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Prepayment strategies: Essentials, analysis, and investing

Executive summary

Prepayment risk is one of the four major risks present in bond markets, along with term structure (or duration) risk, credit risk, and liquidity risk. We believe prepayment risk, largely concentrated in U.S. markets, is one of the least understood and most underutilized risks in a well-diversified portfolio. The risk is significant enough to impact the domestic U.S. volatility surface and rates market, as well as potentially impact global developed market rates.

The intent of this paper is to help institutional investors better understand prepayment opportunities and how best to incorporate prepayment securities into a broader fixed income allocation. The paper outlines the history and drivers behind the prepayment markets and delves into distinct security types and their attributes, potential opportunities, and how prepayment strategies may be incorporated into a broader portfolio. Following is a summary of four key topics we cover.

Refinancing drivers. The starting point for uncovering value in prepayment markets is understanding how and why borrowers prepay their mortgages. The majority of U.S. homeowners have the option to prepay their mortgage at any time without penalty to take advantage of macroeconomic and mortgage industry developments for their financial benefit. The primary drivers of homeowner prepayments include a reduction in interest rate, home price appreciation, and government housing policies that impact the affordability and availability of mortgage financing.

Tranching and prepayment speeds. The securities used to pursue prepayment strategies are created based on the cash flows of a pool of mortgage loans. Mortgage principal and interest payments can be restructured into a variety of collateralized mortgage obligation (CMO) tranches. Redistributing prepayment cash flows may be categorized as time tranching and may further be divided into contraction and extension risks.

Agency IOs. Interest-only (IO) securities are the purest expression of prepayment risk. They tend to increase in value in rising interest-rate environments and generally decrease in value when interest rates are falling or remain very low. While IOs may exhibit a high degree of volatility, they are demonstrable risk mitigants within a broader portfolio when interest-rate risk is hedged. Duration hedging also allows for the capture of prepayment risk premium and an attractive risk-adjusted return. Additionally, we believe agency IOs to be a good diversifier within a broader portfolio given their low correlation to other asset classes, including other types of structured credit.

Identifying opportunities. To compare valuations and characteristics of securities in the prepayment markets, it is critical to have a thorough grasp of the key influential factors for estimating their path-dependent cash flows. The primary factor is how in or out of the money the underlying loans of a mortgage pool are when compared with interest rates. The market generally allows a risk premium for securities that are most susceptible to errors in commonly used prepayment valuation models. We find the pricing of this risk premium to be inconsistent, which creates opportunities for sophisticated investors to buy and sell securities with inefficient pricing.

Successful investing in prepayment strategies requires a thorough understanding of the mortgage market, underlying collateral characteristics and behavior, and cash flow structuring by an experienced team adept at identifying and extracting value based on borrower behavior.

Prepayment essentials

Prepayment risk is one of the four major risks present in bond markets, along with term structure (or duration) risk, credit risk, and liquidity risk. Of these four return drivers, prepayment risk is one of the least understood and, consequently, one of the most underutilized risks in a well-diversified portfolio.

At the highest level, prepayment securities and strategies are based on the timing of cash flows — the receipt by the investor of a payment either earlier or later than anticipated. At its heart, this risk is similar to call risk in the government or corporate credit markets. It manifests itself in a more developed form in agency mortgage-backed securities (MBS). Being guaranteed by Fannie Mae, Freddie Mac, or Ginnie Mae (collectively, the government-sponsored enterprises, or GSEs), agency MBS are insulated against exposure to the credit of the underlying borrowers but are fully exposed to the U.S. borrower's unique option to pay down or refinance their mortgage at any time, without penalty. As a result, prepayment strategies are constructed around the ability of the investor to predict the future timing of cash flows.

In the context of providing a framework for considering prepayment strategies, we focus on agency IO bonds. Following we provide an overview of the securitization process that creates agency MBS pools, the structuring of these pools to create IOs, and the performance dynamics of IO securities, as well as a conceptual framework for analyzing and investing in these securities with an eye toward their use within a broader portfolio framework.

The U.S. mortgage market

Prepayment securities are created based on the cash flows of the underlying mortgage loans. If the investor can reliably estimate the cash flows of the underlying mortgage loans for the valuation and analysis of a mortgage pool security, the cash flow projection and the same valuation and analysis framework may be applied to mortgage structures that direct those cash flows in a variety of ways. The fundamentals of estimating cash flows and option-adjusted analysis are key to analyzing prepayment strategies and are applicable to investing in agency IOs. We provide an overview of these essential concepts as a foundation for exploring interest-only securities.

Creating a mortgage pool

A mortgage loan is established when a borrower receives credit from a lending institution, most often from a bank or via an intermediary mortgage broker who works with multiple lending institutions, in order to purchase a home. Mortgage loans may have fixed or floating interest rates, different maturities, or other differing characteristics, but the most common is the 30-year loan with a fixed monthly payment. The Federal Housing Administration (FHA) played an important role in encouraging the use of the fixed-payment, 30-year loan.

The originator of the loan underwrites, or assesses, the borrower's ability to repay the loan based on a variety of characteristics, including the borrower's income and credit history as well as the amount of the loan versus the value of the home, among others. These risk characteristics determine the interest rate the borrower pays, typically the combination of a spread over the 10-year Treasury yield plus a risk charge based on the possibility the borrower may default. Additional fees are assessed, including fees for Fannie Mae, Freddie Mac, or Ginnie Mae; and fees for providing a guarantee as well as for servicing. The last of these, servicing, entails keeping track of and recording principal and interest payments, ensuring payments are passed through to investors, managing delinquencies and defaults, and so forth.

While the payments on a fixed-rate mortgage remain the same in total each month, the mix of principal and interest changes with more interest paid earlier in the life of the loan and declining over time, while the principal payment makes up the difference and increases over time (see the illustration for calculating mortgage payments).

History of the Federal Housing Administration

The FHA was established in 1934 and became part of the U.S. Department of Housing and Urban Development's (HUD) Office of Housing in 1965.[1] Part of the FHA's mission is to provide affordable mortgage insurance on loans made by FHA-approved lenders. The insurance protects the lender against default by the borrower, and the FHA strictly dictates the required characteristics of the loans it insures. One of the requirements instituted early in the life of the FHA was that loans must have constant, or fixed, payments and be directly amortizing, meaning that each monthly principal payment must be applied directly to the amortization of the loan. This was not particularly common leading up to the Great Depression. Because loans at that time were not directly amortizing, payoff was random and not tied to a particular maturity date per se, but most were paid off in roughly 11 to 12 years. Commercial banks were also not encouraged to extend long-term financing.[2] This changed when the 30-year loan term was approved for the FHA by Congress in 1948[3] for loans on newly constructed homes and in 1954 for those on existing homes.[4] The FHA works alongside the GSEs in providing guarantees on loans, supporting the ongoing extension of credit to homebuyers (for more information, see pages 6–7).

1 https://www.hud.gov/program_offices/housing/fhahistory (accessed 12/21/2021).

2 https://www.atlantafed.org/blogs/real-estate-research/2012/04/05/debunking-a-popular-myth-about-mortgage-lending (accessed 12/20/2021).

3 Congressional Research Service, A Chronology of Housing Legislation, 1892–2003, 2004 (accessed 12/21/2021).

4 https://www.aei.org/economics/housing-finance/housing-finance-fact-or-fiction-fha-pioneered-the-30-year-fixed-rate-mortgage-during-the-great-depression/ (accessed 12/20/2021).

Calculating monthly mortgage payments and abbreviated amortization schedule

Payment calculation formula

Monthly payment[5] = $MP = MB_0 * \frac{[\, i\,(1+i)^n \,]}{[\,(1+i)^n - 1\,]}$

Where: i = loan interest rate / 12

n = # of months in the term of the loan = 12 months * 30 years = 360 months

MB_0 = Mortgage balance = $1,000,000

Amortization schedule: Interest payments decline and principal payments increase over time

Months	Beginning loan balance	Monthly payment	Interest payment	Guarantee and servicing fees	Principal payment	Ending loan balance
1	$1,000,000.00	$4,774.15	$2,916.67	$416.67	$1,440.82	$998,559.18
2	$998,559.18	$4,774.15	$2,912.46	$416.07	$1,445.62	$997,113.56
3	$997,113.56	$4,774.15	$2,908.25	$415.46	$1,450.44	$995,663.13
4	$995,663.13	$4,774.15	$2,904.02	$414.86	$1,455.27	$994,207.85
65	$897,403.14	$4,774.15	$2,617.43	$373.92	$1,782.81	$895,620.33
66	$895,620.33	$4,774.15	$2,612.23	$373.18	$1,788.75	$893,831.58
67	$893,831.58	$4,774.15	$2,607.01	$372.43	$1,794.71	$892,036.87
68	$892,036.87	$4,774.15	$2,601.77	$371.68	$1,800.69	$890,236.18

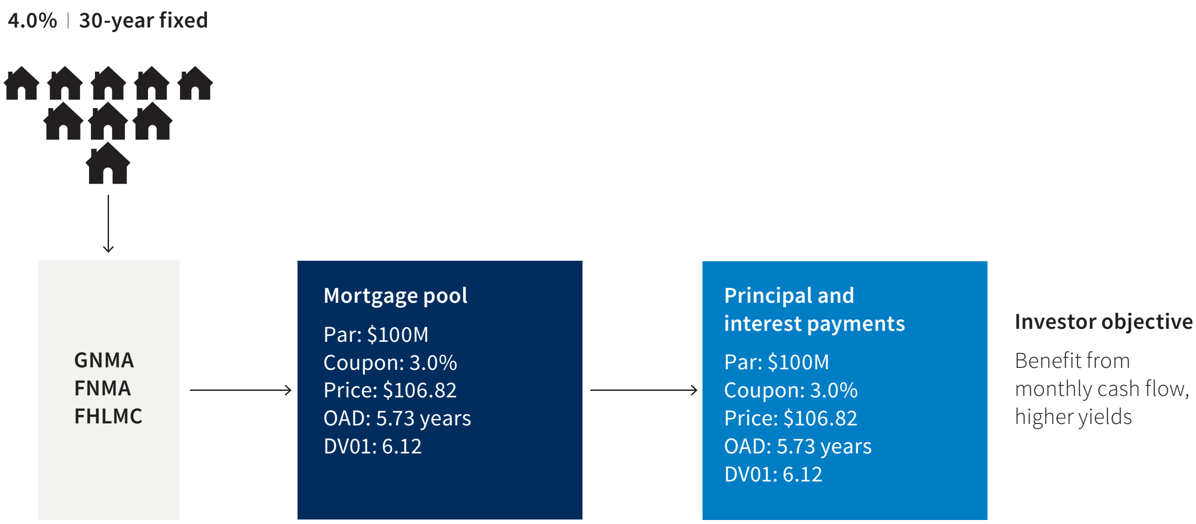
Note: Typically, the guarantee and servicing fees are incorporated in the total interest rate charged on the loan but are shown separately in the example for the sake of clarity.

Source: Putnam.

5 Frank J. Fabozzi, *The Handbook of Mortgage Securities, 7th edition, p. 88.*

FIGURE 1

Example A, part 1: Mortgage pool



Source: Putnam.

For illustrative purposes only. The above example is not intended to be relied upon as a forecast, research, or investment advice, and is not a recommendation, offer, or solicitation to buy or sell any securities or to adopt any investment strategy. As with any investment, there is a potential for profit as well as the possibility of loss.

After a loan is closed (when the terms are settled and contracts are signed), the originator may sell the loan to one of the GSEs, sell the loan to an aggregator that buys mortgage loans, or pool similar loans together on its balance sheet and sell the pool to broker/dealers who then sell these pools on to end investors (Figure 1).

The three GSE agencies generate profit by borrowing at lower rates (because federal backing is assumed) and then investing in loans and mortgage securities purchased from lenders/originators. The loans and mortgage securities are then packaged into pools of loans and sold to investors at a profit. The agencies also receive guarantee fees to assume the credit risk of the borrowers, which are paid by the investor when the pooled loans are sold into the market. The investor is willing to pay the fee to avoid the credit risk and rely on the agency, rather than the borrower, to make the timely payment of principal and interest. To mitigate the credit exposure to the borrower, the agencies have strict requirements each borrower and loan must meet.

The roles of U.S. housing agencies

Government-sponsored enterprises (GSEs)

The Federal National Mortgage Association (Fannie Mae) is the oldest of the agencies and was established in 1938 by an amendment to the National Housing Act of 1934 in order to help solve some of the housing finance issues that arose during the Great Depression. Fannie Mae's original mandate allowed it to buy FHA-insured loans from private lenders and later, in 1948, loans from the U.S. Department of Veterans Affairs' (VA) Home Loan Program for Veterans. As part of the Housing and Urban Development Act of 1968, Congress reorganized Fannie Mae, splitting it in two.

Fannie Mae was reorganized as a private, for-profit company focused on conventional (non-U.S. government-insured or government-guaranteed) mortgages that conform to specific underwriting standards. At the same time, the Government National Mortgage Association (Ginnie Mae, or GNMA) was also created. Ginnie Mae remains a direct government agency within HUD, earning a fee for guaranteeing privately issued mortgage-backed securities collateralized by government-insured or guaranteed loans. Freddie Mac was established in 1970 as a government-chartered corporation, owned by the 11 Federal Home Loan Banks, the system's Office of Finance, and the federally insured savings institutions, which owned stock in the Federal Home Loan Banks. As part of the Financial Institutions Reform, Recovery, and Enforcement Act (FIRREA) in 1989, Freddie Mac was rechartered as a private corporation in the manner of Fannie Mae. Currently, both Fannie Mae and Freddie Mac are in conservatorship with the federal government as a consequence of the bailout required during the global financial crisis (GFC).[6]

GSEs' role in the U.S. residential housing market

Ginnie Mae is solely focused on guaranteeing the principal and interest of mortgage-backed securities backed by pools of loans that meet the standards of several government lending programs. The loans are backed by the FHA, HUD, the VA Home Loan Program, the U.S. Department of Agriculture's (USDA) Rural Development Housing and Community Facilities Programs and Rural Development Guaranteed Rural Rental Housing Program, and the Office of Public and Indian Housing programs. Putting the full faith and credit of the U.S. government behind the government-sponsored programs supports the available supply of mortgage financing and lowers the cost.[7]

The role of Fannie Mae and Freddie Mac is primarily to provide liquidity to the American mortgage-lending system, focused on low- to middle-income earners. Specifically, they are federally mandated to maintain stability in the secondary market for residential mortgages, increase the liquidity of mortgage investments, and make more money available for residential mortgage financing. By purchasing loans from originators, assuming the loans meet the agencies' strict requirements for size, credit, and underwriting standards, they free up the originators' capital to make additional loans. In addition, the two agencies guarantee the timely payment of principal and interest on the loans to outside investors.

The lender, or originator, is incented to offer the long-term, fixed-payment mortgages because they know Fannie Mae and Freddie Mac will most likely purchase them, freeing the lender to create new loans. Investors are also incented to purchase the pooled loans because they do not have to worry about the credit risk of the borrower. Fannie Mae and Freddie Mac guarantee the principal and interest payments.[8]

6 https://www.fhfaoig.gov/Content/Files/History%20of%20the%20Government%20Sponsored%20Enterprises.pdf (accessed 12/21/2021).

7 https://www.ginniemae.gov/about_us/who_we_are/Pages/our_history.aspx (accessed 12/21/2021).

8 Center for American Progress, "7 Things You Need to Know About Fannie Mae and Freddie Mac," September 6, 2012, https://americanprogress.org/article/7-things-you-need-to-know-about-fannie-mae-and-freddie-mac/ (accessed 12/1/2021).

To be clear, Fannie Mae and Freddie Mac are the guarantors, not the U.S. government. Because the two agencies are federally mandated to provide liquidity and stability to the residential mortgage market, there is an implicit, not explicit, guarantee by the U.S. government. The secretary of the Treasury is authorized to buy up to $2.25 billion of securities from each company to support its liquidity, and both agencies are generally exempt from state and local taxes. The Federal Housing Finance Agency (FHFA) was established by the Housing and Economic Recovery Act of 2008 (HERA) and is responsible for the effective supervision, regulation, and housing mission oversight of Fannie Mae, Freddie Mac, and the Federal Home Loan Bank system. Since 2008, FHFA has also served as conservator of Fannie Mae and Freddie Mac. It is the responsibility of FHFA to regulate, enforce, and monitor Fannie Mae and Freddie Mac's capital standards and limit the size of their mortgage investment portfolios. HUD is responsible for monitoring Fannie Mae and Freddie Mac's general housing missions.

Estimating cash flows and prepayments

As with most fixed income instruments, the value of a prepayment-sensitive security is determined by the present value of its expected future cash flows. The notable difference is that the variability of cash flows is not driven by the likelihood of default, but rather by the rate at which the underlying borrowers prepay their mortgages. If a security's realized prepayment speeds exceed expectations, then the security loses value, and vice versa. Understanding how and why borrowers prepay their mortgages is imperative to uncovering value in prepayment markets.

Prepayments represent "unscheduled" principal payments, or those principal payments received faster than expected in the amortization schedule. The most common metric used to measure prepayment speeds is the conditional prepayment rate, which is the percentage of principal expected to be received ahead of schedule per year. However, borrowers make mortgage payments on a monthly basis and, as such, prepayment rates are typically reported each month. These prepayments are reported as the single monthly mortality rate (SMM), which is the amount of principal paid early during the month divided by the expected end of month principal balance.[9] The SMM is then used to calculate the conditional prepayment rate, which provides investors with a forward-looking estimate of a mortgage pool's prepayment rate, and can be applied to project the pool's future cash flows (see illustration for calculation formula and example).

9 dv01.freshdesk.com/support/solutions/articles/42000052036-cpr-calculation (accessed 9/24/2021).

Calculating conditional prepayment rate (CPR) with single monthly mortality rate (SMM)

$$SMM = \frac{\text{Unscheduled principal received}}{\text{Beginning loan balance} - \text{Scheduled principal payment}}$$

The SMM is annualized to calculate the CPR:

$$CPR = 1 - (1 - SMM)^{12}$$

Sample mortgage pool cash flows, including CPR

Months	Beginning loan balance	SMM	Monthly payment	Interest payment	Scheduled principal	Prepayment	Total principal	Total cash flow
1	$100,000,000.00	0.00095	$1,520,055.93	$250,000.00	$1,270,055.93	$93,793.45	$1,363,849.38	$89,636,150.62
2	$98,636,150.62	0.00123	$1,520,055.93	$246,590.38	$1,273,465.55	$119,756.10	$1,393,221.66	$97,242,928.97
3	$97,242,928.97	0.00155	$1,520,055.93	$243,107.32	$1,276,948.61	$148,747.27	$1,425,695.88	$95,817,233.09
4	$95,817,233.09	0.00182	$1,520,055.93	$239,543.08	$1,280,512.85	$172,056.83	$1,452,569.68	$94,364,663.41
5	$94,364,663.41	0.00211	$1,520,055.93	$235,911.66	$1,284,144.27	$196,399.90	$1,480,544.17	$92,884,119.25
6	$92,884,119.25	0.00247	$1,520,055.93	$232,210.30	$1,287,845.63	$226,242.80	$1,514,088.43	$91,370,030.82

Where, MB_0 = Mortgage pool balance = $100,000,000

SMM = Given

i = loan interest rate / 12 = 3.0% / 12

n = # of months in the term of the loan = 12 months * 30 years = 360 months

$$\text{Monthly payment}^5 = MB_0 * \frac{[\, i\,(1+i)^n \,]}{[\,(1+i)^n - 1\,]}$$

However, CPR has its limitations. Most notably, it assumes a constant rate of prepayments based upon the most recent month's data. In actuality, the prepayment rate will change over time as factors such as the macroeconomic environment and government policy evolve. Understanding how these external factors impact prepayment speeds is crucial.

Due to the borrowers' ability to prepay their loan in part or in full at any time without penalty, prepayments occur for a number of reasons (see "Analyzing refinancing behavior" on p. 20). The primary driver of prepayments is refinancing the loan for a lower interest rate — a reaction to changes in the interest-rate environment. This behavior means that the monthly payments from the pool are not fixed or determinable. The pool cash flows change based on the borrowers' reaction to interest rates; as such, probabilistic methods such as Monte Carlo simulations are used to estimate the monthly cash flows and the borrowers' propensity to prepay depending on the loan and borrower characteristics, as well as the historical experience of the underlying loans in different interest-rate environments.

Valuation and adjusting for the effects of interest rates and prepayment behavior

Option-adjusted spread (OAS) analysis is used to value debt securities with differing cash flow patterns and has two distinct differences from traditional bond valuation. The first is that it does not employ a constant discount rate to determine the present value of the security's cash flows but uses discount rates based on the term structure of interest rates. The second is that interest rates are not assumed to remain constant over time, but multiple interest-rate paths are used to evaluate the bond over its life.

A probabilistic model (e.g., Monte Carlo simulation) is used to generate a large number of interest-rate paths based on the current term structure of interest rates as well as historical interest-rate behavior. For each individual interest-rate path, cash flows are estimated and discounted. The discount rates are based on the swap rates associated with that particular path plus a spread. The spread that makes the average price across all paths equal the market price is the OAS. Most importantly, the OAS generated by the model can be used to assess the relative prepayment risk of different mortgage securities. Consider OAS a representation of the incremental yield over swaps/Treasuries after adjusting for variations in interest rates and prepayment behavior on cash flows.

Duration and convexity for interest rate-contingent cash flows

Neither Macaulay nor modified duration are accurate measures of price sensitivity to changes in yield for prepayment securities. Macaulay duration measures how long to hold a bond so that the present value of the cash flows received is equal to the current market price; it is effectively the time horizon of receiving cash flows. Modified duration measures a bond's price sensitivity to changes in yields but does not account for the fact that the cash flows themselves can change due to changes in interest rates. To incorporate the optionality associated with the cash flows, option-adjusted duration (OAD, also effective duration) is a better alternative. The OAD is also useful in calculating the DV01, or dollar duration, of the mortgage pool security.

The process to calculate OAD is relatively simple; the OAS is assumed to remain constant, the initial yield of the short-term Treasury is shifted up and down, and new estimated prices for the security are calculated. The new prices offer a means of estimating convexity (option-adjusted, or effective, convexity). Convexity measures the rate of change in duration, or the trend of acceleration or deceleration in a bond's price sensitivity to changes in yield. The linear approximation of duration breaks down for large changes in yield, making convexity an important measure in evaluating a mortgage pool. When interest rates rise, bond prices fall. In this case, a bond with positive convexity does not lose as much value as an option-free bond. However, a bond with negative convexity does not gain as much in value when interest rates fall.

Calculating option-adjusted duration (OAD)

$$OAD = \frac{V_{-} - V_{+}}{2V_{o}\Delta r}$$

Where, V_o = Current price

V_{-} = Price after a shift down in Treasury yield

V_{+} = Price after a shift up in Treasury yield

Δr = Change in Treasury yield

Estimating convexity

$$\text{Option-adjusted convexity approximation} = \frac{V_{+} - 2V_{o} + V_{-}}{2V_{o}\,\Delta r^{2}}$$

Typically, mortgage securities demonstrate negative convexity. The effect is that upside price potential is lower than that of an option-free bond. This is a cost of investing in mortgage securities.

Having a thorough grasp of the key influencing factors for estimating the path-dependent cash flows is critical for analyzing and comparing security valuation and characteristics. The primary factor is how in or out of the money the underlying loans of the pool are compared with interest rates. The results of the cash flow estimation impact all the subsequent calculations. But once the investor is comfortable with the cash flows, the investor can use them to analyze the various structures derived from the mortgage pool.

Interest-only securities

The U.S. Treasury conducted the first modern issuance of IO and principal-only (PO) Treasury STRIPS (Separate Trading of Registered Interest and Principal of Securities) in 1985.[10] This paved the way for creating other forms of stripped securities issued by the GSEs, who followed closely behind beginning in 1986.[11] Since then, the agency IO market has grown to approximately $100–$200 billion, a relatively small — but powerful — slice of the U.S. residential agency mortgage market, which weighs in at $7.3 trillion.[12] To put the agency IO market into context with other opportunities, the private, or non-agency, residential mortgage market is approximately $600–$700 billion, while the commercial mortgage market is slightly smaller at $500–600 billion.[13]

10 TreasuryDirect, U.S. Department of the Treasury, Bureau of Fiscal Service, "Timeline of Separate Trading of Registered Interest and Principal Securities (STRIPS)," March 10, 2011, https://www.treasurydirect.gov/indiv/research/history/histtime/histtime_strips.htm (accessed 9/24/2021).

11 Elizabeth Balboa, "This Day In Market History: Fannie Mae Rolls Out First Stripped Mortgage-Backed Securities," Benzinga, July 11, 2019, https://www.benzinga.com/general/education/18/07/12004681/this-day-in-market-history-fannie-mae-rolls-out-first-stripped-mort (accessed 9/24/2021).

12 Bloomberg U.S. Aggregate Bond Index, as of 11/30/2021.

13 Putnam Investments.

Allocating prepayment risk

The holder of an agency mortgage pool receives their pro rata share of both principal and interest. These principal and interest payments can be restructured into a variety of collateralized mortgage obligation tranches. CMO structures are intended to match the objectives of investors with varying tolerance for prepayment risk. Prepayment risk is not eliminated by redirecting it; it simply means that some tranches carry more prepayment risk and others, less. It is merely divided up; for those investors willing to assume less prepayment risk, other investors need to be willing to take on more.

The redistribution of the principal and interest cash flows may be broadly categorized as time tranching or credit tranching. Time tranching creates structures with different maturity profiles and divides up prepayment risk. Interest and principal cash flows are directed to different classes of the CMO in order to satisfy different investor desires regarding time to maturity or the degree of prepayment risk assumed. In the examples of creating an IO or an inverse IO, the interest cash flow is directed to the IO and the principal cash flow to the PO or other CMO tranche. Credit tranching directs credit losses (default risk) to specified tranches in a similar manner; however, because agency CMO securities carry either an explicit or implicit government guarantee, there is no credit tranching.

Prepayment risk, part of time tranching, may be divided into contraction and extension risk. Contraction risk occurs when prepayments happen more quickly than anticipated due to a decline in interest rates. The adverse results of contraction are twofold: the investor will be reinvesting cash flows at lower interest rates and the security's inherent negative convexity diminishes the associated upside price potential. Extension risk is the opposite; interest rates rise and prepayments slow more than anticipated. The investor has less cash flow to reinvest at higher rates, and the downside price potential is exacerbated by negative convexity — by prepayments coming in slower than anticipated, there is more principal outstanding invested at a lower-than-market interest rate.

In constructing CMO tranches with different prepayment risk profiles, contraction risk is allocated to certain tranches and extension risk to others. Scheduled principal and prepayments are directed first to the shortest maturity, then the next shortest, and so on. The shortest tranche also has the lowest interest rate — the principal balance of the tranche is outstanding for the shortest amount of time so it generates less interest. The tranche outstanding for longer will have a higher interest rate. The CMO structures follow a strictly defined payment order. The allocation of risk allows greater participation in the mortgage-backed securities market by satisfying varying investor risk tolerance. We focus on the CMO structure most exposed to prepayment risk, namely the forms of IO securities. An IO receives no principal payments, only interest payments. This structure, with IOs receiving only interest cash flow, concentrates the effects of both forms of prepayment risk.

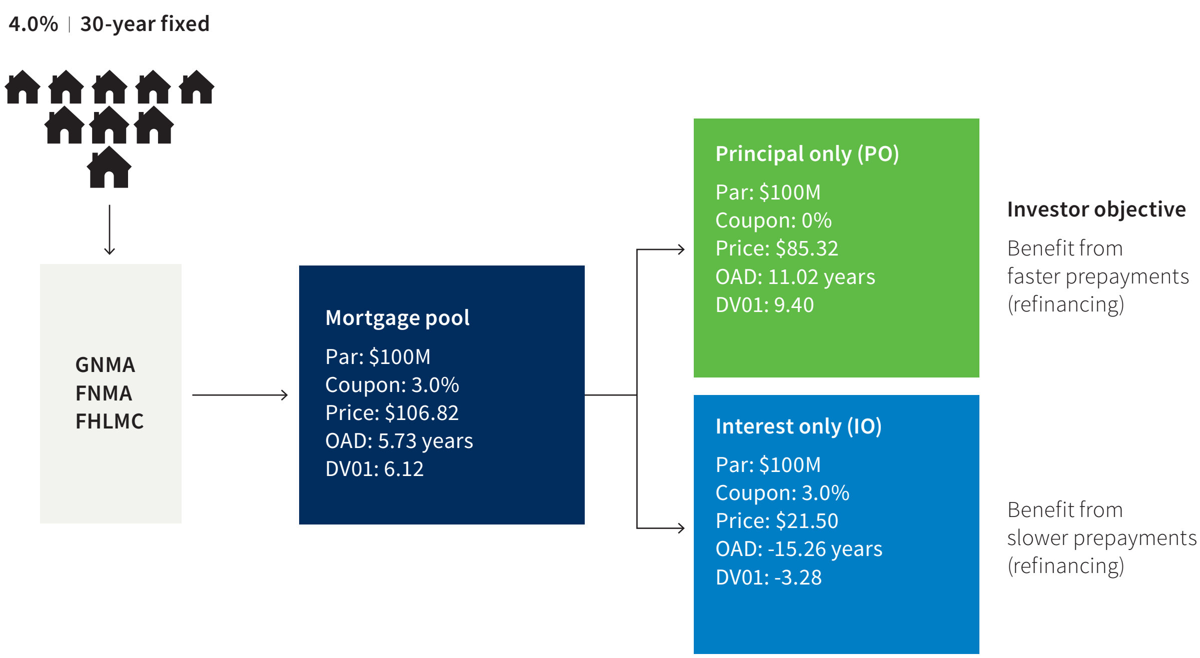
Creation of an IO

An IO is created when the mortgage pool is structured to direct the interest component of the monthly payments to an IO security and the principal component to a principal-only security. PO investors, such as insurance companies or banks, tend to appreciate more cash flow stability with lower volatility versus the IO. Conversely, an IO is subject to more cash flow uncertainty because the cash flows consist solely of interest payments that are a function of outstanding principal and are highly sensitive to prepayments.

As shown in Figure 2, the structuring process concentrates prepayment risk into the IO. The price of the pool equals the price of the PO plus the price of the IO ($106.82 = $85.32 + $21.50). The basis for the price split between the PO and the IO is the pool cash flow generated by the probabilistic model process described earlier. The scheduled principal and prepayment cash flows are directed to the PO, and the price is based on the present value of the cash flows. A PO is essentially a zero-coupon bond with principal repayment based on the scheduled and prepaid principal. The price is higher because there is more certainty associated with the scheduled principal. The interest cash flow is directed to the IO, and the price is based on the present value of the flows. That price is much lower with greater uncertainty of cash flow.

FIGURE 2

Example A, part 2: Mortgage pool and IO/PO construction



Source: Putnam.

For illustrative purposes only. The above example is not intended to be relied upon as a forecast, research, or investment advice, and is not a recommendation, offer, or solicitation to buy or sell any securities or to adopt any investment strategy. As with any investment, there is a potential for profit as well as the possibility of loss.

The mortgage pool is priced at $106.82 in Figure 2. Principal payments are received at $100, par value. For purposes of illustration, we can assume the pool is composed of one loan. If prepayments come in faster than anticipated, the pool owner may lose $6.82 in premium. An IO, which receives no principal payments whatsoever, is dependent on the outstanding principal to generate interest. If prepayments come in faster than anticipated and the principal balance is paid down to zero, there is no interest for the IO, and the full investment of $21.50 may be lost. Alternatively, the same scenario is beneficial for the PO investor.

If they pay $85.32 for the PO security and prepayments come in faster than anticipated, the PO investor may gain $14.68 ($100 – $85.32 = $14.68). Another way to frame the scenario: The sooner prepayments are received, the greater the present value of the PO; while less interest is generated, the price of the IO declines.

The combination of the IO/PO cash flows exactly replicates the cash flow of the pool. The par amount of the PO equals the par amount of the pool and is the principal received over time. The IO interest is calculated based on the total par amount of the pool, but the holder of the IO does not receive any principal payments. As it relates to the calculation of interest on the IO, the pool par amount may be thought of as a notional reference value.

Calculating the coupon of a mortgage pool

Pool coupon = IO coupon + PO coupon

3.00% * $100M = (3.00% * $100M) + (0% * $100M)

$3M = $3M + $0

OAD is also divided between the IO and PO securities. The allocation of interest-rate risk is driven by the interplay of prepayment cash flows and interest-rate movements. As interest rates rise, that risk is borne nearly entirely by the PO. Prepayments of principal slow dramatically, the PO extends, and the average time until repayment of principal is much longer. Coupled with a higher discount factor in the discounted cash flow price calculation due to increasing interest rates, the value of expected future principal payments is also lower. These two factors result in a substantial decrease in the present value of those payments. This gives the PO security a duration significantly longer than that of the original pool. The IO is affected in the opposite manner. As interest rates fall, the lower discount rate increases the value of the scheduled interest payments; however, because the interest payments decline/terminate when principal prepayments increase, it lowers the value of the IO. Typically, the termination of interest payments tends to dominate the effect of lower discount rates and results in a negative duration for the IO.[14] The dollar duration (DV01) of the IO/PO pairing replicates the DV01 of the pool under the assumption that all three (the pool, the IO, and the PO) are run at the same OAS.

The point to note is the negative OAD and DV01 of the IO. With this high degree of negative OAD and DV01, it is a relatively volatile asset.

Calculating dollar duration (DV01) of a mortgage pool

Pool DV01 = IO DV01 + PO DV01

(Pool price * Pool OAD) = IO price * IO OAD + PO price * PO OAD

($1.0682 * 5.73) = ($0.2150 * –15.26) + ($0.8532 * 11.02)

6.12 = –3.28 + 9.40

Note the negative OAD and DV01 of the IO, –15.26 and –3.28, respectively.

14 Alan J. Marcus and Arnold Kling, NBER Working Paper Series #2340: Interest-Only/Principal-Only Mortgage-Backed Strips: A Valuation and Risk Analysis, August 1987, https://www.nber.org/system/files/working_papers/w2340/w2340.pdf (accessed 11/9/2021).

IO cash flows and performance

At the highest level, the coupon interest earned by an IO drives the price of the security and is a function of how long the associated principal balance remains outstanding. The longer principal exists to generate interest, which may be earned by the investor holding the IO. Most interest-only strategies are negatively correlated to interest rates, demonstrating negative duration as shown in the earlier IO/PO example, and tend to outperform when interest rates are rising. As interest rates rise and mortgage rates move higher, there is less financial incentive for the borrower to refinance or prepay their mortgage. Prepayment speeds slow, principal remains outstanding longer, more interest income is generated by the IO security, and the price of the IO increases. This is in direct contrast to other fixed income securities, whose prices most often fall as interest rates rise.

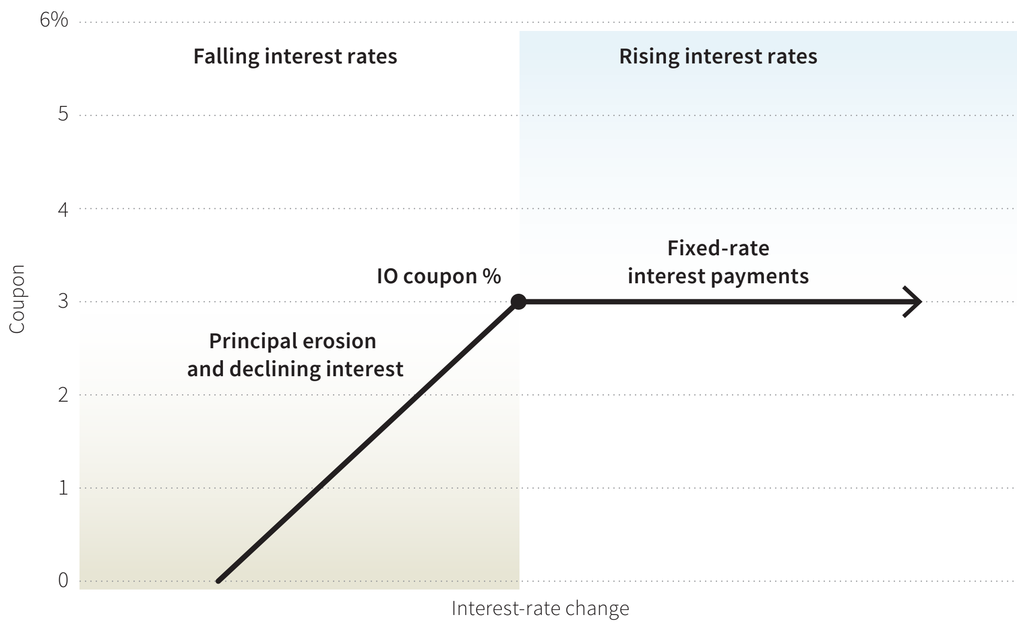
The price of an IO will generally fall in the opposite scenario. When interest rates are falling or remain very low, it creates an incentive for the borrower to refinance at a lower mortgage rate. As more borrowers refinance, prepayments increase, principal is reduced, the amount of interest earned decreases, and the price of the security falls. The IO is highly sensitive to prepayment speeds because the investor only receives interest payments; there are no principal payments. The investor loses the future interest payments when the original loan is paid off and the principal balance used to calculate the interest payment goes to zero.

Beyond the characteristic of negative duration, IO securities also display negative convexity. There is no obligation for the borrower to refinance, creating an asymmetry. If the economic incentive in a falling interest-rate environment is great enough, it prompts the borrower to act and refinance at a lower mortgage rate, resulting in principal erosion (contraction) and the IO investor losing future interest cash flows. However, there is no financial incentive for the borrower to refinance in a rising interest-rate environment. Principal remains outstanding for longer (extension), and the IO generates interest payments for a longer time. The degree of negative convexity, or asymmetry, is influenced by the backdrop of the existing mortgage market relative to the current environment. From a price perspective, if the security is priced at a discount, which typically occurs when expectations are for reduced interest, such as in a declining interest-rate environment, the asymmetry works against the investor. The security cannot extend further but may contract significantly if interest rates decline, borrowers refinance, and principal erosion occurs. Premium is the opposite scenario; as a premium-priced security extends, it may add a fair degree of balance, reducing asymmetry. The degree of convexity depends on the coupon of the IO security relative to those that are at the money, or in line with the current market. This is a more nuanced effect than experienced in the corporate bond market.

The above describes the general unhedged performance characteristics of an IO. In a rising interest-rate environment, the fixed-rate IO is capped at the existing fixed coupon rate (Figure 3). The pace of receiving unscheduled principal, or the prepayment speed, determines the steepness or flatness in our valuation example. The valuation charts (see Figures 3 and 6) are simplified representations of the typical unhedged experience.

FIGURE 3

Valuation of fixed-rate IO shows negative convexity as price declines with falling interest rates but remains flat above the IO coupon rate



Source: Putnam.

For illustrative purposes only. The above example is not intended to be relied upon as a forecast, research, or investment advice, and is not a recommendation, offer, or solicitation to buy or sell any securities or to adopt any investment strategy. As with any investment, there is a potential for profit as well as the possibility of loss.

Creation of an IO: The case of the inverse IO

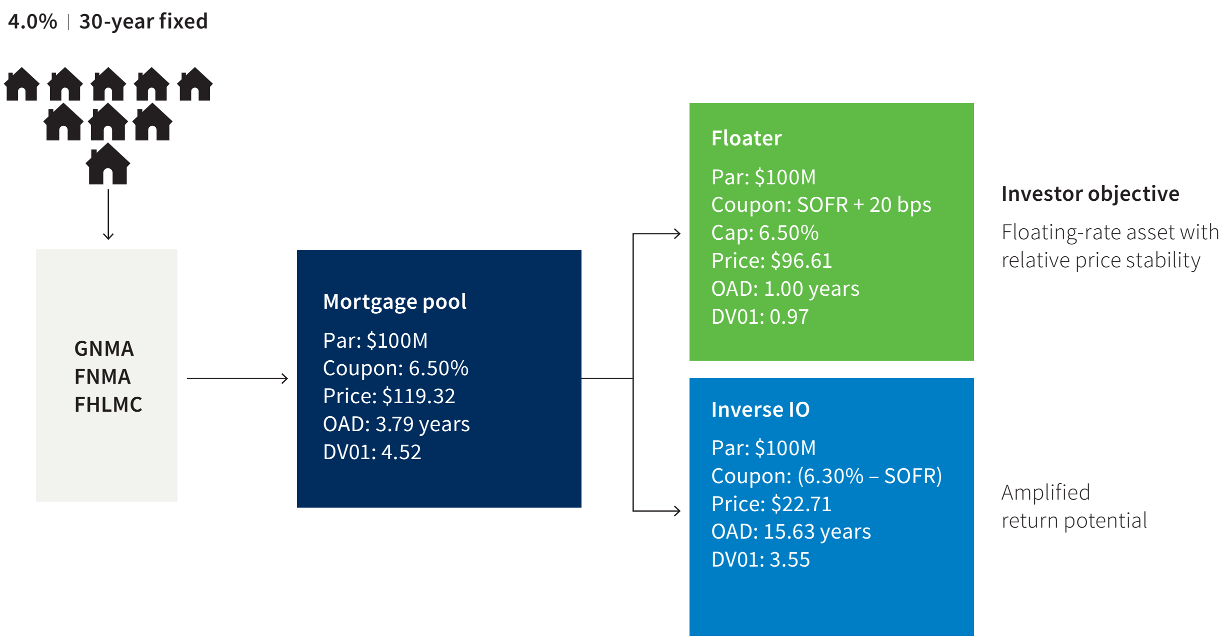
Another common example of IO construction is the inverse IO (Figure 4). The inverse IO (IIO) is created by stripping a floater from a fixed-rate pool. The coupon of the floater is based on a reference rate plus a spread. The floater also includes a cap on the coupon rate, a natural consequence of the underlying pool having a fixed-rate coupon. Once the floater is stripped from the pool, the resulting inverse IO also has a coupon that floats, but it is an inverse floater and moves in the opposite direction. The inverse IO also carries an effective floor. The spread, cap, and floater on the two tranches are coordinated so that the total interest cash flow matches the interest cash flow of the underlying mortgage pool. The scheduled principal and prepayments are directed to the floater tranche, while the inverse IO only receives its designated interest.

The structuring process also concentrates prepayment risk into the inverse IO. The price of the pool equals the price of the floater plus the price of the inverse IO ($119.32 = $96.61 + $22.71). The basis for the price split between the floater and the inverse IO is again the pool cash flow generated by the probabilistic model process described earlier. The scheduled principal and prepayment cash flows are directed to the floater along with its designated interest, and the floater price is based on the present value of the cash flows. The floater, because its coupon resets based on either a 1-month or 3-month reference rate, will price close to par. Similar to the IO construction in Example A, the inverse interest cash flow is directed to the inverse IO, and the price is based on the present value of the flows. Note that the inverse IO price is much lower than the floater and aligns with the greater uncertainty of cash flow, as also illustrated with the IO in Example A.

In Example B, the mortgage pool is priced at $119.32. Principal payments are received at $100, par value. If prepayments come in faster than anticipated, the pool owner may lose $19.32 in premium. The inverse IO, in the same vein as the IO, receives no principal payments and is dependent on the outstanding principal to generate interest. If prepayments come in faster than anticipated and the principal balance is paid down to zero, there is no interest for the inverse IO and the full investment of $22.71 may be lost. Alternatively, the same scenario is beneficial for the floater investor. If they pay $96.61 for the floater security and prepayments come in faster than anticipated, the floater investor may gain $3.39 ($100 – $96.61 = $3.39). Another way to frame the scenario: The sooner prepayments are received, the greater the present value of the floater, while less interest is generated and the price of the inverse IO declines.

FIGURE 4

Example B: Mortgage pool and inverse IO/floater construction



Source: Putnam.

For illustrative purposes only. The above example is not intended to be relied upon as a forecast, research, or investment advice, and is not a recommendation, offer, or solicitation to buy or sell any securities or to adopt any investment strategy. As with any investment, there is a potential for profit as well as the possibility of loss.

The floating coupons of the inverse IO and the floater must move in opposite directions and perfectly offset each other. In this example, the floater cap is activated when SOFR reaches 6.30%.

Calculating a pool coupon with inverse IOs and floater

Pool coupon = IIO coupon + Floater coupon

Pool coupon 6.50% = (6.30% – SOFR) * (Floater par / IIO par) + (SOFR + 0.20%, Max 6.50%)

When SOFR = 2.00%:

6.50% = (6.30% – 2.00%) * ($100M / $100M) + (2.00% + 0.20%, Max 6.50%)

6.50% = 4.30% + 2.20%

The pool coupon (6.50%) and the cap set on the floater (6.50%) define the par amount associated with each component. In this example, the par amounts of the three instruments are equal to one another because we have set the pool coupon and the floater cap both equal to 6.50%.

The inverse IO/floater pairing also preserves the replication of the pool's price, OAD, and DV01.

Calculating pool dollar duration with inverse IOs and floater

Pool DV01 = IIO DV01 + Floater DV01

(Pool price * Pool OAD) = IIO price * IIO OAD + Floater price * Floater OAD

($1.1932 * 3.79) = ($0.2271 * 15.63) + ($0.9661 * 1.00)

4.52 = 3.55 + 0.97

Note that the OAD of the inverse IO is amplified, similar to the negative OAD of the previous IO example; however, it demonstrates amplified *positive* duration because it reacts in the opposite manner of the IO. The inverse IO does continue to demonstrate negative convexity, but to a greater degree. The floater has a very low OAD, and its price will typically fluctuate very little. This implies that the price fluctuations of the pool are carried by the inverse IO and are also amplified in the same manner as the duration.

Inverse IO cash flows and performance

An inverse IO demonstrates different characteristics than a fixed-rate IO. An inverse IO is an IO with an inverse adjustable (floating) rate coupon. Instead of the coupon rate being calculated as a reference rate (typically, LIBOR or SOFR) plus a spread with a specified cap on the coupon rate, the inverse IO coupon is calculated as a fixed interest rate minus a reference rate with a coupon range based on a specified level of the reference rate.

Continuing the example, the inverse IO uses SOFR as the reference rate. In this example, the security has both an effective cap (6.50%) and a floor (0%) determined based on the level of SOFR.

The minimum coupon rate is 0% for this bond when SOFR rises above 6.30%; the security does not pay any interest. However, because this occurs in a rising-rate environment, the associated principal is more protected and less prone to prepayments.

If SOFR rises above 6.30% and the bond coupon resets to 0%, this effectively turns the inverse IO into an option — a derivative that may be compared in some respects to an interest-rate floor.

There is a subtle difference between the two.

1 The coupon formula for a rate floor, the minimum guaranteed coupon if interest rates fall, may look like:

MAX (SOFR + 0.20%, 6.50%)

In this instance, if SOFR falls below 6.30%, the coupon on the security will be 6.50% and is a rate floor. Corporate floating-rate bank loans can have a specified floor when the reference rate falls below a specified threshold.

2 The interest-rate derivative market version of an interest-rate floor has the coupon formula:

MAX (6.30% – SOFR, 0%)

If SOFR is above 6.30%, the coupon floor is 0%. But if SOFR is below 6.30%, it has a coupon greater than zero.

In the familiar instance of a rate floor, a threshold is established for the floor when interest rates are falling, while in the instance of the inverse IO, the threshold for the minimum coupon is established when interest rates are rising due to the inverse nature of the coupon calculation (see Figure 5).

FIGURE 5

Calculation of inverse IO coupons using SOFR rates

	Falling rates							Rising rates
SOFR	-1.00%	-0.50%	0.00%	1.00%	3.00%	5.00%	6.00%	6.50%
IIO coupon	6.50%	6.50%	6.50%	5.50%	3.50%	1.50%	0.50%	0.00%
	Max coupon							**Min coupon**

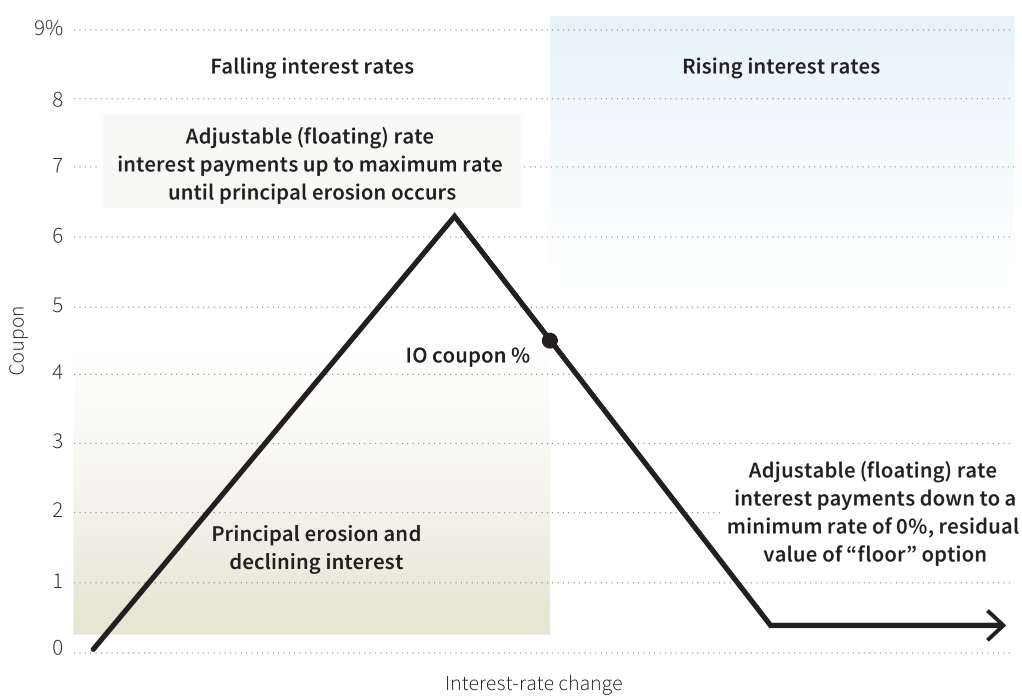
As a result, in a rising-interest-rate environment, interest payments will be lower as rates rise until they reach the minimum coupon rate of 0%. The inverse IO tends to underperform in a rising interest-rate environment, demonstrating positive duration as demonstrated earlier. Its floating-rate nature also creates exposure to the short end of the curve. In a falling interest-rate environment, interest cash flows will rise but only until principal erodes as borrowers take advantage of the lower rates and refinance (Figure 6). However, the value of the IO asset can grow: The potential to earn cash flow exists as rates fall and the price increases until principal degrades.

The security may not generate interest when rates move higher, but it does maintain value due to the potential for interest to increase if rates fall, at least until principal goes away.

Interestingly, many times investors shy away from inverse IOs when they have no cash flows and will likely sell them extremely cheaply (e.g., 1000 OAS). Understanding how to monetize the optionality when there are no cash flows can be an advantageous strategy. The valuation of the nonpaying inverse IO as essentially a floor may result in an opportunity: An investor can purchase it at a discount to the equivalent interest-rate floor.

FIGURE 6

Valuation of inverse IO — Payments increase as rates fall only until refinance threshold



Source: Putnam.

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Investing in prepayment securities

Analyzing refinancing behavior

Homeowners prepay their mortgage for various reasons, some of which are structural in nature — such as when a homeowner moves to a new home due to job relocation, marriage/divorce, or to upgrade living standards. In these events, dubbed "turnover," the homeowner typically sells the property and uses the proceeds to prepay/pay off the remaining principal balance due on their mortgage. These decisions are often driven by life changes rather than a financial incentive. While not as variable in nature as refinancing based on financial incentive, even an increase of 1 CPR in turnover can have a significant impact on the valuation of prepayment securities.

Prepayments driven by financial incentive can vary significantly over time due to changes in several factors, such as interest rates, home price appreciation, and government policy. The U.S. homeowners' option to prepay their mortgage at any time without penalty affords them the opportunity to take advantage of macroeconomic and mortgage industry developments for their own financial benefit. In such an event, the borrower refinances their mortgage by entering into a new loan agreement for the same property and uses all or a portion of the proceeds to prepay/pay off the principal balance on their existing loan. This optionality creates the potential for significant variability in prepayment speeds and is the primary driver of performance in prepayment markets.

Macro drivers

Understanding and analyzing the different macro environment variables and their influence, either alone or in combination, on prepayment speeds is crucial to successfully implementing a prepayment strategy.

Interest rates

Interest rates have historically been the most influential driver of prepayment speeds for traditional mortgage borrowers, and thus the price of prepayment-sensitive assets. When a borrower has the option to refinance their existing mortgage at a lower interest rate, they may be able to reduce their monthly payments and save money over the long run if the decrease in their interest payments exceeds the additional costs borne to originate the new mortgage loan. Since mortgage rates offered on new loans are driven by long-term interest rates (e.g., 10-year U.S. Treasury note), expectations for the long end of the U.S. yield curve play a key role in forecasting prepayment speeds.

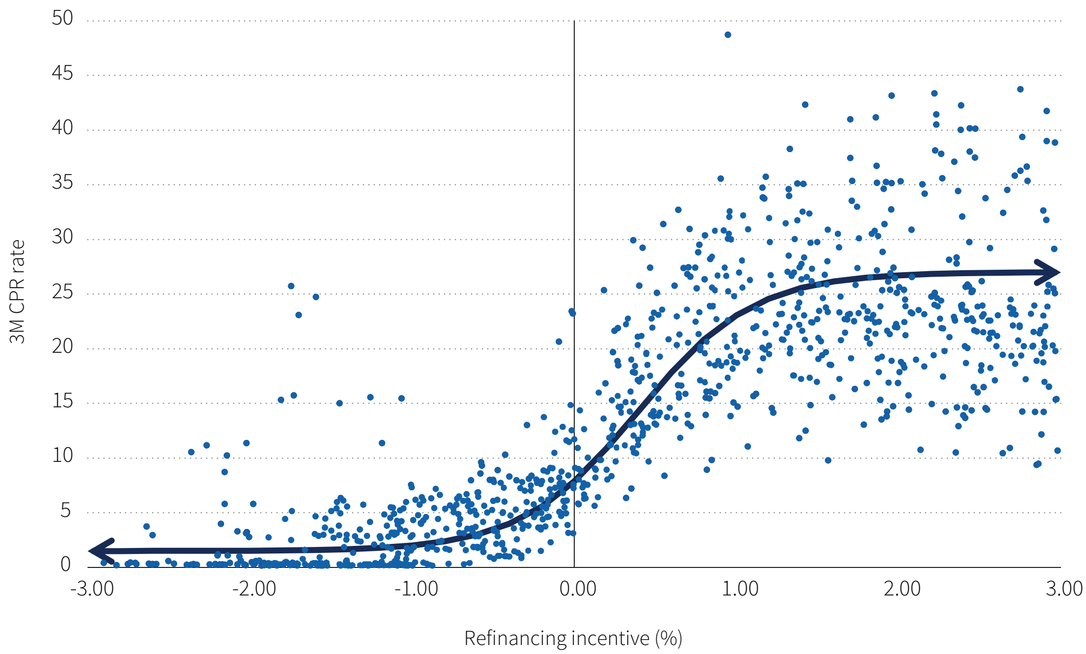
It is critically important to understand the context of the existing mortgage within the current interest-rate environment, such as the mortgage rates paid by existing borrowers relative to the prevailing mortgage rates offered on new loans. If most current borrowers have mortgage rates of 4% and the prevailing mortgage rate falls 100 bps from 4.5% to 3.5%, then a financial incentive arises for those borrowers to refinance. However, such an incentive does not result from a 100 bps drop if prevailing rates are at 5.5%.[15]

The borrower's response function to interest-rate movements is best illustrated by the "S curve" shown in Figure 7. The x-axis illustrates the interest-rate change a borrower may achieve if they refinanced (refinancing incentive), with the right side of the graph representing a decrease in their interest rate and, hence, a potential financial incentive to refinance. The left side represents an increase in interest rate for the borrower, and a potential financial disincentive to refinance. The y-axis displays the rate at which borrowers prepay their mortgages, represented by CPR. As seen on the left side of the graph, there is a relatively low percentage of borrowers that refinance even when they have a disincentive, a result of structural prepayments that are not driven by financial incentive (described previously as "turnover"). To the right side of the x-axis, the curve slopes upward as the refinancing incentive increases and borrowers capitalize on it, until it gradually levels off. The borrower response function to interest rates (the slope of the S curve) does change over time and is highly dependent on the existing mortgage market at the time. The evolution of government policy and technological advancements also impact borrower behavior and are addressed in subsequent sections.

15 Siddhartha Jha, *Interest Rate Markets: A Practical Approach to Fixed Income,* 1st Edition, Wiley, 2011.

FIGURE 7

Borrower refinancing behavior: The S curve



Sources: Bloomberg, Putnam, as of April 2021. For illustrative purposes only.

Interest rates may also fall to very low levels and remain there for a considerable period of time. In this scenario, prepayments typically spike in the early months as borrowers react to the newly created financial incentive. Over time, prepayment speeds are less likely to be as sensitive to further interest-rate movements because the bulk of borrowers who are interested and able to do so have already refinanced. This is termed "burn out."

Home price appreciation (HPA)

Another significant macro driver influencing the prepayment environment is home price appreciation. Faster HPA generally increases prepayment speeds through a variety of mechanisms such as higher turnover, easier and faster loan underwriting, and higher "cash out" refinancings. When a home increases in value, the borrower's equity in the home also increases, and default rates and loss severities decline. However, this gain is unrealized until the borrower either sells the home or unlocks the equity through a cash-out refi. This occurs when a borrower enters into a new loan agreement with a higher principal balance, which is made possible by the increased value of the property. A portion of the proceeds from the new loan are used to prepay the existing loan principal, and the remainder is made available to the homeowner. This type of refinancing activity becomes more popular when home prices rise substantially.

For example, consider a borrower who purchased a home for $250,000, currently owes $200,000 in principal, and has homeowner's equity of $50,000. If the home appreciates in value and is now worth $350,000, the homeowner's equity increases to $150,000. The borrower can access this equity by refinancing into a larger loan of $300,000, providing them with an extra $100,000 in cash for other expenses, e.g., building an addition to the home.

Due to the potential for faster prepayments, faster HPA can negatively impact the value of an IO, which in general tend to benefit from slower HPA and likely slower speeds. This is in contrast to bonds in the residential credit space, where faster HPA improves the borrower's equity in their home and makes it less likely for them to default on their mortgage.

Collateral factors

Within the context of the macroeconomic environment, it is important to remember that all borrowers do not necessarily behave in a similar manner. An individual borrower's response function can vary for a multitude of reasons, such as the terms of their current loan, their credit profile, and geography. As such, the collateral composition of a mortgage pool plays an important role in forecasting the pool's prepayment speed and the resulting impact on its cash flows.

Loan type and terms

Beyond the interest rate, there are several loan factors that affect a borrower's refinance incentive. The cost/benefit analysis must consider metrics such as principal balance, loan age, and loan-to-value ratio, among others. Consider the two borrowers outlined in Figure 8; both currently pay 5% interest on their mortgages at a time when prevailing mortgage rates are 4.5%. Both borrowers have a similar credit profile and can refinance at a rate of 4.5%; however, the first borrower has a $500,000 principal balance outstanding on their current mortgage, while the second borrower has $100,000 outstanding. In this scenario, the first borrower is much more likely to refinance and realize the cost savings than the second borrower, given the available information.

Similar calculations and comparisons can be made among the various loan maturities and interest-rate options available to borrowers. While the 30-year fixed-rate mortgage has historically been the most popular product, lenders also offer mortgages with shorter terms, including 20 years, 15 years, and 10 years. The length of the loan has significant implications for the borrower's amortized payment schedule and will impact the financial incentive accordingly. Also, borrowers may choose a fixed-rate mortgage that maintains a set interest rate throughout the life of the loan or an adjustable-rate mortgage that resets at specified periods based on a reference rate. As such, a borrower's response function to a change in market interest rates will differ depending on the interest-rate structure of their current loan.

There are also mortgage products that serve a different purpose than traditional mortgages, such as reverse mortgages. Reverse mortgages extend a line of credit to borrowers age 55 and older,[16] which allows retirees to access their home equity. Unlike a conventional mortgage, which amortizes over time, a reverse mortgage loan does not get repaid until one of a few possible events, including mortality, morbidity, or refinancing. The refinancing incentive to the borrower is quite narrowly beneficial, and unlike prepayment incentives on typical mortgages, the level of interest rates plays a weak role in the refinancing activity of reverse mortgages. Rather, policy changes have historically been the primary driver of refinancing events.

16 Borrowers must be 55 years of age in all states with the following exceptions: Louisiana, New Jersey, and Washington require 60 years of age, while North Carolina, Texas, and Utah require 62 years.

FIGURE 8

Comparison of refinancing incentives

	Borrower 1			Borrower 2		
	Current	Refi	Refi incentive	Current	Refi	Refi incentive
Home value	$750,000	$750,000	—	$750,000	$750,000	—
Principal balance	$500,000	$500,000	—	$100,000	$100,000	—
Term (months)	360	360	—	360	360	—
Interest rate	5.0%	4.5%	0.5%	5.0%	4.5%	0.5%
Monthly payment	$2,684	$2,533	$151	$537	$507	$30
Total interest due	$466,479	$412,034	**$54,445**	$93,256	$82,407	**$10,849**

Source: Putnam.

Borrower credit and demographics

A borrower's credit profile impacts not only their ability to access credit, but also the mortgage rate they are offered and the lending platform under which they may qualify. These factors can influence the borrower's response function to the refinance incentive and are important to consider within the context of the macro environment when determining the rate at which a given pool of loans will prepay. Compare two borrowers currently paying 5% interest on their mortgages at a time when the prevailing mortgage rate is 4.5%. Ostensibly, both borrowers have an incentive to refinance at the lower rate. However, if one of these borrowers has a credit score (FICO) of 800 and the other a FICO of 690, lenders will likely offer them different mortgage rates. The borrower with the higher FICO score may receive a mortgage rate of 4.5%, in line with the prevailing mortgage rate, which maintains the refinance incentive. If the second, weaker borrower receives a mortgage rate of 4.8%, the potential interest savings from refinancing may not exceed the additional costs associated with the refinancing process, eliminating the incentive. The adjustment to the mortgage rate for borrower quality characteristics is outlined in more detail within the "Security selection: Assessing underlying collateral section" (see page 26).

What is a FICO score?[17]

The FICO score is a widely used metric by mortgage lenders to help assess the likelihood a loan applicant will repay their loan. The score was created by Fair, Isaac and Company (now known as FICO). A borrower's FICO score impacts their ability to receive credit and the interest rate charged on the loan. Scores range from 300 to 850 and incorporate five key data points from an individual's credit report: payment history, amounts owed currently, length of credit history, new credit, and credit mix (types of credit).

History has shown that the geography of the borrower and property also influence the refinancing incentive and/or the borrower's behavior. The reasons for this vary. Some states have more rigorous local regulations that affect the ease and speed with which a refinance can be processed. Others, such as New York, impose additional taxes that result in higher up-front costs for the borrower, thereby decreasing the refinance incentive for its residents. Cultural factors may also play a role. For instance, borrowers in Puerto Rico have historically shown a greater reluctance to refinance their mortgages despite a clear financial incentive, and as a result, collateral in Puerto Rico tends to prepay slower than in other regions.

17 https://www.myfico.com/credit-education/whats-in-your-credit-score (accessed 9/24/2021).

Non-model considerations

Government policy

The U.S. government plays a key role in the functioning of the mortgage finance system and the agency MBS market. Housing policies, such as those implemented through the FHFA and GSEs, can impact the affordability and availability of mortgage financing and are subject to ever-changing political, economic, and financial considerations. As such, prepayment speeds can be influenced by new or changing government policies and are an important consideration of the valuation process.

For example, the FHFA implemented the Home Affordable Refinance Program (HARP) in the wake of the 2008 housing crisis when many borrowers found themselves "under water"; the principal they owed on their mortgage exceeded their property value. HARP encouraged borrowers that remained current on their mortgage payments to refinance despite the decline in their home's value. This led to meaningful differences in prepayment speeds in mortgage pools with otherwise similar collateral characteristics.

The process to comprehensively evaluate policy risk and its impact on an individual security's cash flows is important in determining the risk/reward trade-off in prepayment-sensitive sectors. Policy risk is ever evolving and does not fit within the constraints of a quantitative model, thus requiring careful consideration of policy changes on model inputs and outputs.

All models try to fit historical data, but there is no such thing as a perfect fit in empirical data modeling. As a result, irrespective of sophistication, all models have inherent biases and constraints. Being aware of these biases allows for improving and deepening the security selection process.

Technology's impact on the mortgage industry

In the wake of 2008, lenders such as Quicken Loans, Guaranteed Rate, and LoanDepot emerged as a growing source of mortgage credit. Through technological innovation, they offer borrowers a more seamless and streamlined application process that is now conducted almost entirely online. The growth of fintech accelerated during the pandemic as companies were]forced to adopt technology to continue operations remotely at a time when the mortgage industry faced a surge in demand. The result offers benefits to both borrowers and lenders.

Improved experience: Applicants can receive preapproval within minutes, connect to their financial institutions electronically for streamlined asset verification, sign documents from a mobile device, and access tools (e.g., real-time payment calculators) that may improve their decision-making.

Faster originations: On average, fintech lenders process mortgage applications 20% faster than non-fintech lenders (approximately 10 days).[18] The increased efficiency is even more pronounced for refinance applications.

Supply elasticity: Increased automation of underwriting processes and electronic data collection reduces the effect of staffing constraints, allowing fintech lenders to respond rapidly to surges in demand.

In an industry where profitability is driven by volume, technology that allows originators to process loans more quickly and nimbly accommodate fluctuating demand is a disruptor. Traditional mortgage lenders have taken notice and are increasingly implementing similar technology on their own lending platforms. The result is a more efficient mortgage industry and, in turn, an increased borrower response rate to refinance incentives as evidenced by a historically steep S curve during the most recent refinancing wave.

18 FRBNY, "The Role of Technology in Mortgage Lending," February 2018 (accessed 11/5/2021).

Security selection

Assessing underlying collateral

An agency mortgage pool comprises thousands of underlying mortgages with similar maturities (e.g., 30 years) and interest rates. At first glance, an investor may view two recently issued mortgage pool securities with the same maturity and weighted average coupon (WAC) as identical, and thus be ambivalent about which to purchase. However, the collateral underlying these securities can consist of a very different mix of characteristics that potentially impact the pool's prepayment speed (see descriptions below).

Key metrics for evaluating prepayment securities

Spread at origination (SATO)

SATO measures the credit premium borrowers pay over the prevailing market rate to account for the higher credit risk associated with the borrower. This metric amalgamates a number of factors related to a loan's credit profile, including observable metrics such as the borrower's FICO score and the loan-to-value (LTV) ratio, as well as unobservable metrics, such as the borrower's previous payment history. On average, SATO is a good measure of the pool's credit profile and can help ascertain whether the underlying borrowers may face additional frictions that make it harder for them to refinance.

Loan age

Borrowers tend to be more responsive to a refinance incentive in the first 1 to 2 years after their loan is originated. This is largely a behavioral phenomenon, partly because a recent borrower will face fewer frictions during the underwriting process, as well as the complacency and comfort felt by more seasoned borrowers that have been paying their mortgage for several years.

Loan purpose

Mortgages can be originated to purchase a home or to refinance an existing loan. Additionally, the mortgage may be used to purchase the borrower's primary residence or to finance an investment property used for rental income. This data is provided to investors and can be helpful in understanding the underlying borrower behavior.

Originator type

With the regulations placed on banks in the wake of the 2008 financial crisis, an increasing number of non-bank lenders have entered the industry and increased their market share. These lenders have developed and adopted technology to help build their platforms, which has led to notably faster prepayment speeds on the loans they originate.

Geographical distribution

As discussed previously, borrower behavior can be influenced by local regulations and/or customs. The geographic distribution of the underlying collateral can have a material impact on the pool's prepayment rate.

Identifying value

Most prepayment market participants use one of the predominant vendor models (e.g., Yield Book, Bloomberg) to evaluate prepayment securities. These are sophisticated and complex models that consider various aspects of the collateral, such as weighted average coupon, loan size, loan age, SATO, loan-to-value, purpose of loan, geographical distribution of borrowers, type of originator, and the specific servicer, to project future probability of prepayments and the resulting future cash flows. After averaging spread expectations across hundreds of simulations of forward interest rates, the resulting output is an option-adjusted spread that can be used to assess a security's worth and determine its value relative to other securities in the sector. Many investors take a black-box model approach, making investment decisions based upon the off-the-shelf model output.

The market generally allows a risk premium for securities that are most susceptible to errors in these commonly used prepayment models. We find the pricing of this risk premium to be inconsistent, which creates potential opportunities to buy and sell securities with inefficient prepayment pricing. In particular, we believe the agency IO sector provides a relatively liquid market for isolating and capitalizing on these inefficiencies. We use the third-party vendor models and then adjust various inputs and assumptions to tailor the models to our specifications, inherently creating a custom model. This allows us to compare the outputs from our custom model with the off-the-shelf model(s) to identify pockets of value that may be overlooked, or conversely, pinpoint overvalued securities. Given the complexity of this model, significant effort is expended monitoring its outputs. As an example, our monitoring system compares the mortgage rate being used by the model with what is truly available to borrowers in the primary market. We use periods of dislocation between the actual primary rate and model to capture value.

We also closely track prepayment speed errors in the third-party models for various collateral types. We are proactive in reviewing sectors that are either paying much slower or faster than model projections, because these have the potential to be significant return opportunities and are, in fact, the first indicator of changes in the prepayment environment. Each month when prepayment speeds are released, we conduct a rigorous analysis of sectors where the model seems to be missing on speeds and use that as feedback to determine what changes, if any, need to be made to the model parameters. Any differences between model speeds and actual speeds provide opportunities to pursue alpha.

Value is ultimately determined using a combination of an OAS framework and manager insights into non-modellable aspects of the investment process, such as policy risks and regime shifts. An OAS framework works well when the future is anticipated to behave like the past: The model is, after all, a calibration of prior empirical data. This "static-ness" can be disrupted by policy risks or market factors that change the S curve and the prepayment environment. Additionally, technical factors, such as supply/demand, the performance of related sectors such as MBS pools, TBAs, and demand for the PO or floater play a role in determining value for various types of bonds in the agency IO market.

Prepayment strategies as part of a broader portfolio

As concerns surrounding rising interest rates and inflation continue to percolate throughout the economy, many investors are seeking strategies to diversify their fixed income exposure away from more interest-rate and corporate credit-sensitive sectors. Among the four principal risks inherent to fixed income investments (credit, interest rate, liquidity, and prepayment), we believe prepayment risk may be underrepresented as a risk premium in many global investors' fixed income portfolios. Agency IOs tend to receive less attention from investors due to the specialization required to extract value and the sector's relatively small size. However, we believe this segment of the market offers exposure to a risk premium that can complement portfolios and provide significant diversification benefits.

Diversification and correlation

Agency IO securities have historically performed better and tend to increase in value in rising interest-rate environments as U.S. homeowners lose the incentive to refinance. Consequently, they are often used to hedge portfolios against interest-rate risk. For example, in a Federal Reserve tapering environment, the Fed gradually slows the pace of large-scale asset purchases initially designed to support the economy and subsequently reduces its balance sheet by not replacing maturing securities. A prominent example of tapering as well as the diversification benefit of agency IOs was experienced in 2013. Fears that the Fed was beginning to unwind its accommodative policy following the GFC led to a spike in market interest rates. During this time, interest-rate and credit-sensitive strategies generally underperformed, while agency IO securities experienced positive excess returns versus Treasuries.

Additionally, we believe agency IOs to be a good diversifier as a part of a broader portfolio given their historically low correlation versus other asset classes, including other types of structured credit. The low correlations stem from the fact that agency IOs are exposed to a different risk premium, prepayment risk, and investing in agency IOs is one of the purest ways of expressing a view on the prepayment environment. The factors that drive prepayment behavior are independent of factors that drive the balance sheets of other asset classes.

The diversification benefit of agency IO securities can be demonstrated through empirical correlation analysis. Running correlation analysis on various financial sectors is useful because it helps measure and quantify the degree of association between the sectors based on historical returns. Effective portfolio diversification is enhanced when assets are either uncorrelated or negatively correlated. Typically, a correlation between two variables of less than 0.60 is considered lower/weaker, and a correlation of less than 0.30 generally indicates there is no linear correlation or relationship. The correlation table below (Figure 9), constructed using duration-hedged monthly returns to remove the effect of duration, illustrates that agency IO securities have had very low correlations and, in some cases, nearly no linear relationship to other sectors. Given these low correlation values, agency IO securities prove to be very effective in diversifying portfolio exposure and helping to mitigate risk.

FIGURE 9

Correlation of duration-hedged monthly excess returns, 10 years rolling

		Corporate debt				Equities				Securitized			
		Global	U.S.	Euro	U.K.	Global	U.S.	Euro	U.K.	NA RMBS	Agency IO	CMBS	Agency MBS
Corporate debt	Global	—											
	U.S.	0.98	—										
	Euro	0.91	0.83	—									
	U.K.	0.86	0.78	0.86	—								
Equities	Global	0.74	0.72	0.68	0.66	—							
	U.S.	0.65	0.64	0.59	0.55	0.94	—						
	Euro	0.75	0.71	0.74	0.72	0.90	0.77	—					
	U.K.	0.70	0.67	0.65	0.66	0.84	0.71	0.94	—				
Securitized	NA RMBS	0.56	0.53	0.50	0.53	0.35	0.25	0.43	0.39	—			
	Agency IO	0.16	0.13	0.14	0.11	(0.04)	(0.06)	0.02	0.01	0.20	—		
	CMBS	0.43	0.40	0.39	0.46	0.34	0.26	0.38	0.44	0.47	0.14	—	
	Agency MBS	0.43	0.40	0.39	0.39	0.27	0.17	0.39	0.45	0.29	0.33	0.32	—

Sources: Bloomberg, Putnam as of 4/30/22. For illustrative purposes only. Indices used in the above calculations include the Bloomberg Global Aggregate Corporates Index (USD hedged), Bloomberg U.S. Corporate Index, Bloomberg Euro-Aggregate Corporates Index (USD hedged), Bloomberg Sterling Aggregate Corporates Index (USD hedged), MSCI World Index (USD hedged), S&P 500 Index, Stoxx Europe 600 USD, and the FTSE 100 USD. Where there is no available representative index, data is based on a universe of securities selected by Putnam that are representative of various fixed income sectors and subsectors within the mortgage market. Past performance is not a guarantee of future results. Diversification does not assure a profit or protect against loss. It is possible to lose money in a diversified portfolio.

Historical returns versus other fixed income sectors

An important consideration when analyzing a diversified portfolio is the excess return generated by the various sector allocations within the portfolio. Additionally, investors generally focus on maximizing returns in the context of managing risk. The Sharpe ratio may be used to measure the risk-adjusted performance of individual sectors, as well as the portfolio itself, by comparing the associated total returns in excess of the risk-free rate per unit of volatility (standard deviation of total return). In general, a higher Sharpe ratio is preferred as it means that the sector or portfolio has achieved a better return relative to its risk. If two sectors offer similar returns, the one with the higher standard deviation will have a lower Sharpe ratio, and in order to compensate for the higher standard deviation, the sector must deliver correspondingly higher returns to maintain a higher Sharpe ratio. The Sharpe ratio is a good measure of how much additional return an investor earns by taking on additional risk.

In Figure 10, most sectors have demonstrated Sharpe ratios of either above 1 or close to 1. A Sharpe ratio above 1 indicates that the sector is achieving higher returns above the risk-free rate relative to its risk. However, the agency IO sector has achieved a Sharpe ratio of 0.14 during the same time period. This is due to the fact that the total return used in the numerator for the agency IO calculation includes embedded duration. Agency IO securities exhibit negative duration, meaning that as interest rates rise, the prices of agency IOs also rise, and vice versa. During the historical time period reflected in the Sharpe ratios calculated below, interest rates have declined overall, and since agency IOs exhibit negative duration, this has weighed more heavily on returns compared with other sectors and has contributed to heightened volatility. When investing in agency IO securities, using the total unhedged return in the numerator results in a skewed Sharpe ratio for agency IOs compared with other asset classes.

The information ratio (IR) is also a measure to gauge risk-adjusted returns; however, it compares excess returns wth the returns of a benchmark, while also accounting for the volatility of those returns. In other words, the IR represents risk-adjusted alpha. In general, the higher the IR the better, and if the IR is less than zero, it signifies the manager did not achieve the objective of outperforming the benchmark.

With regard to agency IOs, unlike the Sharpe ratio formula in which the unhedged total return is used in the numerator, the information ratio uses duration-hedged excess returns, eliminating the duration bias. The duration of our agency IO securities is managed at the portfolio level. This is accomplished by aggregating the term structure exposure of each bond via four risk factors: level, slope, bend, and wave at the portfolio level. These factor exposures are matched by building a replicating basket of swaps/swaptions for the term structure exposures. The resulting duration-hedged excess return equals the total return of agency IOs minus the total return of the basket of hedging securities.

As evidenced in the table below, the agency IO sector has achieved an information ratio of 0.73 since 2009, showing that the sector has outperformed on a risk-adjusted basis (Figure 11, on following page).

FIGURE 10

Annual excess returns over risk-free rate and Sharpe ratios

Since 2009	INV GR Corporates	HI YLD Corporates	LOANS	EM USD	S&P 500	MSCI World	NA RMBS	Agency IO	CMBS	Agency MBS
Annual excess return	4.50%	8.95%	7.11%	5.84%	13.76%	10.25%	11.05%	2.55%	5.59%	1.46%
Annual volatility	5.53	8.09	6.19	7.03	14.78	15.23	9.70	18.82	6.25	2.84
Sharpe ratio	0.81	1.11	1.15	0.83	0.93	0.67	1.14	0.14	0.89	0.51

Sources: Bloomberg, Putnam as of 4/30/22. Data is provided for informational use only. Past performance is no guarantee of future results. IG corporates are represented by the Bloomberg U.S. Corporate Index. High yield is represented by the Bloomberg U.S. High Yield Index. Loans are represented by the S&P/LSTA Leveraged Loan Index. Emerging market debt is represented by the Bloomberg EM USD Aggregate Index. S&P 500 is represented by the S&P 500 Index. MSCI World is represented by the MSCI World Index (USD hedged). Where there is no available representative index, data is based on a universe of securities selected by Putnam that are representative of various fixed income sectors and subsectors within the mortgage market. Diversification does not assure a profit or protect against loss. It is possible to lose money in a diversified portfolio.

FIGURE 11

Annual excess returns over duration-matched swaps and information ratios

Since 2009	INV GR Corporates	HI YLD Corporates	LOANS	EM USD	S&P 500	MSCI World	NA RMBS	Agency IO	CMBS	Agency MBS
Annual excess return	2.78%	7.65%	7.69%	4.14%	14.37%	10.84%	8.57%	8.38%	7.22%	0.40%
Annual volatility	5.28	8.91	6.21	7.77	14.82	15.27	7.98	12.13	6.85	1.86
Information ratio	0.53	0.86	1.24	0.53	0.97	0.71	1.07	0.69	1.05	0.21

Sources: Bloomberg, Putnam as of 4/30/22. Data is provided for informational use only. Past performance is no guarantee of future results. IG corporates are represented by the Bloomberg U.S. Corporate Index. High yield is represented by the Bloomberg U.S. High Yield Index. Loans are represented by the S&P/LSTA Leveraged Loan Index. Emerging market debt is represented by the Bloomberg EM USD Aggregate Index. S&P 500 is represented by the S&P 500 Index. MSCI World is represented by the MSCI World Index (USD hedged). Where there is no available representative index, data is based on a universe of securities selected by Putnam that are representative of various fixed income sectors and subsectors within the mortgage market. Diversification does not assure a profit or protect against loss. It is possible to lose money in a diversified portfolio.

It was noted earlier that other investment managers typically use agency IOs, given their negative duration characteristic, to hedge their broader portfolio duration. Rather than use agency IOs as a duration hedge, we invest in IOs as a prepayment strategy and hedge the strategy's duration, seeking to capture the prepayment risk premium rather than be subject to the interest-rate risk of the securities. This approach is intended to provide our investors with the attractive duration-hedged, risk-adjusted return potential of the strategy whether in the context of a multisector fixed income portfolio or a stand-alone prepayment portfolio.

Consider investing in prepayment risk

Of the four primary bond risks, prepayment risk is typically underrepresented within investor portfolios because of the limited degree of market understanding. The heart of the challenge lies in analyzing the unique ability of the U.S. homeowner to prepay their mortgage loan at any time without a penalty. We believe successful investing in prepayment strategies requires a thorough understanding of the mortgage market, cash flow structuring, and the means to analyze borrower behavior incentives in order to identify and extract value.

Agency IO securities are the purest expression of prepayment risk. While IOs may exhibit a high degree of volatility based on their sensitivity to borrower refinancing, they are demonstrable risk mitigants within a broader portfolio when duration is hedged. Hedging the interest-rate risk of the strategy also allows for the capture of prepayment risk premium and an attractive risk-adjusted return potential.

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