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Kamiya, Shinchi

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Credit Crunch and Insurance Consumption: The Aftermath of the Subprime Mortgage Crisis

Abstract

Using cross-state panel data of the U. S. personal auto insurance premiums from 2007 to 2012, this study provides evidence that consumer purchases of insurance were reduced by more than expected from losses of risk exposure during and after the subprime mortgage crisis. Analyses show that the credit crunch of auto loans and a deterioration of net worth in housing resulting from the bursting housing bubble contributed to the reduced consumption of auto insurance. This result is robust even after controlling for associated factors, such as the insurance price, personal spending on vehicles, and general consumption. These findings provide evidence for a real effect of the financial crisis.

JEL Codes: G01, G22, E22

Keywords: crisis, credit, auto loan, insurance

1. Introduction

Financial crises tend to disproportionately reduce insurance purchases in post-crisis periods. For instance, the real private auto insurance premium per capita (density) in the U.S. fell over the subprime mortgage crisis and remained at 88 percent of the 2006 base year in 2012.^{1, 2} This long-

¹ The 2007–2009 U.S. subprime crisis is considered a credit crisis with a banking panic. See, for instance, Gorton (2009).

² The premium level represents inflation-adjusted direct premiums written per capita. Premium data are taken from the NAIC annual statement from various years, and the GDP, population and inflation data are obtained from the Bureau of Economic Analysis (BEA).

lasting post-crisis trend sharply contrasts the quick recovery of output, which was below the 2006 base year but only in 2009. A further decline in the premium level after 2009 also suggests that the trend of insurance consumption could not be explained by the general economic slowdown measured by the recession that ended in June 2009.³

It is also observed that the shock of the crisis on insurance consumption is geographically very diverse in that the post-crisis premium levels fell as low as 76-77 percent in Arizona, Hawaii, Massachusetts and Nevada but were mostly unaffected in some states, such as Oklahoma and Texas. The contraction in the premium volume was most pronounced in states that had a combination of high household debt and larger declines in house prices (Arizona, California, Florida and Nevada). This finding is consistent with the literature that highlights the geographic distribution of housing wealth shocks in explaining the large and unequal decline in consumption from 2006 to 2009 (Mian, Rao and Sufi, 2013).

The decline in non-life insurance consumption after the U.S. subprime mortgage crisis was also reported by the National Association of Insurance Commissioners (NAIC) (NAIC, 2008). The survey reports that 8 percent of respondents made changes to their auto insurance policies (i.e., by reducing coverage, falling behind on payments or cancelling policies) and that 6 percent made changes to their homeowner policies (with 4 percent cancelling their policies).⁴ The following NAIC survey, which was conducted in 2011, asked individuals about any car-related lifestyle changes that affected their car insurance premiums in the previous 12 months (NAIC, 2011). The results are summarized as follows: more than half of the respondents saved on car insurance

³ The U.S. subprime mortgage crisis began with the bursting of the housing bubble from its 2006 peak, and it caused a recession that started in 2007. The NBER determined that the recession began in December 2007 and ended in June 2009. The recession lasted 18 months.

⁴ The survey results had a significance level of 5 percent.

premiums by reducing their coverage and/or switching to a cheaper policy without changing coverage. Close to 40 percent of the respondents drove less (and/or took public transportation more frequently). Approximately 20 percent of car owners reduced the value or the number of their vehicles. Approximately 20 percent of drivers reduced their car insurance coverage. Thus, the subprime mortgage crisis and the following recession reduced not only the exposure to risks but also the degree of auto insurance coverage.

These findings suggest several interesting empirical questions. The first question is whether the large decline in auto insurance consumption can be fully explained by the consumer purchase of vehicles (i.e., exposure to loss) dropping by 23 percent during the 2007–2009 recession period.⁵ If the loss in auto insurance premiums cannot be explained by the consumer purchase of vehicles, the next question would be to determine the contributing factors that are associated with the marginal decline of insurance consumption in the post-crisis period. Our primary interest is the marginal effect of three factors: income, housing wealth and auto credit. The first two factors are motivated by the theoretical prediction that the household purchase of insurance is expected to be positively related to both income and household wealth (Rampini and Viswanathan, 2015) as well as the marginal propensity to consume (MPC) out of a wealth shock, which implies the following: 1) consumption responds to the shock on net worth and 2) the consumption of low-wealth households responds more aggressively to changes in wealth (Mian, Rao and Sufi, 2013). The third factor, auto loans, is also expected to be directly related to auto insurance consumption for several reasons. First, the post-crisis trend of auto insurance consumption may be related to more vehicle purchases using auto loans than those paid by cash. Second, auto loans tend to require the purchase

⁵ This large decline was determined by the author's calculation based on state-level personal expenditure data taken from the Bureau of Economic Analysis (BEA). Johnson, Pence, and Vine (2014) also find that household vehicle purchases fell by more than 20 percent during the period.

of insurance coverage. Third, credit tightening severely affects credit supply to low-credit-score consumers, who tend to pay a higher premium, all else being equal (e.g., Ramcharan and Crowe, 2013; Mian, Rao, and Sufi, 2013; Mian and Sufi, 2014).

To test those predictions, our empirical analyses use a subnational panel that covers 50 U.S. states plus D.C. from 2007 through 2012. This choice is motivated by the fact that the shock of the crisis on the economy is geographically very diverse because there are striking regional differences in the U.S. housing market. This choice is also encouraged by the recent literature that provides evidence of the large and geographically unequal decline in consumption after the crisis (Benemelech, Meisenzahl, and Ramcharan, 2015; Mian, Rao and Sufi, 2013). The state-year panel structure of the data allows us to exploit both cross-sectional and within-state variation to assess the association between the variables of interest and the purchase of auto insurance.

Our empirical findings suggest that there is a link between reduced consumer purchases of insurance and the crisis, although this study does not claim causality in the relationship. After a shock in house prices, consumer vehicle purchases were reduced because declining house prices led low-income households to face credit rationing or credit at a higher price, and it took years for the auto loan market to start recovering because the credit channel through shadow banking was shut down (Johnson, Pence, and Vine, 2014). Insurance purchases reacted to the auto loan market. Analyses also support that the shock in housing wealth had a direct negative effect on individual auto insurance purchases and that the direct wealth effect was stronger for states with a lower housing net worth. However, a more in-depth analysis finds significant differences in the determinants of auto physical damage coverage and other types of coverage. The former positively reacts to the shock on consumers' purchase of vehicles and to income, whereas the latter reacts to

the shock on housing wealth. In addition, the effect of the external shock on auto claim behavior is investigated.

The remainder of this study is organized as follows. The related literature and the factors associated with insurance consumption and banking crises are reviewed in Section 2. Section 3 illustrates the bivariate relationship among auto loans, personal spending on vehicles and individual purchases of auto insurance during and after the U.S. subprime mortgage crisis. Section 4 describes our methodology and data and tests the presence of the marginal effect of the shocks on income, house prices, and the credit crunch. Several robustness checks follow. A summary of our findings is given in Section 5.

2. Related Literature

The collapse of house prices during the subprime mortgage crisis played a key role in reduced credit and consumption. The credit channel that links house prices with consumption predicts that declining house prices with the potential for higher default probabilities and worsening balance sheets cause homeowners to face greater credit rationing or to obtain credit at a higher price (Stiglitz and Weiss 1981, Diamond 1991, Holmstrom and Tirole 1997). There is ample evidence that household leverage during the house price boom and depressed consumer demand during the bust may have caused the slow recovery in output and consumption (Mian and Sufi, 2011; Mian, Rao, and Sufi, 2013; Mian and Sufi, 2014).⁶ Using consumer loan data, Ramcharan and Crowe (2013) find evidence that a decline in house prices has a large adverse effect on both the supply and cost of unsecured consumer credit, with a particularly large effect

⁶ Related studies on the housing market crisis include Demyanyk and Van Hemert (2009), Doms, Furlong, and Krainer (2007), Keys et al. (2010), Leamer (2007) and Mian and Sufi (2009).

for subprime applicants (Bajari, Chu, and Park 2008, Demyanyk and Van Hemert 2009). The effect of the 2007–2009 recession on household vehicle purchases is also documented. Johnson, Pence, and Vine (2014) find that auto loan originations fell by one third and that household vehicle purchases fell by more than 20 percent. They also document evidence of a causal link between credit conditions and household vehicle purchases during the recession period.

Even after controlling for the decrease in consumer purchases of motor vehicles and consumer auto loans, the economic downturn and loss of household wealth could also marginally affect the consumption of insurance coverage. Recent theoretical work by Rampini and Viswanathan (2015) predicts that the household purchase of insurance should be positively related to both income and household wealth because insurance is considered state-contingent savings (i.e., less savings for future contingent claims if current funds are not sufficient). The relationship is supported by sufficient empirical evidence (see Beenstock, Dickinson, and Khajuria, 1988; Outreville, 1990; Browne, Chung, and Frees, 2000; Outreville, 2012 for a comprehensive literature review of insurance demand). The highly unequal geographic distribution of private auto insurance consumption may also be explained by the MPC out of a wealth shock (Main, Rao and Sufi, 2013). Furthermore, their study suggests that the insurance consumption of low-wealth households responds more aggressively to changes in wealth.

This study is closely related to the underwriting cycle literature that investigated the relationship between insurance pricing and macroeconomic factors, including the stock index (Cummins and Nye, 1980; Cummins and Harrington, 1985, 1988; Lamm-Tennant and Weiss, 1997; Chen, Wong and Lee, 1999; Jawadi, Bruneau, and Sghaier, 2009; Bruneau and Sghaier, 2014), the interest rate (Doherty and Kang, 1988; Fields and Venezian, 1989; Smith, 1989; Haley, 1993, 1995, 2007; Doherty and Garven, 1992; Cummins and Danzon, 1997; Lamm-Tennant and

Weiss, 1997; Chen, Wong and Lee, 1999; Guo, Fung and Huang, 2009), the inflation rate (Bruneau and Sghaier, 2014), the general economy (Grace and Hotchkiss, 1995; Lamm-Tennant and Weiss, 1997; Chen, Wong and Lee, 1999; Leng and Meier, 2006; Meier, 2006; Guo, Fung, and Huang, 2009) and oil prices (Guo, Fung and Huang, 2009). This study contributes to the literature by adding a new explanation of how a financial crisis could affect insurance consumption.

The effect of financial crises on insurers' capacity is also particularly relevant because a decrease in the post-crisis premium volume may be explained by supply shock, which can be described as an underwriting cycle in non-life insurance markets (e.g., Gron, 1994a, 1994b). According to the capacity-constraint hypothesis, when capacity is reduced by a financial crisis, the short-run supply curve shifts to the left, resulting in higher prices and a lower quantity of available coverage. A decline in aggregate premiums after a crisis may therefore result from reduced capacity and/or lower investment returns, which increases the price of insurance and decreases the coverage per premium. However, regardless of the prediction, if a decrease in the market size due to a credit crunch dominates the effect of reduced capacity, the market will result in a decline in the aggregate premium volume due to a decline in both premium rates and coverage.

Investigating the pricing of U.S. life insurance during the crisis period, Koijen and Yogo (2015) show fire sales of life insurance with a 57 percent discount and annuities with a 16 percent discount. They show that this extraordinary pricing behavior improves statutory capital adequacy and helps avoid a rating downgrade and regulatory attention. Although their findings are not directly applicable to auto insurance because the pricing and loss reserving are much less flexible, it is reasonable to expect that non-life insurers are also tempted to increase the volume of premiums by excessively discounting policies to at least temporarily reduce the shock of the crisis on their

assets. Thus, there are multiple explanations of how the price level was affected during and after the crisis.

3. Auto Loans, Vehicle Purchases and Auto Insurance Purchases

Historically, the balance of auto loans has risen because the price of cars is beyond the reach of many individual purchasers and because individuals are willing to buy cars they cannot afford without borrowing the money. In 2007, the annual average loan-to-value ratio for car loans from auto finance companies was approximately 95 percent for new car loans and 100 percent for used car loans.⁷ The average annual amount for new car loans reached \$28,287 in 2008.⁸ Thus, personal spending on vehicles relies heavily on the availability of auto loans to smooth the expenditure, and a reduction in the auto loan supply by banks and other financial institutions could immediately cause a decrease in car purchases and then a decline in auto insurance purchases.

Facing prior financial crises, banks shifted their portfolios away from private credit toward safer investments (Demirgüç-Kunt et al., 2006), and the same happened during the subprime mortgage crisis. According to a Senior Loan Officer Opinion Survey on Bank Lending Practices conducted by the Board of Governors of the Federal Reserve System, banks tended to tighten their standards for consumer loans from the 1st quarter of 2007 to the 4th quarter of 2009, with a peak of 67 net percentage of domestic banks tightening their standards in the 3rd quarter of 2008.⁹

⁷ This annual average is calculated by the authors. The monthly average data are based on statistics given by the Board of Governors of the Federal Reserve System (U.S.), Average Loan-To-Value Ratio of Car Loans at Auto Finance Companies (TERMFLVRNCNS and DTCTLVULNM), retrieved from FRED, the Federal Reserve Bank of St. Louis.

⁸ The annual average is calculated by the authors. The monthly average data are based on figures given by the Board of Governors of the Federal Reserve System (U.S.), Average Amount Financed for New Car Loans at Auto Finance Companies (TERMFAAFNCNS), retrieved from FRED, the Federal Reserve Bank of St. Louis.

⁹ The Board of Governors of the Federal Reserve System (U.S.), Net Percentage of Domestic Banks Tightening Standards for Consumer Loans Excluding Credit Card (DRTSCOCL), retrieved from FRED, the Federal Reserve Bank of St. Louis.

Although it may not be the only determinant, the tightening of lending standards from the beginning of 2007 to the end of 2009 corresponds to a declining real auto loan debt balance during the period, in which the real auto loan debt balance started declining in 2007, reached approximately 80 percent of the 2006 Q1 level by the end of 2009, and remained at that level during 2010–2011, until it recently started to recover.¹⁰

Consistent with the theoretical prediction and empirical evidence of the wealth effect, states show a close relationship between house prices and auto loans during and after the crisis.¹¹ For instance, the level of the real house price index even went below 40 percent of the 2006 base year for Nevada in 2011–2012, and the level of auto loans declined to approximately 70 percent for some states, such as Nevada, Arizona, California and Florida. After 2011, auto loan debt started increasing in many states, and recovered to the pre-crisis level in 2012, whereas their house price indices remained below the pre-crisis level.¹²

Importantly, outstanding auto loan debt was reduced significantly as a result of the crisis but behaved quite differently from the output and personal income. Such a negative deviation in the auto loan debt balance from the aggregate measures of economic activities differentiates insurance consumption after a credit crunch from that in ordinary business cycles and highlights the importance of understanding how a financial crisis can be associated with insurance consumption.

The amount individuals spend on vehicles depends heavily on their arrangements for car finance and hence individuals tend to spend less on vehicles when lending institutions reduce the

¹⁰ The real auto loan debt is calculated by the authors. The original data are taken from the FRBNY Consumer Credit Panel – Household Debt and Credit, retrieved from the Federal Reserve Bank of New York.

¹¹ House prices are retrieved from the Federal Housing Finance Agency.

¹² See, for instance, the article by Haughwout, et. al., “Just Released: Looking under the Hood of the Subprime Auto Lending Market,” Federal Reserve Bank of New York (August 14, 2014).

supply of auto loans (see, Johnson, Pence, and Vine, 2014). By 2009, the vehicle purchase expenditure declined to approximately 60 percent of the 2006 base year for some states, such as Nevada, Arizona, California and Florida.¹³ A reduction in personal spending on vehicle purchases is a sufficient indication of a decline in auto insurance purchases, if other factors such as premium rates and individual risk attitudes are unchanged. However, as mentioned earlier, vehicle expenditures do not fully explain the post-crisis decline in insurance purchases.

3.1. Is This Time Different?

The aforementioned bivariate relationships illustrate the link between the crisis and auto insurance purchases, but the crisis could be considered part of an ordinary business cycle. Therefore, it is unclear whether studying insurance purchases during and after this crisis would yield important findings. The crisis literature supports the view that the 2007 subprime crisis was similar to prior crises (Reinhard and Rogoff, 2008a, 2008b). In addition, comparing the 2007–2009 recession with other recessions, Johnson, Pence, and Vine (2014) conclude that the contractions of consumer auto loans and purchases of motor vehicles are not unusual, although the size of the decreases during the 2007–2009 recession was quite large.

That said, there is growing evidence that the 2007 financial crisis is different from previous business cycles in terms of the role of shadow banking in the credit supply. Ramcharan, van den Heuvel, and Verani (2012) and Benmelech, Meisenzahl, and Ramcharan (2015) show that illiquidity in short-term funding markets, such as the asset-backed commercial paper market, one of the major sources of short-term credit in the U.S., caused a limited supply of non-bank consumer

¹³ Personal expenditure data are retrieved from the BEA, at <http://www.bea.gov/regional/downloadzip.cfm/>, as of December 16, 2014.

credit during the crisis.¹⁴ Benmelech, Meisenzahl, and Ramcharan (2015) show that the loss of financing capacity at non-bank institutions (e.g., captive finance companies vertically integrated to automotive manufacturers such as GMAC, Chrysler Financial, and Ford Motor Credit) amplified the effect of the recent financial crisis on car sales and estimate that the loss of captive financing capacity explains 31 percent of the decline in car sales from 2008 to 2009. Mian and Sufi (2014) document that the house price recovery from 2011 onward did not contribute to spending on vehicles because the credit channel, especially new borrowing, was effectively shut down for the low-income households most responsive to house price gains.

In summary, the recent evidence suggests that the outcome of the 2007–2009 recession may not be unique, regardless of the size of the economic downturn, but the channel of credit supply (i.e., the role of shadow banking) can differentiate the recession from others and further distinguish the 2007 subprime mortgage crisis from a usual business cycle. Thus, the uniqueness of the marginal effect of the recent economic downturn on insurance consumption may lie in the credit supply of auto loans affected by the collapse of the shadow banking system, which highlights the importance of investigating the impact of the crisis on auto insurance purchases.

4. Empirical Analyses

4.1. Data

The empirical tests are based on state-level data for the 2007–2012 period, which allow us to investigate the effect of heterogeneous shocks to house prices and the credit crunch within the U.S.. Working with state-level data has an important benefit relative to country-level analysis: a cross-state panel analysis reduces unobserved heterogeneity related to social, institutional, and

¹⁴See Acharya, Schnabl and Suarez (2013) for the disruption of the asset-backed commercial paper market.

other unobservable factors while retaining sufficient variability in our variables of interest (see Millo and Carmeci, 2015, for a further discussion about the benefits of a subnational panel).

The data used in the analyses were obtained from several sources. Private auto insurance premium, loss and expense data were taken from NAIC annual financial statements. To construct the state-level measures, the data reported by each insurer were aggregated at the state level. The state-level population, consumer price index and all personal expenditure data were taken from the BEA of the U.S. Department of Commerce. State-level auto loan and mortgage debt data were from the FRBNY Consumer Credit Panel – Household Debt and Credit. The annual house price index was calculated from the Quarterly Purchase-Only Indices reported by the Federal Housing Finance Agency. The definitions and summary statistics of the variables are reported in Tables 1 and 2, respectively.

4.2. Methodology

The model used is designed to find the determinants of a private auto insurance premium, which can be stated as:

$$P = f(p, q, x, z)$$

where P is household consumption of a premium of a private auto insurance policy, p is the price of private auto insurance, q is exposure to loss that can be covered by the insurance policy, x is a vector of variables of interest (i.e., income, household net wealth, and auto loan), and z is a vector of other explanatory variables. Our primary objective is to understand how the premium P is affected by exogenous shocks on the three variables denoted by x . The crisis shock on those factors could influence the premium through insurers' pricing behavior, represented by p , and the household purchase of coverage to loss exposure, denoted by q . The relationship is estimated by the sensitivity of each factor to insurance consumption:

$$P = p^a \times q^b \times \prod_{k=1}^3 x_k^{c_k} \times \prod_{l=1}^L z_l^{d_l} \quad (1)$$

which can be restated by

$$\log P = a \log p + b \log q + c_k \sum_{k=1}^3 \log x_k + d_l \sum_{l=1}^L \log z_l \quad (2)$$

where the coefficients a - d reflect the sensitivity between the premium and each factor, and k and l stand for the number of variables of interest and other explanatory variables, respectively.

To evaluate the response of insurance consumption by the crisis shock on factors, equation (2) is first differenced, and the following first difference model is estimated with the dependent variable denoted by $\Delta \log(\text{Auto Prem})_{it} = \log(\text{Auto Prem})_{i,t} - \log(\text{Auto Prem})_{i,t-1}$.¹⁵

$$\begin{aligned} \Delta \log(\text{Auto Prem})_{it} = & \alpha + \alpha_t + \beta_1 \Delta \log(\text{Price Fitted})_{it} + \beta_2 \Delta \log(\text{Vehicle Exp.})_{it} + \\ & \beta_3 \Delta \log(\text{Personal Income})_{it} + \beta_4 \Delta \log(\text{HWN})_{it} + \beta_5 \Delta \log(\text{Auto Loan})_{it} + \theta \Delta Z_{it} + \varepsilon_{it} \end{aligned} \quad (3)$$

where α stands for an intercept, α_t represents a year fixed-effect for year t , Z_{it} represents a vector of other controls, and ε_{it} is a normally distributed error term. The intercept α reflects the nationwide constant effect over the 2007–2012 period, and the year fixed-effect captures the nationwide constant effect by year.

The measure we explain is real private auto direct premiums written per capita (or the premium density), denoted by Auto Prem_{it} , which represents the real dollar value that an individual pays for private auto insurance.¹⁶ The national average was \$496 during the sample

¹⁵ The first-difference model is consistent with that used in the underwriting cycle literature, which investigates the determinants of aggregate premium volume (e.g., Lamm-Tennant and Weiss, 1997; Chen, Wong and Lee, 1999).

¹⁶ An alternative measure of insurance consumption would be the ratio of premium to income, typically defined as a penetration by premium divided by GDP. However, there are two primary reasons that the study uses premium per capita: 1) income is one of the variables of interest and 2) the potential time lag of insurance consumption reaction to changes in output (i.e., the time lag between the ratio's numerator and denominator) makes it difficult to interpret the change in penetration during the crisis period and the empirical results.

period, the highest value being \$693 in Louisiana in 2007, and the lowest value being \$370 in Idaho in 2012.

As a proxy for exposure to loss, the real per-capita personal expenditure on motor vehicles (*Vehicle Expenditure*) is prepared.¹⁷ The national average was \$1,148, with the highest expenditure being \$1,895 in North Dakota in 2012 and the lowest expenditure being \$665 in Michigan in 2009. Additionally, North Dakota, South Dakota and Wyoming showed the highest expenditure levels, and Michigan had the lowest expenditure over this period. Because insurance purchases are expected to change with spending on vehicles, if all other things are equal, this expenditure variable is also expected to control for the changes in exposure to loss that could be covered by an insurance policy.

The next three variables are of primary interest and are expected to be associated with demand for coverage. First, we prepare real state personal income (*Personal Income*) as a measure of income. The average real personal income was \$39,888 over the sample period, with the highest being \$66,687 in D.C. in 2012 and the lowest being \$28,019 in Mississippi in 2006.

To evaluate the marginal propensity to consume out of a household wealth shock, this study constructs an index of housing net wealth (*HNW*), which is defined by:

$$HNW_{it} = 100 + (House\ Price\ Index_{it} - Mortgage\ Debt\ Outstanding\ Index_{it}) \quad (4)$$

where the indices are 100 in 2006. The national average of the housing net wealth was 86.1 over the sample period, with the highest being 104.5 in Colorado in 2012 and the lowest being 54.0 in Nevada in 2009. Colorado, South Dakota and D.C. had the highest rankings, and Nevada, Florida,

¹⁷ The vehicle expenditure variable is the item “Motor vehicles and parts” in Personal Consumption Expenditures (PCE) by State (Source: U.S. Department of Commerce / Bureau of Economic Analysis / Regional Product Division). The data are available at <http://www.bea.gov/regional/downloadzip.cfm>.

California and Arizona had the lowest rankings over the sample period. The measure does not include other assets because state-level financial asset information is not available. However, for the purpose of comparing insurance consumption between states in the post-crisis period, the housing wealth measure seems a reasonable proxy for net worth because most of the cross-state variation in net worth is driven by variation in net worth due to housing (Main, Rao and Sufi, 2013). Given little cross-sectional variation in the financial net worth shock, Main, Rao and Sufi (2013) also focus on cross-sectional variation in the housing net worth shock to test how consumption responds to changes in household wealth. Due to the results of these studies, we expect that year dummy variables are able to effectively capture the effect of the shock on financial assets.

Auto Loan denotes the real auto loan debt balance per capita. The national average was \$2,892 over the sample period, with the highest being \$4,609 in Wyoming in 2007 and the lowest being \$1,918 in D.C. in 2011. Wyoming and Texas had the highest rankings, and D.C., Hawaii and Wisconsin had the lowest rankings over the sample period. This variable separates the effect through the credit channel from personal spending on vehicles. Despite the close relationship between auto loan debt and spending on vehicles, there are several major reasons why auto loans affect insurance purchases differently from spending on vehicles. First, not all vehicles on the road are purchased with auto loans, and auto loans tend to be repaid in 3-4 years. Thus, the auto loan variable measures the size of the exposure of relatively new vehicles purchased with an auto loan, and hence, it could be related to a large fluctuation in auto insurance purchases. Second, lending institutions typically require borrowers of an auto loan to purchase and maintain insurance coverage to cover the potential costs in the event of an accident. Lending institutions may require liability coverage with a higher limit than is required by the law and collision/comprehensive

insurance. Therefore, a change in auto loans is expected to have a stronger effect on insurance purchases than the change in overall spending on vehicles, including non-loan expenditures. Third, as shown by Ramcharan and Crowe (2013), credit tightening is expected to more strongly affect subprime auto loan applicants who have a low credit score. Hence, those who are affected by the crisis tend to be policyholders who pay, on average, a larger amount of auto insurance premiums because U.S. insurance companies may use credit scores for pricing purposes, unless an applicant lives where the practice has been banned (Hawaii, Massachusetts and California).¹⁸ Therefore, the loss of subprime auto loans is expected to have a large negative impact on insurance consumption.

There are several other factors that may affect auto insurance consumption. We consider real per-capita personal expenditure on gasoline and other energy goods (*Gas Expenditure*) and real per-capita personal expenditure on transportation services (*Transport Expenditure*).¹⁹ These variables are expected to capture changes in the use of vehicles during/after the crisis. The *Gas Expenditure* variable is a proxy for gasoline consumption, which is expected to control for the effect of gas prices during the period. An increasing trend of gas prices during the period and a sharp drop in 2009 could have affected how individuals drive.²⁰ An increase in gasoline prices and expenditures on gasoline may reduce the use of private vehicles and spending on insurance purchases. *Transport Expenditure* is expected to capture the use of alternative transportation because individuals tend to use public transportation more and private vehicles less during an economic downturn. Controlling for the effects of changes in motor vehicle use is important

¹⁸ The use of credit scores is banned by state law in Hawaii and Massachusetts. It is not technically prohibited but is practically banned in California.

¹⁹ Note that the personal expenditure on gasoline and other energy goods includes expenditure unrelated to driving.

²⁰ The average retail gas price dropped from 3.3 dollars per gallon in 2008 to 2.4 dollars per gallon in 2009 (U.S. retail gasoline prices for all grades and all formulations). The prices are obtained from the U.S. Energy Information Administration.

because the 2011 NAIC survey documents that 40 percent of respondents reported driving less (and/or taking public transportation more frequently) after the subprime mortgage crisis.

For robustness, tests also investigate the effect of consumer belt-tightening, with which diminishing economic activity causes a reduction in personal spending on overall consumption, including auto insurance purchases. The effect of aggregate consumption expenditures is controlled by including *Personal Expenditure*, which denotes real per-capita personal expenditures on overall consumption. The national average was \$30,924, with the highest expenditure being \$62,266 in D.C. in 2008 and the lowest being \$23,769 in Alaska in 2009.

4.3. Insurance Price

Price is certainly one of most important determinants of insurance consumption and needs to be controlled in order to properly evaluate the effect of our factors of primary interest. However, in studying the determinants of insurance consumption, researchers face the challenge of controlling for price effects because information consisting of premiums, such as premium loading, is typically unavailable. The literature on international non-life insurance consumption uses the inverse of the loss ratio as a proxy for price (Esho et al., 2004), but the price measure, as defined by the ratio of aggregate premium over loss, is clearly endogenous without a proper treatment.

To overcome this problem, the following analyses use instrumental variable (two-stage least square) regressions. In the first stage, a price measure (*Price*) defined by the reciprocal of the state-level combined ratio is estimated by two exogenous variables in addition to all explanatory variables explained above.²¹ In the second stage, the predicted price variable (*Price Fitted*) is

²¹ The state-level combined ratio is defined by the sum of the direct loss and the LAE ratio and the direct expense ratio. Furthermore, the direct loss and LAE ratio is defined by direct losses incurred plus direct defense and cost containment expense incurred as a percent of direct premiums earned. The direct expense ratio is calculated by commissions and brokerage expenses plus taxes, licenses and fees as a percent of direct premiums written. All these

introduced in equation (3), although the two stages are simultaneously estimated. One of the exogenous variables is state-level investment income per asset (*Investment Return*), which is defined as the average of insurers' investment returns including unrealized gains on assets weighted by insurers' private auto market shares. This variable is expected to reflect insurers' performance on the asset side of their balance sheet. Because insurers' investment incomes were adversely affected during the crisis period, the investment measure is expected to capture insurers' incentives of pricing behaviors (Koijsen and Yogo, 2015).

The second exogenous variable is the measure of market competition, *Market Competition*, which denotes the group-level Herfindahl index of private auto insurance premiums written by insurers operating in a state. This variable is defined by the sum of the squared insurer groups' market share of state private auto insurance as a percentage. The national average was 10.3 during the surveyed period. The least competitive state was D.C. throughout the sample period. The most competitive state was Maine, with the highest rating being 18.6 (for D.C.) in 2009 and the lowest being 6.2 (for Maine) in 2007. Using those two exogenous variables, we run the following first stage regression:

$$\Delta \log(\text{Price})_{it} = \alpha + \alpha_t + \beta_1 \Delta \log(\text{Invest. Return})_{it} + \beta_2 \Delta \log(\text{Market Comp.})_{it} + \gamma \Delta \log(\text{X})_{it} + \delta \Delta \log(\text{Z})_{it} + \varepsilon_{it} \quad (5)$$

where X_{it} and Z_{it} represent a vector of explanatory variables included in equation (3). The fitted price variable (*Price Fitted*) in this regression is included in the second stage regressions.

variables are taken from Exhibit of Premiums & Losses – State Page in the NAIC annual statements. Each variable used for the calculation is a summation of the individual insurers at the state level.

4.4. Estimation

In scrutinizing the data, we decided to remove two states, Michigan and North Dakota, from our analyses. Michigan is removed because its state-level combined ratio for private auto insurance was 106 percent over the six-year average and above 100 percent for six straight years, which is exceptionally high relative to the other states (which had an average of 74 percent). North Dakota is excluded due to its exceptional economic growth during the crisis and recession period. The six-year average real per-capita GDP growth rate reached approximately 7 percent in North Dakota due to a shale gas boom, despite approximately zero real growth for the country overall during the same period.²² After excluding these two states, we have 294 state-year samples.

Our primary approach is to estimate first-difference models by two-stage least square regressions with year fixed effects. Standard errors are clustered at the state level and are robust to autocorrelation and heteroscedasticity.

A. Income, Housing Wealth, and Auto Loan

Table 3 reports the parameter estimates of the models for the first difference in the log of the private auto insurance density with different specifications. Model 1 focuses only on the 2007–2009 sample period, corresponding to the Great Recession. The coefficient of the price variable is not significant during the recession period. Strong positive effects are observed for vehicle expenditures at a 5 percent significance level and auto loans at a 1 percent significance level, as expected. Specifically, the coefficient for vehicle expenditure implies that a 10 percent decrease in the expenditure on motor vehicles is related to a 1.3 percent ($0.987 \approx 0.9^{0.124}$) decrease in the current private auto premium density. The coefficient for the auto loan variable implies that a 10

²² Although the results reported below do not include these two states, the results are mainly unaffected by including them.

percent decrease in the auto loan variable is associated with a 1.7 percent decrease in the current private auto premium density. For our variables of interest, we do not find a statistically significant relationship between income/housing net worth and auto insurance density when investigating the Great Recession period.

Model 2 explains the regression based on the sample of 2007–2012. The sensitivity of price on premiums becomes significant, and a 10 percent decrease in the price level corresponds to a 7 percent increase in the premium density. The reaction of auto loans and vehicle expenditures to auto insurance purchases remains significant even after the recession period. It is worth noting that the marginal sensitivity of auto loan becomes larger (a 1.9 percent drop in insurance consumption for a 10 percent decrease in auto loans) for the extended period than that for the recession period. Again, insurance consumption seems to not be sensitive to changes in income and housing net worth on average. To see if the cross-sectional relationships hold for within-state variation, the model with state fixed-effects (Model 3) is also estimated. The inclusion of state fixed effects slightly changes the regression outcome in that vehicle expenditures are no longer significant whereas the coefficient of auto loans is nearly intact. This highlights the robustness of the positive reaction of auto insurance consumption to auto loans. In the state fixed effect specification, gas expenditures become significantly negative, which may imply that a rise in gasoline prices is associated with less vehicle use and fewer purchases of auto insurance.

To further investigate the influence of states that were severely affected by the collapse in house prices (Arizona, California, Florida, and Nevada), a model without those states (Model 4) is estimated. Interestingly, the estimation result is mostly consistent with Model 2, implying that the identified relationships are not driven by those states. Overall, the income and the average MPC out of the housing wealth shock is insignificant in these model specifications.

B. Heterogeneity of Marginal Propensity to Consume

To evaluate the heterogeneity of the MPC out of the housing net worth shock, we take the empirical approach used by Mian, Rao, and Sufi (2013) and modify equation (3) by adding two new variables: a one-year lagged housing net worth variable and an interaction term between the first difference of the variable and the one-year lagged variable:

$$\begin{aligned}\Delta \log(\text{Auto Prem})_{it} = & \alpha + \alpha_t + \beta_1 \Delta \log(\text{Price Fitted})_{it} + \beta_2 \Delta \log(\text{Vehicle Exp.})_{it} + \\ & \beta_3 \Delta \log(\text{Personal Income})_{it} + \beta_4 \Delta \log(\text{HWN})_{it} + \beta_5 \log(\text{HWN})_{it-1} + \\ & \beta_6 \Delta \log(\text{HWN})_{it} \times \log(\text{HWN})_{it-1} + \beta_7 \Delta \log(\text{Auto Loan})_{it} + \theta \Delta \log(Z)_{it} + \varepsilon_{it}\end{aligned}\quad (6)$$

In this model, a negative coefficient for β_6 implies that the insurance consumption of households with low (high) housing wealth responds more (less) aggressively to changes in wealth.

Table 4 reports the parameter estimates of the augmented model with four different specifications, as outlined in Table 3. Model 1, focusing on the Great Recession, does not indicate a significant effect of the average MPC or of the heterogeneity. In contrast, Model 2 shows that both are significant at 5 percent with the expected sign: the marginal consumption of auto insurance reacts positively to the housing wealth shock on average, whereas the insurance consumption of households with low (high) housing wealth responds more (less) aggressively to the shock on housing wealth. The coefficient for the housing net worth variable indicates a significantly large effect, a 10 percent decrease in the housing net worth is associated with a 8.7 percent decrease in the current private auto premium consumption. The difference in the average MPC between Table 3 and Table 4 indicates that the reaction of the wealth shock depends on the level of housing wealth.

The average MPC and the heterogeneity identified for the cross-sectional model (Model 2) are not supported in the within-state variation (Model 3). The insignificance of the wealth effect

in the state fixed-effect model (Model 3) and the model without the severely affected states (Model 4) implies that the housing wealth effect is largely driven by the severely affected states with a house price collapse. This contrasts the consistent results for auto loans, highlighting the cross-sectional robustness of the positive reaction of auto insurance consumption to the change of auto loans.

C. Heterogeneity among Types of Coverage

Auto insurance is a bundle of several types of coverage (e.g., bodily injury liability coverage, property damage liability coverage, no-fault coverage, comprehensive physical damage coverage, and collision coverage) that could be differently affected by crisis shocks. This allows us to separately evaluate the effect of factors on different exposures.²³ In particular, the consumer purchase of auto physical damage is expected to be more tightly related to income and vehicle expenditures because collision and comprehensive coverage premiums largely depend on the value of the insured vehicle and because the premium can also be flexible with choices of deductible and coverage (collision and/or comprehensive). To evaluate the potential heterogeneity among types of coverage, this study re-categorizes the private passenger auto insurance premium into two categories—auto physical damage and other coverage (non-physical damage)—and it uses the premium density of those lines as dependent variables instead of the aggregate private auto insurance density. The price variables are constructed for those two categories by their state-level combined ratios as explained above.

The estimation results for the 2007-12 sample period are summarized in Table 5. Models 1 and 2 explain the physical damage premium density, and Models 3 and 4 explain the non-

²³ The NAIC annual statement categorizes private insurance into three lines: private passenger auto no-fault (personal injury protection), other private passenger auto liability, and private passenger auto physical damage.

physical damage premium density (primarily non-fault coverage and liability coverage). For both types of coverage, changes in their prices have no significant impact on their premium. Models 1 and 2 show that changes in consumer expenditures on vehicles and income are strongly related to changes in the physical damage premium, as expected. For a 10 percent decline in expenditures on vehicles and income, the physical damage premium density decreases by 1.3-1.5 percent and 1.6-1.8 percent, respectively. The premium is also sensitive to changes in auto loans (1.5-2.3 percent decrease for 10 percent loss of auto loan). Model 1 indicates a significant negative effect of housing net worth, which means that a negative shock on housing net worth is associated with an increase in the purchase of physical damage coverage on average. Thus, the positive relationship between income and auto physical damage premium is consistent with the theoretical prediction by Rampini and Viswanathan (2015), whereas the negative relationship between housing net worth and insurance purchases is inconsistent with their argument of insurance as state-contingent saving. It may be better explained by decreasing risk aversion, in which less wealthy individuals purchase more insurance and/or by stringent requirements of auto loans for collision/comprehensive coverage in states with a large drop in housing wealth.

Models 3 and 4 sharply contrast Models 1 and 2. For non-physical damage, both income and vehicle expenditures are insignificant, whereas both the average MPC and the heterogeneity are highly significant, with the expected signs. The coefficient of housing net worth in Model 4 is strikingly large—a 10 percent decrease in housing net worth is associated with a 12.2 percent decrease in the private auto non-physical damage coverage density. This high sensitivity of non-physical damage coverage on housing wealth might contribute to consumers' saving behavior of auto premiums in the post-crisis period. In addition, a highly significant positive coefficient for the interaction term implies that households with low housing wealth respond more aggressively

to the shock. Thus, the housing net wealth effect on non-physical damage coverage consumption is consistent with the findings in the consumption literature (e.g., Mian, Rao, and Sufi, 2013) and the theoretical prediction by Rampini and Viswanathan (2015).

D. Level of Auto Insurance Density

As a robustness check, the private auto insurance density level is estimated by the following state fixed effects model:

$$\log(\text{Auto Prem})_{it} = \alpha + \alpha_i + \alpha_t + \beta_1 \log(\text{Price Fitted})_{it} + \beta_2 \log(\text{Vehicle Exp.})_{it} + \beta_3 \log(\text{Personal Income})_{it} + \beta_4 \log(\text{HNN})_{it} + \beta_5 \log(\text{Auto Loan})_{it} + \theta \log(\text{Z})_{it} + \varepsilon_{it} \quad (7)$$

where the differences from equation (3) are that all the variables are level and that state fixed-effects are included.

The estimation results summarized in Table 6 are largely consistent with the results for the first difference models, except for the positive and significant coefficients for the price variable in Models 1 and 2. Model 1 explains the aggregate private auto premium density and shows that consumers' expenditures on vehicle purchases and auto loans outstanding are both significant at the 1 percent level. Their coefficients imply that a 10 percent decrease in personal expenditures on vehicles and auto loan debt reduces the private auto premium density by 2.2 percent and 2.8 percent, respectively. This model also indicates the substitution effect of the use of public transportation—the level of premium declines as consumer expenditures on transportation increases (a 2 percent drop for a 10 percent increase in consumer expenditures on transportation). Model 1 also shows a negative and weakly significant coefficient for personal expenditures, yet the sign is inconsistent with the belt-tightening hypothesis.

Model 2 shows that expenditures on vehicle purchases, income, and auto loans are positively related to the household purchase of physical damage coverage at 1 percent significance. Income and auto loans have especially strong effects in that a 10 percent decrease in income and auto loan debt is associated with a 3 percent decline in physical damage coverage consumption. In contrast, housing net wealth is shown to be negatively related to consumption of physical damage, which is also observed in Table 5 Model 1. Model 3, with the non-physical damage premium density, shows that consumer expenditures on vehicles, housing wealth, and auto loans are positively related to the level of the premium. The significant and negative coefficient for the transportation expenditure variable indicates that the substitution effect of the use of public transportation mostly comes from the non-physical damage coverage.

E. Other Specifications

Other model specifications are also estimated to confirm that the findings are robust. First, instead of the 2SLS regressions, feasible generalized least square (FGLS) regressions with AR(1) are estimated with an alternative price variable and two other control variables, *Market Competition* and *Investment Return*. The new price variable is defined as the one-year lagged value of the historical price variable (*Price 5-year*) defined by the reciprocal of the five-year average state-level combined ratio. The estimated coefficients are not reported but are summarized as follows.²⁴ We find a significant effect for the average MPC and the heterogeneity, which are primarily driven by Arizona, California, Florida and Nevada. In this FGLS specification, auto loan becomes less significant in terms of both the magnitude of the coefficients and the statistical significance, although it remains significant at 10 percent level regardless of the models. Thus, this

²⁴ These estimation results are available upon request.

alternative regression specification supports the contribution made by housing net wealth and auto loans.

Several different combinations of explanatory variables are also examined. For instance, models are estimated without vehicle expenditures, personal expenditures, or both. Our primary findings reported in Tables 3-6 are mostly unaffected by dropping these consumption expenditure variables.

4.3. Loss Ratio and Expense Ratio

Regression analyses show that a decline in income, housing wealth, and auto loan debt explains aggregate auto insurance purchases, even after controlling for changes in price and exposure. However, the findings do not reject the possibility that income, wealth, and auto loans are positively related to the frequency and/or severity of the loss such that consumers reduce their demand for coverage because they expected less frequent and/or less severe losses when income, wealth, and auto loans decline.

To investigate this possibility, we tested whether those factors are systematically related to the loss ratio and the expense ratio because the direct relationship between those factors and the loss experience may partially explain the decline in demand for coverage. In particular, we consider the following four ratios: *Loss Ratio*, *Loss and Loss adjustment Expense (LLAE) Ratio*, *Expense Ratio* and *Combined Ratio* (see Table 1 for the definition of variables), and we estimate the first difference in the log of those ratios with the first difference in the log of the explanatory variables used in the previous analyses.

The estimation results reported in Table 7 are consistent for the loss ratio (Model 1), the LLAE ratio and the combined ratio (Model 4). The weakly significant and negative coefficients

for the auto loan variable do not support the hypothesis that claims were reduced during and after the crisis period; rather, they imply deteriorated underwriting performance due to either a worse claims experience and/or a higher premium discount during the period. The negative association remains weakly significant over underwriting performance measures. In contrast, the positive relationship between vehicle purchase expenses and the loss ratio supports the hypothesis that claims were reduced as vehicle purchases were reduced and/or delayed. The overall effect is unclear due to the offsetting effects, but we cannot reject the possibility that demand for auto insurance was reduced due to consumers' expectations regarding the claim experience.

5. Conclusion

Despite the severe losses in the insurance market during and after the 2007 subprime mortgage crisis and the following recession, very little attention has been paid to investigating how insurance purchases are affected.

Using cross-state panel data on private auto insurance premiums during and after the crisis, which was triggered by a collapse in house prices, we conducted a state-level investigation of how the sharp drop in house prices and subsequent contraction in auto loans were associated with declines in auto insurance purchases. Regression analyses confirmed that the shock of loan debt and housing wealth helps explain the decline in aggregate private auto insurance premiums, even after controlling for insurance prices, personal spending on vehicles, and general consumption. The sensitivity of housing wealth shocks to auto insurance purchases is heterogeneous in that households with low housing wealth react more aggressively to wealth shocks than high-wealth households. Thus, the tests provide evidence of a link between the crisis and declines in the purchase of insurance coverage, as mediated by the credit crunch originated by the house price

collapse. Our data provide evidence that the relationship between factors and the premium volume depends on the type of coverage. Therefore, the results need to be interpreted with caution.

Further analyses found some indications that a shock in auto loans is also associated with a worse underwriting performance, whereas a reduction in the consumer purchase of vehicles is related to a better underwriting performance. The in-depth investigation of the relationship between the crisis and claims behavior is left for our future research.

There are several immediate extensions that can be made from this study. First, by using state-level commercial credit data, the effect of a banking crisis on commercial lines of credit can be investigated. This extension may be particularly insightful for understanding the U.S. market due to the large size of its commercial insurance sector. Second, the banking crisis effect could be directly investigated using household panel data. Household-level data would allow us to investigate how a shock in wealth, including incomes, financial assets and real estate, affects risk aversion.

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Table 1: Definition of Variables

Variable	Definition	Source
Auto Premium	Real private auto insurance direct premium written per capita in 2006 dollar	NAIC
Physical Damage Density	Real private auto physical damage insurance DPW per capita in 2006 dollar	NAIC
Non-Physical Damage Density	Real private auto insurance non-physical damage insurance DPW per capita in 2006 dollar	NAIC
Personal Income	Per-capita real personal income in 2006 dollar	BEA
Housing Net Worth (HNW)	The ratio of housing price index to mortgage debt outstanding index	FRBNY/FHFA
Auto Loan	Real auto loan debt balance per capita in 2006 dollar	FRBNY
Vehicle Expenditure	Per-capita real personal motor vehicle expenditure in 2006 dollar	BEA
Gas Expenditure	Per-capita real personal expenditure on gasoline and other energy goods in 2006 dollar	BEA
Transportation Exp.	Per-capita real personal expenditure on transportation services in 2006 dollar	BEA
Personal Expenditure	Per-capita real personal expenditure in 2006 dollar	BEA
Market Competition	The Herfindahl index of private auto insurance premiums by insurers at group level	NAIC
Investment return	The net private auto insurance market share weighted insurers' investment return on asset (%)	NAIC
Price 5-year	The reciprocal of the 5-year average of combined ratio	NAIC
Loss Ratio	Direct losses incurred as a percent of direct premiums earned	NAIC
LLAE Ratio	Direct losses incurred plus direct defense and cost containment expense incurred as a percent of direct premiums earned	NAIC
Expense Ratio	Commissions and brokerage expenses plus taxes, licenses and fees as a percent of direct premiums written	NAIC
Combined Ratio	Direct loss and loss adjustment expense ratio plus direct expense ratio	NAIC

Table 2: Summary Statistics

Variable	Mean	Median	Std. Div.	Minimum	Maximum
Private Auto Density	490	479	72.9	370	693
Physical Damage Density	291	276	64.0	202	477
Non-Physical Damage Density	200	199	26.9	140	290
Personal Income	39,888	39,183	5,756	28,416	66,687
Housing Net Worth	83.12	84.19	8.74	51.54	105.4
Auto Loan	2,892	2,829	518	1,918	4,609
Vehicle Expenditure	1,148	1,120	214	665	1,895
Gas Expenditure	1,288	1,182	451	625	3,472
Transportation Exp.	851	794	267	333	1,583
Personal Expenditure	30,924	30,171	4,873	23,769	52,266
Market Competition	10.3	10.1	2.4	6.2	18.6
Investment return	2.9	3.9	2.2	-4.7	5.5
Price 5-year	126.5	126.7	8.4	90.1	151.8
Loss Ratio	62.9	61.8	8.88	46.9	144
LLAE Ratio	64.5	63.7	9.42	47.9	150
Expense Ratio	11.3	11.5	1.38	7.05	17.1
Combined Ratio	75.8	75.0	9.24	58.4	160

Table 3: First Difference 2SLS Models for Private Auto Insurance Density

The dependent variable is the first difference of the log of private auto insurance direct premium written. Explanatory variables are also the first difference of the log of variables: Price fitted defined by the fitted value of the reciprocal of state-level combined ratio by instruments in the 1st stage model; Vehicle Expenditure defined by per-capita real personal motor vehicle expenditure; Personal Income defined by per-capita real personal income; Housing Net Wealth defined by the ratio of House Price Index to Mortgage Debt Outstanding Index; Auto Loan defined by real auto loan debt balance per capita; Gas Expenditure defined by per-capita real personal expenditure on gasoline and other energy goods; Transportation Expenditure defined by per-capita real personal expenditure on transportation services; Personal Expenditure defined by per-capita real personal expenditure. The 1st stage of the 2SLS regressions also includes Investment Return defined by the net private auto insurance market share weighted insurers' investment return on asset and Market Competition defined by group-level private auto insurance premium Hertindahl Index. Results shown are the 2nd stage of the 2SLS regressions. All models include intercept and year dummy variables (not reported). ***, **, and * denote significance at the 1 percent level, 5 percent level, and 10 percent level by heteroskedasticity and cluster robust standard errors.

	(1)		(2)		(3)		(4)	
	2007-09		2007-12		2007-12 with State FEs		2007-12 without AZ, CA, FL, NV	
Variable	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat
$\Delta \ln(\text{Price fitted})$	-0.516	-1.60	-0.640 **	-2.53	-0.563 **	-2.25	-0.764 ***	-2.95
$\Delta \ln(\text{Vehicle Expenditure})$	0.124 **	2.19	0.107 ***	2.88	0.054	1.44	0.113 ***	2.83
$\Delta \ln(\text{Personal Income})$	0.089	1.11	0.088	1.56	0.064	1.18	0.091	1.51
$\Delta \ln(\text{Housing Net Worth})$	0.005	0.14	-0.004	-0.21	0.013	0.51	-0.015	-0.77
$\Delta \ln(\text{Auto Loan})$	0.158 ***	2.95	0.178 ***	4.34	0.180 ***	4.31	0.157 ***	3.97
$\Delta \ln(\text{Gas Expenditure})$	-0.070	-1.29	-0.051	-1.32	-0.091 **	-2.03	-0.061	-1.52
$\Delta \ln(\text{Transportation Exp.})$	-0.034	-0.42	-0.042	-0.83	-0.008	-0.17	-0.048	-0.97
$\Delta \ln(\text{Personal Expenditure})$	-0.022	-0.18	0.048	0.51	0.120	1.56	0.002	0.02
Year Fixed-Effects	Yes		Yes		Yes		Yes	
State Fixed-Effects	No		No		Yes		No	
Observations	147		294		294		270	
Pseudo R ²	0.57		0.60		0.63		0.60	

Table 4: First Difference 2SLS Model with Housing Net Worth Interaction Term

The dependent variable is the first difference of the log of private auto insurance direct premium written. Explanatory variables are also the first difference of the log of variables: Price fitted defined by the fitted value of the reciprocal of state-level combined ratio by instruments in the 1st stage model; Vehicle Expenditure defined by per-capita real personal motor vehicle expenditure; Personal Income defined by per-capita real personal income; Housing Net Wealth defined by the ratio of House Price Index to Mortgage Debt Outstanding Index; Auto Loan defined by real auto loan debt balance per capita; Gas Expenditure defined by per-capita real personal expenditure on gasoline and other energy goods; Transportation Expenditure defined by per-capita real personal expenditure on transportation services; Personal Expenditure defined by per-capita real personal expenditure. The 1st stage of the 2SLS regressions also includes Investment Return defined by the net private auto insurance market share weighted insurers' investment return on asset and Market Competition defined by group-level private auto insurance premium Hertindahl Index. Results shown are the 2nd stage of the 2SLS regressions. All models include intercept and year dummy variables (not reported). ***, **, and * denote significance at the 1 percent level, 5 percent level, and 10 percent level by heteroskedasticity and cluster robust standard errors.

	(1)		(2)		(3)		(4)	
	2007-09		2007-12		State FEs		2007-12 Without AZ, CA, FL, NV	
Variable	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat
$\Delta \ln(\text{Price fitted})$	-0.610 *	-1.91	-0.654 **	-2.60	-0.662 ***	-2.79	-0.749 ***	-2.89
$\Delta \ln(\text{Vehicle Expenditure})$	0.067	1.16	0.096 **	2.62	0.073 *	1.97	0.105 **	2.64
$\Delta \ln(\text{Personal Income})$	0.107	1.24	0.077	1.38	0.085	1.53	0.085	1.41
$\Delta \ln(\text{Housing Net Worth})$	0.118	0.08	0.864 **	2.67	0.195	0.48	0.510	0.67
$\ln(\text{Housing Net Worth}, t-1)$	0.100 **	2.24	0.033	1.83	0.108 ***	2.74	0.045 *	1.91
$\Delta \ln(\text{HNW}) * \ln(\text{HNW}, t-1)$	-0.035	-0.10	-0.196 **	-2.64	-0.021	-0.21	-0.117	-0.69
$\Delta \ln(\text{Auto Loan})$	0.164 ***	3.03	0.155 ***	3.93	0.164 ***	4.25	0.148 ***	3.69
$\Delta \ln(\text{Gas Expenditure})$	-0.061	-1.12	-0.054	-1.42	-0.110 **	-2.36	-0.064	-1.59
$\Delta \ln(\text{Transportation Exp.})$	-0.049	-0.61	-0.038	-0.78	0.001	0.01	-0.051	-1.05
$\Delta \ln(\text{Personal Expenditure})$	-0.022	-0.16	-0.013	-0.14	0.025	0.33	-0.011	-0.11
Year Fixed-Effects	Yes		Yes		Yes		Yes	
State Fixed-Effects	No		No		Yes		No	
Observations	147		294		294		270	
Pseudo R ²	0.60		0.61		0.67		0.61	

Table 5: Auto Physical Damage Coveraeg and Non-Physical Damage Coverege - 2SLS Models

The dependent variable is the first difference of the log of private auto insurance direct premium written (Auto Physical Damage Coveage for (1) and (2) and Non-Physical Damage Coveage for (3) and (4)). Explanatory variables are also the first difference of the log of variables: Price fitted defined by the fitted value of the reciprocal of state-level combined ratio by instruments in the 1st stage model; Vehicle Expenditure defined by per-capita real personal motor vehicle expenditure; Personal Income defined by per-capita real personal income; Housing Net Wealth defined by the ratio of House Price Index to Mortgage Debt Outstanding Index; Auto Loan defined by real auto loan debt balance per capita; Gas Expenditure defined by per-capita real personal expenditure on gasoline and other energy goods; Transportation Expenditure defined by per-capita real personal expenditure on transportation services; Personal Expenditure defined by per-capita real personal expenditure. The 1st stage of the 2SLS regressions also includes Investment Return defined by the net private auto insurance market share weighted insurers' investment return on asset and Market Competition defined by group-level private auto insurance premium Hertindahl Index. Results shown are the 2nd stage of the 2SLS regressions. All models include intercept and year dummy variables (not reported). ***, **, and * denote significance at the 1 percent level, 5 percent level, and 10 percent level by heteroskedasticity and cluster robust standard errors.

Variable	(1) Auto Physical Damage Density		(2) Auto Physical Damage Density		(3) Non-Physical Damage Density		(4) Non-Physical Damage Density	
	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat
$\Delta \text{Ln}(\text{Price fitted})$	-0.159	-0.79	-0.098	-0.50	-0.460	-1.15	-0.491	-1.16
$\Delta \text{Ln}(\text{Vehicle Expenditure})$	0.140 ***	2.77	0.122 **	2.43	0.067	1.63	0.057	1.42
$\Delta \text{Ln}(\text{Personal Income})$	0.176 ***	3.20	0.154 ***	2.90	0.064	0.77	0.060	0.72
$\Delta \text{Ln}(\text{Housing Net Worth})$	-0.073 ***	-3.01	0.334	0.62	0.045	1.36	1.235 ***	3.57
$\text{Ln}(\text{Housing Net Worth, t-1})$			0.083 ***	4.87			0.018	0.64
$\Delta \text{Ln}(\text{HNW}) * \text{Ln}(\text{HNW, t-1})$			-0.085	-0.68			-0.271 ***	-3.35
$\Delta \text{Ln}(\text{Auto Loan})$	0.214 ***	4.00	0.148 ***	2.91	0.161 ***	3.06	0.154 ***	3.11
$\Delta \text{Ln}(\text{Gas Expenditure})$	-0.026	-0.58	-0.036	-0.82	-0.066	-1.56	-0.066	-1.59
$\Delta \text{Ln}(\text{Transportation Exp.})$	0.025	0.40	0.041	0.67	-0.076	-1.16	-0.077	-1.21
$\Delta \text{Ln}(\text{Personal Expenditure})$	0.202 *	1.72	0.031	0.30	-0.067	-0.51	-0.095	-0.69
Year Fixed-Effects	Yes		Yes		Yes		Yes	
State Fixed-Effects	No		No		No		No	
Observations	294		294		294		294	
Pseudo R ²	0.48		0.53		0.56		0.56	

Table 6: Level of Private Auto Insurance Density - 2SLS

The dependent variable is the level of the log of private auto insurance direct premium written (Auto Physical Damage Coverage for (2) and Non-Physical Damage Coverage for (3)). Explanatory variables are also the first difference of the log of variables: Price fitted defined by the fitted value of the reciprocal of state-level combined ratio by instruments in the 1st stage model; Vehicle Expenditure defined by per-capita real personal motor vehicle expenditure; Personal Income defined by per-capita real personal income; Housing Net Wealth defined by the ratio of House Price Index to Mortgage Debt Outstanding Index; Auto Loan defined by real auto loan debt balance per capita; Gas Expenditure defined by per-capita real personal expenditure on gasoline and other energy goods; Transportation Expenditure defined by per-capita real personal expenditure on transportation services; Personal Expenditure defined by per-capita real personal expenditure. The 1st stage of the 2SLS regressions also includes Investment Return defined by the net private auto insurance market share weighted insurers' investment return on asset and and Market Competition defined by group-level private auto insurance premium Hertindahl Index. Results shown are the 2nd stage of the 2SLS regressions. All models include intercept and year dummy variables (not reported). ***, **, and * denote significance at the 1 percent level, 5 percent level, and 10 percent level by heteroskedasticity and cluster robust standard errors.

Variable	(1)		(2)		(3)	
	Private Auto		Private Auto Physical Damage		Private Auto Non-Physical Damage	
	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat
Ln(Price fitted)	1.232 **	2.43	1.268 ***	5.45	-4.011 *	-1.73
Ln(Vehicle Expenditure)	0.211 ***	3.53	0.218 ***	3.42	0.176 **	2.12
Ln(Personal Income)	0.117	0.85	0.314 ***	2.72	-0.075	-0.44
Ln(Housing Net Worth)	0.031	1.23	-0.079 **	-2.66	0.125 ***	3.48
Ln(Auto Loan)	0.266 ***	3.82	0.291 ***	4.79	0.259 ***	3.22
Ln(Gas Expenditure)	-0.004	-0.06	0.010	0.19	-0.002	-0.02
Ln(Transportation Exp.)	-0.190 **	-2.04	0.004	0.03	-0.290 **	-2.37
Ln(Personal Expenditure)	-0.306 *	-1.73	0.127	0.89	-0.456 **	-2.36
Year Fixed-Effects	Yes		Yes		Yes	
State Fixed-Effects	Yes		Yes		Yes	
Observations	294		294		294	
Pseudo R ²	0.81		0.87		0.57	

Table 7: Loss Ratios, Expense Ratio and Combined Ratio - OLS Models

The dependent variable is the first difference of the log of loss ratios and expense ratio. Explanatory variables are also the first difference of variables: Market Competition defined by group-level private auto insurance premium Hertindahl Index; Investment Return defined by the net private auto insurance market share weighted insurers' investment return on asset; Vehicle Expenditure defined by per-capita real personal motor vehicle expenditure; Personal Income defined by per-capita real personal income; Housing Net Wealth defined by the ratio of House Price Index to Mortgage Debt Outstanding Index; Auto Loan defined by real auto loan debt balance per capita; Gas Expenditure defined by per-capita real personal expenditure on gasoline and other energy goods; Transportation Expenditure defined by per-capita real personal expenditure on transportation services; and Personal Expenditure defined by per-capita real personal expenditure. Results shown are from OLS regressions for 2007-12. All models include intercept and year dummy variables (not reported). ***, **, and * denote significance at the 1 percent level, 5 percent level, and 10 percent level by heteroskedasticity and cluster robust standard errors.

Variable	(1)		(2)		(3)		(4)	
	Loss Ratio		Loss and LAE Ratio		Expense Ratio		Combined Ratio	
	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat
$\Delta \ln(\text{Market Competition})$	0.069	0.54	0.039	0.31	-0.048	-0.66	0.036	0.37
$\Delta \ln(\text{Investment Return})$	-0.112	-0.17	-0.413	-0.63	0.082	0.32	-0.375	-0.66
$\Delta \ln(\text{Vehicle Expenditure})$	0.227 *	1.72	0.220 *	1.69	0.010	0.16	0.187 *	1.69
$\Delta \ln(\text{Personal Income})$	0.396	1.15	0.400	1.22	0.004	0.04	0.337	1.23
$\Delta \ln(\text{Housing Net Worth})$	-0.035	-0.37	-0.041	-0.43	-0.010	-0.31	-0.042	-0.53
$\Delta \ln(\text{Auto Loan})$	-0.228 *	-1.72	-0.230 *	-1.79	0.073	1.16	-0.185 *	-1.70
$\Delta \ln(\text{Gas Expenditure})$	-0.089	-1.00	-0.073	-0.79	0.167 ***	3.87	-0.039	-0.52
$\Delta \ln(\text{Transportation Exp.})$	0.310	1.34	0.266	1.18	0.097 *	1.90	0.248	1.31
$\Delta \ln(\text{Personal Expenditure})$	0.389	0.84	0.384	0.83	-0.476 ***	-2.77	0.257	0.64
Year Fixed-Effects	Yes		Yes		Yes		Yes	
State Fixed-Effects	No		No		No		No	
Observations	294		294		294		294	
Pseudo R ²	0.22		0.19		0.10		0.20	