Signaling in the Mortgage Market

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Summary: Asymmetric information is a defining feature of mortgage markets. Borrowers often know more about their own characteristics than they can credibly disclose to lenders. Lenders often know more about the riskiness of the loans they have made than do potential investors. In the face of such information asymmetries, the mortgage market has developed many mechanisms in which informed participants take costly actions that credibly reveal their information to other market participants. For example, a mortgage borrower might select a mortgage from a menu that features a low interest rate and high mortgage points, thereby revealing a low propensity to prepay. Alternatively, the seller of a mortgage-backed security (MBS) may retain a portion of the MBS to demonstrate that the deal has low risk of default. Such information revelation mechanisms constitute signaling in the mortgage market.

This review provides an overview of signaling in the mortgage market. Its first goal is to provide a transparent and flexible theoretical framework that illustrates the core economic forces behind signaling applied to the mortgage market. The second goal is to provide an overview of the literature on the topic covering both theoretical insights and supporting empirical evidence with a focus on data from the US.

Keywords: Mortgage markets, asymmetric information, signaling, screening, securitization.

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The US Mortgage Intermediation Chain: Asymmetric Information and Signaling

The stock of outstanding mortgage debt in the US totaled more than $19 trillion by the fourth quarter of 2024. This includes more than $15.5 trillion of mortgages secured by residential real estate and more than $3.6 trillion secured by commercial properties.[2] The size of the mortgage market makes it one of the largest debt markets in the US, rivaling the economic significance of the Treasury and corporate bond markets. Moreover, the growth and development of this market have been instrumental in shaping the balance sheet of the typical American household.[3] Given the size and importance of the mortgage market, it is vitally important for economists to understand the frictions and resulting equilibrium outcomes that shape it.

While a number of different types of mortgages are available in the US, the 30-year fixed rate mortgage (FRM) is by far the most common. These mortgages offer a fixed interest rate for the life of the mortgage and, crucially, are prepayable without penalty. When interest rates fall, borrowers with an FRM may refinance by taking out a new mortgage with a lower rate or sell their existing house to purchase a new one with a lower rate mortgage. This option poses a risk for the investors that hold FRMs because they face the potential of having the duration of their holdings shorten substantially precisely when reinvestment yields a lower return, a problem broadly referred to as prepayment risk. In addition to being prepayable, all US mortgages are defaultable. Depending on the state in which the mortgaged house is located, lenders may have no recourse to the borrower in the event of default. Thus, there are two main risks facing investors in the mortgage market: prepayment and default.

Mortgage markets in the US are also complex and entail a long intermediation chain connecting investors to borrowers. Consider a typical residential mortgage: it may be originated by a non-bank lender, insured against default, then sold to an aggregator who pools it with other mortgages. These pools are purchased by securitization sponsors such as investment banks, structured into mortgage-backed securities (MBS), and sold to investors as bonds with different risk profiles. At each step, asymmetric information can arise because borrower quality, income

[2] Source: Board of Governors of the Federal Reserve System (2025)

[3] Source: U.S. Census Bureau (2024)

characteristics, collateral values, and prepayment propensity can all be difficult for market participants to credibly disclose or verify. For example, a borrower in a 30-year FRM may know much more about their own ability to monitor interest rates and determine an optimal refinancing strategy than do potential lenders. These informational frictions provide scope for costly mechanisms for conveying private information—for example, when a lender retains a mortgage on balance sheet prior to sale (costly signaling) or when a borrower selects a mortgage with points from a contract menu (screening). This broad class of costly information-transmission mechanisms can collectively be referred to as *signaling*. Studying them helps explain otherwise puzzling features of mortgage markets—such as the prevalence of multi-tranche securities or the decision by lenders to delay loan sales despite apparent gains from trade.

Figure 1 shows a schematic of the mortgage intermediation chain from borrowers who obtain mortgages through to the eventual investors who ultimately finance these mortgages through their purchase of MBS. At multiple links in the chain, market participants take actions to mitigate asymmetric information through signaling or related activities. This review summarizes the economic literature that studies these mechanisms and provides a simple theoretical framework to understand signaling in the mortgage market. It begins with a brief overview of evidence on information asymmetries, then presents a model that highlights two core mechanisms for conveying private information—menu design at origination and lender risk retention (including seasoning). The framework is used to organize and interpret empirical findings drawn mostly from data on the US mortgage market. Findings that apply to the primary market in which mortgages are originated through to later stages of intermediation are discussed. The review concludes with implications and directions for future research.

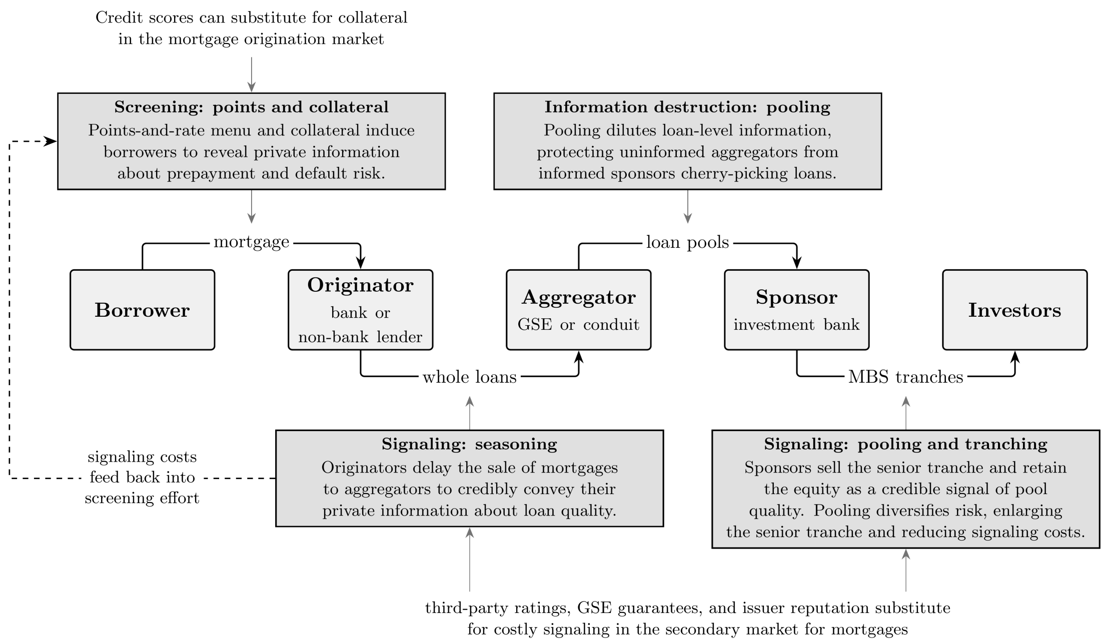

Figure 1: Signaling and screening along the mortgage intermediation chain.

Adverse Selection in the Mortgage Market

A necessary condition for signaling to be present is some asymmetry of information between agents in the market. Before going on to specifically discuss signaling, a brief overview of the extensive literature on asymmetric information problems present in mortgage markets is in order. In order to organize this literature, it is useful to categorize agents in the mortgage markets into three broad types: borrowers, lenders, and investors. Borrowers are those households that obtain a mortgage using real estate as collateral. Lenders are the banks and non-bank intermediaries that originate and fund the mortgage. Finally, investors are the agents who purchase the mortgages from lenders and hold them for investment purposes. While all three types of agents interact in mortgage markets, borrowers and lenders are typically the participants with private information relevant to a mortgage's value. Moreover, there are two broad categories of information that each of the agents could have. Namely, an agent can have private information about default risk (including about expected recovery in the event of default) or prepayment risk. When such private information is present, market participants potentially face an adverse selection problem in the manner of the seminal work of Akerlof (1970).

There is extensive empirical literature documenting adverse selection in consumer credit markets. This literature often indicates that borrowers have private information about their own default risk. For example, randomized credit-card solicitation experiments show that consumers who respond to higher-APR offers subsequently default more, consistent with the idea that such offers adversely select borrowers (Agarwal, Chomsisengphet, and Liu 2010). In subprime auto credit, higher-risk borrowers often select larger sized loans (Adams, Einav, and Levin 2009; Einav, Jenkins, and Levin 2012). There is also evidence that online consumer-lending platforms use maturity menus to screen risk: higher-risk borrowers select longer-maturity, higher-APR options when they are available (Hertzberg, Liberman, and Paravisini 2018). Evidence from the payday loan market is similar: borrowers that select larger loans are more likely to default (Dobbie and Skiba 2013).

In mortgage markets, some of the earliest evidence on adverse selection indicates that borrowers have private information about their own prepayment risk (Brueckner 1994). There is also evidence that higher-risk borrowers choose low-documentation loans when they are available: borrowers with verifiable income who choose low-documentation loans have substantially higher default rates (Ambrose, Conklin, and Yoshida 2016). Subsequent work decomposes the correlation between leverage and default into moral hazard and adverse selection and attributes the majority of the correlation to adverse selection, indicating that mortgage borrowers have substantial private information about their own default risk, especially for low-documentation loans (Gupta and Hansman 2022).

There is also extensive literature examining how asymmetric information shapes the secondary market for mortgage credit, in which loans are pooled and sold to investors. A common finding in that literature is that originating lenders possess private information about loan performance—particularly regarding both default and prepayment risk—and use it strategically when deciding which loans to securitize. Lenders tend to securitize loans with higher prepayment risk and retain those expected to prepay at a slower rate, indicating adverse selection on prepayment (Downing, Jaffee, and Wallace 2009). Loans placed in private-label securitizations default more often than observably similar loans sold to the US government-sponsored entities that provide guarantees against default (Elul 2016). Further evidence shows that loans that are ex ante more likely to be sold given measured characteristics exhibit weaker underwriting. At the same time, loans that are sold perform better ex post than those retained, implying that investors acquire information between origination and sale that partly offsets lenders' informational advantage (Jiang, Nelson, and Vytlacil 2014). In the prime mortgage market, there is evidence that lenders retain loans with higher expected default but lower prepayment probability while selling loans with the opposite characteristics (Agarwal, Chang, and Yavas 2012). Investors appear to recognize and price these frictions; securitizations backed by loans from less transparent or lower-reputation lenders have higher spreads and greater credit enhancement. This finding is consistent with the idea that investors demand compensation for hidden default risk (An, Deng, and Gabriel 2011; Demiroglu and James 2012). Collectively, these findings indicate that informational frictions in securitization include both default and prepayment dimensions. Moreover, these frictions affect which loans are sold, how they are priced, and how risk is allocated between lenders and investors.

Summing up, this empirical evidence demonstrates that asymmetric information is a pervasive feature of mortgage markets, indicating significant scope for mechanisms such as signaling and screening to arise in equilibrium.

A Simple Model of the Mortgage Market

A simple model of the mortgage market can formalize how costly information transmission, such as signaling and screening mechanisms, shapes equilibrium outcomes in mortgage markets. At the center of this model is a mortgage contract that pays a continuous coupon until termination through prepayment, default, or maturity. Depending on which agent (borrower, originator, or secondary market investor) has private information, different informational frictions emerge. In each scenario, informed agents take actions that credibly signal their private information in equilibrium. These signaling equilibria in turn give rise to empirically testable implications.

Before specifying particular informational environments, it is useful to introduce the basic mortgage contract at the center of the analysis. Time, denoted by t, is continuous and infinite. At time $t = 0$, a borrower enters a mortgage contract and receives net proceeds normalized to $1 - m$, where m represents upfront mortgage points paid to the lender. Assume the borrower is eligible to receive at most \$1 in proceeds from entering the mortgage contract so that $m \geq 0$. The cap in loan proceeds captures the idea that for sufficiently large loan proceeds, the lender would demand such a high coupon that the borrower would immediately default and there would be no way the lender could break even.

In exchange for the loan proceeds the borrower collects at origination, she makes constant coupon payments c per unit of time until termination, which occurs at a random stopping time τ representing either default, prepayment, or maturity. At termination, the borrower makes a final lump-sum repayment of either 1 in the event of full repayment or 0 in the event of default. Although amortization is a common feature in real-world mortgage contracts, it is not modeled here, as it does not directly affect the main mechanisms. This basic mortgage contract allows an analysis of signaling and screening within specific informational settings.

Screening for Prepayment Risk with Points

An environment in which borrowers are privately informed about their prepayment risk can illustrate the role mortgage contract menus play in screening borrowers by their prepayment risk, as first emphasized by Stanton and Wallace (1998). The economy consists of a continuum of borrowers who differ in terms of their prepayment risk served by a competitive market of lenders. Specifically, borrower i has a stochastic termination time $\tau_i \sim \text{Exp}(\theta_i)$ with $\theta_i \in [\underline{\theta}, \overline{\theta}]$. All borrower types make a lump-sum payment of 1 upon termination, so there is no default risk. Borrowers observe their own type, but lenders do not. Borrowers discount future payments at rate r_B, so a borrower of type θ_i who accepts a mortgage with terms (c, m) has utility

$$U(\theta_i; c, m) = 1 - m - \frac{c + \theta_i}{r_B + \theta_i}. \qquad (1)$$

Lenders discount at rate $r_L < r_B$ and value the final lump-sum payoff as $1 - \alpha$ with $0 < \alpha < 1$. The wedge α between the borrower's and lender's valuation of the terminal payoff captures the idea that prepayments tend to occur when market interest rates fall, implying that the lender would have been better off had the loan remained outstanding. A richer model with stochastic interest rates could generate such a wedge endogenously, but this would add complexity without changing the core intuition.

Given these assumptions, the expected profit per dollar of principal for a lender offering a contract (c, m) to a borrower of type θ_i is

$$\Pi(\theta_i; c, m) = \frac{c + (1 - \alpha)\theta_i}{r_L + \theta_i} - (1 - m). \qquad (2)$$

Lenders are free to offer any number of contracts that differ in coupon rate c and mortgage points m.

Before characterizing the equilibrium, it is useful to relate the contract terms to real-world mortgage pricing. The coupon c corresponds to the contract interest rate for a mortgage. The quantity m represents an upfront fee which reduces the net proceeds from borrowing. For example, a mortgage with 1% in points is recorded at par, but the borrower receives net proceeds of only \$0.99 per dollar of principal after paying the fee. This fee is known in the mortgage industry as "discount points."[4] These fees are called discount points because a lender will reduce the mortgage contract interest rate if the borrower is willing to pay the discount points, a process the mortgage industry refers to as "buying down the rate." When a borrower approaches a lender for a rate quote, they are often quoted a schedule of discount points–interest rate pairs. Lenders also maintain an internal schedule called the "rate sheet" which shows the full schedule of discount point and interest rate pairs they are willing to offer. The rate sheet is what the model refers to as the contract menu.

Borrowers with high prepayment risk (high θ) prefer mortgages with higher interest rates and lower discount points since they expect to repay early and thus place little value on a lower long-term interest rate. Conversely, borrowers who expect to continue paying their mortgage for a long time are willing to pay higher discount points in exchange for a lower interest rate.

In the absence of private information, the optimal mortgage contract maximizes gains from trade between the borrower and the lender. Because borrowers are less patient than lenders, it is optimal to allocate the borrower as much upfront loan proceeds as possible. That is, under the first best, the constraint that points must be non-negative binds, and the optimal mortgage for every type would call for zero points and a type-dependent coupon rate set so that lenders break even. Setting $\Pi(\theta; c, 0) = 0$ gives

$$c_{FB}(\theta) = r_L + \alpha\theta. \qquad (3)$$

[4] Mortgages also often include "origination points" to indicate lender closing costs that do not affect the rate charged on the mortgage.

The coupon on full information will serve as a benchmark to which the welfare of the allocation under asymmetric information can be compared.

An equilibrium in this model follows the standard competitive screening framework of Rothschild and Stiglitz (1976). Lenders offer a menu of contracts $\left(c(\theta), m(\theta)\right)$, and borrowers select into contracts. The menu satisfies an incentive compatibility (IC) condition that requires that each borrower weakly prefers her assigned contract to that intended for any other type θ':

$$U\left(\theta; c(\theta), m(\theta)\right) \geq U\left(\theta; c(\theta'), m(\theta')\right) \quad \text{for all } \theta, \theta' \in \left[\underline{\theta}, \overline{\theta}\right]. \qquad (4)$$

Given the relatively simple preferences of the borrowers, it is sufficient for the menu to be locally incentive compatible, which is guaranteed by the standard Mirrlees–Spence envelope condition:

$$\frac{\partial U\left(\theta; c(\theta), m(\theta)\right)}{\partial \theta} = \left.\frac{\partial U\left(\theta; c(\theta'), m(\theta')\right)}{\partial \theta}\right|_{\theta\prime=\theta} = \frac{c(\theta) - r_B}{(r_B + \theta)^2}. \qquad (5)$$

Competition among lenders further implies zero expected profits for lender conditional on each borrower type:

$$\Pi\left(\theta; c(\theta), m(\theta)\right) = \frac{c(\theta) + (1-\alpha)\theta}{r_L + \theta} - \left(1 - m(\theta)\right) = 0. \qquad (6)$$

Solving (6) for $c(\theta)$ and substituting into (5) yields the following ODE for the equilibrium schedule of points

$$m'^{(\theta)} = \frac{1}{r_B - r_L}\left(m(\theta) - \alpha\right). \qquad (7)$$

The boundary condition for this ODE is determined by competition at the edge of the feasible contract space. The borrower type with the highest prepayment risk pays zero points:

$$m\left(\overline{\theta}\right) = 0. \qquad (8)$$

To see why, suppose instead that the highest-risk borrower paid positive points. A lender could profitably deviate by offering a contract with slightly lower points and slightly higher coupons. Because borrowers discount future payments more heavily than lenders, such a contract would increase the borrower's utility and give positive profits to the deviating lender. Hence, competition drives the highest-risk borrower's points to zero and $m(\overline{\theta}) > 0$ cannot be sustained in equilibrium.

The solution to (7) subject to (8) gives

$$m(\theta) = \alpha\left(1 - e^{-\frac{\overline{\theta}-\theta}{r_B - r_L}}\right), \qquad (9)$$

which is strictly decreasing in θ. In words, borrowers with higher prepayment risk select mortgages with lower upfront points. Intuitively, points are a pure transfer between borrower and lender, whereas the exchange of coupon payments for loaned funds generates gains from trade because the two sides of the transaction discount future payments at different rates. Under full information, all borrowers would pay zero points and coupons would be set to maximize the utility of the borrower subject to the lender earning zero profits. With asymmetric information, however, points become a screening device. Low-risk borrowers, for whom potential gains from trade are greatest, must accept higher upfront points to credibly reveal their type. Riskier borrowers decline such contracts since they expect to prepay before recouping the upfront cost.

Substituting the equilibrium schedule of points $m(\theta)$ into the zero-profit condition (6) yields the coupon schedule:

$$c(\theta) = \left[(1-\alpha) + \alpha e^{-\frac{\overline{\theta}-\theta}{r_B - r_L}}\right](r_L + \theta) - (1-\alpha)\theta. \qquad (10)$$

Coupon payments are strictly increasing in θ: borrowers with higher prepayment risk select mortgages with higher coupons because they contribute less in upfront points. At the top of the distribution, the highest-risk borrower pays zero points and a coupon of $c(\overline{\theta}) = r_L + \alpha\overline{\theta}$, which is the same rate that the borrower would obtain under full information.

Together, the schedules $m(\theta)$ and $c(\theta)$ define a monotone equilibrium contract menu in which borrowers face a clear tradeoff between upfront points and coupon rates. Substituting $m(\theta)$ into (6) yields the following closed-form relation between coupons and points:

$$c(m) = r_L(1-m) + (\alpha - m)\overline{\theta} + (r_B - r_L)(\alpha - m)\log\left(1 - \frac{m}{\alpha}\right). \qquad (11)$$

The function $c(m)$ is strictly decreasing in m. The first two terms give the coupon that makes the lender break even if the borrower is type $\overline{\theta}$ and chooses points m. The third term is the cumulative reward a borrower receives for choosing a mortgage with more points. The marginal decrease in coupon from paying higher points, that is, the slope of $-c(m)$,

$$-c'(m) = r_B + \overline{\theta} + (r_B - r_L)\log\left(1 - \frac{m}{\alpha}\right) = r_B + \theta(m) \qquad (12)$$

is exactly the marginal rate of substitution between coupons and points of the type θ that chooses points m. Thus, $c'(m)$ perfectly provides incentives for borrowers to choose the point on the $c(m)$ menu that corresponds with their type.

Although a menu of points and coupon rates effectively separates borrowers by prepayment risk, this separation comes at a welfare cost. In the full-information first-best benchmark, all borrowers pay zero points and a type-dependent coupon given by $c_{FB}(\theta) = r_L + \alpha\theta$. With asymmetric information, lower-risk borrowers must pay more points to separate themselves from higher-risk types. These upfront transfers reduce their utility relative to the first best, even though they continue to enjoy lower coupons than higher-risk borrowers. For a borrower with type θ the welfare loss due to points is

$$L(\theta) = m(\theta) + \frac{c(\theta) - c_{FB}(\theta)}{r_B + \theta} = \alpha\left(1 - e^{-(\overline{\theta}-\theta)/(r_B - r_L)}\right)\left(\frac{r_B - r_L}{r_B + \theta}\right) \qquad (13)$$

For the highest-risk type, this loss is $L(\overline{\theta}) = 0$ because that type does not pay points in equilibrium. As the prepayment risk θ of the borrower decreases, the loss $L(\theta)$ increases due to forgone gains from trade. Thus, the welfare losses due to asymmetric information are borne by the borrowers with lower prepayment risk.

Signaling Default Risk with Delayed Trade

When lenders sell mortgages into secondary markets, they may possess information, such as the default risk of the mortgages they are offering for sale, that potential investors do not. The canonical costly signaling intuition of Spence (1973) implies an informed lender may signal her information if there is an action to take that is less costly when the lender's information is positive. The common practice of "seasoning"—holding the mortgage on balance sheet for some time before offering it for sale—is less costly when a mortgage is less likely to default and can thus serve as a signal of low default risk.

The structure of the economy follows Adelino, Gerardi, and Hartman-Glaser (2019) and consists of a mortgage lender who holds a single mortgage and a competitive market of mortgage investors. The mortgage contract is unchanged from the screening model and calls for a constant stream of cash flow c until termination. The lender discounts future cash flows at rate r_L, while investors discount at a lower rate $r_I < r_L$. The difference between the lenders and investors' discount rates gives rise to gains from trade.

It is common knowledge that upon termination the mortgage repays nothing, so that termination in this context corresponds to default. The default time is exponentially distributed, $\tau \sim \mathrm{Exp}(\lambda)$, where $\lambda \in [\underline{\lambda}, \overline{\lambda}]$ indexes the default risk of the mortgage. Default is publicly observable. However, the lender is privately informed about the default intensity λ, while investors only know the prior distribution of λ and the date of origination ($t = 0$). The lender chooses a time t to offer the mortgage for sale. Since default is publicly observable, it is without loss of generality to assume that if the mortgage defaults while still being held by the lender, no sale occurs. Thus, if the lender plans to sell the mortgage at time t and expects price p (for a mortgage that has not yet defaulted), her time-0 expected payoff is

$$U(t, \lambda; p) = \frac{c}{r_L + \lambda}\left(1 - e^{-(r_L+\lambda)t}\right) + e^{-(r_L+\lambda)t} p. \qquad (14)$$

The first term is the lender's valuation of the coupons collected while the mortgage is held on balance sheet, accounting for default arrival at intensity λ. The second term is the discounted resale price p conditional on survival to t. Intuitively, seasoning trades off collecting coupons for longer against the risk that the loan defaults before sale.

These preferences imply that when the lender holds a safer loan, she is more willing to delay trade. Formally, the lender's preferences satisfy a single-crossing property in (t, λ). Holding t and p fixed,

$$\frac{\partial^2 U}{\partial \lambda\, \partial t}(t, \lambda; p) = e^{-(r_L+\lambda)t}[-p - t(c - (r_L + \lambda)p)]. \qquad (15)$$

In particular, at $t = 0$,

$$\left.\frac{\partial^2 U}{\partial\lambda\,\partial t}\right|_{t=0} = -p < 0, \qquad (16)$$

so the marginal value of delay is strictly decreasing in λ.[5] Intuitively, when the lender holds a safer loan (lower λ), she values an additional unit of seasoning more because the loan is more likely to survive and deliver interim coupons. Conversely, for high λ, the loan is less likely to survive the seasoning period and lead to a sale. This single-crossing property provides scope for signaling through delayed trade. In equilibrium, seasoning time can serve as a credible signal of quality because extending the holding period is relatively inexpensive for low-λ types but prohibitively costly for high-λ types.

The remaining objects required to define equilibrium are investors' payoffs and beliefs about mortgage quality. If an investor purchases a mortgage of type λ at price p, her profit is

$$\Pi(\lambda; p) = \frac{c}{r_I + \lambda} - p. \qquad (17)$$

Since the only observable action is the seasoning time t, investors' beliefs can be represented by a conditional distribution $\mu(\lambda \mid t)$.

Equilibrium consists of a seasoning strategy $t(\lambda)$ for lenders, a pricing rule $p(t)$ for investors, and a system of beliefs $\mu(\lambda \mid t)$ such that:

1. The lender chooses $t(\lambda)$ to solve $t(\lambda) = \text{argmax}_t U\big(t, \lambda{:}\, p(t)\big)$
2. Investors earn zero profits given their beliefs, $p(t) = E\left[\frac{c}{r_I+\lambda} \,\middle|\, \mu(\lambda \mid t)\right]$.
3. Beliefs $\mu(\lambda|t)$ are derived using Bayes' rule whenever possible.

In words, lenders optimally choose how long to hold their loans, investors price mortgages competitively given their beliefs about types, and those beliefs are consistent with observed

[5] Because the exponential distribution is memoryless, the marginal value of delaying sale at any t conditional on survival is identical to the expression at $t = 0$, so the local single-crossing condition is generic.

behavior. In equilibrium, seasoning time thus conveys information about loan quality, and secondary-market prices reflect that information in a manner consistent with rational expectations.

As in many signaling models, multiple equilibria can arise. The focus here will be on the least-cost separating equilibrium, in which each lender type chooses a distinct seasoning time, so that seasoning fully reveals the lender's information about mortgage quality. The equilibrium is least cost in the sense that it achieves separation using the shortest possible seasoning times consistent with incentive compatibility. This equilibrium is the unique equilibrium that satisfies the D1 criterion of Cho and Kreps (1987).

The method for deriving the least-cost separating equilibrium is similar to one that determines the competitive screening menu in the model of mortgage points. First, characterize the incentive-compatibility condition by taking a first-order condition for the lender's problem given a price schedule:

$$c - (r_L + \lambda)p(t) + p'(t) = 0. \qquad (18)$$

In a separating equilibrium, investors correctly infer type from t, so that

$$p\big(t(\lambda)\big) = \frac{c}{r_I + \lambda}. \qquad (19)$$

Substituting (19) into (18) gives an ODE for the equilibrium price schedule:

$$p'(t) = (r_L - r_I)p(t). \qquad (20)$$

Because the highest-risk lender does not benefit from revealing her type, she does not engage in seasoning in the least-cost separating equilibrium, so

$$p(0) = \frac{c}{r_I + \bar{\lambda}}. \qquad (21)$$

Solving the ODE in Equation (20) subject to the boundary condition in Equation (21) gives the following characterization of the least-cost separating equilibrium:

$$p(t) = e^{(r_I - r_L)t} \frac{c}{r_I + \bar{\lambda}}, \qquad (22)$$

$$t(\lambda) = \frac{1}{r_L - r_I} \ln\left(\frac{r_I + \bar{\lambda}}{r_I + \lambda}\right). \qquad (23)$$

The equilibrium price schedule captures the central implication of the model: longer seasoning times are associated with higher prices and lower default risk. Investors infer that loans held longer on balance sheet are less likely to default and are therefore willing to pay more for them. Correspondingly, the lender optimally chooses a longer seasoning time for a safer mortgage, while lenders sell riskier loans more quickly to avoid default before sale. Intuitively, the safer the loan, the greater the expected return from waiting and collecting additional coupons before trading.

Beyond predicting a positive relationship between seasoning time and loan quality, the signaling mechanism has implications for allocative efficiency. Unlike a delay in trade due to randomness or other non-information-based frictions, a delay used to signal quality is strategic choice and that distorts the timing of trade. Lenders with safer loans hold them longer to signal quality which delays trade in higher-quality mortgages relative to the first-best. This strategic delay in turn implies that lenders have higher realized holding costs when they sell higher quality mortgages. If these costs are passed on to borrowers, higher-quality borrowers ultimately face higher fees or interest rates as a result of adverse selection and signaling in the secondary market. Thus, as in the screening model, the welfare costs of asymmetric information are borne by the safest borrowers.

Signaling through delayed trade is closely related to another common mechanism in mortgage and securitization markets: signaling through retention. In both cases, informed lenders demonstrate loan quality by taking actions that are costly for low-quality types to imitate. Holding a fraction of a mortgage on balance sheet or retaining a portion of a security both serve as credible signals of lenders' private information about loan quality, since each exposes the lender to losses in the event of default. For example, the lender could retain a fraction of the mortgage's cash flows and sell the residual at time zero and the mathematics of the equilibrium would be largely the same. Seasoning is therefore a dynamic counterpart to retention—rather than permanently retaining a stake in the mortgage, the lender temporarily bears performance risk to convey private information to investors.

Costly Information Transmission: Mechanisms and Evidence

The mechanisms formalized in the benchmark model apply at several links in the mortgage intermediation chain. A substantial literature provides both a theoretical grounding and empirical evidence for these mechanisms as summarized by Figure 1. At origination, contract menus separate borrower types, allowing borrowers to signal their type to lenders. After a mortgage has been originated, lenders use retention, tranching, and seasoning to signal information to investors. Certification and reputation change the informational environment, sometimes undermining costly signaling. Finally, anticipated signaling costs can feed back into the screening effort incentives at origination. The evidence is organized accordingly, emphasizing where the empirical findings confirm the theory.

Borrower to Lender: Screening Borrowers with Menus

Adverse selection at the origination stage can take two main forms depending on the type of private information held by borrowers. First, borrowers may have private information about their likelihood of prepaying the mortgage early, which can be screened through contract design as the screening model illustrates. Second, borrowers may have private information about their likelihood of defaulting on the mortgage, which they can signal through their behavior. In both cases, asymmetric information leads to equilibrium outcomes that deviate from the full-information benchmark, with significant implications for market efficiency and borrower welfare.

The screening model predicts that borrowers with lower prepayment risk select mortgages with higher points and lower coupons. This mechanism builds directly on the foundational work of Stanton and Wallace (1998), who first demonstrated that points can serve as a screening mechanism when borrowers differ in mobility. Their key insight is that refinancing transaction costs make high-mobility borrowers assign a higher cost to any given mortgage contract. Moreover, this difference in valuations increases with the coupon rate, which implies the single-crossing property required for separation: high-mobility borrowers have steeper indifference curves than low-mobility borrowers. Without refinancing costs, no stable separating equilibrium would exist—any contract menu would unravel as high-risk borrowers mimic low-risk types.

The theoretical framework differs from Stanton and Wallace (1998) primarily in the source of heterogeneity across borrower types. Rather than facing transaction costs, borrower in the screening model internalize gains from trade due to a discount rate wedge between borrowers and lenders. Mobility, i.e. prepayment risk, affects the expected duration over which those gains from trade can be realized. Low-prepayment-risk borrowers expect to continue paying their mortgages for longer and are thus willing to pay higher upfront points in exchange for lower coupon rates. Despite this difference in microfoundations, the main economic forces underlying Stanton and Wallace (1998) and the simple screening model are the same.

A contrasting view is offered by Chari and Jagannathan (1989), who interpret points as part of an insurance mechanism rather than a screening device. In their model, borrowers who are more likely to move face income risk correlated with mobility, so points and due-on-sale clauses provide partial insurance. Consequently, high-mobility borrowers pay points—the opposite of what the screening framework predicts.

There is strong empirical evidence supporting the screening interpretation. Brueckner (1994) documents that mobile borrowers select loans with lower points and higher coupon rates, consistent with the predictions of the screening model. The paper establishes both the presence of a points/interest-rate trade-off in the market and that borrowers choose contracts from this menu according to their mobility characteristics. The empirical relationship between points and prepayment has also been incorporated into industry practice. Hayre and Rajan (1999) document that prepayment models used by practitioners account for the effect of origination points on prepayment speed, with loans originated with lower points exhibiting systematically faster prepayment rates.

Contract terms can also screen for default risk. Early theories of collateral, such as Bester (1985), Besanko and Thakor (1987), Chan and Thakor (1987) demonstrate that requiring collateral can serve as a screening device for borrower quality. There is empirical evidence consistent with this theory. Agarwal et al. (2015) find that loans with higher initial loan-to-value (LTV) ratios have higher default rates even after controlling for borrower characteristics and marked-to-market housing values. While the authors attribute this finding to sub-optimal behavior of the borrower, this finding is also consistent with the notion that a schedule of collateral requirements and interest rates can effectively screen a borrower's private information about their own default risk.

These studies demonstrate that contract design serves an important screening mechanism in mortgage markets, consistent with the theoretical frameworks of Stanton and Wallace (1998) and the screening model. While screening through contract menus can ameliorate adverse selection, it is not without a loss of efficiency relative to the full-information benchmark. Importantly, it is the borrower types with the highest gains from trade, i.e., those with the lowest prepayment risk or default risk, who bear the greatest welfare costs from asymmetric information.

Lender to Investor: Signaling through Retention

There is an extensive literature on how lenders signal private information to investors through securitization structures and risk retention. Theoretical models suggest that lenders can use these mechanisms to credibly convey information about loan quality, thereby mitigating adverse selection in the secondary market and shaping the structure of mortgage securitization. Starting with the seminal works of Leland and Pyle (1977) and Spence (1973), a rich theoretical literature has developed exploring how the seller of an asset can use partial retention to signal quality to potential investors. In the context of mortgage markets, the literature has shown that lenders' use of retention as a signaling device can explain features of the market such as "tranching and pooling." For example, the seasoning model illustrates the framework Adelino, Gerardi, and Hartman-Glaser (2019) use to show how lenders can use seasoning, i.e., the process of holding a particular mortgage on balance sheet, to credibly signal loan quality to investors.

An important strand of the theoretical literature on retention as a signal of mortgage quality focuses on the design of mortgage-backed securities. DeMarzo and Duffie (1999) present a model of security design in which the seller of a single asset can use retention to credibly signal quality to investors. If the seller can create an asset-backed security prior to observing the quality of the asset, then it is optimal to create two securities: one senior claim and one junior claim on the asset's cash flow. These claims are often referred to as tranches. The structure allows the seller to retain a portion of the junior tranche to minimize the cost of signaling to investors. The intuition is that the senior tranche is less sensitive to the seller's private information and can therefore be sold to investors without seller retention. The junior tranche, by contrast, is more sensitive to the seller's private information and therefore requires less retention to credibly signal the same information to investors than would be necessary if the seller tried to sell the asset without tranching.

DeMarzo (2005) builds on the work of DeMarzo and Duffie (1999) by showing that an informed seller can pool multiple loans prior to tranching and increase equilibrium efficiency relative to tranching individual assets. On the one hand, pooling dilutes the seller's private information by forcing them to retain similar shares of high- and low-quality loans, what DeMarzo (2005) calls the "information-destruction" effect. On the other hand, it diversifies idiosyncratic risk across loans, enabling the creation of larger senior tranches and allowing the seller to retain a smaller equity tranche to signal the same information, what DeMarzo (2005) calls the "risk-diversification" effect. When the diversification effect dominates, pooling and tranching jointly improve efficiency relative to selling loans individually. This trade-off provides a theoretical rationale for the widespread practice of pooling and tranching in mortgage securitization.

DeMarzo (2005) also identifies a role for the pooling of loans that is separate from signaling. Pooling can prevent informed buyers from cherry picking loans from uninformed sellers. In DeMarzo (2005)'s framework, the uninformed seller is called an "originator," however in the mortgage intermediation chain, this role is likely best described by loan aggregators, who create pools of loans to sell to MBS sponsors who then engage in further pooling and subsequent tranching.

Taken together, DeMarzo (2005)'s results give clear implications for security design based on seller information that help to understand the mortgage intermediation chain. Informed sellers whose information is mostly loan-specific, for example, about a particular borrower's likelihood of default, prefer to sell and signal one loan at a time to prevent the information destruction effect of pooling. Such sellers most closely resemble bank and non-bank mortgage originators. Uninformed sellers, such as mortgage aggregators, prefer to pool loans and sell "pass-through certificates," i.e., pools of loans that are not tranched. Informed sellers whose private information is mostly at an aggregate level, for example, an MBS sponsor who has private information about broader trends in the housing market, prefer to first pool mortgages and then tranche them to maximize the efficiency of signaling their private information.

Building on this framework, Hartman-Glaser, Piskorski, and Tchistyi (2012) analyzes a model similar to the seasoning model to study a lender with private information about the default risk of multiple mortgages who can sell these loans to investors. Each loan's cash flows follow the same basic structure as in the benchmark model, i.e., a constant stream of coupons until default. The lender can retain an arbitrary claim on the cash flows of the mortgages to signal information to investors. The key result is that retaining a "first-loss piece," in other words, the tranche that is most exposed to the earliest losses in the pool, is the most efficient way for the lender to signal loan quality to investors because it minimizes the amount of time the lenders must retain risk to credibly signal their private information.

When taken in isolation, the welfare effects of signaling models such as DeMarzo (2005) operate through the forgone gains from trade induced by the costly action that sellers take to signal quality. Vanasco (2017) that when the seller is also the originator of the assets and thus responsible for screening them, the quality of assets that get originated can be an additional source of welfare effects. When gains from trade are low, screening effort is too high relative to second-best, and the market for assets features too much seller retention. When gains from trade are higher, there is an equilibrium in which sellers neither screen nor signal, leading to the origination of low quality assets. This effect could help to explain the rise of subprime lending during the early 2000s.

The key empirical prediction of signaling models in mortgage sale and securitization is that the sellers of whole mortgages or MBS will choose their retention levels or seasoning times strategically based on their private information about loan quality. This equilibrium configuration should lead to a negative correlation between retention or seasoning and subsequent default rates. A related prediction is that even after controlling for observable characteristics of the loans, retention or seasoning should still contain information about loan quality that is not captured by these observables. There are significant challenges to empirically testing these predictions. First, it can be difficult to observe the amount of retention or seasoning chosen by the seller. Second, even if retention or seasoning is observable to the econometrician, it can be challenging to rule out alternative explanations for any observed correlation between retention or seasoning and default rates, such as selection effects or omitted variables.

Adelino, Gerardi, and Hartman-Glaser (2019) address the challenges of testing signaling models in the secondary market using data on seasoning times in the market loans that are eventually privately securitized, i.e. not guaranteed against default by a US government-sponsored entity. They find that loans that are held on the balance sheet of the originator for longer periods prior to sale to loan aggregators tend to have lower default rates, consistent with the notion that seasoning serves as a credible signal of loan quality. They show this relationship holds even when restricting the analysis to the sample of loans which do not default within the first nine months of their lives. This finding rules out the possibility that the relationship between seasoning and default is driven purely by mechanical selection effects, i.e., that loans that are more likely to default do so early and therefore are less likely to be seasoned. Instead, the evidence suggests that even among loans that survive the initial period, those that are seasoned longer are of higher quality, consistent with the signaling hypothesis.

While the originator of a mortgage may signal quality through seasoning, the sellers of residential mortgage-backed securities (RMBS) may use the structure of securitization to achieve a similar effect. Begley and Purnanandam (2017) show that private label securitizations (PLS, which are the types of RMBS that contain the loans studied by Adelino, Gerardi, and Hartman-Glaser (2019)) that have larger equity tranches have significantly lower delinquency rates and sell for higher prices, conditional on observable characteristics. This effect is concentrated in RMBS deals containing loans with no-documentation, which are precisely the deals in which asymmetric information between investors and the RMBS seller is likely to be most severe. Begley and Purnanandam (2017) interpret this finding as evidence that sellers signal pool level mortgage quality through the equity tranche, which can take longer to sell than other tranches and is therefore retained, albeit not for the life of the securitization. The signaling action in Begley and Purnanandam (2017) is therefore inferred rather than observed in contrast to Adelino, Gerardi, and Hartman-Glaser (2019) where the signal—a mortgage originator's choice of seasoning time—is measured directly.

In 2010, the US congress passed the Dodd-Frank Act, which included provisions requiring the sellers of securitizations to retain risk exposure. Prior to this act, the sellers of commercial mortgage-backed securities (CMBS) rarely directly retained such skin-in-the-game and instead often sold the most risky tranches, known as the "B-piece" in this context, to informed investors.

Still, B-piece tranches could have forced sellers to internalize risk through the price informed investors were willing to pay, and thus could serve as a signal of pool quality. Ashcraft, Gooriah, and Kermani (2019) provide evidence that B-piece buyers could lay-off their exposure to default risk through a collateralized debt obligation (CDO) without the knowledge of other investors in the CMBS. This reduction of “skin-in-the-game” led to more default in the CMBS. Ashcraft, Gooriah, and Kermani (2019)’s findings highlight the difficulty faced by a seller of a CMBS in using the B-piece as a credible signal of quality. Because of the ability to re-securitize assets in the collateralized debt obligation (CDO) market, sellers were unable to credibly internalize risk exposure through the B-piece. So while Begley and Purnanandam (2017) use the size of the equity tranche as a measure of risk retention that is observable to investors, Ashcraft, Gooriah, and Kermani (2019) focus on a form of risk-retention that is explicitly not observable to other investors.

A potential consequence of the Dodd-Frank risk-retention requirements is that they could undermine the signaling role played by retention. If all CMBS issuers are required to retain a fraction of the securities they offer to the market, then there might not be differences across issuers in the amount they retain and therefore no signaling. Flynn Jr, Ghent, and Tchistyi (2020) present a model that shows that issuers can use the composition of the retained fraction of the securitization to convey information to investors. Consistent with their model’s predictions, they find empirical evidence that issuers of CMBS choose the composition of their retained tranches strategically. Specifically, they find that issuers retain a larger fraction of the riskier tranches of the securitization when the underlying pool of commercial mortgages is of higher quality. This finding suggests that even in the presence of regulatory retention requirements, issuers can still use retention strategically to signal private information about loan quality to investors.

Several other empirical studies have addressed issues related to signaling in the secondary market for mortgages but have not directly confronted the role of retention. For example, Agarwal, Chang, and Yavas (2012) find that lenders appear to use the choice of whether to securitize a loan as a signal of quality. Their main finding is that loans that get sold to the US government-sponsored enterprises (GSEs) such as Fannie Mae and Freddie Mac have on average lower default rates than loans retained by lenders or sold to private-label securitizations, controlling observable characteristics.

Furfine (2014) finds that more complex securitization structures in the CMBS market are associated with higher default rates. He also finds that these more complex deals do not exhibit higher levels of retention and interprets this as evidence against the signaling theory of security design. However, the evidence presented by Furfine is not a sharp test of signaling theory. In particular, the theory predicts that retention should vary with the seller's private information about loan quality, not necessarily with publicly observable features such as deal complexity.

A common feature of equilibria in signaling games such as the one modeled in DeMarzo and Duffie (1999) and DeMarzo (2005), or in the seasoning model of Adelino, Gerardi, and Hartman-Glaser (2019), is that after the signaling action is observed, the market fully infers the private information of the seller. In other words, in equilibrium, the signaling action perfectly reveals the quality of the underlying asset to investors. However, in practice, it is unlikely that retention or seasoning fully reveals loan quality to investors. At the same time, other market mechanisms exist to mitigate adverse selection, such as reputation for accurate reporting of quality and third party ratings. Hartman-Glaser (2017) presents a model of repeated securitization in which the seller of an asset-backed security can retain a portion of the security to signal its quality, while at the same time developing a reputation for accurately reporting via repeated disclosures.

In Hartman-Glaser (2017)'s model, the seller faces a trade-off between using retention to signal quality at a given point in time and building a reputation for accurate reporting that will reduce adverse selection in later periods. The key insight of this model is that when the seller values future profits sufficiently highly, they will choose to build a reputation rather than relying solely on retention to signal quality. However, reputation does not lead to full information revelation. At some point, a strategic issuer will burn their reputation by falsely labeling a low-quality asset as high quality to reap single period profits. Thus the model provides a rationale for the fact that issuers of mortgage-backed securities during the run-up to the Great Recession maintained some skin in the game but at the same time did not fully reveal quality to the market.

Like reputation, a third party who certifies public information can also shift the market away from signaling. Daley, Green, and Vanasco (2020) develop a model in which credit ratings substantially change the information environment in securitization markets. In their model, banks can either signal quality by retaining a fraction of the loan or rely on a noisy public signal, such as a credit rating, to credibly convey information to investors. The introduction of ratings leads to an equilibrium to resemble the "originate-to-distribute" model of mortgage lending in which banks sell whole loans, lending standards are lower, and more borrowers receive loans. This equilibrium features imperfect information revelation and can generate inefficient lending in which the marginal borrower is of lower quality. That being the case, welfare is improved relative to the equilibrium with no ratings because the improvement in allocative efficiency that arises from reducing costly signaling outweighs the losses that arise from the origination of worse loans.

Summary and Directions for Future Research

Signaling in the mortgage market arises as a response to the asymmetric information problems at are present at each stage of the mortgage intermediation chain. Borrowers reveal private information about mobility and default risk by selecting a mortgage contract from menu, lenders signal loan quality through retention and seasoning, and MBS sponsors and mortgage lenders may rely on reputation and third-party certification to substitute for costly signaling. The evidence and models reviewed here show that while signaling and screening lead to information revelation, they also require allocative distortions that reduce welfare through forgone gains from trade.

Directions for future research include quantifying the welfare costs the distortions associated with signaling in the mortgage market and investigating how advancements in data processing and underwriting technologies potentially change the information environment in a way that could lead to new forms of signaling.

Further Reading

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