.0540	0.0646	0.0859	0.1175	0.1231	0.1243
R1	0.0238	0.0282	0.0339	0.0347	0.0889	0.0966	0.0646	0.0859	0.1164	0.1221	0.1243
R0	0.0200	0.0279	0.0338	0.0347	0.0347	0.0959	0.0646	0.0859	0.1160	0.1218	0.1243
beta	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0

Figure 8. Required Returns with Banks and Securities



Valuation

Given an assumption on the initial position in each asset it is possible to compute the value of the Investment Universe I under the various market structures. The table shows the average discount required to purchase a portfolio that produces one unit of each asset at the end of the period. The Household pricing function has a discount of 11.20% versus the CAPM discount of 7.00%. The combined intermediaries without securitization and corporate bonds produces a 10.40% discount. Including securities reduces the discount to 8.94%, reducing the difference between the CAPM and Household discount by over 50% and producing a lower discount than the pure standard deviation model.

Table 8. Comparison of Valuations

	Discount	To CAPM
CAPM	-0.0700	
Standard Deviation Pricing	-0.0977	-0.0277
Household	-0.1120	-0.0420
Mutual Fund + Bank	-0.1040	-0.0340
Securities	-0.0894	-0.0194

Each position is priced based on the best execution shown in the color-coded return table in Table 8. The average discount (required return) and the percentage of positions for each component is shown below.

Table 9. Best Execution Choice

	Discount	Positions
Household	-0.1027	14.8%
Mutual Fund	-0.1243	29.5%
Bank	-0.0347	4.9%
Corporate	-0.0831	39.3%
Securitization	-0.0297	11.5%

Allocation of Assets

While initially there was an even distribution of all assets, the transformation of the assets through leverage and securitization has significantly changed the asset profile. While there was originally only one risk free asset, 43.0 are now risk-free assets resulting from bank deposits and AAA tranches of securitizations. Bank assets represent 34.5 of payoffs and mutual funds hold 62.0 of payoffs, and at 26.0 nearly half represent leveraged securities.

Table 10. Asset Holdings of Intermediaries

Risk Free Funds		
	Bank Deposits	31.1
	Money Market	10.9
	Pure	1.0
		43.0
Banks		
	Loans	6.0
	Corp. Debt	26.1
	Mezz	2.4
		34.5
Mutual Fund		
	Leveraged Equities	
	First loss	0.7
	Corporate	21.9
	Bank	3.5
	Unlevered Equities	36.0
	Total mutual fund	62.0

When we look at the allocation of assets from the perspective of the holdings of the household sector and the financial sector, as shown in Figure 9, the allocation looks much like the allocation in the economy shown in Figure 1. Households hold risk free instruments and equities. Much of their equities are held via mutual funds. The Financial sector holds bonds, loans and equities, with only small holdings in the risk-free assets.

Figure 9. Model Financial Assets

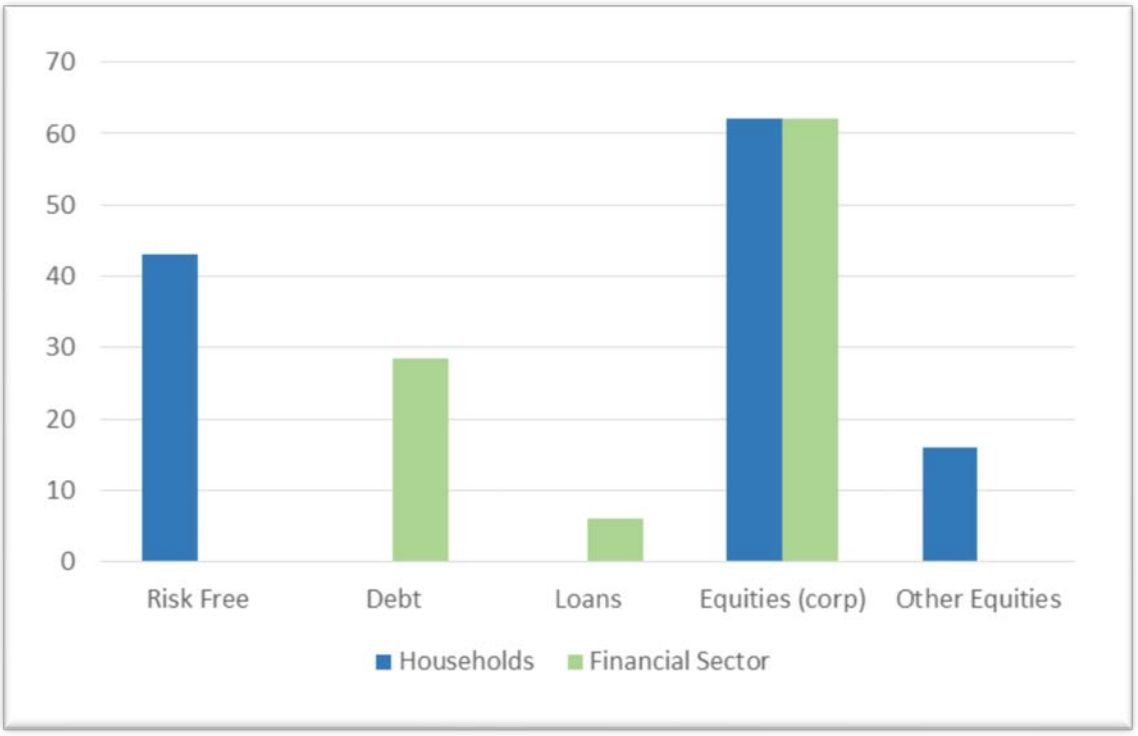


Table 11 summarizes the parameters in the model. Relatively few parameters generate a reasonable allocation of risk between intermediaries and households.

Table 11. Summary of Parameters

Households		
price of risk	k_r	0.25
Mutual Funds		
Fund fee	F_f	0.25%
Banks		
Banking Fee	B_f	0.50%
Banking Equity	B_e	10%
Bank cost of capital	B_c	3.45%
Bank asset max std dev	B_σ	8%
Corporate Leverage		
Max std dev for leveraged assets	L_s	25%
Securitization		
AAA multiple	A_m	8.5
Mezz %Jr	M_m	1.9
Securitization Diversification	D_s	70%
Securitization fee	S_f	0.2%
Min AAA%	AAA	65%

Risks of Securitization

While securitization increases the value of the asset, it also has the potential to introduce greater price instability through the risk that the intermediaries will need to alter their financing or holding of bonds.

In this model, the bank faces the risk that a bond will no longer meet the definition allowable investment. If the risk, as measured by standard deviation, increases sufficiently the bank will be forced to sell the bond. In addition, if the credit enhancement of money market instrument falls below its required credit enhancement it must also be sold to an investor who doesn't require risk-free assets. This sale is required even though the probability of default still remains very near zero.

It is important to recognize the difference between the risk of the asset and the risk of the bonds. A small change in the risk of the asset could lead to a large change in the value of the tranches created in securitization. We use the model to assess the impact of a small change in risk for a borderline asset.

Starting Asset: The asset falls into category $A_{2,1}$. This asset has $\sigma_{2,1}$ = (4%,2%) a beta of 0.2 and a standard deviation of 4.5%.

Under the model, this asset would be securitized and transformed into 66% senior bond, sold as a risk-free investment, 26% mezzanine investment sold to a bank and 8% first loss equity sold to a mutual fund. The combined value would be 0.9661.

If the asset had not been securitized its value under various pricing regimes would vary from 0.9292 if retained by households to 0.9653 if held directly by a bank.

Apply the Stress: In a stress situation we assume that there is a decrease in the payoff of the asset from 1 to 0.99. We also assume that there is an increase in risk, so the asset matches the characteristics of $A_{2.2}$.

$\sigma_{2,2}$ = (4%,4%). The standard deviation increases to 5.6% and beta remains at 0.2. Under the CAPM pricing structures, the value of the bond would fall by approximately 1% to reflect the lower ending value. Under the household model the price would fall by about 1.7% to .9137 reflecting loss in value and higher risk. However, given the securitization structure the combined asset value falls by 3.4% and the price of the component positions fall by 1.5 to 13.2%. The securitization structure leads to the greater declines because the components were designed to just meet the requirements of the intermediary investors. As the risk increased risk-free best-execution was no longer available for the senior bond and bank best-execution was no longer available for the mezzanine bond.
(Imagine the additional impact on price if a large volume of similar assets were also subject to forced sale at the same time.)

Table 12 also shows the clear violation of the theory of one price. The value and the risk of the asset depends on who holds the asset. Securitization produces the highest initial valuation of the asset, but then creates the greatest risk. The sum of the values of the parts in stress ends up being worth less value of the sum of the parts. And as with Humpty Dumpty, it may not be possible to put all the parts back together again.

Table 12. Impact on Stress on the Value of Securitization Tranches

Securitization Valuation					
Tranche	**Size**	**Base**	**Stress**	**Change**	**%**
Sr	0.66	0.6468	0.6371	-0.0097	-1.5%
Mezz	0.26	0.2548	0.2405	-0.0220	-5.6%
Jr	0.08	0.0666	0.0578	-0.0088	-13.20%
Fee		-0.0020		0.0200	
Total	***1.00***	***0.9662***	***0.9354***	***-0.0328***	***-3.4%***
Raw Asset Valuation:					
CAPM		.9600	.9504	-0.0096	-1.0%
Household		.9292	.9137	-0.0155	-1.7%
Bank		.9653	.9557	-0.0096	-1.0%

Asset reallocation

To this point we have assumed that the investor return requirements do not have an impact on the amount of each asset in the economy. Assuming however that the amount of asset created by the economy reflects the relative pricing will change the initial structure of the investment universe.

If we tie the balances in each asset to the difference between the CAPM price and the best execution price there is a shift in assets away from those held directly by households and mutual funds towards those created by securitization, corporate leverage and held directly by banks. Assuming that the change in assets is proportional to the difference between the market required return and the CAPM return, we can re-compute the value of the assets in the economy. In our example, as a result of the reallocation the average discount to acquire the payoffs is reduced to 8.37%, further approaching the CAPM result of 7% discount.

Tables 13 and 14 show the allocation of assets in the adjusted economy and the shift in ownership structure towards securitization and banks as low-cost funding sources.

Table 13. Change in Asset Origination

$A_{i,10}$	0.00	0.00	0.00	0.11	0.23	0.35	0.47	0.59	0.71	0.83	0.95
$A_{i,9}$	0.06	0.18	0.28	0.37	0.45	0.35	0.47	0.59	0.71	0.83	0.95
$A_{i,8}$	0.19	0.30	0.40	0.49	0.56	0.63	0.68	0.59	0.71	0.83	0.95
$A_{i,7}$	0.32	0.43	0.53	0.61	0.68	0.74	0.78	0.82	0.71	0.83	0.95
$A_{i,6}$	0.85	0.56	0.65	0.73	0.79	0.84	0.88	0.92	0.71	0.83	0.95
$A_{i,5}$	0.87	0.97	0.77	0.84	0.90	0.94	0.98	1.00	0.71	0.83	0.95
$A_{i,4}$	0.89	0.99	0.38	0.45	1.00	1.04	1.06	1.05	0.74	0.83	0.95
$A_{i,3}$	0.91	1.00	1.06	0.52	0.57	1.12	1.14	1.05	0.77	0.83	0.95
$A_{i,2}$	0.93	1.01	1.06	1.18	0.62	1.19	1.19	1.05	0.79	0.84	0.95
$A_{i,1}$	0.95	1.02	1.07	1.18	0.65	0.68	1.19	1.05	0.80	0.85	0.95
$A_{i,0}$	1.00	1.03	1.07	1.18	1.30	0.69	1.19	1.05	0.81	0.86	0.95
beta	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0

Table 14. Shift in Asset Ownership

	Original Positions	Adj Volume
Household	14.8%	13.7%
Mutual Fund	29.5%	26.1%
Bank	4.9%	7.5%
Corporate	39.3%	38.2%
Securitization	11.5%	14.6%
Avg.Discount	-0.0894	-0.0837

It is interesting to note the tradeoff in these two allocations. We can think of the first allocation of how the economy would choose assets if all were priced according to an optimal scheme, for example CAPM. However, since the market prices of the assets do not match CAPM, the economy reallocates assets to better match optimal pricing. Which is better for the economy to have the optimal mix of assets, or to have more appropriate pricing of more assets?

As can be seen by comparing Figure 6 and Figure 8 above, the full economy with intermediaries and securities produces required returns that are much closer to the CAPM levels. The square root of the average square difference between the returns for just households in 6 and the CAPM returns is 0.0482, while the square root of the average square differences for the economy in Figure 8 is cut to 0.0315. Along with the reduction in difference in required returns would be a comparable change in the assets created by the economy.

Summary

The Best Execution Pricing Model is a plausible and realistic, but simplified, model of financial intermediation. It shows the holdings of assets by banks and mutual funds rather than directly by households and the value of leverage and securitization. The model has very few assumptions:

- Households have limited ability to diversify or leverage
- Households pricing of assets is based on a concave pricing function.
- Mutual funds can diversify but not leverage.
- Banks have limits on the risk of their assets but can issue risk-free deposits.
- Firms can borrow to increase leverage and securitization can diversify risk.

Yet even these few assumptions create a rich environment and are consistent with many observations of the structure of the financial system. The model also shows how small changes in asset risk characteristics could lead to significant changes in value. The ability to structure instruments to just meet the requirements of intermediaries then creates the risk of large-scale disruptions in the financial system from small changes in value.

This analysis does not explain why households have a required return profile that leads to a preference for return equities and risk-free assets. Informational asymmetries, expertise requirements, wealth constraints, access to leverage, and costs of diversification are all plausible motivations for household behavior, but they are not explored here.

This analysis does demonstrate that looking at the utility functions of households or managers of intermediaries may not be the best place to look to determine the overall pricing function for financial assets, rather it is the interaction between these functions and the regulatory structure of the financial system that determines the pricing of financial assets. The concept of a single Stochastic Discount Factor (SDF) should be thought of as an outcome of a more complex process of best execution rather than a fundamental aspect of the economy. To the extent that a model like CAPM describes the pricing of assets, it is a result of a combination of pricing models producing a similar overall result.

The analysis may also provide some guidance to regulators on the need to keep structured securities away from the edges of the envelope of allowable investments, but also the need to soften those edges in times of financial and economic stress.

Given the importance of intermediaries in the pricing and allocation of financial resources, this analysis raises more questions than it answers. What utility function is consistent with the assumed pricing equation for households? Why do some intermediaries exist and not others? What determines the institutional and regulatory limits on intermediary activities? When are new types of intermediaries formed? When are old types eliminated? Do changes in the structure of intermediaries generally move toward that of an idealized utility function for society? Are there other unifying themes in the development and evolution of intermediation?

The Best Execution Pricing Model is a step toward creating a framework for evaluating these questions and providing a better understanding of the role of intermediaries in the capital markets.

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