Racial Disparities in Mortgage Lending: New Evidence Based on Processing Time

Bin Wei and Feng Zhao

Abstract: This paper examines racial disparities in mortgage processing time prior to the global financial crisis. We find that Black borrowers are underrepresented and experience a longer processing time than White borrowers among the mortgages securitized by government-sponsored enterprises. At the same time, Black borrowers are overrepresented and face a similar processing time among privately securitized mortgages. Additionally, Black borrowers are strongly associated with the faster segments of mortgage markets, faster lenders within each segment, and the types of loan products that are processed faster, all of which subsequently experienced higher defaults.

1 Introduction

Blacks and other minorities have fallen behind in building wealth, and large racial and ethnic gaps have formed in recent decades. Expanding homeownership among minority groups has been embraced as an important public policy to reduce the wealth gap. A necessary component for this policy is to combat racial and ethnic disparities in residential mortgage lending that have long been documented in academic research and popular media. Minority home buyers need to be able to access mortgage financing at a reasonable cost and in a timely and predictable manner. Existing studies have shown that minorities are more likely to be denied a mortgage and have to bear a higher cost even if they do get credit. We add to the existing studies and investigate an important yet often overlooked dimension of mortgage lending: *processing time*—the time needed for a loan application to be processed (i.e., accepted or denied). Lengthy delays add uncertainty to the mortgage application process and could put minority home buyers at a disadvantage, especially in a competitive housing market. An investigation on whether disparities in processing time exist and an examination of the potential causes are important to fully grasp the extent of racial and ethnic disparities in mortgage lending.

The expansion of housing credit in the early 2000s led to historically high rates of homeownership among minority groups. This period is, however, not devoid of discriminatory lending practices.[1] Furthermore, the use of lax lending standards by subprime lenders during this period is well-documented; for example, income verification was not required for many borrowers.[2] In a recent study, Wei and Zhao (2020) argue that mortgage processing

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[1] In *United States v. Countrywide Settlement*, December 21, 2011, the U.S. Department of Justice filed its largest residential fair lending settlement in history to resolve allegations of lending discrimination by Countrywide Financial Corp. from 2004 through 2008, stating that "qualified African-American and Hispanic borrowers were placed in subprime loans rather than prime loans even when similarly-qualified non-Hispanic white borrowers were placed in prime loans. ...Countrywide gave mortgage brokers discretion to request exceptions to the underwriting guidelines."

[2] "Some of the problems are surfacing in a mortgage program called 'Fast and Easy,' in which borrowers were asked to provide little or no documentation of their finances, according to these people and to former Countrywide employees. ...Fast and Easy borrowers aren't required to produce pay stubs or tax forms to substantiate their claimed earnings." See Glenn R. Simpson and James R. Hagerty, "Countrywide Loss Focuses Attention on Underwriting", *Wall Street Journal*, April 30, 2008,

time is a good indicator of lending standards during this period. They show that processing time shortened by 6%-10% around securitization thresholds in the run-up to the 2007-2008 mortgage crisis, and those hastily processed loans became delinquent more frequently. In this paper, we further examine racial disparities in mortgage lending along the dimension of processing time.

In our main analysis of racial and ethnic differences in processing time, we use the data from Home Mortgage Disclosure Act (HMDA) and focus on the time period from 2001 to 2006, which include 22 million home purchase loans and 37 million refinance loans. Our sample period saw the rise of private-label securitization (PLS). As opposed to traditional securitization wherein government-sponsored enterprises (GSEs) purchase and bundle loans into mortgage-backed securities and then provide a guarantee for the underlying credit risk, PLS does not provide such guarantee and credit risk is thus borne by investors. Moreover, after a mortgage is purchased by GSEs, the originating lender faces the put-back risk of repurchasing the mortgage from GSEs (Bartlett et al., 2021). So lax lending standards were more common in the PLS segment. As shown in Wei and Zhao (2020), we find that the average processing time in the PLS segment is substantially shorter than that in the GSE segment (26 days versus 44 days).

We first show that white borrowers are over-represented in the GSE segment, whereas Black and Hispanic borrowers are over-represented in the PLS segment. In our sample, minority borrowers account for one-quarter of the total origination volume for home purchases, but almost one-half in the PLS segment. In contrast, white borrowers account for more than 80% of the origination volume in the GSE segment.

Interestingly, racial disparities manifest themselves in a distinct way in these segments of mortgage markets. In our loan-level regression analysis controlling for various loan and borrower characteristics and for fixed effects on county, month and lenders, we find that the processing time for Black borrowers is about one week *longer* than for white borrowers in

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https://www.wsj.com/articles/SB120945775409852363.

the GSE segment in 2004-2006, but is about the same in the PLS segment. Averaged across the two segments, the gap between Black and white borrowers is 1.8 days.

We find that including lender fixed effects almost doubles the processing time gap between Black and white borrowers to 3.4 days on the whole sample. Our finding that the inclusion of lender fixed effects widens the racial disparities in processing time has important implications for across- and within-lender racial disparities. First, the positive racial gap in processing time following the inclusion of lender fixed effects indicates a differential treatment of minority and white borrowers by the same lender. Second, the larger racial disparities after including lender fixed effects imply that Black and Hispanic borrowers are more likely to obtain mortgage loans from faster lenders, even within the same segment.

In our second set of results, we find less disparity in processing time between Black and white borrowers for loans originated by subprime lenders, for loans with non-traditional features as opposed to traditional fixed-rate mortgages, for loans that have shorter time span between origination and securitization, for low-documentation loans, and for high-cost loans.[3] Furthermore, Black and Hispanic borrowers are over-represented in these loan types and these loan types are commonly processed faster.

Is reduced processing time for Black borrowers in the PLS market associated with higher default? To answer this question, we merge the HMDA data with the CoreLogic LoanPerformance data. The latter data contain important information on borrower credit risk characteristics at loan origination (e.g., FICO score, LTV, and DTI) as well as information on loan performance (e.g., delinquency) mostly for privately securitized subprime mortgages.[4] The construction of the merged HMDA-CoreLogic data constitutes another critical contribution of this paper.

In our third set of results, using the merged HMDA-CoreLogic data for the PLS segment, we find that the loan delinquency rate is significantly higher among Black borrowers relative

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[3]Bayer et al. (2018) find that lenders that have more ex post foreclosures (so-called high-risk lenders) account for a large part of high-cost mortgages received by Black and Hispanic borrowers.

[4]As noted by Keys et al. (2010), the CoreLogic LoanPerformance data encompass over 90% of the mortgage loans that are privately securitized.

to white borrowers. Furthermore, we find larger delinquency gaps between Black and white borrowers in the sample of non-traditional mortgages, low-documentation loans, and loans that are more quickly securitized. Lastly, we find more significant negative relation between processing time and loan delinquency in these loan types than other PLS loans.

What explain the large disparities in mortgage processing time in the GSE segment but not in the PLS segment? The answer might lie in the underwriting procedures for GSE-securitized loans. In the 1990s, GSEs developed the automated underwriting systems that were distributed to loan originators: Loan Prospector at Freddie Mac and Desktop Underwriter at Fannie Mae. These software packages conduct risk evaluation from the inputs of borrower and loan characteristics, such as the FICO score, LTV ratio, DTI ratio, type of loans, and months of reserves. Then they report how the GSEs would treat the loan: either a rating for acceptance indicating that the GSEs would purchase the loan without conducting additional analysis or a lower rating that would require the originator to perform additional screening before submitting the mortgage to the GSEs for purchase. The differences in processing time could reflect whether additional analysis is required after loan originators enter the information into the systems. In contrast, the underwriting for the PLS loans during our sample period is known for lax lending standards and therefore forgoing additional screening that would be necessary for GSE loans.

Our findings suggest that there are differences across minority groups. In the HMDA data for purchase loans, the average processing time for Asian borrowers trends closely to that for white borrowers. Between Black and Hispanic borrowers, however, even though their time-series movements are nearly parallel, we find that the processing time for Hispanic borrowers is generally shorter, especially among the GSE loans. In regression analyses, we find that the processing time difference between Hispanic and white borrowers or between Asian and white borrowers is often close to zero or even negative. Especially among the GSE loans, Hispanic borrowers do not face as much delay as Black borrowers, even though both Black and Hispanic borrowers are under-represented in the GSE sample. In the merged

HMDA-CoreLogic data for the PLS loans, both Black and Hispanic borrowers are over-represented, but with different patterns. Among the PLS loans, Hispanic borrowers have higher FICO scores but a higher percentage of low-documentation loans relative to white borrowers, whereas Black borrowers have lower FICO scores but a slightly lower percentage of low-documentation loans relative to white borrowers. The FICO score is based on past credit history, and low documentation reflects insufficient records of income and assets. The GSE loans have requirements for both of these criteria, which could drive Hispanic and Black borrowers to obtain mortgage financing in the PLS segment. Furthermore, among the PLS loans, the loan delinquency rate of Black borrowers is much higher than white borrowers, but Hispanic borrowers have a lower delinquency rate than white borrowers. In this aspect, lax lending standards contribute to the demise of the PLS market, destroy this alternative access to mortgage credit for creditworthy minority borrowers, and potentially exacerbate the disparities in mortgage lending.

Several recent papers examine mortgage origination timeline. Foote et al. (2019) show that technology development in mortgage underwriting induces a dramatic decline in the average processing time between 1995 and 1998. Fuster et al. (2019) find that FinTech lenders shorten processing time through enhanced efficiency. The dramatic decline in processing time in our paper is related to the rise of non-agency securitization and the associated lax lending standards. Other studies focus on the time span from loan origination to securitization. Keys et al. (2012) show that lax screening is more pronounced for loans that have a shorter time to securitization. Adelino et al. (2019) show that the PLS mortgages that are sold faster have worse loan performance and a lower selling price. Adding to these findings, we find that loans that are sold faster after origination are also processed faster before origination. Examining the trading costs in the agency mortgage backed securities market with to-be-announced (TBA) trading, Gao et al. (2017) show that the TBA trading lowers the transaction costs for the underlying mortgage pools and dealers are reluctant to take inventory of securities that are difficult to hedge. Focusing on the coverage of credit default swaps (CDS) on the

subprime mortgage pools, Arentsen et al. (2015) find that when the start date of the CDS coverage and the issuance date of the mortgage pools are close the covered pools experience higher defaults, and within these pools the loans originated after or shortly before the start of CDS coverage have an even higher delinquency rate. Our findings indicate that faster processing mortgage market segments, lenders and loan product types have higher defaults.

Our paper contributes to the literature on disparities in mortgage lending. Earlier studies document the phenomenon of redlining against minority neighborhoods (see, e.g., Holmes and Horvitz, 1994; Ross and Tootell, 2004). Using the HMDA data, Black et al. (1978) show that minorities are more likely to be denied a mortgage. Munnell et al. (1996) reach a similar conclusion after controlling for borrower characteristics collected from loan applications in Boston in 1990, which are unavailable in the HMDA data. Giacoletti et al. (2020) argue that at least half of the observed approval gap for Black borrowers is attributable to within-month variation in loan officers' subjectivity. Conditional on the sample of originated mortgages, studies have shown that minority borrowers have to bear a higher cost (Courchane and Nickerson, 1997; Black et al., 2003; Ghent et al., 2014; Cheng et al., 2015; Reid et al., 2017; Bayer et al., 2018; Delis and Papadopoulos, 2018; Ambrose et al., 2020). Studying the incidence of consumer complaints on financial services, Begley and Purnanandam (2021) find the level of complaints is significantly higher in markets with lower income, lower educational attainment, and a higher share of minorities. For the mortgage loans securitized by GSEs, Bartlett et al. (2021) explore a rule from the U.S. fair lending law for identification and show that Black and Hispanic borrowers pay higher interest rates. Bhutta and Hizmo (2020) and Gerardi et al. (2020) argue that the rate gap is attributable to differences in discount points or prepayment behavior, respectively. Our findings of longer processing time for Black borrowers among the GSE loans also speak to the disparities in lending practices in this segment.

Our findings also contribute to the understanding on financial development and inequality. The level of inequality in income and wealth has risen significantly in the United States

in recent decades (see, e.g., Stiglitz, 2016). The credit expansion leading to the 2007-2008 mortgage crisis was fueled by financial innovation and private securitization, transforming subprime mortgage loans from borrowers with limited income and poor credit history into purportedly "safe" assets to meet investor demand.[5] Many minority home buyers financed through private securitization which expanded access to credit unavailable through traditional mortgage lending and agency securitization. However, the promise that this financial development would improve economic opportunities for disadvantaged minorities was broken by the collapse of the subprime mortgage market. Minority homebuyers suffered disproportionately from the collapse, and racial and ethnic disparities in homeownership worsen following the 2008 financial crisis (see, e.g., Bayer et al., 2016). Our findings illustrate the difficulties faced by Black borrowers through the traditional GSE lending channel and provide an explanation for why they pursue alternative channels for financing.

Our paper also relates to a large literature on agency problems in mortgage lending that led to the 2007-2008 mortgage crisis.[6] These agency problems could distort lenders' incentives in loan origination and loosen lending standards, thereby accelerating mortgage processing time. Our findings are relevant to the recent literature on the relation between credit supply and the housing cycle. Mian and Sufi (2018) propose the credit-driven household demand channel as a driver for the business cycle. Justiniano et al. (2019) argue that an increase in credit supply driven by looser lending constraints can reconcile key empirical features of the housing boom before the Great Recession. Dokko et al. (2019) document that in 2005 about 60% of all purchase mortgage loans have non-traditional features, and the rise in the

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[5]Faced with a scarcity of safe assets during this period, investors bought these purportedly "safe" securities offering higher yields than traditional safe assets. The shortage of safe assets before the 2008 financial crisis has been well studied (see, e.g., Gorton, 2017).

[6]Notable examples, among others, include Mian and Sufi (2009), Barlevy and Fisher (2011), Haughwout et al. (2011), Keys et al. (2012), Chinco and Mayer (2012), and Agarwal et al. (2014) on weakened standards; Ben-David (2011), Jiang et al. (2014), Piskorski et al. (2015), Griffin and Maturana (2016), and Garmaise (2015) on misrepresentations and fraud; Keys et al. (2010), Purnanandam (2011), Nadauld and Sherlund (2013), and Rajan et al. (2015) on a market fueled by poor ratings models and the rapid expansion of non-agency securitization markets; Demiroglu and James (2012) on affiliation-related agency issues; and Tzioumis and Gee (2013) and Agarwal and Ben-David (2014) on loan officer pay structure and the use of other credit derivatives.

number of non-traditional mortgages preceded the housing boom. We find that processing time declines before the 2007-2008 mortgage crisis, led by the PLS segment in the mortgage market, and that the non-traditional mortgages have a faster processing speed relative to traditional mortgages. These findings are consistent with the credit expansion driven by looser lending constraints. Furthermore, our finding that Black borrowers experience a large reduction in processing time by taking on non-traditional mortgages illustrates the rising household demand and leverage.

The road map for the remainder of the paper is as follows. In Section 2, we discuss the main data used in our analysis and take a preliminary look at racial disparities based on the summary statistics. Section 3 contains main results from our regression-based analysis using the comprehensive HMDA data. In this section, we further discuss the racial disparities in processing time in different segments of the mortgage market, such as GSE versus PLS segments. In Section 4, we focus on our regression-based analysis on the PLS market using the merged HMDA-CoreLogic data. The analysis in this section further sheds light on racial disparities in loan performance and across loan product types. Section 5 offers a brief conclusion.

2   First Glance at Racial Disparities in Mortgage Processing Time

In this section, we take a first glance at racial disparities in mortgage processing time. We first describe the main sources of data used in our analysis and then report the summary statistics. We find that Black borrowers of home purchase loans have a larger presence in the segments of the mortgage market associated with shorter processing time (e.g., the segments for PLS or non-traditional loans), whereas white borrowers have a predominant presence in the GSE segment, with their loans being processed about 5 days faster than those by Black borrowers.

2.1 Data

The main dataset used in our analysis is the HMDA dataset, which contains important information on borrower and loan characteristics such as loan amount, census tract of property, loan purpose, loan disposition, and the applicant's income, race, and gender. The HMDA dataset also provides the identity of the lenders, which we use to control for lender fixed effects and also to classify whether the lender is a subprime lender following Avery et al. (2007). Subprime lenders take a sizable market share between 2003 and 2007, right before the mortgage crisis.

The confidential HMDA data provide additionally the exact application date and action date (approved or denied). As such, we are able to calculate processing time for a given loan—one key variable of interest in this paper—as the difference between these two dates. Note that the public version of this data cannot be used for such calculation because it only reports the year of mortgage origination. Following Foote et al. (2019), we clean the HMDA data by dropping loans that lack information on race and gender, and by removing potentially miscoded outliers in the borrower's income entries. We also drop loans with a processing time in the bottom and top 1% of the distribution, which are most likely due to input errors. We also remove observations for second liens, investment properties, and multi-family residence.

In a typical mortgage processing timeline, a home buyer sometimes will start with getting preapproval from lenders who may or may not be used for the official loan application. In processing a preapproval, a lender will check the borrower's credit history and review information about the borrower's income, debts, and assets. The home buyer then will find a home to buy and sign a purchase agreement after negotiation. The home buyer often shops for a mortgage and chooses a mortgage lender at the start, with the intention of proceeding with the mortgage application. Afterward, a home inspection is scheduled to determine the condition of the home, a home appraisal is done to validate the home's value, and then a title company will research the home's legal history to make sure there are no other liens on

the property. The mortgage lender will then verify the borrower's income, assets, debt and home value. The mortgage lender may ask the borrower for additional documents, such as explanations for sources of large bank deposits. Once the mortgage is cleared to close, the lender will provide a closing disclosure and the home buyer will schedule a date for closing.

One caveat in our measure of processing time is that the action date coincides with the settlement or closing date for approved loans. Because some borrowers may have the incentive to close at the end of the month (e.g., to avoid paying additional interest in arrears in closing costs, or to avoid paying another month's rent in the old rental unit), our measure of processing time is also influenced by the endogenous behavior of the buyer to choose the closing date. Additionally, the timeline can vary across racial groups due to circumstances beyond a lender's control such as home inspection and appraisal or the borrower taking the time to submit necessary documents. As a result, we cannot exclude the possibility that racial disparities in processing time found here are attributable to the differences across racial groups that are unrelated to lender behavior and are not captured by the various controls in our regression analysis.

The CoreLogic LoanPerformance dataset is the second main dataset, which has an extensive coverage of privately securitized mortgages and supplements the HMDA data by providing information on whether a loan is current, delinquent, or in foreclosure—the basis for our loan performance measure. We use loan default within 10 to 15 months of origination as our primary loan performance measure. Following the convention in the mortgage loan industry, a loan is classified as being in default if payments on the loan are 60+ days late as defined by the Office of Thrift Supervision, the loan is in foreclosure, or the loan is real estate owned (REO). The CoreLogic LoanPerformance data also provide important information on borrower credit risk characteristics at loan origination, including FICO scores, combined loan-to-value (CLTV) ratios (including first and second liens), back-end debt-to-income (DTI) ratios, and whether the lender has complete documentation on the borrower's income and assets. We also have information on loan origination date, loan amount, ap-

praised value or sale price of the property, location of the property (five-digit ZIP code), and whether the borrower-owner occupies the property. As for loan specifics, the data also include information on whether the loan rate is fixed or adjustable, the initial loan rate, the margin and first rate reset for adjustable rate loans, and whether the loan has features such as a prepayment penalty or balloon payment at maturity.

As a key step in our investigation, we merge the HMDA and CoreLogic LoanPerformance data by using the exact application and action dates together with the loan amount and other loan characteristics. The merging algorithm in our paper parallels the one used in Rosen (2011) which matches the confidential HMDA data with the McDash data from Black Knight Financial Services. The most important variables used to merge these two datasets include the geographic location (i.e., ZIP code) and certain loan characteristics such as the amount and closing date of the loan. Details about merging these two datasets can be found in Wei and Zhao (2020). In Table 1 we report key variables from these two datasets as well as those measuring local macroeconomic conditions.

2.2 Summary Statistics and Preliminary Findings

In Table 2 we report the summary statistics for our sample of mortgage applications for the purchase or refinance of owner-occupied homes in 2001-2006 by racial and ethnic groups from the confidential HMDA data. The sample includes both accepted applications that led to mortgage origination and applications rejected by lenders.[7] Panels A and B of the table report the summary statistics for home purchase and refinanced loans, respectively.

In our HMDA sample, there are 22 million originated home purchase loans, 4 million rejected home purchase loan applications, 37 million originated refinance loans, and 11 million rejected refinance applications. About 24.1% of originated home purchase loans are from minority borrowers, and about 40.6% of the rejected home purchase loan applications are from minority borrowers, which indicates that the unconditional rejection rate is higher

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[7]We do not include the applications that are approved by lenders but rejected by borrowers because they do not lead to loan origination.

for minority relative to white borrowers. Similarly, minority borrowers of refinance loan applications face a higher rejection rate relative to white borrowers.

The average processing time is about 40 days for originated home purchase loans, 24 days for rejected home purchase loan applications, 38 days for originated refinance loans, and 21 days for rejected refinance applications. The unconditional average processing time for originated home purchase loans is longer for white and Asian borrowers relative to Black (by about 4 days) and Hispanic borrowers (by about 6 days). The distribution of processing time is positively skewed, with the averages being higher than the medians.

Within the sample of originated home purchase loans from subprime lenders, the average mortgage processing time is 22.3 days with a standard deviation of 18.3 days, and both are significantly lower than those from the whole sample.[8] Comparing the racial/ethnic representation in the whole sample and in the sample of subprime lenders, we find that Black and Hispanic borrowers are over-represented. Specifically, Black (Hispanic) borrowers account for 18.8% (27.4%) in the subprime segment, but only 6.9% (11.4%) in the whole sample.

To illustrate the time-series pattern of average processing time by race, we plot in Figure 1 the averages and standard deviations of processing time by race in each year between 2001 and 2006 based on the originated mortgages for home purchases (Panel A) as well as refinance (Panel B). From Panel A of the figure, we see that the average processing time for home purchase mortgages generally decreases during our sample period and more drastically for Blacks and Hispanics after the year 2003 than for Asians and whites, which shows a bifurcated pattern between Black and Hispanic on one side and white and Asian on the other side. The average processing time for originated home purchase loans decreases by about 3 days for white and Asian borrowers from the period 2001-2003 to the period 2004-2006, whereas it decreases by 9 days for Black and by 7 days for Hispanic borrowers.

The time-series pattern for the standard deviations of processing time also shows a bi-

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[8]The average processing time for originated home purchase loans from subprime lenders is 22.3, 21.7, 22.6, and 23.0 days for white, Black, Hispanic, and Asian borrowers, respectively.

furcated pattern of a near-parallel decline for Black and Hispanic borrowers and relative stability for white and Asian borrowers. One interesting observation appears when comparing the averages and standard deviations of processing time between white and Black borrowers. After the year 2003, both the average and the standard deviation of processing time are significantly lower for Black borrowers, which indicates an increase in processing speed for a wide spectrum of Black borrowers. Wei and Zhao (2020) argue that the reduction in processing time in the period 2004-2006 indicates a loosening of lending standards, which can provide a potential explanation for these time-series patterns.

Turning to the refinance mortgage, shown in Panel B of Figure 1, we observe that the time-series trends in the averages and standard deviations of processing time are almost parallel across all of the groups. Interestingly, the processing time decreases evenly across borrower groups for refinance mortgages, but in a bifurcated pattern for home purchase loans. One explanation is that we focus on owner-occupied mortgages and the sample of home purchase mortgages includes many new entrants into the housing market, a key feature in the credit expansion before the 2008 mortgage crisis.

We plot in Figure 2 the averages and standard deviations of processing time between 2001 and 2006 for the rejected mortgage applications for home purchases (Panel A) and refinance (Panel B). Interestingly in Panel A, the average processing time for rejected home purchase mortgage applications increases from the period 2001-2003 to the period 2004-2006 for each borrower group (by about 9 days for white applicants and 3 days for other groups). This finding indicates that mortgage rejection takes longer after the year 2003. Note that the standard deviations of processing time actually decline for Black and Hispanic applicants after 2003, even though in the same period the average processing time for these groups increases, which is an indication of more homogeneous mortgage processing for these two groups of borrowers. Panel B of Figure 2 shows that within rejected refinance applications, the average processing time decreases from the period 2001-2003 to the period 2004-2006 fairly evenly by 6 to 8 days across borrower groups, and the standard deviations also decline

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fairly evenly.

To sum up, home purchase mortgage applications get faster approvals and slower rejections over our sample period, but refinance applications, either approved or rejected, get processed faster over our sample period. The contrast between home purchase and refinance loans indicates a structural change in the mortgage market for home purchase loans.

The most significant change in the mortgage market during our sample period is the rise of subprime mortgages fueled by private-label securitization, as opposed to securitization by the GSEs. It is therefore important to discern how the changes in the mortgage market contribute to the changes in mortgage processing speed. The HMDA data provide important information on loan purchaser types for us to identify different market segments. The loan purchaser type is the type of institution that purchases a particular loan from the lender that originates the loan. The types of purchasers include GSE, PLS ("PLSP"), commercial banks and savings associations ("Bank"), lender-affiliated institutions ("Affiliate"), insurance companies and mortgage banks and finance companies ("MC"), and an unspecified other type ("Other"). Additionally, if the mortgage loans are not sold to a purchaser within the calendar year of origination ("Unsold"), they are also identified. We label the PLS purchaser type as "PLSP", which refers to the case in which mortgage lenders sell loans directly to private-label securitization. As we show later in the merged HMDA-CoreLogic data of the PLS loans, loans initially unsold or purchased by other types of institutions can eventually be sold to private-label securitization. The HMDA data changes the codification of loan purchaser type after the year 2003 to reflect the changes in the mortgage market: PLSP is added and mortgage banks and finance companies are included with insurance companies.[9]

In Table 3, we report the summary statistics for the home purchase mortgages across

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[9]The classification of the purchaser type for insurance companies changed after 2004 in the HMDA data. It includes only life insurance companies before 2004 and adds credit union, mortgage bank, and finance company after 2004. The number of loans purchased by insurance companies is negligible before the category expands after 2003. We therefore attribute the loans in this category to mortgage banks and finance companies. While mortgage financing is traditionally done by depository financial institutions—commercial banks, thrifts, and savings and loans—independent mortgage financing companies had taken a sizable market share between 2003 and 2007, right before the mortgage crisis.

loan purchaser types based on the HMDA data. The number of loans broken down by purchaser type is reported in Panel A. There have been significant increases for the purchaser types of PLSP, Bank, Affiliate, and MC. In Panel B, we report the percentage of loans from each borrower group. In aggregate during the period 2001-2003 (2004-2006), 79.6% (72.7%) of home purchase loans are originated for white borrowers, 5.6% (8.0%) for Black borrowers, 9.3% (13.3%) for Hispanic borrowers, and 5.5% (6.1%) for Asian borrowers. The share of minority borrowers grew during this period, especially the share of Black and Hispanic borrowers. White borrowers are over-represented for the GSE type, making up 82.9% (81.2%) in the period 2001-2003 (2004-2006), whereas Black and Hispanic borrowers are under-represented with 4.0% (4.6%) and 7.4% (8.1%), respectively. In sharp contrast to the GSE type, the composition in the PLSP sample is 53.4%, 15.2%, 24.5%, and 7.0% for white, Black, Hispanic, and Asian borrowers, respectively. Black and Hispanic borrowers are also over-represented in the unspecified other type and the type including mortgage bank and finance companies, but to a lesser degree. These types also sell a higher volume of loans to private securitization.

In Panel C of Table 3, we report average processing time by the borrower's racial/ethnic group and purchaser type. In the period 2001-2003, the average processing time for white, Black, and Asian borrowers is comparable and 2-3 days faster for Hispanic borrowers. This pattern holds across purchaser types with two notable exceptions. First, for the GSE type, it takes about 5 more days of processing time for Black borrowers than for white borrowers. Second, for the other type, the processing time for Black borrowers is about 6 days shorter than for white borrowers. As Black borrowers are least represented in the GSE type and most represented in the other type, we argue that Black borrowers may have their preferred segments in obtaining mortgage credits, possibly related to the length of mortgage processing time.

In the period 2004-2006, we observe a prominent decreasing trend in processing time across all purchaser types. The average processing time for Black borrowers becomes closer

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to that of Hispanic borrowers. Across purchaser types, PLSP loans are processed the fastest and GSE loans the slowest, with PLSP loans processed faster by 15, 24, 17, and 16 days for white, Black, Hispanic, and Asian borrowers, respectively. Interestingly, the processing time for Black and Hispanic borrowers is also shorter among the MC and other type of purchasers. All three types consist of a higher proportion of Black and Hispanic borrowers, whereas these two groups of borrowers are most under-represented in the GSE type.

In Panel D of Table 3, we report the standard deviation of processing time by the borrower's racial/ethnic group and purchaser type. The GSE (PLSP) type has the highest (lowest) standard deviation among all types. For the PLSP type, the standard deviations are 7 days shorter for Black and Hispanic borrowers relative to white and Asian borrowers.

We next explore the time-series patterns in different segments of the mortgage market. The time-series patterns of processing time in Figure 1 show the more drastic decline in processing time for Black and Hispanic borrowers relative to white and Asian borrowers in the sample of home purchase mortgages. By exploring the patterns in the different segments, we can discover the roots of the change in the aggregate market. In Figure 3, we plot the averages and standard deviations of processing time based on the originated mortgages for home purchases from the sample of the GSE purchaser type (Panel A) and the PLS sample from the merged HMDA-CoreLogic data (Panel B).[10] Panel A of the figure shows that the average processing time for the GSE type generally decreases during our sample period, but is still longest for Black borrowers. Both the averages and standard deviations have similar trends across borrower groups. When we turn to the PLS sample in Panel B, we make a striking observation that the averages across borrower groups move in tandem and stay close to each other, especially between Black and white borrowers. The standard deviations for Black and white borrowers also closely track each other, whereas the standard deviation for Hispanic borrowers is further away from the rest.

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[10]The PLS sample includes loans initially sold to all purchaser types and unsold during the origination year and covers our sample period from 2001 to 2006. The PLSP type in the HMDA data only starts from 2004.

In Panel A of Figure 4, we plot the averages and standard deviations of processing time based on the originated mortgages for home purchases from the sample mortgages from the subprime lenders identified in the HMDA data. Strikingly, focusing on the loan sample by subprime lenders, the ranges for the averages and standard deviations across borrower groups are tight over time, indicating few differences in processing speed across the groups. We also note that the average processing time from subprime lenders is similar to that of the PLS sample, and both are much shorter than the GSE sample shown in Figure 3. The time-series patterns for the GSE type, the PLS sample, and the subprime lender sample, are in contrast to the pattern in the whole sample, which shows a bifurcated pattern for Black and Hispanic borrowers and for white and Asian borrowers. We argue that Black and Hispanic borrowers are over-represented in the fast-processing segments, such as the PLS sample and the subprime lender sample, which accounts for a larger market share in the later years of our sample period, and therefore these borrowers experience a much faster processing time than white and Asian borrowers.

We next turn to other segments in the mortgage market. In Panel B of Figure 4, we plot the time-series pattern for the Bank purchaser type and find a bifurcated pattern for Black and Hispanic borrowers and for white and Asian borrowers. Both the averages and standard deviations for Black and Hispanic borrowers declined more than for white and Asian borrowers. In our data, we find an increased presence in the PLS sector by commercial banks in the latter part of our sample period, which can explain the time-series pattern for the Bank purchaser type.

So far, our results show that the rise of the private-label securitization greatly speeds up mortgage processing time for Black and Hispanic borrowers. To delve into the PLS segment, we provide summary statistics for the merged HMDA-CoreLogic data on the PLS loans in Table 4. In Panel A, we report the mean and standard deviation of processing time, the percentage of borrowers from each racial/ethnic group, the average FICO score, the average combined LTV ratio, the percentage of low-documentation loans, and the average

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delinquency rate. While the mean processing time is close among the borrower groups, the standard deviation is lower for Hispanic borrowers. The racial/ethnic representation is similar to that for the PLSP type in the HMDA data, except that the percentage for Black borrowers is higher. The average FICO score of Black borrowers is the lowest, whereas the Hispanic and Asian borrowers have higher average FICO scores than white borrowers. The combined LTV ratios are above 90% across all groups. Hispanic and Asian borrowers have a higher percentage of low-documentation loans than Black and white borrowers. The average delinquency rate is similar at around 10% for white, Hispanic, and Asian borrowers, but much higher at 19.4% for Black borrowers.

In Panel B, we break down the processing time and racial representation by loan product type. We consider different amortization schedules such as fixed rate mortgage (FRM), interest only (IO), balloon, and hybrid mortgages that have a low initial loan rate for the first 24 or 36 months and then reset to a higher loan rate. These non-traditional mortgages, as opposed to the FRM, allow borrowers to make lower monthly mortgage payments in the early years of the mortgage and require substantially higher payments later on. Demyanyk and Van Hemert (2009) show that these mortgages experienced a much higher default rate than the FRMs in the aftermath of the mortgage crisis. Interestingly, we find that these non-traditional mortgages are processed faster than the FRMs, consistent with the notion that these mortgages suffer from loose lending standards. The differences in processing time across borrower groups are small; however, we find that Black and Hispanic borrowers are over-represented in the sample of non-traditional mortgages and under-represented in the sample of FRMs. We further compare loans with low and full documentation and find, somewhat surprisingly, that they have a similar processing time with few differences across borrower groups. Consistent with existing observations, white borrowers are under- (over-) represented in low- (full-) documentation loans. However, we also find that Black borrowers are under-represented in low-documentation loans, whereas Hispanic borrowers are over-represented in low-documentation loans. Lastly, we compare loans in terms of the time span

from loan origination to securitization (OTS), defining the loans in the longest (shortest) quartile of OTS as slow (fast) OTS. Keys et al. (2012) show that lax screening is more pronounced for loans that have faster OTS. Consistent with their finding, we find that loans with fast OTS are processed faster than loans with slow OTS. The patterns of the standard deviations of processing time follow those of the averages, but the differences are much larger in magnitude. The difference in the averages between fast and slow OTS is 2.3 days for Black borrowers, whereas the difference in the standard deviations is 8.8 days, indicating a much wider distribution.

3 Racial Disparities in Processing Time

In this section we investigate empirically whether there are racial disparities in processing time based on the HMDA data. The sample period is from 2001 to 2006.

3.1 Baseline Results

As our first analysis, we examine whether there are systematic differences in processing time for borrowers with different racial and ethnic backgrounds. We first focus on the evidence based on the HMDA data. Although it has incomplete information on borrower creditworthiness, it is by far the most comprehensive universe of mortgage loans and serves as a benchmark for comparison.

We consider the following loan-level regression specification:

$$PT_{i,j,c,t} = \alpha + \beta \times Race_i + \gamma \times X_{i,j,t} + \delta_{c,t} + \delta_j + \epsilon_{i,j,c,t}, \tag{1}$$

where $PT_{i,j,c,t}$ denotes the processing time for loan i originated by lender j in county c and year t, and $Race_i$ denotes the racial and ethnic background of the borrower. We also control for other borrower and loan characteristics in $X_{i,j,t}$, such as loan amount and borrower's income and gender. Loan purchaser information is also included in loan characteristics since

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summary statistics show that processing time varies across loan purchaser types, with the GSE being the slowest and the PLSP being fastest. Therefore, any racial disparities in processing time can be the result of different levels of exposure to these characteristics.

We include county-month fixed effects, $\delta_{c,t}$, so that we can control for the variations across geographic locations and origination cohorts. The county-month fixed effects can account for varied local and macroeconomic conditions, such as local housing price dynamics, local mortgage origination volume, labor market conditions, and average household income, in addition to the overall time trend that processing time declines during the sample period. We further include regression specifications with and without lender fixed effects, δ_j. Mortgage processing time varies across lenders as subprime lenders tend to be faster. Black and Hispanic borrowers are more likely to finance through subprime lenders and therefore can have a faster processing time on average. In assessing racial/ethnic disparities in processing time, we explore both between-lender and within-lender variations.

Table 5 reports the results in the whole sample of originated home purchase loans and the subsamples based on mortgage purchaser types from the regression (1) of processing time on borrower's racial/ethnic background, controlling for other loan and borrower characteristics available in the HMDA data and county-month fixed effects. The standard errors are clustered by lender and month. We run the regression separately for the two subperiods of 2001-2003 and 2004-2006 because some HMDA variables become available or change classification after 2003, and, more importantly, the summary statistics of processing time display distinct patterns in the two subperiods. The racial/ethnic dummy variables capture the differences in processing time from the base group (white borrowers).

As reported in Table 5 for the whole sample, we find that, during the period 2001-2003, the difference in processing time between Black and white borrowers is 2.561 (4.996) days without (with) lender fixed effects, -0.545 (1.502) days between Hispanic and white borrowers, and -0.287 (-0.485) day between Asian and white borrowers. These estimates show an interesting twist from what we report in the summary statistics. After controlling for various

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loan characteristics and fixed effects, the processing time is longer for Black borrowers than white borrowers, whereas the difference is small unconditionally. Hispanic borrowers have a shorter average processing time (4 days) than white borrowers unconditionally, and a longer processing time conditionally. The difference is still small between white borrowers and Asian borrowers both unconditionally and conditionally. These comparisons indicate a potential association between Black and Hispanic borrowers and loan and lender characteristics related to faster processing. In other words, Black and Hispanic borrowers are likely to be selected into the fast-processing loan sample, and when we compare like with like, Black and Hispanic borrowers have a longer processing time.

Across the two subperiods, the difference in processing time for Black borrowers are much reduced during the period 2004-2006, as reported for the whole sample results in Table 5, to 1.235 (2.416) days without (with) lender fixed effects in 2004-2006. The estimates for Hispanic borrowers are also reduced to -1.717 (0.118) days without (with) lender fixed effects in 2004-2006. The estimates for Asian borrowers increase in 2004-2006, but still statistically insignificant. These estimates show that the differences across borrower groups become smaller during the later part of the sample period, or the disparities become smaller, differing from the unconditional averages reported in the summary statistics.

The summary statistics show that processing time decreases by 3.5, 9.0, 7.1, and 2.5 days for originated purchase loans for white, Black, Hispanic and Asian borrowers respectively from the period 2001-2003 to the period 2004-2006. The regression results also show that processing time for Black and Hispanic borrowers decreases more than for white borrowers with and without lender fixed effects. The decreasing trend in processing time is documented in Wei and Zhao (2020), who argue that mortgage lenders may form overly optimistic beliefs by extrapolating from the recent housing price growth and subsequently make loans hastily by loosening lending standards. One potential explanation for the more pronounced decreasing trend for Black and Hispanic borrowers than for white and Asian borrowers is that Black and Hispanic borrowers are more likely to be associated with faster processing

lenders with growing market share during our sample period. We next try to shed some light on the association between minority borrowers and lenders.

Comparing the estimates with and without lender fixed effects, we find that the estimates for Black and Hispanic borrowers increase when lender fixed effects are included. The estimates with lender fixed effects illustrate within-lender variations since we compare Black borrowers to white borrowers using the same lender. The estimates without lender fixed effects further reflect between-lender variations. When Black borrowers are more likely to use faster processing lenders than white borrowers, the estimates are less positive than those with lender fixed effects, as we find comparing column (a) to (b) in Table 5. Specifically, we find that the differences in the estimates with and without lender fixed effects are around 2.4 (1.2) days in 2001-2003 (2004-2006) for Black borrowers, and around 2.0 (1.8) days for Hispanic borrowers in 2001-2003 (2004-2006). These results suggest that both Black and Hispanic borrowers are more likely to be associated with faster processing lenders relative to white borrowers.

We next briefly discuss the estimates for other control variables in the regression results for the whole sample, which are reported in the Internet Appendix for brevity. The estimates on purchaser types are consistent with the summary statistics on the differences in processing time in the mortgage market. We find that the GSE loans are processed at about the same speed as other types during the period 2001-2003 but more slowly during the period 2004-2006. PLSP loans are processed the fastest. We also find that loans purchased by commercial banks and saving associations are processed slower in 2001-2003, but faster in 2004-2006 than the GSE loans.[11] These findings are consistent with the growing demand pressure from the secondary loan markets during our sample period, especially for the segments associated with non-GSE securitization. As for other loan characteristics, we find that processing time is increasing in loan amount, decreasing in borrower's income, and longer when there is a co-applicant or preapproval is requested. Interestingly, we also find that high-cost loans

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[11]We also find that loan purchases by commercial banks are much more likely to eventually end up in the PLS deals in 2004-2006, relative to 2001-2003.

and loans with higher rate spreads are processed faster, especially when comparing across lenders.[12] This result is consistent with the observation that borrowers may be able to lower loan rates with the submission of extra documentation, provided that the loan applications are approved, which can delay the process. When controlling for loan rates, we focus on the variations from the lender side, not the borrower side.

One special feature of our sample period is the rise of the subprime mortgage market, which offers borrowers mortgage credits with lower lending standards relative to traditional mortgages. When we examine the subsample of loans that are originated by subprime lenders, we find that the differences in processing time between Black or Hispanic and white borrowers are much smaller than in the whole sample. We also find the differences are much smaller in the subsample of high-cost mortgages. These results are reported in the Internet Appendix. The findings of less disparity in processing time in these subsamples are consistent with the patterns in Figure 3.

We further conduct the analysis of refinance loans. The application process for refinances is typically simpler and the processing time shorter because the borrower is not required to move to new residences. Foote et al. (2019) show a dramatic decline in the average processing time for refinances between 1995 and 1998, but no such pattern for purchase loans. Fuster et al. (2019) also find that FinTech lenders shorten the processing time more for refinances than for home purchase loans. We find that the differences in processing time between Black and white borrowers are smaller in the refinance sample and the decline in processing time from the period 2001-2003 to the period 2004-2006 is weaker for refinance loans. These findings are consistent with the time-series plots and indicate that the changes in the mortgage market have less of an impact on refinance loans than on home purchase loans. Finally, we investigate the differences in processing time for denied mortgage applications and find no evidence of slower processing for Black and Hispanic borrowers. These results are also reported in the Internet Appendix.

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[12]In the HMDA data, the rate spreads for high-cost loans, whose rates are higher than the prevailing comparison rate, are reported after 2004.

3.2 Disparities across Mortgage Purchaser Types

Disparities in processing time can arise if delays in the screening process vary systematically across racial/ethnic groups or if loan demand from the secondary market affects minorities differently from white borrowers. Purchaser types in the HMDA data can be exploited to disentangle these two determinants of processing time. The most prominent phenomenon during our sample period is the rise of the PLS market, where most subprime mortgages are securitized. As we show in the summary statistics, Black and Hispanic borrowers account for almost half of the HMDA-CoreLogic merged sample, and the PLS market has a disproportional impact on minority borrowers. In the HMDA data, we draw a comparison between GSE loans, PLSP loans, commercial banks, mortgage financing companies, and lender-affiliated institutions.

Table 5 reports the results from the regression (1) for originated home purchase loans across loan purchaser type. For each purchaser type, we report the regression results for 2001-2003 and 2004-2006 separately with and without lender fixed effects, controlling for loan and borrower characteristics and county-month fixed effects.

In the GSE sample, the processing time for Black borrowers is 8.26 (7.16) days longer than for white borrowers without (with) lender fixed effects during 2001-2003 and 5.15 (5.25) days during 2004-2006. These differences are both statistically and economically significant. The close estimates from specifications with and without lender fixed effects indicate that the differences are mostly from within-lender variations. In the summary statistics, the differences in average processing time between Black and white borrowers are 5.5 days during 2001-2003 and 2.1 days during 2004-2006. After including various controls, the differences become even larger. The estimates for Hispanic borrowers are much smaller: about one day slower than for white borrowers during 2001-2003 and near zero during 2004-2006 with lender fixed effects. The processing time for Asian borrowers is about one day faster during both subperiods.

The large gap of 7 to 8 days in processing time for Black borrowers in the GSE segment

may result from the observation that a larger portion of Black applicants do not get the approval from the GSEs' automated underwriting systems and need to go through manual underwriting with additional analysis before obtaining final approval of their loan applications. For instance, Giacoletti et al. (2020) show that Black applicants are recommended for approval approximately 6 percentage points less frequently in the post-2018 HMDA data containing the recommendations of the automated underwriting systems. The GSEs' procedural underwriting process may be less flexible to speed up the timeline, which can explain the persistent disparities in processing time.

In the PLSP sample, which covers the period 2004-2006, the differences between Black and Hispanic borrowers and white borrowers are quite small: less than one day with lender fixed effects. Interestingly, as shown in the summary statistics, the differences in average processing time between Black (Hispanic) and white borrowers are 6.3 (4.5) days during 2004-2006. These unconditional differences disappear after adding various controls, again indicating an association between Black borrowers and loan and lender characteristics related to faster processing.

As shown in Figure 4, commercial banks reduce the mortgage processing time for Black and Hispanic borrowers dramatically during our sample period. In our regression analysis, the processing time for Black borrowers is 6.25 days longer than for white borrowers during 2001-2003, one of the longest among purchaser types, and 1.77 days during 2004-2006, one of the shortest among purchaser types, both with lender fixed effects. The processing time for Hispanic borrowers also decreases, but to a lesser extent. These changes may illustrate that commercial banks have responded to the rise of PLS and subprime markets by speeding up mortgage processing. The regression results from the samples of lender-affiliated institutions also show reduced processing time for Black and Hispanic borrowers relative to white borrowers. But the reduction for Black borrowers is smaller relative to commercial banks. Demiroglu and James (2012) show that mortgage screening is positively associated with the incentive alignment between the lender and sponsor (i.e. "skin in the game"). When lenders

sell loans to affiliated sponsors, their incentives are better aligned, and thus the problem of lax lending standards is less severe. Lastly, consistent with the observation that mortgage financing companies are often associated with lax lending standards, the estimates for Black and Hispanic borrowers from the sample of mortgages purchased by mortgage financing companies are closer to the PLSP type than to the GSE type.

Comparing the estimates with and without lender fixed effects, we find Black borrowers tend to select fast processing lenders for each purchaser type except for the GSE segment since estimates are generally larger with lender fixed effects. The processing time for Asian borrowers is usually not much slower relative to white borrowers, but we find significant differences in the samples for the MC and Other types during 2004-2006 without lender fixed effects, which indicates that Asian borrowers tend to select certain slow lenders in these types.

Overall, the GSE sample shows persistent disparities in processing time for Black borrowers, whereas evidence of disparities exists mostly during 2001-2003 for other types, but is not as pronounced during 2004-2006. We do not find evidence of disparities for the PLSP type. The impact of the PLS market on the overall mortgage markets during 2004-2006 can help explain the time variation in disparities since loan purchasers such as commercial banks become more involved in the PLS market.

An alternative explanation to our finding of longer processing time for Black borrowers is that Black borrowers could be economically disadvantaged so that they may choose a later closing date to minimize prepaid interests in closing costs and the overlap in rent and mortgage payments.[13] However, this explanation has difficulty to reconcile the contrast between regression-based (Table 5) and unconditional (based on summary statistics in Table 3) results in the GSE sample. Specifically for the GSE sample, in Table 3 the differences in processing time between Black and white borrowers are 5.5 days in 2001-2003 and 2.1 days in 2004-2006, and in Table 5 the differences widen to around 7-8 days in 2001-2003 and 5

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[13]This can also fit the patterns of small disparities in processing time in the PLS sample since those borrowers may have similar economic situations across Black and white groups.

days in 2004-2006 after controlling for borrower income and other loan characteristics, and fixed effects for county and lender. If household economic conditions are the main reason for longer processing time for Black borrowers, we would expect that the differences shrink in the regression analyses. Another alternative explanation is that the additional delay faced by Black borrowers is unrelated to household economic conditions, or exogenous to our control variables but correlated with race. However, this explanation is challenged by the summary statistics in Table 3 across purchaser types in that the processing time for Black borrowers is similar to or several days shorter than that for white borrowers for all the purchaser types except the GSE. If the Black borrowers have a preference for a later closing date, unrelated to household social economic conditions, we should observe longer processing time for Blacks borrowers in non-GSE purchaser types as well. Therefore, our findings cast doubt on these alternative explanations based on borrowers' choice, rather than lending standards. Furthermore, Wei and Zhao (2020) provide evidence showing that shorter processing time is associated with lax lending standards during this sample period.

3.3 Application Volume and Disparities in Processing Time

The mortgage application volume has risen significantly during our sample period and more so for home purchases than refinances. Fuster et al. (2019) find that shocks in the volume of mortgage applications can significantly affect lenders' capacity constraints and thus mortgage processing time. These shocks can potentially affect disparities in processing time during our sample period.

To compare the impacts of shocks in application volume across racial and ethnic groups, we run the following regressions:

$$PT_{i,j,c,t} = \alpha \times Applications_t + \beta \times Race_i + \gamma \times Applications_t \times Race_i + \theta \times Controls_{i,c,t} + \delta_j + \delta_c + \epsilon_{i,j,c,t},$$
$$(2)$$

where $Applications_t$ is the log of aggregate mortgage applications or refinance applications

in month t, and the control variables include borrower and loan characteristics and calendar month dummies to account for seasonality. We also include fixed effects for lenders and counties. Standard errors are clustered by lender and month of origination.

Table 6 reports the results in the sample of originated home purchase loans and refinance loans separately from the regression (2) of processing time on borrower's racial/ethnic background and application volumes, controlling for other loan and borrower characteristics available in the HMDA data and for county and lender fixed effects. In the sample of home purchase loans, we find that an increase of a one standard deviation change in aggregate application volume (refinance application volume) lengthens loan processing by 0.83 (0.81) day, and both have a 1% statistical significance. Furthermore, we find that an increase in application volume will lengthen the processing time for Black applicants even more by 0.50 (0.73) day than white applicants. The increase in processing time for Hispanic applicants is much smaller in comparison at 0.12 (0.14) day, and both are statistically insignificant. We do not find evidence of additional delays for Asian applicants. In contrast, in the sample of refinance loans, we find that the impacts on processing time by an increase in application volume are larger in magnitude, but have little additional impact on Black applicants. Notably, our estimates on race dummy variables remain similar to what we have without including application volumes, which indicates that our previous findings are robust to shocks to mortgage application volume.[14]

Interestingly, the finding that processing time for Black applicants for home purchase mortgage increases more than white borrowers when application volume increases indicates that the rise in application volume is not the driver for the reduction in processing time for Black borrowers relative to white borrowers in 2004-2006, but rather works against such reductions.

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[14]We standardize the variables, log of aggregate mortgage applications and refinance applications, to have zero means, so their interactions with racial/ethnic dummy variables do not affect the estimates on these dummy variables given that the application variables are at average.

4 Disparities in Processing Time and Delinquency

Our results based on the HMDA data suggest that the rise of the PLS market contributes to the reduction in processing time during our sample period and especially so for Black and Hispanic borrowers since they are over-represented in this market. The disparities in mortgage processing time may be the result of differential lending standards or unobserved credit quality issues that are associated with borrower demographics. Is the reduction in disparities in processing time the result of removing differential standards or lax underwriting by the lenders? To shed light on this question, we delve into the PLS market using the merged HMDA-CoreLogic data.

The merged data provides loan performance information on whether a loan is current, delinquent, or in foreclosure. If the reduction in processing time is related to lax screening, we would expect worse loan performance or a higher default rate unexplained by our observable control variables. The unexplained loan delinquency is often considered as an indication of lax lending standards (see, e.g., Keys et al., 2010). Thus, drawing inferences from both processing time and loan default can shed light on the causes for the reduction in processing time.

Furthermore, the merged HMDA-CoreLogic data add additional loan and borrower characteristics, including FICO scores, combined loan-to-value (CLTV) ratios (including first and second liens), back-end debt-to-income (DTI) ratios, and whether the lender has complete documentation on the borrower's income and assets. These additional characteristics can be used to corroborate our findings from the HMDA data on the PLS loans. We also have information on various loan product types, which enables us to compare processing time across different loan products.

With the merged HMDA-CoreLogic data on the PLS loans, we first compare processing time for borrowers with varied backgrounds and examine whether processing time varies systematically with borrower background beyond the differences in borrower creditworthiness. In particular, we expand the control variables $X_{i,j,t}$ in the regression specification (1) to in-

clude additional variables, such as FICO, LTV, DTI, and indicator variables for loan product type, initial loan rate, margin for adjustable rate mortgages, and an indicator variable for a prepayment penalty. We also include lender, origination year, and county fixed effects in the regression.

To compare the ex post loan delinquency across racial and ethnic groups, we run similar regressions for processing time, but now replace processing time by a loan delinquency dummy variable that equals one if the loan becomes delinquent within 10-15 months of origination, or zero otherwise. We also control for processing time in the delinquency regression and expect a negative relation if reduction in processing time relates to lax underwriting.

Table 7 reports the results from the regression based on the merged HMDA-CoreLogic data on PLS loans during 2001-2006. We repeat our analysis for all loans in the merged data, and across various subsamples. The results based on all loans on processing time show that the differences between Black and white borrowers are much smaller than the estimates for the whole sample reported in Table 5, unsurprisingly because the merged HMDA-CoreLogic data contains mortgage loans that are privately securitized. The differences between Hispanic and white borrowers are small based on the HMDA data, and also small in the merged data. One interesting observation is that Asian borrowers have a slightly longer processing time than white borrowers in the merged data, but not in the HMDA data. We also compare to the results in Table 5 for the PLSP type during 2004-2006 and find the estimates are quite close, which ensures that our results based on the HMDA data are robust to the expanded set of control variables.[15]

The summary statistics show that the loan delinquency rate for Black borrowers is 19.4% and 10% for white borrowers. The results from the loan delinquency regression show that the delinquency rate is 6.0% higher for Black borrowers than for white borrowers after controlling for various loan characteristics and fixed effects. On the other hand, the delinquency rate is

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[15]The PLSP sample represents the portion of the PLS loans that are directly purchased from the lenders by the non-agency securitizers, who also acquire loans from commercial banks and others after they purchase loans from the lenders.

about 1% lower for Hispanic borrowers than for white borrowers and also about 0.4% lower for Asian borrowers. Given that we include detailed controls on loan characteristics and various fixed effects, the magnitude of the unexplained delinquency gap between Black and white borrowers is economically significant.

We find significantly negative relation between processing time and loan delinquency, in the magnitude of 0.7 bp lower delinquency for one day increase in processing time, an indication of lax underwriting by the lenders since their loan performance benefits from additional processing time. On the relation between other loan characteristics and processing time and delinquency, we find that the borrower's FICO score is negatively correlated with processing time or delinquency, low-documentation loans have a faster processing time and higher delinquency rate than full-documentation loans, the LTV ratio is positively associated with the delinquency rate and negatively associated with processing time, and the DTI ratio is positively associated with the delinquency rate and positively (negatively) associated with processing time in 2001-2003 (2004-2006).[16] These findings are consistent with the previous studies (Demyanyk and Van Hemert, 2009) that show pervasive lax underwriting in the PLS market especially in the latter years preceding the GFC.

The time period leading up to the 2007-2008 mortgage crisis has seen the proliferation of many non-traditional mortgage loan products, as opposed to the traditional fixed rate mortgages in the PLS market. Non-traditional mortgages have been shown to have a larger impact on the housing price cycle than the FRMs. Dokko et al. (2019) document that about 60% of all purchase mortgage loans have non-traditional features and the rise of non-traditional mortgages preceded the housing boom. Demyanyk and Van Hemert (2009) show that these mortgages experienced a much higher default rate than the FRMs in the aftermath of the mortgage crisis. These non-traditional features include hybrid loans with a low initial rate, interest only (IO), and balloon. As reported in the summary statistics, these non-traditional mortgages are processed faster than the FRMs, and Black and Hispanic borrowers

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[16]For brevity, we report these estimates in the Internet Appendix.

are over-represented in the sample of non-traditional mortgages and under-represented in the sample of FRMs.

Table 7 also reports the results from the regression based on the merged HMDA-CoreLogic data on the PLS loans by loan types. The overall patterns in loan delinquency remain: the loans from Black borrowers experience a significantly higher default rate than those of white borrowers. The differences in processing time are generally small in magnitude. However, a comparison across different loan types sheds light on the differences within the PLS sample. We find that the differences in processing time between Black and white borrowers are the largest for the FRM type, at 1.35 days, and less than 0.6 day for non-traditional loan types. The differences in the delinquency rate across different loan types are more pronounced. The delinquency gap between Black and white borrowers is 4.3% for the FRM type and 6.2%, 4.5% and 7.2% for the Hybrid, IO, and Balloon types, respectively. Given that the delinquency gap is 6.0% for all of the merged sample, these differences are economically significant. The relation between processing time and loan delinquency varies by loan type, strongest for the Balloon type, with 2.8 bps reduction in delinquency for one day increase in processing time, and in contrast insignificant for the FRM type. Interestingly, the largest (smallest) delinquency gap is for the Balloon (FRM) type, which also has the smallest (largest) difference in processing time. These findings are consistent with the notion that non-traditional mortgages are more likely to have lax lending standards relative to the FRMs.

The growth of non-traditional mortgages is fueled by extraordinary demand for securities backed by these loan products. The heightened demand is reflected in the shortening of the shelf time of the mortgages, the time span from loan origination to securitization (OTS). We classify the loans in the longest (shortest) quartile of OTS as slow (fast) OTS. Keys et al. (2012) show that lax screening is more pronounced for loans that have faster OTS. Our summary statistics also show that fast OTS loans have a faster processing time. In Table 7, we report the results on the fast and slow OTS loans based on the merged HMDA-CoreLogic data on the PLS loans. We find a consistent pattern when comparing fast and slow OTS

loans: fast OTS loans have a greater delinquency gap between Black and white borrowers and a smaller difference in processing time relative to slow OTS loans.

Mortgage lenders screen applicants by collecting both "hard" information, such as credit score, and "soft" information that can help predict borrowers' future income stability. While hard information, by definition, can easily be verified and credibly transmitted, lenders have to exert effort to collect and process soft information (Stein, 2002). Because investors purchase securitized loans based on mostly hard information, lenders bear the cost of producing soft information in the screening process. So, lax lending standards can be more severe for low-doc loans, as argued in Keys et al. (2010).

Table 7 reports the results for low- and full-doc loans based on the merged HMDA-CoreLogic data on the PLS loans. We find that the delinquency gap between Black and white borrowers is about 7.2% in the low-doc sample and 5.2% in the full-doc sample, and the difference in processing time is higher in the full-doc sample.[17] The relation between processing time and delinquency is also more negative in the low-doc sample. These findings are consistent with the argument of lax lending standards for low-doc loans.

We further break down the merged HMDA-CoreLogic data on the PLS loans by the initial loan purchaser type as defined in the HMDA data. Loan purchasers may sell the loans to the PLS after initial purchase. The GSEs are more likely to keep the loans for their own securitization and may occasionally put back mortgages to the lenders due to quality problems, which may then be sold to others including the PLS. We find that the difference in processing time between Black and white borrowers is larger, and the delinquency gap smaller for the GSE purchaser type than other purchaser types. The negative relation between processing time and delinquency is strongest for the PLSP type and insignificant for the GSE type.[18]

Our results from analyzing cross-sectional variations by loan types echo the same message

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[17]The smaller difference in processing time in the low-doc sample can also result from less information to process for low-doc loans relative to full-doc loans.

[18]These results are reported in the Internet Appendix.

as the results from the comparison across segments in the HMDA data: the differences in processing time between Black and white borrowers are smaller in the type of mortgages with lax lending standards, such as comparing the PLS to the GSE, non-traditional mortgages to the FRMs, fast to slow OTS loans, and low-doc to full-doc loans.

5 Conclusion

We examine racial disparities in mortgage lending along a novel dimension: processing time. In the period of 2001-2006 prior to the global financial crisis, processing time shortened substantially at aggregate, reflecting lax lending standards (Wei and Zhao, 2020). In this paper, we further show that the PLS segment of mortgage markets—which had grown rapidly during the same period and started to surpass the GSE segment in 2004—had the shortest processing time with an average of 26 days. In contrast, the average processing time in the GSE segment was 44 days.

In the PLS segment during our sample period, Black borrowers were over-represented, had similar processing time as white borrowers, but defaulted much more often. A larger racial gap in processing time existed in the GSE segment where Black borrowers, who were under-represented, faced a one-week delay in processing time compared to white borrowers. Including lender fixed effects further widens the gap.

Another important finding in this paper is evidence for the concentration of Black borrowers in the space of non-traditional loans and subprime lenders. Our findings point to the shift of Black borrowers from the traditional mortgage financing channel (e.g., GSE) to alternative mortgage financing channel (e.g., PLS) during our sample period. As a future research direction, it would be interesting to further analyze the possible causes behind the obstacles that minority borrowers face in obtaining mortgage financing.

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Figures & Tables

Figure 1: Processing Time for Originated Mortgage Loans
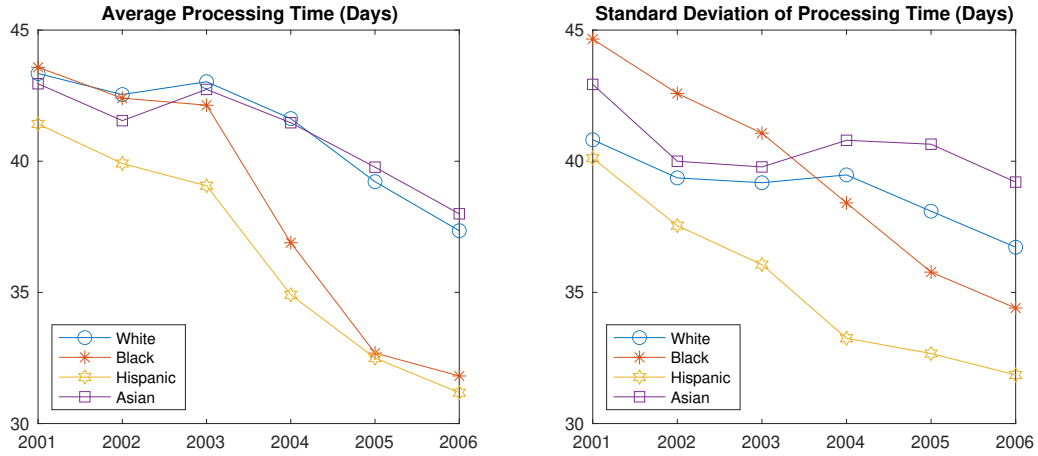
A. Home Purchase Mortgage
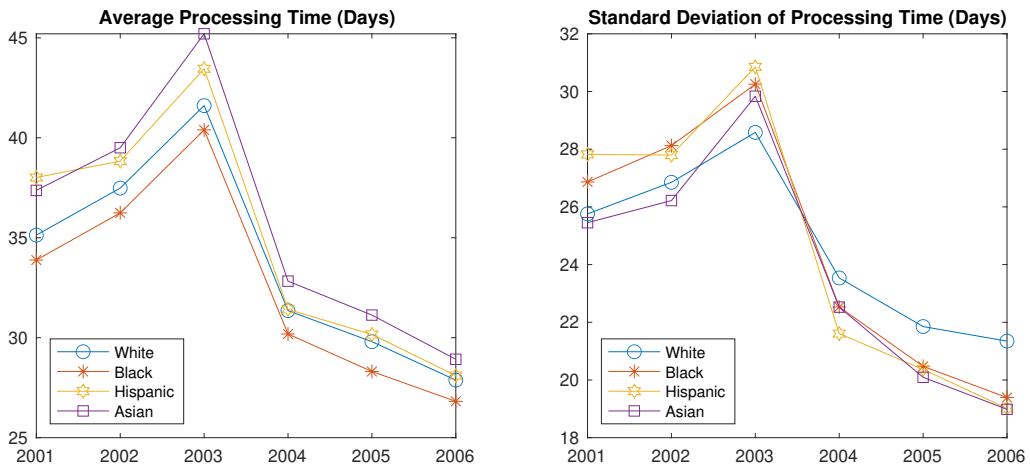
B. Refinance Mortgage

NOTE: This figure presents the time series of processing time for mortgage loan applications that were approved and originated between 2001 and 2006. Panel A and Panel B plot the average processing time (left panels) and the standard deviation (right panels) for home purchase loans and refinancing loans, respectively.

FIGURE 2: Processing Time for Denied Mortgage Applications
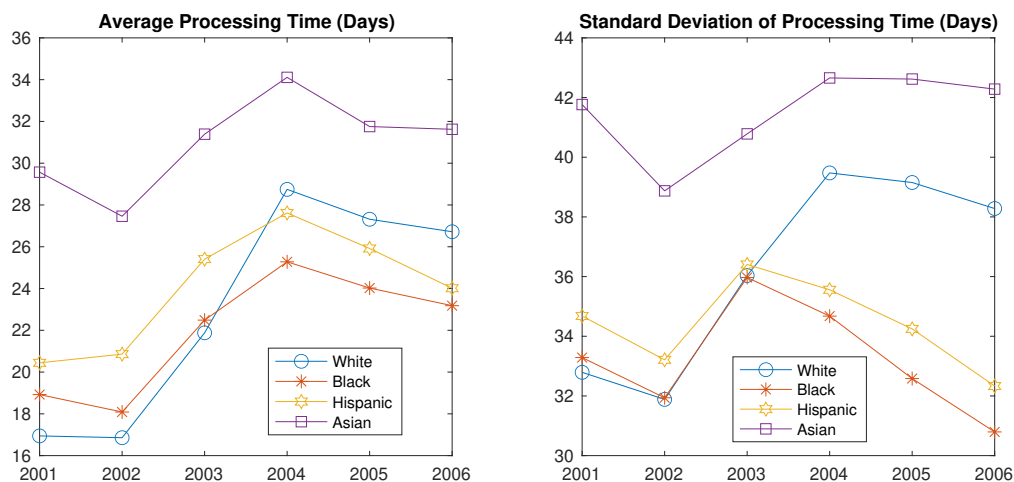
A. Home Purchase Mortgage

B. Refinance Mortgage

NOTE: This figure presents the time series of processing time for mortgage loan applications that were denied between 2001 and 2006. Panel A and Panel B plot the average processing time (left panels) and the standard deviation (right panels) for home purchase loans and refinancing loans, respectively.

FIGURE 3: Processing Time for Originated Mortgage from GSE and PLS
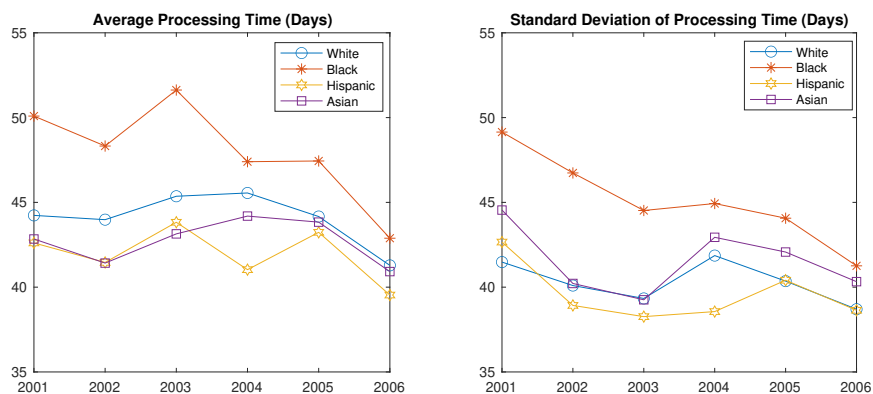
A. GSE
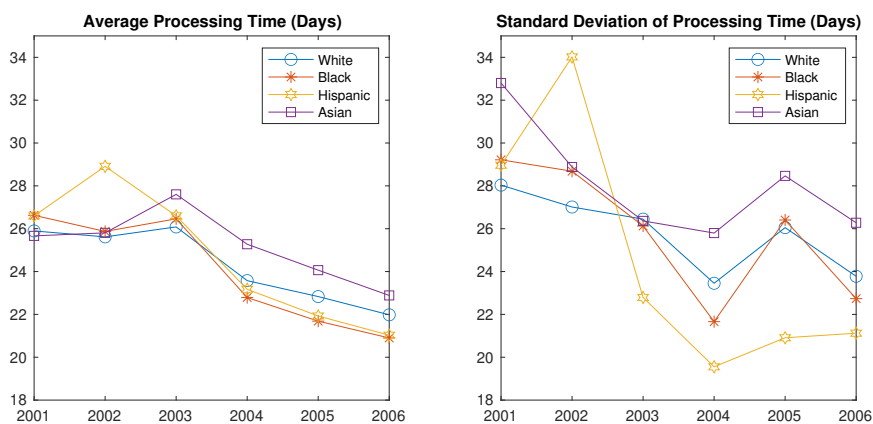
B. PLS

NOTE: This figure presents the time series of processing time for home purchase mortgage loans that were approved and originated between 2001 and 2006. Panels A and B plot the average processing time (left panels) and the standard deviation (right panels) for home purchase loans purchased by GSE and PLS, respectively.

A. Subprime Lenders
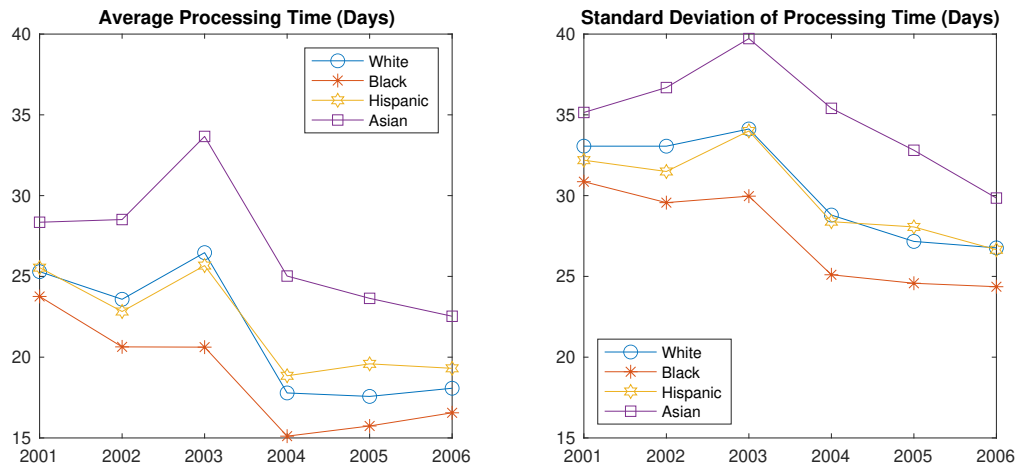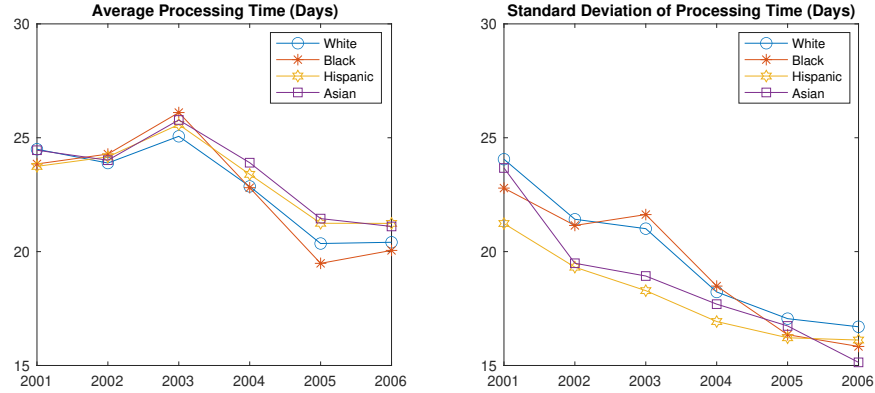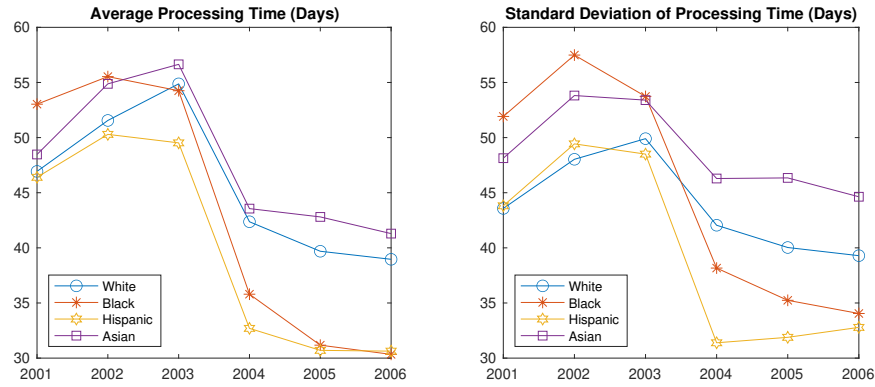

B. Banks

NOTE: This figure presents the time series of processing time for home purchase mortgage loans that were approved and originated between 2001 and 2006. Panels A and B plot the average processing time (left panels) and the standard deviation (right panels) for home purchase loans originated by subprime lenders and purchased by banks, respectively.

TABLE 1: Key Variables

Variable List	Definition
Panel A: Variables from the confidential HMDA data	
Action Date	Date that action was taken on application
Applicant Race	Indicator variable for the race and ethnicity of the loan applicant
Applicant Sex	Indicator variable to classify male or female
Applicant Income	Total gross annual income of applicant in thousands of dollars (nominal)
Application Date	Date of loan application
Loan Amount	Loan amount granted or requested in thousands of dollars
Coapplicant	Indicator variable that equals one if there is a coapplicant in the application
Preapproval	Indicator variable that equals one if the preapproval is requested in the application
High Cost	Indicator variable that equals one if the mortgage rate is higher than the prevailing benchmark rate
Rate Spread	The difference between the mortgage rate and the prevailing benchmark rate; only available for high cost mortgages
Jumbo	Indicator variable that equals one if the mortgage is a jumbo loan
Purchaser type	The types of institutions purchasing loans from the originators, including Government-Sponsored Enterprises("GSE"), private-label securitization("PLSP"), commercial banks and savings associations ("Bank"), lender-affiliated institutions ("Affiliate"), insurance companies and mortgage banks and finance companies ("MC"), an unspecified other type ("Other"). The mortgage loans that are not sold to a purchaser within the calendar year of origination are also identified ("Unsold").
Panel B: Variables from the CoreLogic LoanPerformance data	
Delinquency	Indicator variable for whether the loan is in default within 10-15 months of origination: (a) payments on the loan are 60+ days late; (b) the loan is in foreclosure; or (c) the loan is real estate owned (REO)
Document Type	Loan documentation level (low or full)
DTI	Back-end debt-to-income ratio
FICO	FICO score at origination
Initial Rate	Initial or original interest rate as of the loan's first payment date
LTV	Combined loan-to-value (CLTV) ratio (including first and second liens)
Prepayment Penalty	Indicator variable for whether the loan has a prepayment penalty
Loan product type	Fixed rate mortgage (FRM), adjustable rate mortgage (ARM), interest only (IO), balloon, and hybrid mortgages
Margin	Margin for an adjustable-rate or hybrid mortgage over an index
MBS Issuance Date	Date that the MBS is issued, used to calculate the time span from loan origination to securitization (OTS)
Panel C: Local macro variables	
Wage	The average wage in the borrower's county in the year of loan origination
HPA	The 36-month change in the housing price index for the borrower's county prior to loan origination
Loan Number	The number of loans originated in the borrower's county in the origination year
Unemployment	The unemployment rate in the borrower's state in the year of loan origination

NOTE: This table reports the list of key variables used in our empirical analysis.

TABLE 2: Summary Statistics

	Accepted					Rejected				
	All	White	Black	Hispanic	Asian	All	White	Black	Hispanic	Asian
Panel A: Home Purchase										
PT(Mean)	40.2	41.2	37.0	35.5	41.0	23.6	22.9	22.3	24.5	31.5
PT(SD)	38.7	39.0	38.9	34.7	40.5	36.0	36.6	33.1	34.3	41.9
PT(P25)	17	18	14	15	17	1	1	1	1	3
PT(Med.)	29	30	25	25	28	8	7	8	11	15
PT(P75)	49	50	44	42	47	31	29	31	34	42
Obs.(M)	22.5	17.1	1.6	2.6	1.3	4.1	2.4	0.7	0.8	0.2
% of Appl.		75.9%	6.9%	11.4%	5.8%		59.4%	16.7%	18.6%	5.4%
Panel B: Refinance										
PT(Mean)	35.7	35.9	32.7	35.2	38.1	20.9	21.2	17.8	21.4	27.1
PT(SD)	26.2	26.3	25.4	25.7	26.3	30.2	30.7	26.9	29.9	35.5
PT(P25)	19	19	17	19	21	1	1	1	1	2
PT(Med.)	29	29	26	28	31	8	8	6	9	14
PT(P75)	45	45	41	43	48	29	29	25	30	38
Obs.(M)	36.9	29.8	2.3	3.1	1.7	11.2	7.5	1.8	1.5	0.4
% of Appl.		80.8%	6.3%	8.3%	4.5%		67.0%	16.1%	13.3%	3.5%

NOTE: This table reports summary statistics for processing time for all applicants, white, Black, Hispanic, and Asian applicants, respectively, based on the confidential HMDA data. We report the mean, standard deviation (SD), median, 25- and 75-percentile (P25 and P75) for the processing time, the number of applications in millions, and the percentage of applicants for each racial/ethnic group.

TABLE 3: Summary Statistics Across Loan Purchaser Types

Panel A. Total number of originated home purchase loans (in Thousands)

	All	GSE	PLSP	Bank	Affiliated	MC	Unsold	Other
2001-2003	10,556	3,240		301	664		4,140	2,179
2004-2006	11,969	2,877	535	604	984	937	3,799	2,233

Panel B. Percentage of originated home purchase loans in each borrower group

	All	GSE	PLSP	Bank	Affiliated	MC	Unsold	Other
				2001-2003				
White	79.6%	82.9%		81.9%	77.2%		79.7%	74.8%
Black	5.6%	4.0%		4.7%	6.9%		5.8%	7.6%
Hispanic	9.3%	7.4%		7.3%	9.5%		9.5%	11.8%
Asian	5.5%	5.7%		6.0%	6.4%		5.0%	5.7%
				2004-2006				
White	72.7%	81.2%	53.4%	71.8%	72.4%	67.3%	74.4%	65.8%
Black	8.0%	4.6%	15.2%	7.4%	7.5%	10.2%	7.7%	11.0%
Hispanic	13.3%	8.1%	24.5%	13.9%	12.6%	16.5%	12.5%	17.2%
Asian	6.1%	6.1%	7.0%	6.9%	7.5%	6.1%	5.4%	6.0%

Panel C. Average processing time (Days)

	All	GSE	PLSP	Bank	Affiliated	MC	Unsold	Other
				2001-2003				
White	43.0	44.6		48.5	40.2		41.5	42.6
Black	42.6	50.1		48.8	39.5		42.7	36.2
Hispanic	39.9	42.7		44.3	39.7		39.6	36.8
Asian	42.4	42.5		48.5	43.3		40.9	42.5
				2004-2006				
White	39.5	43.8	28.3	41.7	37.0	39.3	38.1	38.0
Black	33.6	45.9	22.0	33.8	34.2	31.2	35.3	29.5
Hispanic	32.8	41.3	23.8	32.3	31.8	30.6	34.4	29.9
Asian	39.8	43.1	28.4	41.1	37.9	43.7	38.9	39.2

Panel D. Stardard Deviation of Processing Time (Days)

	All	GSE	PLSP	Bank	Affiliated	MC	Unsold	Other
				2001-2003				
White	39.7	40.3		44.4	37.3		37.7	41.7
Black	42.5	46.5		49.4	40.6		40.7	39.5
Hispanic	37.5	39.7		42.5	38.5		35.3	36.9
Asian	40.7	41.1		47.4	38.9		37.3	43.4
				2004-2006				
White	38.2	40.5	27.9	39.6	34.9	40.9	36.2	39.0
Black	36.2	43.5	20.9	36.2	36.3	35.3	36.0	34.1
Hispanic	32.6	39.2	20.1	31.9	31.8	32.2	32.0	31.6
Asian	40.3	41.9	28.3	41.9	35.4	48.5	36.7	43.6

NOTE: This table reports summary statistics for white, Black, Hispanic, and Asian borrowers based on the confidential HMDA data.

TABLE 4: Summary Statistics for the Merged HMDA-CoreLogic Sample

Panel A: All loans

	Mean PT	SD PT	% of Borr.	FICO	CLTV	Delinq.
White	23.5	25.2	52.0%	630	91.8	10.0%
Black	22.6	24.7	20.6%	618	93.4	19.4%
Hispanic	22.8	21.9	23.4%	648	93.5	10.3%
Asian	24.7	27.3	4.0%	654	91.7	9.5%

Panel B: By loan product types

	FRM	IO	Balloon	Hybrid	Low Doc	Full Doc	Fast OTS	Slow OTS
				Mean Processing Time				
White	27.4	22.9	20.8	22.7	23.3	23.7	22.5	24.9
Black	27.6	21.9	19.7	21.8	22.4	22.7	21.8	24.1
Hispanic	28.4	21.8	20.7	22.0	22.8	22.8	22.1	24.1
Asian	30.4	24.2	22.7	23.8	24.2	25.4	23.2	26.4
				SD of Process Time				
White	31.2	27.1	21.3	23.6	25.4	25.1	22.1	28.6
Black	31.6	27.9	18.5	23.2	24.0	25.1	20.7	29.5
Hispanic	33.1	20.3	19.4	19.7	21.6	22.1	19.4	25.3
Asian	35.3	26.9	24.8	25.6	26.7	28.2	22.7	31.4
				% of Borrowers				
White	57.5%	46.2%	40.0%	51.1%	44.1%	57.1%	51.5%	53.7%
Black	18.9%	17.0%	23.8%	20.9%	16.5%	23.3%	20.6%	20.6%
Hispanic	20.2%	31.2%	31.8%	23.9%	33.6%	16.7%	24.2%	21.8%
Asian	3.4%	5.7%	4.4%	4.1%	5.8%	2.8%	3.7%	3.9%

NOTE: This table reports summary statics for Asian, African American, Hispanic, and white borrowers based on the merged HMDA-Corelogic data on the PLS loans. In Panel A, we report the mean and standard deviation of processing time, the percentage of borrowers in each racial/ethnic group, the average FICO score, the average combined LTV ratio, and the average delinquency rate for all loans in the merged sample. In Panel B, we report the mean and standard deviation of processing time, and the percentage of borrowers in each racial/ethnic group separately for each loan type.

Table 5: Processing-Time Regression Results of the HMDA Home Purchase Loans

	Whole sample				GSE				PLSP	
	2001-2003		2004-2006		2001-2003		2004-2006		2004-2006	
	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)
Black	2.561***	4.996***	1.235***	2.416***	8.261***	7.16***	5.147***	5.25***	-.9032**	.5351*
	(.765)	(.464)	(.417)	(.320)	(.8225)	(.583)	(.645)	(.6077)	(.3421)	(.2681)
Hispanic	-.545	1.502***	-1.717***	.118	.786	1.089**	-1.706**	.0057	-1.522***	-.6595*
	(.517)	(.333)	(.393)	(.276)	(.596)	(.4399)	(.7641)	(.4124)	(.246)	(.3419)
Asian	-.287	-.485	.722	.198	-1.478*	-1.279***	-1.293	-1.017	-.1341	.441
	(.583)	(.302)	(.622)	(.306)	(.799)	(.4224)	(1.176)	(.6622)	(.3223)	(.2859)
R^2	0.072	0.188	0.094	0.218	0.083	0.184	0.090	0.175	0.155	0.206
Obs.	10483349	10483101	11899823	11899464	3218407	3218128	2851258	2850844	518609	518494

	Banks				Affiliate institutions				MC	
	2001-2003		2004-2006		2001-2003		2004-2006		2004-2006	
	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)
Black	3.938**	6.254***	.6844	1.768***	1.587	4.94***	2.014**	2.831***	.9141	1.702***
	(1.684)	(.8405)	(.5434)	(.3952)	(1.524)	(1.123)	(.8068)	(.6344)	(.7366)	(.3877)
Hispanic	-.4434	2.158***	-2.163***	-.4072	.862	2.815***	-1.191***	-.1853	-2.756***	-.2217
	(.9408)	(.3959)	(.5051)	(.3421)	(.9519)	(.7698)	(.4039)	(.4935)	(.8756)	(.2861)
Asian	1.279	-.2439	.5549	.4167	-.912	-.8822	-.4225	-.183	4.22**	.8243**
	(1.294)	(.5227)	(.7832)	(.2969)	(1.077)	(.7383)	(.5792)	(.5326)	(1.934)	(.3761)
R^2	0.187	0.330	0.177	0.291	0.194	0.306	0.180	0.269	0.162	0.375
Obs.	288642	288425	584348	584090	644256	644107	963955	963778	916608	916417

NOTE: This table reports loan-level regression results for home purchase loans for the whole sample and by the purchaser type in the confidential HMDA data that are originated between 2001 and 2006 for the purchase of owner-occupied single-family homes, condos, and co-ops. The dependent variable is processing time. The county by origination month fixed effects are included in model specification (a) and (b), and the lender fixed effects are added in model specification (b). We include borrower and loan characteristics as listed in Table 1 with detailed information. Standard errors are clustered by lender and month, and the t-statistics are reported in parentheses. Significance level: $^*(p < .10)$; $^{**}(p < .05)$; and $^{***}(p < .01)$.

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TABLE 6: Processing Time and Mortgage Application Volume

	Purchase Loan Sample		Refinance Sample	
	(1)	(2)	(1)	(2)
Black	3.428***	3.511***	1.333***	1.341***
	(.3634)	(.3616)	(.1769)	(.1746)
Hispanic	.6319**	.6455**	1.464***	1.489***
	(.2578)	(.2595)	(.2744)	(.276)
Asian	−.1277	−.1236	−.1096	−.1319
	(.271)	(.2725)	(.2947)	(.2972)
Application	.8314***		2.691***	
	(.1301)		(.5549)	
Application*Black	.4994**		.1013	
	(.2216)		(.2488)	
Application*Hispanic	.1197		.3745	
	(.1304)		(.4345)	
Application*Asian	−.0966		.0276	
	(.1403)		(.2477)	
Refi. Vol.		.8147***		2.498***
		(.124)		(.5209)
Refi. Vol.*Black		.731***		.1731
		(.2061)		(.2318)
Refi. Vol.*Hispanic		.1433		.4529
		(.1338)		(.4276)
Refi. Vol.*Asian		−.0699		.0995
		(.1368)		(.2701)
Other controls	Y	Y	Y	Y
F.E. (Lender, Cnty, Month)	Y	Y	Y	Y
R^2	0.190	0.190	0.188	0.187
Obs.	22386745	22386745	36732318	36732318

NOTE: This table reports loan-level regression results of processing time in the confidential HMDA data that are originated between 2001 and 2006 for the purchase and refinance of owner-occupied single-family homes, condos, and co-ops. The dependent variable is processing time. See Table 1 for detailed information on the control variables. We include the standardized volume of all applications and refinance separately, along with their interactions with borrower groups. We add calendar month dummies to account for seasonality. We also include fixed effects for lenders and counties. Standard errors are clustered by lender and month of origination, and the t-statistics are reported in parentheses. Significance level: $^*(p < .10)$; $^{**}(p < .05)$; and $^{***}(p < .01)$.

Table 7: Regression Results Based on the Merged HMDA-CoreLogic Data

	All	Loan type				Originate-to-sell		Documentation	
		FRM	Hybrid	IO	Balloon	Fast	Slow	Low	Full
					Panel A: Processing time				
Black	0.657***	1.351***	0.579***	0.584***	0.342*	0.335***	1.023***	0.563***	0.721***
	(0.075)	(0.207)	(0.077)	(0.160)	(0.176)	(0.108)	(0.121)	(0.114)	(0.080)
Hispanic	0.002	0.050	−0.073	−0.393***	0.050	−0.021	0.107	0.145	−0.174*
	(0.097)	(0.218)	(0.096)	(0.152)	(0.204)	(0.122)	(0.138)	(0.125)	(0.096)
Asian	0.614***	0.863*	0.562***	0.795***	1.089***	0.059	1.069***	0.674***	0.655***
	(0.128)	(0.455)	(0.130)	(0.258)	(0.371)	(0.211)	(0.228)	(0.153)	(0.185)
R^2	0.188	0.238	0.181	0.207	0.216	0.205	0.207	0.205	0.186
					Panel B: Delinquency				
Black	0.060***	0.043***	0.062***	0.045***	0.072***	0.064***	0.051***	0.072***	0.052***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.006)	(0.004)	(0.003)	(0.004)	(0.002)
Hispanic	−0.010***	−0.009***	−0.010***	−0.000	0.009	−0.016***	−0.006***	−0.016***	−0.001
	(0.002)	(0.002)	(0.002)	(0.003)	(0.005)	(0.003)	(0.002)	(0.002)	(0.002)
Asian	−0.004**	−0.008**	−0.004	0.011***	0.013*	−0.008**	−0.004*	−0.009***	0.000
	(0.002)	(0.003)	(0.002)	(0.004)	(0.007)	(0.003)	(0.002)	(0.003)	(0.002)
PT(x100)	−0.007***	−0.002	−0.009***	−0.017***	−0.028***	−0.013***	−0.002	−0.011***	−0.005***
	(0.002)	(0.002)	(0.002)	(0.003)	(0.009)	(0.003)	(0.002)	(0.003)	(0.002)
R^2	0.084	0.096	0.084	0.097	0.104	0.102	0.092	0.109	0.076
Fixed effects	Y	Y	Y	Y	Y	Y	Y	Y	Y
Other controls	Y	Y	Y	Y	Y	Y	Y	Y	Y
Obs.	1345535	157303	1143935	200959	98271	296862	428159	514664	830024

NOTE: This table reports loan-level regression results of processing time and delinquency based on the merged HMDA-CoreLogic data for all PLS loans and for each loan type. The dependent variable is processing time in Panel A and the delinquency rate in Panel B. We control for the loan-level processing time in the delinquency regression and report the coefficient estimates multiplied by 100. We include borrower and loan characteristics, local economic conditions, and lender, origination year, and county fixed effects in the regression. See Table 1 for detailed information on the control variables. Standard errors are clustered by lender and loan cohort, and the t-statistics are reported in parentheses. Significance level: *($p < .10$); **($p < .05$); and ***($p < .01$).