

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

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Abstract

Using cross-state panel auto insurance premium data from the U.S. between 2007 and 2012, this study provides an evidence that individual purchases of private auto insurance are excessively reduced during and after the U.S. subprime mortgage. Analyses show that a shock on house prices and a credit crunch are contributing factors of the reduced consumption of auto insurance during and after the crisis. This result is robust even after controlling for associated factors such as insurance prices, personal spending on vehicles and general consumption, recession indicators and the use of alternative transportation. Tests also find that a shock on house prices is related to deterioration of underwriting performance as well. These findings provide evidence for a real effect of the banking crisis.

JEL Codes: G01, G22, E22

Keywords: Banking crisis, credit, auto loan, insurance

1. Introduction

Banking crises tend to disproportionately reduce insurance purchases in the post-crisis period. To illustrate how insurance consumption is suffered during and after the U.S. subprime crisis,² Figure 1 shows the trend of the real private auto insurance premium per capita and the real GDP per capita from 2006 to 2013 for the 32 largest private auto insurance markets in the U.S..³ The premiums fell over the crisis years and remained below the 2006 level (of 100 in 2006) as of 2012, with the exception of North Dakota (not shown in Figure 1).⁴ The post-crisis premium levels reached as low as 76-77 in Arizona, Hawaii, Massachusetts and Nevada. The contraction of premium volume was most pronounced among the states with a combination of high household debt and larger housing price declines (Arizona, California, Florida and Nevada). In the U.S. total, the premium level remained at 88 (below the 2006 level) in 2012. This long-lasting post-crisis trend sharply contrasted with the quick recovery of output, which was below the 2006 base year only in 2009. A further decline of premium levels after 2009 observed in many states also suggests that the trend of insurance consumption cannot be explained by a general economic slowdown measured by the recession that ended in June 2009.⁵

Immediately after the U.S. subprime mortgage crisis, an excessive decline of non-life insurance consumption was reported by the NAIC (National Association of Insurance Commissioners), which studied how the economic downturn affected various types of insurance policies in 2008 (NAIC, 2008). The association's survey reports that 8 percent of respondents made changes to their auto insurance policies (by reducing coverage, falling behind on payments or cancelling policies) and 6 percent made changes to their homeowner's policies (with 4 percent cancelling their policies).⁶ The following NAIC

² The 2007-2009 US subprime crisis is considered a credit crisis with a banking panic. See, for instance, Gorton (2009).

³ 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 (EBA).

⁴ The relatively quick recovery to the pre-crisis level in North Dakota is explained by economic growth due to a shale gas boom.

⁵ The U.S. subprime mortgage crisis began with the bursting of the U.S. housing bubble from its 2006 peak and caused a recession that started from 2007. The NBER determined that a recession began in December 2007 and ended in June 2009. The recession lasted 18 months.

⁶ With a significance level of 5 percent.

survey, which was conducted in 2011, asked individuals about any car-related lifestyle changes that affected their car insurance premiums in the past 12 months (NAIC, 2011). The results are summarized as follows: More than half of the respondents saved on car insurance 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). About 20 percent of the car owners reduced the value or the number of their vehicles. About 20 percent of drivers reduced their car insurance coverage. Thus, the reports suggest that the U.S. subprime mortgage crisis reduced not only exposure to risks but also the degree of auto insurance coverage.

The persistent adverse effect of the recent crisis on insurance consumption is also consistent with the findings that the total of non-life insurance premiums relative to GDP falls by approximately 20 percent after a banking crisis in high income countries and that the effect lasts at least five years after the crisis (Kamiya, Lee and Zanjani, 2014). They also show that this post-crisis effect is primarily driven by declines in auto insurance purchases. The adverse effect is considered as a result of reduced risk exposure due to credit crunch but the mechanism remains largely unexplained by the cross-country data.

To investigate the mechanism, this study focuses on the heterogeneity of private auto insurance consumption between states during and after the bank panic in 2007 crisis and evaluates how individual purchases of auto insurance were affected by the crisis through the collapse of home prices followed by the credit crunch on auto loans. It is important to figure out the relationship not only because auto insurance has a large share in the non-life insurance sector but also because this implication could be extended to other lines of business in which the size of risk exposure is strongly related to credit availability for the private sector.

Our results suggest several links that led individual purchases of auto insurance to suffer excessively from the crisis. First, vehicle purchases were reduced because auto loan supply was reduced after a shock on house prices and it took years for the auto loan market to start recovering. Insurance

purchase reacted to the auto loan market. Second, the shock on house prices has a direct negative impact on individual auto insurance purchases in addition to the wealth effect through credit channel.

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 between 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 test the presence of the marginal effect of the shock on house prices and the credit crunch. Several robustness checks follow. A summary of our findings is given in Section 5.

2. Related Literature

The contraction of aggregate non-life insurance consumption neatly dovetails with recent findings in the macroeconomics literature concerning persistent and significant declines in output after a financial crisis (Hutchson and Noy, 2005; Boyd et al., 2005; Reinhart and Rogoff, 2008; Cerra and Saxena, 2008; Furceri and Mourougane, 2012).⁷ For instance, using a sample including 190 countries from 1960 to 2001, Cerra and Saxena (2008) estimate that the negative and persistent output loss from a banking crisis averages 7.5 percent. The significant and persistent output loss after a crisis indicates the shrinkage of risk exposure to be covered by non-life insurance and hence a decline in non-life insurance consumption because output and income are positively correlated to insurance consumption (Beenstock, Dickinson, and Khajuria, 1988; Outreville, 1990; Browne, Chung, and Frees, 2000; Outreville, 2012, for a comprehensive literature review of insurance demand).

Insurance consumption is affected through pricing by macroeconomic conditions: stock index (Cummins and Nye, 1980; Cummins and Harrington, 1985, 1988; Lamm-Tennant and Weiss, 1997; Chen,

⁷ The size of estimated output loss depends on the estimation approach taken and the sample countries included in the estimations.

Wong and Lee, 1999; Jawadi, Bruneau, and Sghaier, 2009; Bruneau and Sghaier, 2014), 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), inflation rate (Bruneau and Sghaier, 2014), 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 price (Guo, Fung and Huang, 2009). However, the literature has limited implications to a banking problem while it provide insights on insurance purchase in mild business cycle fluctuation. The prolonged adverse trend of private auto insurance consumption illustrated in Figure 1 and reported by Kamiya, Li and Zanjani (2014) appears to require additional explanations.

One of plausible explanations for the reductions of insurance consumption after a banking crisis is excessively reduced risk exposure through credit crunch.⁸ If we focus particularly on the effect of the subprime mortgage crisis on household credit, a collapse of house prices plays a key role on reduced credit and consumption. The credit channel linking house price with consumption predicts that declining house prices with the potential for higher default probabilities and worsening balance sheets leads homeowners to face greater credit rationing, or 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 cause the slow recovery in output and consumption (Mian and Sufi, 2011).⁹ Using consumer loan data, Ramcharan and Crowe (2013) find evidence that a house price decline has a large adverse effect on both the supply and cost of unsecured consumer credit, especially the large effect for subprime applicants (Bajari, Chu, and Park 2008, Demyanyk and Van Hemert 2009). These results suggest that house price declines would reduce

⁸ The finance literature also provides evidence that shocks to bank lending cause reductions in capital expenditures (Kroszner et al., 2007; Dell’Ariccia et al., 2008; Chava and Purnanandam, 2011; Kahle and Stulz, 2013).

⁹ 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).

consumption through reduced credit supply (Carroll, Otsuka, and Slacalek, 2006; Campbell and Cocco, 2007; Gan, 2010; and Case, Quigley, and Shiller, 2005).

The effect of insurance prices is also particularly relevant in evaluating the effect of financial crises, because large adverse shocks to the insurers' financial condition could substantially reduce industry capacity. Therefore, a decrease in the post-crisis premium volume may be explained by supply shock, which can be described as an underwriting cycle in the 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 lower quantity. A decline in aggregate premiums after a crisis may therefore result from reduced capacity and/or lower investment return, which increase the price of insurance and decrease 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 would result in a decline in premium volume due to a decline of both premium rates and coverage.

3. Auto Loans, Vehicle Purchases and Auto Insurance Purchases

3.1. Auto Loans

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 that they cannot afford without borrowing the money. In 2007, the annual average loan-to-value ratio for car loans from auto finance companies was around 95 percent for new car loans and 100 percent for used car loans.¹⁰ The average annual amount for

¹⁰ 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 (TERMFCLVRNCNS and DTCTLVULNM), retrieved from FRED, Federal Reserve Bank of St. Louis.

new car loans reached \$28,287 in 2008.¹¹ Thus, personal spending on vehicles heavily relies on the availability of auto loans to smooth the expenditure, and a reduction of 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 a financial crisis, banks shift 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 2008.¹² Although it may not be the only determinant, tightening of lending standards from the beginning of 2007 to the end of 2009 clearly appeared as a declining real auto loan debt balance during the period, as is shown in Figure 2.¹³ The real auto loan debt balance index (100 in 2006Q1) started declining in 2007, reached about 80 by the end of 2009 and remained at that level during 2010-2011 until starting to recover recently. This trend contrasts with that of mortgage loan debt, which continued to increase until 2008 and remained to be above the pre-crisis level until 2011. Thus, auto loan debt responded to the banking problem more quickly than mortgage loan debt and was reduced proportionately much larger than mortgage loans.¹⁴

¹¹ 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, Federal Reserve Bank of St. Louis.

¹² 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, Federal Reserve Bank of St. Louis.

¹³ The real auto loan debt and mortgage debt are calculated by the authors. The original data is taken from the FRBNY Consumer Credit Panel – Household Debt and Credit, retrieved from the Federal Reserve Bank of New York.

¹⁴ The auto loan debt balance was roughly 10 percent of mortgage debt during the post-crisis period. In the 4th quarter of 2012, the total debt from auto loans stood at 0.78 trillion and the mortgage debt was 8.0 trillion. Therefore, the reduction of loan balance was larger for mortgage loans than for auto loans, and consequently the aggregate personal loan debt substantially deviate from the situation of auto loans.

The wealth effect on auto loan is illustrated in Figure 3 with plots of the real house price index versus the real auto loan index.¹⁵ Both indexes were at 100 in 2006 and show small deviations in 2007. Arizona, California, Florida and Nevada started experiencing large declines in house price in 2008 and the magnitude of the declines is much larger than that of auto loan index. Consistent with the theoretical prediction and empirical evidence of the wealth effect, states show close relationship between the two indexes, both of which tend to decline until 2010. The level of the real house price index went even below 40 in Nevada in 2011-2012 and the level of auto loan declined to levels around 70 for some states, such as Nevada, Arizona, California and Florida. After 2011, many states start increasing auto loan debt regardless of small changes in house price. In 2012, several states recovered the 2006 level of auto loan while their house price indexes were still below the reference level.¹⁶ This shift is indicated in Figure 3 by the intercept of the fitted line shifted upward.

Importantly, auto loan debt outstanding tends to be significantly suffered by the banking crisis and to behave quite differently from output (see Figure 4) and personal income as well. Such negative deviation of auto loan debt balance from the aggregate measures of economic activities differentiates insurance consumption after a credit crunch and that in ordinary business cycle, and highlights the importance of understanding how credit is associated with insurance consumption.

3.2. Personal Vehicle Expenditures

The amounts that individuals spend on vehicles depend heavily on their arrangements for car finance. Therefore, individuals tend to spend less for vehicles when lending institutions reduce the supply of auto loans. Using personal expenditure data taken from the Bureau of Economic Analysis (EBA), we

¹⁵ Dates are retrieved from the Federal Housing Finance Agency.

¹⁶ See, for instance, Haughwout, et. al. (2014) "Just Released: Looking under the Hood of the Subprime Auto Lending Market," Federal Reserve Bank of New York (August 14, 2014).

investigate the relationship between auto loan debt and personal expenditure on vehicles.¹⁷ Figure 5 illustrates how auto loan debt and personal spending on vehicles changed during and after the crisis. By 2008, all states moved below the reference level of personal vehicle expenditure and in some states the level went below 80. The auto loan indexes deviated from the reference by lesser degrees. The faster shift in personal spending on vehicles may capture faster declines in the non-loan portion of personal expenditure on vehicles. In 2009 this trend continued and the vehicle expenditure index declined to levels around 60 for some states, such as Nevada, Arizona, California and Florida. After 2010, the size of the deviations from the 2006 base year grew similar for both auto loan debt and spending on vehicles. This shift is indicated in Figure 5 by the fitted line passing the reference point with the slope of approximate unity. The plots in the later years indicate the close relationship between debt and expenditure, and show that both indexes improved (or shifted to the upper-right) for most states.

3.3. Auto Insurance Purchases

A reduction in personal spending on vehicle purchases is a sufficient indication for a decline in auto insurance purchases, if other factors such as premium rates and individual risk attitudes are unchanged. In Figure 6 we observe the relationship between personal spending on vehicles and personal spending on auto insurance during and after the crisis.¹⁸ In 2007, all states except Washington were below the reference for private auto insurance purchases, even though personal vehicle expenditure was little changed. Both indexes similarly decline in 2008 with an exception of Massachusetts. In 2009-2010, lessening expenditure on vehicles led to declines in auto insurance purchases in the states hit very hard by the crisis. Despite the improvement in vehicle expenditure from 2011, auto insurance purchases remained roughly flat (or shifted to the right in Figure 6) during 2011-2012. The negative intercept of the 2012

¹⁷ Personal expenditure data are retrieved from the EBA, at <http://www.bea.gov/regional/downloadzip.cfm/>, as of December 16, 2014.

¹⁸ Private auto insurance direct premium written data were obtained from the NAIC annual financial statements for various years.

fitted line in Figure 6 also indicates that the recovery of auto insurance purchases lagged by roughly 9 percent relative to personal vehicle expenditure. Thus, the plots show that auto insurance premiums severely suffered over the period and that vehicle expenditure does not fully explain the post-crisis decline in insurance purchases.

The aforementioned bivariate relationships illustrate the link between the crisis and auto insurance purchases through the credit channel. In the next section, we formally test the marginal effect of these factors to evaluate how the crisis affected auto insurance purchases.

4. Regression Analyses

4.1. Methodology

We conduct state-level analyses for the 2007 to 2012 period. Working with state-level data has several benefits relative to country-level analysis. First, the state-level sample allows us to investigate the effect of heterogeneous shocks on house prices and credit crunch within the U.S. Second, the within-country analysis can reduce the concerns of heterogeneity between countries such as difference in insurance regulation and social/cultural factors.

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

We first investigate whether purchase of private auto insurance premiums reacts to change in various crisis-associated factors. The measure we explain is real private auto direct premiums written per capita (or the premium density), denoted by $AutoPrem_{it}$, which represents the real dollar value that an individual pays for private auto insurance. The national average was \$496 during the sample period, with the highest value being \$693 in Louisiana in 2007 and the lowest being \$370 in Idaho in 2012. To evaluate crisis effects, we consider the following log-log regression model with the first difference of the log of the premium density denoted by $\Delta \log(AutoPrem)_{it} = \log(AutoPrem)_{i,t} - \log(AutoPrem)_{i,t-1}$:

$$\begin{aligned} \Delta \log(AutoPrem)_{it} = & \alpha + \alpha_i + \alpha_t + \beta_1 \Delta \log(InsPrice)_{it} + \beta_2 \Delta \log(Competition)_{it} \\ & + \beta_3 \Delta \log(VehicleExp)_{it} + \beta_4 \Delta \log(AutoLoan)_{it} + \beta_5 \Delta \log(House Price)_{it} \\ & + \boldsymbol{\theta} \Delta \log(X)_{it} + \varepsilon_{it}, \end{aligned} \quad (1)$$

where α stands for an intercept, α_i represents a state fixed-effect for state i , α_t represents a time fixed-effect for year t , X_{it} represents a vector of other controls and ε_{it} is a normally distributed error term. The intercept α reflects the nation-wide constant effect over 2007-2012 and the year fixed-effect captures the nation-wide constant effect by year. The other explanatory variables are also the first difference of the log of variables described as follows.

Insurance Price is defined by the inverse of the five-year average combined ratio (as a percentage) from year $t-6$ to year $t-1$.¹⁹ The variable is 100 if the earned premium is equal to the sum of costs, including losses, loss adjustment expenses and other expenses. If the earned premium is larger (smaller) than the operational costs, then the ratio is greater (smaller) than 100. Thus, the ratio reflects the state-level aggregate price of private auto insurance. During the sample period, the national average was 127. The highest ratio was 152 in North Dakota during 2012 and Michigan was the lowest throughout the

¹⁹ The combined ratio indicates an insurer's overall operational result. This ratio is the sum of the loss ratio and the expense ratio. The loss ratio is calculated by dividing the incurred losses plus the loss adjustment expenses by the earned premiums. The expense ratio is calculated by dividing all other expenses by the earned premiums. In the literature, the inverse of the loss ratio is used as a price measure (e.g., Esho et al., 2004).

period, with the lowest ratio being 90 in 2012. As current premiums are determined by the past experience of costs, current premiums can decrease (increase) simply because of low (high) costs in previous years. We include the *Insurance Price* variable to control for the price effect.

Market Competition denotes the Herfindahl index of private auto insurance premiums charged by the insurers operating in a state. This variable is defined by the sum of the squared market share of private auto insurance for the state's insurers, as a percentage. The national average was 6.8 during the surveyed period. The least competitive state was Massachusetts and the most competitive state was Connecticut throughout the sample period, with the highest rating being 14.7 (for Massachusetts) in 2012 and the lowest being 2.7 (for Connecticut) in 2007. The level of market competition among insurers should be mostly reflected in the level of the combined ratio, in that intense competition gives insurers pressure to reduce their premium levels. However, it may be possible that current market competition becomes more intense than in the previous year, which causes a decline in the aggregate premium level because an economic downturn reduces the size of the market. To evaluate the effect of current competition, we include the *Market Competition* variable.

Vehicle Expenditure denotes real per-capita personal expenditure on motor vehicles. The national average was \$1,148, with the highest expenditure being \$1,895 in North Dakota in 2012 and the lowest being \$665 in Michigan in 2009. North Dakota, South Dakota and Wyoming showed the highest expenditure levels and Michigan had the lowest over the period. We consider this *Vehicle Expenditure* variable as a proxy for risk exposure, because insurance purchases are expected to change with spending on vehicles, if all other things are equal. Thus, including this expenditure variable is expected to control for the changes in exposure during and after the crisis.

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. If auto insurance premiums react to a credit crunch on auto loans

instead of change in overall spending on vehicles, then the *Auto Loan* variable should capture this relationship. This variable should also separate the effect through the credit channel from personal spending on vehicles. In spite of the close relationship between auto loans debt and spending on vehicles (see Figure 5), there are several major practical reasons that auto loan affects insurance purchase differently from spending on vehicles. First, not all vehicles on the road are purchased with auto loan and auto loans tend to be repaid in 3-4 years. Thus, the auto loan variable measures exposure of relatively new vehicles purchased by auto loan. Second, lending institutions typically require a borrower of 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 required by the law, and collision/comprehensive. Therefore, change in auto loans is expected to have a stronger impact on insurance purchase than change in overall spending on vehicles including non-loan expenditure. Third, as shown by Ramcharan and Crowe (2013), credit tightening affects subprime auto loan applicants more, who have a low credit score. Hence, subprime auto loan applicants tend to be a policyholder who pays a larger amount of auto insurance premiums because U.S. insurance companies may use credit scores for pricing purpose unless an applicant lives where the practice has been banned (Hawaii, Massachusetts and California).²⁰ Therefore, loss of subprime auto loans is expected to have a large negative impact on insurance consumption.

To evaluate the wealth effect on insurance purchases, we use the house price index (*House Price Index*) as a proxy for personal wealth, which cannot be captured by nation-wide economy such as stock market return. The annual *House Price Index* is constructed by the average of Quarterly Purchase-Only Indexes, with a value of 100 set for 2006 as the base year. The national average was 86 during the surveyed period, with the highest being 110 in North Dakota during 2012 and the lowest being 38 in Nevada during 2011. Nevada continued to have the lowest rank from 2009. Arizona, Florida and

²⁰ Use of credit score is banned by state law in Hawaii and Massachusetts. It is not technically prohibited but is practically banned in California.

California also exhibited house price indices of between 40 and 50 after 2009. The theory of wealth effect predicts that declining house prices cause to reduce insurance consumption through credit rationing and/or high auto loan rates. Thus, if the wealth effect is fully explained through auto loans, this variable should not exhibit statistically significant marginal effect on insurance consumption. The presence of the marginal effect implies the presence of other channels relating house price to purchase of insurance.

There are several other crisis-related factors that may affect auto insurance consumption. First, to control for the effect of the 2007-2009 recession, we prepare two variables: real state gross domestic product (*GDP per capita*) and real state personal income (*Personal Income*). The average of real per-capita GDP was \$49,249 and the average of real personal income was \$39,888. If auto insurance purchases decline simply because of business cycle, then either or both of these variables should capture that effect. For robustness, we also investigate whether a reduction in auto insurance purchases is explained by consumer belt-tightening, with which diminishing economic activity causes a reduction in personal spending on overall consumption including auto insurance purchases. To control for the effect of aggregate consumption expenditure, we consider *Personal Expenditure* denoting real per-capita personal expenditure 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.

We also consider real per-capita personal expenditure on gasoline and other energy goods (*Gas Expenditure*) and real per-capita personal expenditure on transportation services (*Transport Exp.*).²¹ 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 price during the period. An increasing trend of gas price during the period and a sharp drop in 2009 could affect how individuals drive.²² Increase in gasoline price and expenditure on gasoline may reduce use of private vehicles and hence spending on insurance purchases. The *Transport Expenditure* variable

²¹ Note that the personal expenditure on gasoline and other energy goods includes expenditure unrelated to driving.

²² The average retail gas price dropped from 3.3 dollars per gallon in 2008 to 2.4 dollars per gallon in 2009 (U.S. all grades all formulations retail gasoline prices). The prices are obtained from U.S. Energy Information Administration.

is expected to capture the use of alternative transportation, because individuals tend to use public transport more and private vehicles less during an economic downturn. Investigating the effects of change in motor vehicle use is important, because the 2011 NAIC survey documents that 40 percent of the respondents reported driving less (and/or taking public transportation more frequently) after the subprime mortgage crisis.

4.2. Results

In scrutinizing the data, we decide 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 (average 74 percent for other states). 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 about 7 percent in North Dakota by a shale gas boom, despite approximately zero real growth for the country overall during the same period.²³ After excluding these two states, we have 294 state-year samples.

We conduct several tests to validate the regression models. First, to determine which regression model to be fit, we run Hausman tests to decide between fixed or random effects, rejecting the null hypothesis that error terms are uncorrelated with the independent variables. Therefore, Hausman tests support fixed-effects models. Second, fixed-effects models are confirmed to be a better choice against pooled cross-sectional models by F-tests. Including firm fixed-effects is appropriate not only to control for heterogeneity among states such as insurance regulations but also to reduce concerns of omitted variable bias. Therefore, we estimate models by OLS with firm and year fixed-effects. Standard errors are

²³ Although the results reported below do not include these two states, the results are mainly unaffected by including them.

clustered at the state level and are robust to autocorrelation and heteroskedasticity. The normality assumption is supported by the residuals.

A. First Difference of Auto Insurance Density

Table 3 reports the parameter estimates of the models for the first difference of the log of private auto insurance density. To investigate how the marginal effects of auto loan and house prices interact with those of controls, we estimate models with different combinations of variables. Model 1 indicates a strong positive effect of insurance prices, as expected. Specifically, the coefficient implies that a 10 percent decrease in the price variable is associated with a 4.1 percent ($1.041 \approx e^{0.42 \times \log 1.1}$) decrease in current private auto premium density. We also observe a statistically significant relationship between current market competition and auto insurance density. The coefficient implies that a 10 percent increase in the competition variable (meaning an increase of market concentration) is related to a 0.9 percent ($0.991 \approx e^{-0.094 \times \log 1.1}$) decreases in current private auto premium density. For variables of our interest, we confirm that a 10 percent decrease in auto loan debt reduces current private auto premium density with 0.9 percent at 5 percent significance, while we do not find statistically significant relationship between house price and auto insurance density. The marginal effect of auto loan is economically significant because auto loan debts decline even by 30 percent in severely suffered states. Furthermore, a negative and significant coefficient for the gas expenditure variable implies that an increase in gas price is related to auto insurance premium. The coefficients for year dummy variables and intercept in Model 1 imply that the aggregate nation-wide effect during the sample period from 2007 to 2012 explains about 7.5 percent of auto premium density decreases.²⁴

The personal vehicle expenditure variable is introduced in Model 2. Contrary to our expectations, the marginal effect vehicle expenditure variable is insignificant, meaning that the proportional change in

²⁴ $0.925 \approx e^{0.001-0.003+0.027+0.017+0.020-0.028 \times 5}$

personal spending on vehicles does not marginally contribute in explaining the proportional change in current year's auto insurance premiums. Insignificant vehicle expenditure variable again highlights the importance of auto loan to figure out how insurance consumption is affected in the aftermath of the crisis. Model 3 includes the recession indicators: real personal income and real GDP per capita. Only the latter is statistically significant at 5 percent level. The coefficient implies that a 10 percent decrease in real per-capita GDP is associated with 1 percent reduction of current private auto premium density, which is quantitatively equivalent to the effect of auto loan. Notably, auto loan variable is mostly unaffected by including these recession indicators.

Model 4 further includes the overall personal expenditure to control for the effects of belt-tightening during the recession. The positive and weakly significant coefficient implies that belt-tightening during the general recession was another reason for the decline in auto insurance premiums. The size of the effect is quantitatively similar to that of auto loan and real GDP per capita.

The coefficient of year dummies and the intercept used in Model 1 are changed in Model 4, but the five-year aggregate nationwide loss is mostly unchanged, in that the aggregate effect given by Model 4 remains at 8.1 percent. Thus, a large portion of the decline in premiums over the sample period remains unexplained, while insurance price, credit tightening, recession and belt-tightening are all marginally important. Overall, the considerable decline in premiums is consistent with the change in individual behavior of policy purchases after the U.S. subprime mortgage crisis as reported by the NAIC surveys.

B. One Year Lagged Exposure Variables

The previous analyses assume an immediate reaction of auto insurance premiums to changes in auto loan debt and house prices. However, there may be a time lag between these variables. To allow for a potential time lag in the reaction of insurance purchases, we introduce one-year lagged variables for auto loan, house price, expenditure variables and recession indicators.

The results summarized in Table 4 in which the one-year lagged variables are indicated by “(-1)” in the end of the variable names. Note that the sample period is reduced by one year due to the introduction of lagged variables: The earliest year in the sample is 2007 (change from 2006 to 2007) for one-year lagged explanatory variables and 2008 (change from 2007 to 2008) for auto premium density to be estimated. Although the loss of sample period does not allow us to directly compare the results with those in Table 3, the larger adjusted R-squared statistics reported in Table 4 indicate a better fit for models with lagged variables.

Again, results are supportive of the marginal effect of auto loan. The two coefficients for auto loan variables in Model 1 imply that a 10 percent decrease of auto loan debt in two consecutive years implies a 1.4 percent decrease in current private auto premium density. Estimation results also show several notable differences from the models reported in Table 3. First, auto insurance is found to react to change in house prices with one year lag. The highly significant and positive coefficient implies that a 10 percent decline in house prices in the previous year corresponds to an 1 percent decline in premium density. The impact is economically significant because real house price index went even below 50 for severely suffered states. Note that this marginal effect cannot be explained by the wealth effect through credit channel and hence potentially indicates the presence of other channels through which a shock on house prices pick the effect of credit crunch individual auto insurance consumption. One potential explanation is that the house price variable might complement the auto loan variable because the auto loan variable may underestimate the actual effect of reduced auto loan on premium volume in this model specification. The reason is that credit rationing causes a decline in the proportion of subprime auto loans, which are related to relatively high premiums due to low credit score. Therefore, the actual effect of change in auto loan could be larger due to loss of subprime loans than the effect estimated by the auto loan variable.

Second, recession effect and belt-tightening effect are not observed in this specification. Lastly, the introduction of lagged variables substantially reduces the 5-year aggregate decline in auto insurance

premiums captured through both the year dummies and the intercept. The aggregate nation-wide effect is approximately 2 percent change of premium density. This reduction may be partially attributable to the house price effect.

C. Feasible Generalized Least Squares

For the sake of the robustness of our results, we repeat all regressions with a feasible generalized least squares (FGLS) model with AR(1) in controlling for serial correlation instead of assuming state fixed-effects. This approach has been often used in the insurance literature (e.g. Lamm-Tennant and Weiss, 1997; Chen Wong and Lee, 1999). Estimated parameters are summarized in Table 5. When using FGLS regressions with an AR(1) autocorrelation within panels and panel heteroskedasticity correction, we obtain stronger support for our conjecture that auto insurance density reacts to crisis associated factors: auto loans and house prices, though only their one-year lagged variables are associated with premium density in this specification. Coefficients of estimated variables are qualitatively similar to those obtained by fixed-effect models and more statistically significant than fixed-effects models. Again, the result highlights that both auto loans and house prices are considered important factors to explain a decline of insurance consumption. One major difference from results for fixed-effect models is that one-year lagged personal vehicle expenditure is shown to be related to auto premium density at 1 percent level and that the size of the coefficients is similar to that of auto loan.

D. Level of Auto Insurance Density

As another robustness check, we replace the first difference of the log of private auto insurance density with the level and estimate the following linear model:

$$\begin{aligned} \log(\text{AutoPrem})_{it} = & \alpha + \alpha_i + \alpha_t + \beta_1 \log(\text{InsPrice})_{it} + \beta_2 \log(\text{Competition})_{it} \\ & + \beta_3 \log(\text{VehicleExp})_{it} + \beta_4 \log(\text{AutoLoan})_{it} + \beta_5 \log(\text{House Price})_{it} \end{aligned}$$

$$+\theta \log(X)_{it} + \varepsilon_{it}, \quad (2)$$

where the differences from Equation 1 is that all of the variables are level and that personal expenditure variable is not included because of multicollinearity.

Estimation results summarized in Table 6 are largely consistent with the results for the first difference models. Model 1 shows that the insurance price variable and the auto loan variable are both significant at 1 percent level. Their coefficients imply that a 10 percent decrease of insurance price and auto loan debt reduces current private auto premium density by 2.6 percent and 3 percent, respectively. In Model 2, the house price variable is included. The variable is weakly significant but becomes insignificant at 10 percent level when controls are included. Model 3, which further includes vehicle expenditure, indicates that overall vehicle expenditure have a marginal effect on auto insurance purchases, although the marginal effect is smaller than auto loan.

Model 4 confirms that insurance price, auto loan, spending on vehicle and transportation expenditure are related to auto insurance density. The marginal effect of auto loan on auto insurance purchase remains to be 2.2 percent for a 10 percent change of auto loan debt. The significant and large coefficient for the auto loan variable and insignificance for the house price variable may suggest that the effect of auto loan including the wealth effect is sufficiently estimated through the auto loan variable in this model specification. The insignificance of the recession indicators in Model 4 rejects the argument that auto insurance purchases were reduced with general business cycle. Another notable result from this level models is that the loss of auto insurance density in 2007-2010 is largely explained by how much individuals spent on vehicles, while a large portion of the prolonged trend in 2011-2012 remains to be unexplained.

The level model is also estimated by the feasible generalized least squares with AR(1). Again, we obtain stronger support for our conjecture that auto insurance density is associated with auto loan, though the results are not reported.

4.3. Loss Ratios and Expense Ratio

Regression analyses show that crisis related factors, auto loan and house prices, are positively related to private auto insurance consumption during and after the subprime crisis even after controlling for insurance price. Therefore, our results suggest that a decline of auto loan debt and house prices reduces demand for coverage, but do not reject the possibility that those factors are related to premium volume through pricing. Especially, the link between house price and private auto insurance density may be also channeled through the effect on pricing.

To investigate the possibility, we test whether those crisis related factors are systematically related to loss ratios and expense ratio, because if those factors are related to premium volume only through coverage, they should not systematically related to loss ratios and expense ratio. Particularly, we consider 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 estimate the first difference of the log of those ratios with the first difference of the log of explanatory variables used in the previous analyses.

Estimation results reported in Table 7 are consistent for loss ratio (left), LLAE ratio and combined ratio (right). The insignificance of the coefficients for auto loan variable suggests that a change in auto loan debt is not associated with a change in premium rate, implying that the credit crisis reduces private auto insurance consumption because purchase of coverage is reduced. In contrast, the one-year lagged house price variable is significantly related both the loss ratios and the expense ratio. The negative and significant coefficients for the loss ratio models imply that a shock on house prices is related to worse underwriting performance with one year lag. Little difference of the coefficients between the loss ratio model and the LLAE ratio model indicates that the impact on loss adjustment expenses is trivial. The coefficient of the house price variable for the loss ratio model, -0.426, implies that a 10 percent decrease of house prices in the previous year corresponds to a 4 percent increase in current private auto loss ratio. This result is not sufficient to conclude that a shock on house prices is related to a decline of premium rate because increased claim payments may fully explain the identified relationship. Yet, it still leave the

possibility that a shock on house prices causes an increase of loss ratio due to a decline of premium rate. Similarly, the positive and significant coefficient of house price variable for the expense ratio model may be attributable not to reduced premium volume but to a decline of underwriting expenses after the crisis, but it cannot reject the effect of house prices on premium rate.

5. Conclusion

It is well accepted that the total credit supplied from lending institutions generally falls after a banking crisis due to the credit crunch and the decline in demand for investment and consumption. Previous experiences of long-term reductions in non-life insurance consumption after banking crises also show the adverse effect on insurance purchases. However, very little attention has been paid to investigating the ways that credit crunches and insurance purchases are related.

Using cross-state panel auto insurance premium data from during and after the U.S subprime mortgage crisis triggered by a collapse of home prices, we conduct a state-level investigation of how a sharp drop in house prices followed by a contraction in auto loans were associated with declines in auto insurance purchases. Bivariate relationships show that the states that suffered most severely from the credit crunch tended to experience large reductions in personal spending on both vehicles and auto insurance premiums. We confirm that auto loan debt helps to explain the decline in auto insurance premiums, even after controlling for insurance prices, personal spending on vehicles and general consumption, recession indicators and other associated variables. Thus, our tests support the link between the banking crisis and declines in the purchase of insurance coverage as mediated by the credit crunch. Our data also support the theory that a belt-tightening effect due to recession-caused cuts to overall personal expenditure determined the decline in auto insurance purchases.

Another notable set of findings from our tests is the robust positive relationship between house prices and auto insurance purchases during the period even after controlling for auto loan. One potential

explanation is that the house price variable might reflect further loss of premium due to a decline in auto loans with low credit score relating to higher insurance premium. The relatively large marginal wealth effect would also reflect the presence of channels through which a shock on wealth affects the purchase of insurance coverage. Further analyses find some indications that a shock on house prices is also associated with a worse underwriting performance, potentially suggesting the effect on pricing, although the mechanism for this association is not explored due to data restriction. Investigation of this relationship 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 approach may be particularly helpful for analysis of the U.S. market, due to the large size of its commercial insurance sector. Second, the banking crisis effect could be directly investigated by using household panel data. Household-level data would allow us to investigate how a shock on wealth including income, financial assets and real estate affects risk aversion.

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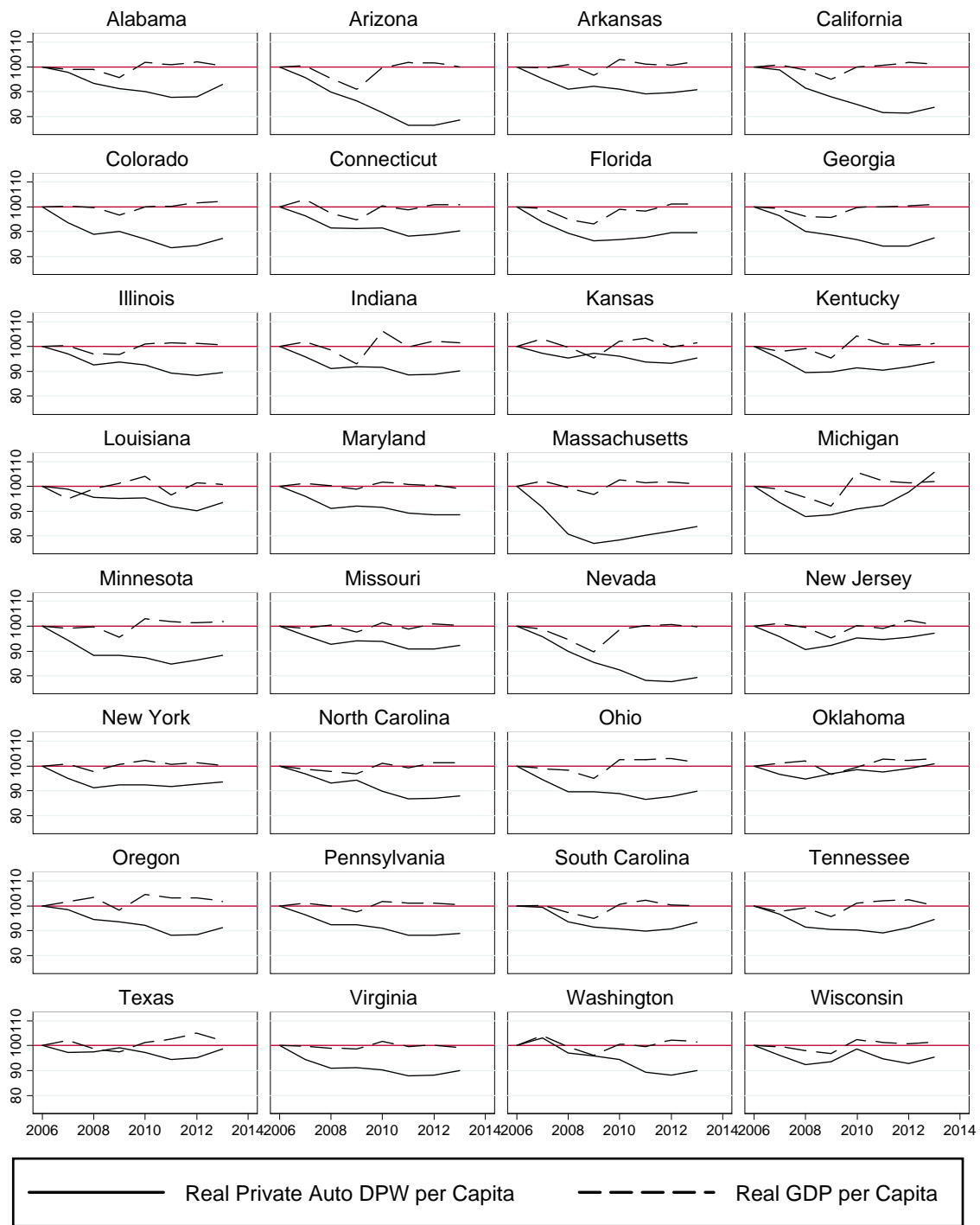


Figure 1 Real Private Auto Direct Premiums Written per Capita and Real GDP per Capita in the Largest 20 Private Auto Insurance Markets (100 in 2006)

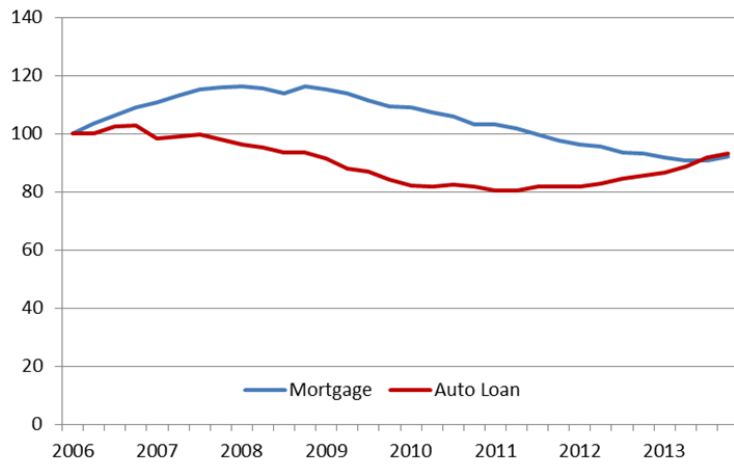


Figure 2: The US Mortgage and Auto Loan Debt per Capita (100 in 2006 Q1)

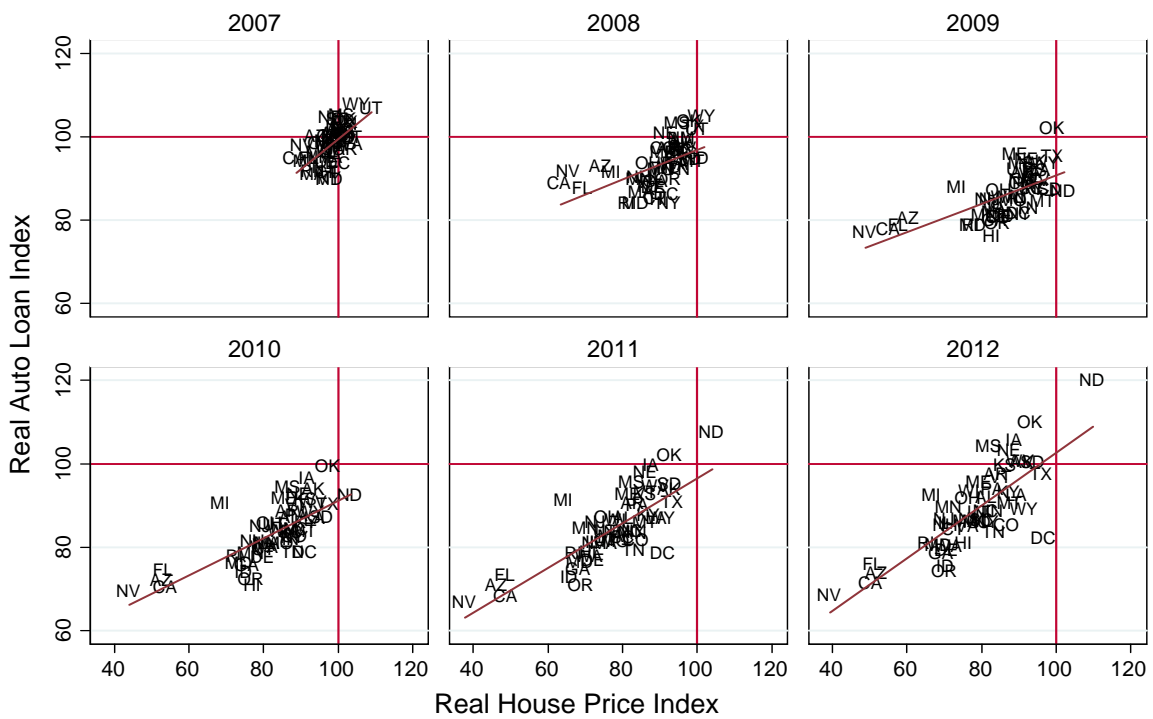


Figure 3 Real House Price Index vs. Real Auto Loans (Both Indexes=100 in 2006)

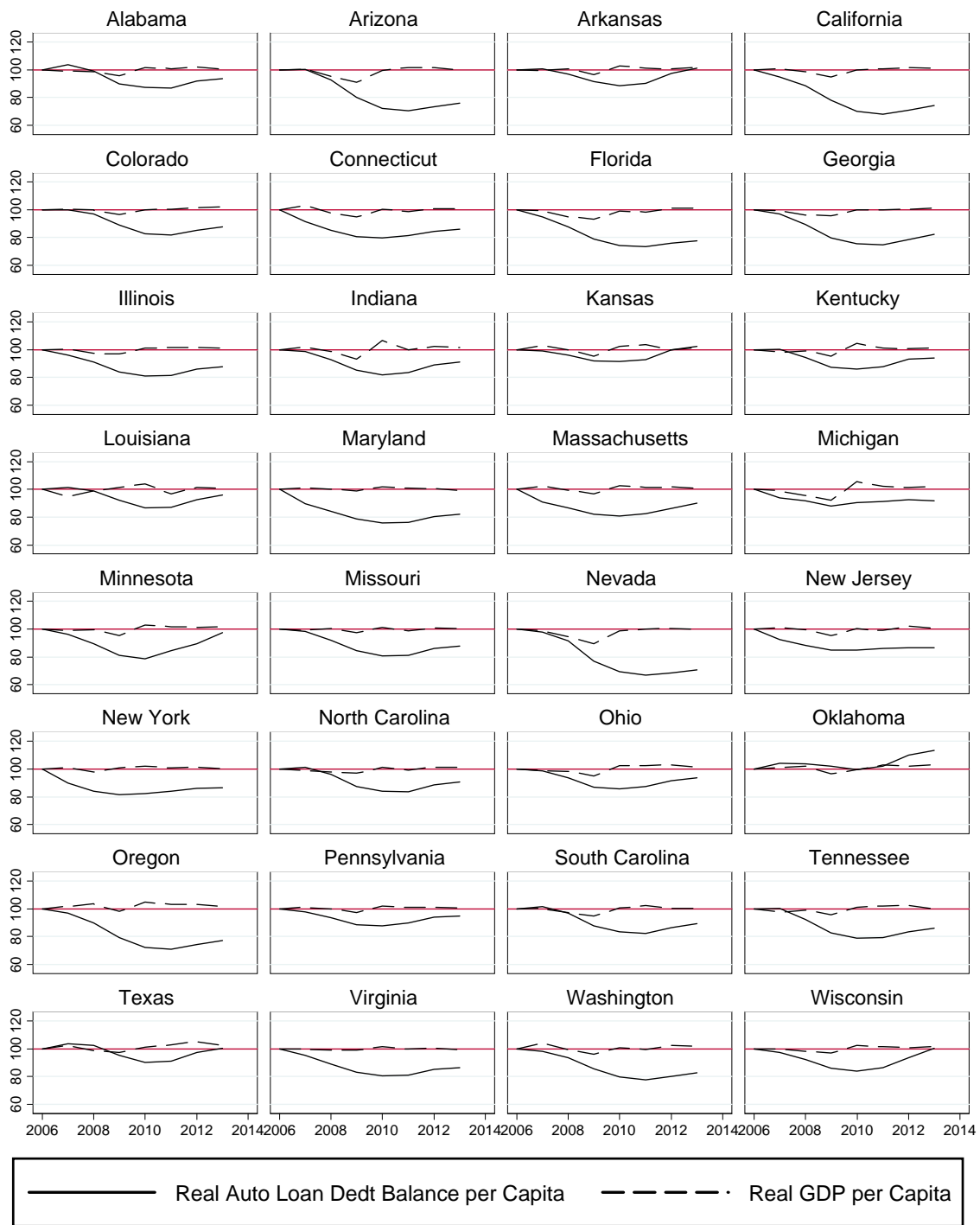


Figure 4 Real Auto Loan Debt Balance per Capita vs. Real GDP per Capita (Both Indexes=100 in 2006)

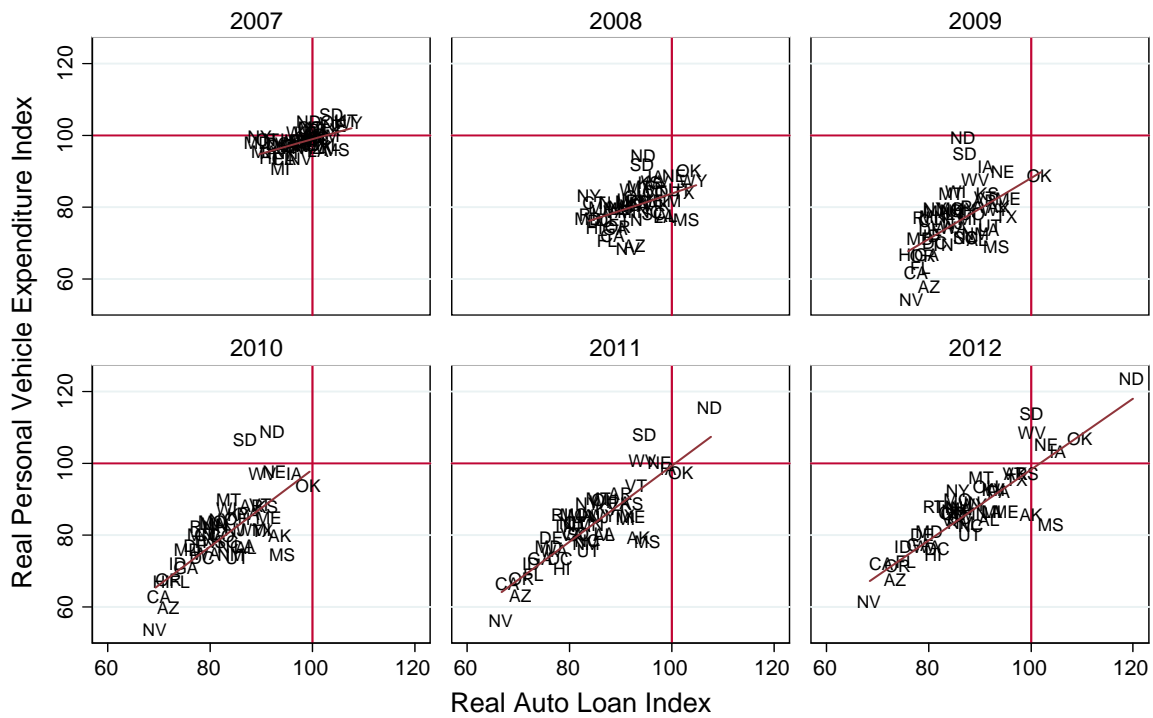


Figure 5 Real Auto Loans vs. Real Personal Vehicle Expenditure

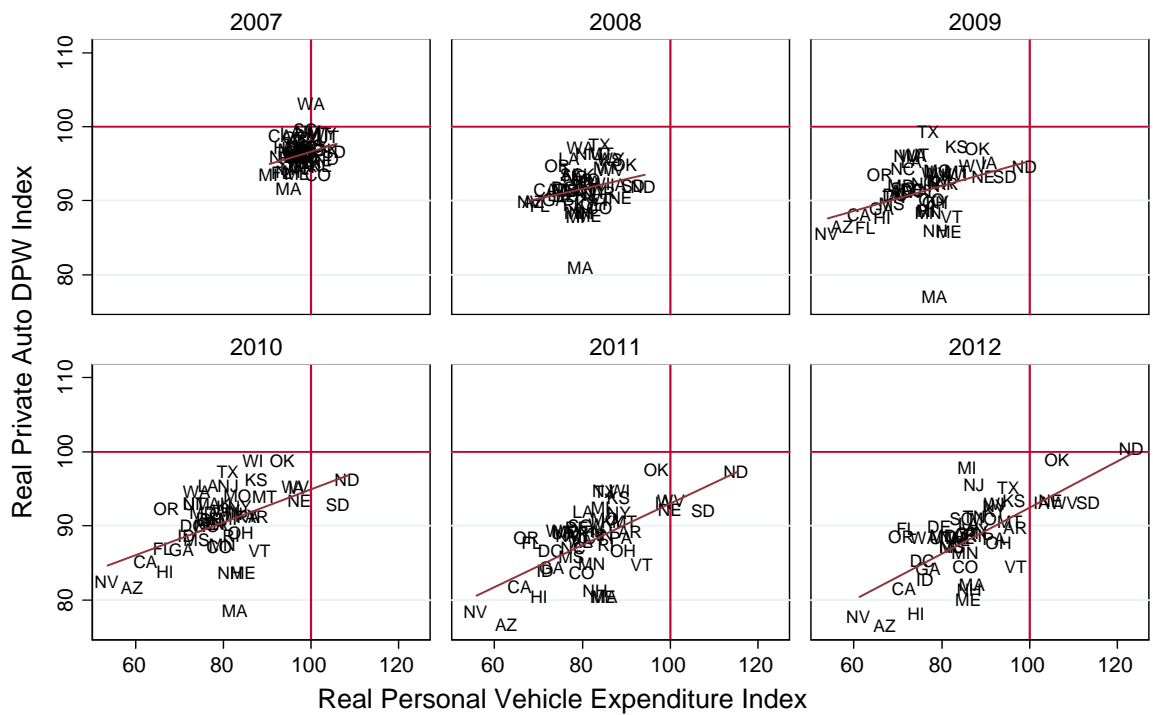


Figure 6 Real Personal Vehicle Expenditure vs. Real Private Auto DPW

Table 1 Definition of Variables

Variable	Definition	Source
Auto Premium	Real private auto insurance direct premium written per capita in 2006 \$	NAIC annual statements
Insurance Price	The inverse of the 5-year average combined ratio from year t-6 to year t-1	NAIC annual statements
Market Competition	The Herfindahl index of private auto insurance premiums by insurers	NAIC annual statements
Auto Loan	Real auto loan debt balance per capita in 2006 \$	FRBNY
Vehicle Expenditure	Per-capita real personal motor vehicle expenditure in 2006 \$	EBA
Personal Income	Per-capita real personal income in 2006 \$	EBA
GDP per capita	Per-capita real gross domestic product in 2006 \$	EBA
Personal Expenditure	Per-capita real personal expenditure in 2006 \$	EBA
Gas Expenditure	Per-capita real personal expenditure on gasoline and other energy goods in 2006 \$	EBA
Transportation Exp.	Per-capita real personal expenditure on transportation services in 2006 \$	EBA
House Price Index	Annual real house price index calculated by Quarterly Purchase-Only Indexes reported at Federal Housing Finance Agency	Federal Housing Finance Agency
Loss Ratio	Direct losses incurred as a percent of direct premiums earned	NAIC annual statements
LLAE Ratio	Direct losses incurred plus direct defense and cost containment expense incurred as a percent of direct premiums earned	NAIC annual statements
Expense Ratio	Commissions and brokerage expenses plus taxes, licenses and fees as a percent of direct premiums written	NAIC annual statements
Combined Ratio	Direct loss and loss adjustment expense ratio plus direct expense ratio	NAIC annual statements
Δ Variable	$\ln(\text{Variable}_{it}) - \ln(\text{Variable}_{i,t-1})$	

Table 2 Summary Statistics

Panel A	Mean	Median	Std. Div.	Minimum	Maximum
Auto Premium	490	479	72.9	370	693
Insurance Price	127	127	8.40	90.1	152
Market Competition	6.83	6.53	2.03	2.70	14.7
Auto Loan	2,892	2,829	518	1,918	4,609
Vehicle Expenditure	1,148	1,120	214	665	1,895
Personal Expenditure	30,924	30,171	4,873	23,769	52,266
Personal Income	39,888	39,183	5,755	28,416	66,686
GDP per capita	49,249	45,803	19,352	30,988	177,934
House Price Index	86.0	88.9	12.8	37.7	109.9
Gas Expenditure	1,288	1,182	451	625	3,472
Transportation Exp.	851	794	267	333	1,583
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 Model - Estimation Results

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. Variables of our primary interest are Auto Loan defined by real auto loan debt balance per capita and House Price defined by annual real house price index. Results shown are from fixed effects regressions by income groups. All models include intercept, country fixed-effects, 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)	
	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat
ΔInsurance Price	0.420 ***	4.49	0.432 ***	4.54	0.429 ***	4.61	0.431 ***	4.62
ΔMarket Competition	-0.094 **	-2.24	-0.088 *	-1.99	-0.087 *	-1.98	-0.086 *	-1.98
ΔAuto Loan	0.093 **	2.23	0.101 **	2.53	0.100 **	2.56	0.095 **	2.42
ΔHouse Price	0.037	1.29	0.054 *	1.80	0.051 *	1.79	0.049 *	1.74
ΔVehicle Expenditure			-0.061	-1.43	-0.078 *	-1.75	-0.083 *	-1.87
ΔPersonal Income					0.018	0.29	-0.008	-0.13
ΔGDP per capita					0.103 **	2.29	0.099 **	2.22
ΔPersonal Expenditure							0.100 *	1.75
ΔGas Expenditure	-0.075 **	-2.10	-0.064 **	-1.91	-0.068 **	-2.14	-0.073 **	-2.29
ΔTransportation Exp.	-0.033	-0.92	-0.008	-0.23	-0.021	-0.58	-0.027	-0.77
Year 2008	0.001	0.35	-0.008	-0.97	-0.010	-1.19	-0.008	-1.03
Year 2009	-0.003	-0.20	0.000	0.01	0.002	0.12	0.000	0.03
Year 2010	0.027 ***	4.55	0.030 ***	4.66	0.031 ***	4.98	0.031 ***	5.04
Year 2011	0.017 **	2.55	0.019 **	2.67	0.019 ***	2.79	0.021 ***	2.98
Year 2012	0.020 ***	4.45	0.023 ***	4.81	0.024 ***	4.99	0.024 ***	5.14
Intercept	-0.028 ***	-10.3	-0.029 ***	-11.0	-0.030 ***	-12.0	-0.031 ***	-12.1
State Fixed-effects	Yes		Yes		Yes		Yes	
Observations	294		294		294		294	
Adjusted R ²	0.75		0.75		0.76		0.76	

Table 4: First Difference Model with Lagged Variables

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. Variables of our primary interest are Auto Loan defined by real auto loan debt balance per capita and House Price defined by annual real house price index. Results shown are from fixed effects regressions by income groups. All models include intercept, country fixed-effects, 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)	
	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat
Δ Insurance Price	0.431 ***	4.91	0.431 ***	4.52	0.426 ***	4.72	0.428 ***	4.69
Δ Market Competition	-0.029	-0.73	-0.024	-0.59	-0.028	-0.69	-0.026	-0.67
Δ Auto Loan	0.071 **	2.18	0.073 **	2.24	0.073 **	2.23	0.068 *	1.95
Δ Auto Loan (-1)	0.071 *	1.97	0.061	1.67	0.060	1.67	0.059	1.66
Δ House Price	-0.024	-0.99	-0.019	-0.78	-0.025	-1.12	-0.024	-1.05
Δ House Price (-1)	0.106 ***	3.83	0.101 ***	3.19	0.100 ***	3.11	0.100 ***	3.16
Δ Vehicle Expenditure			-0.024	-0.63	-0.042	-1.06	-0.038	-0.96
Δ Vehicle Expenditure (-1)			0.017	0.47	0.031	0.80	0.024	0.66
Δ Personal Income					0.084	1.57	0.073	1.07
Δ Personal Income (-1)					0.078 **	2.60	0.053	1.33
Δ GDP per capita					0.039	0.71	0.031	0.57
Δ GDP per capita (-1)					-0.065	-1.34	-0.067	-1.36
Δ Personal Expenditure							0.016	0.21
Δ Personal Expenditure (-1)							0.072	0.86
Δ Gas Expenditure	-0.070 **	-2.10	-0.066 **	-2.12	-0.071 **	-2.32	-0.071 **	-2.30
Δ Transportation Exp.	-0.019	-0.58	-0.012	-0.37	-0.031	-0.96	-0.031	-0.99
Year 2009	0.010	0.77	0.018	1.25	0.024 *	1.77	0.023	1.67
Year 2010	0.035 ***	7.60	0.040 ***	4.59	0.047 ***	5.13	0.046 ***	5.04
Year 2011	0.022 ***	3.76	0.025 **	2.22	0.028 **	2.48	0.028 **	2.43
Year 2012	0.030 ***	7.30	0.035 ***	4.00	0.037 ***	4.22	0.037 ***	4.42
Intercept	-0.030 ***	-10.3	-0.035 ***	-5.77	-0.039 ***	-6.39	-0.039 ***	-6.75
State Fixed-effects	Yes		Yes		Yes		Yes	
Observations	245		245		245		245	
Adjusted R ²	0.83		0.83		0.83		0.83	

Table 5: First Difference Model - Feasible Generalized Least Squares

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. Variables of our primary interest are Auto Loan defined by real auto loan debt balance per capita and House Price defined by annual real house price index. Results shown are from fGLS regressions by income groups. All models include intercept, and year dummy variables (not reported). AR(1) is assumed for serial correlation. ***, **, 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)	
	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat
ΔInsurance Price	0.413 ***	13.49	0.386 ***	12.44	0.376 ***	11.96	0.380 ***	12.43
ΔMarket Competition	-0.037 *	-1.66	-0.031	-1.39	-0.032	-1.43	-0.033	-1.51
ΔAuto Loan	0.062 **	2.47	0.043	1.61	0.043	1.56	0.039	1.36
ΔAuto Loan (-1)	0.071 ***	3.62	0.064 ***	3.06	0.056 ***	2.62	0.052 **	2.33
ΔHouse Price	0.001	0.09	-0.005	-0.43	-0.010	-0.76	-0.010	-0.73
ΔHouse Price (t-1)	0.077 ***	6.66	0.069 ***	5.20	0.066 ***	4.72	0.066 ***	4.84
ΔVehicle Expenditure			0.010	0.50	0.004	0.19	0.003	0.17
ΔVehicle Expenditure (-1)			0.050 ***	2.66	0.062 ***	3.12	0.062 ***	3.10
ΔPersonal Income					0.052	1.42	0.063	1.51
ΔPersonal Income (-1)					0.013	0.35	0.014	0.33
ΔGDP per capita					0.034	1.11	0.036	1.19
ΔGDP per capita (-1)					-0.040	-1.35	-0.040	-1.38
ΔPersonal Expenditure							-0.027	-0.40
ΔPersonal Expenditure (-1)							0.002	0.04
ΔGas Expenditure	-0.035 **	-2.10	-0.035 **	-2.25	-0.035 **	-2.18	-0.031 *	-1.88
ΔTransportation Exp.	-0.008	-0.29	-0.015	-0.52	-0.028	-0.90	-0.027	-0.84
Year 2009	0.022 ***	3.12	0.030 ***	3.55	0.034 ***	3.95	0.035 ***	4.02
Year 2010	0.030 ***	10.93	0.031 ***	6.12	0.031 ***	5.45	0.032 ***	5.45
Year 2011	0.015 ***	5.21	0.012 **	2.45	0.011 **	2.20	0.012 **	2.34
Year 2012	0.027 ***	7.30	0.026 ***	4.58	0.026 ***	4.59	0.028 ***	4.75
Intercept	-0.030 ***	-11.7	-0.031 ***	-7.16	-0.032 ***	-6.89	-0.033 ***	-7.05
State Fixed-effects	Yes		Yes		Yes		Yes	
Observations	245		245		245		245	
AR(1)	0.43		0.37		0.36		0.35	
Wald chi-2 test (p-value)	0.00		0.00		0.00		0.00	

Table 6: Level of Private Auto Premium Density

The dependent variable is the level of the log of private auto insurance direct premium written. Explanatory variables are also the log of variables. Variables of our primary interest are Auto Loan defined by real auto loan debt balance per capita and House Price defined by annual real house price index. Results shown are from fixed effects regressions by income groups. All models include intercept, country fixed-effects, 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)	
	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat
Insurance Price	0.267 ***	3.55	0.251 ***	3.17	0.194 **	2.43	0.192 ***	2.35
Market Competition	-0.019	-0.30	-0.020	-0.32	-0.043	-0.66	-0.042	-0.65
Auto Loan	0.313 ***	4.79	0.270 ***	4.12	0.224 ***	3.27	0.223 ***	3.23
House Price			0.066 *	1.82	0.031	0.86	0.030	0.83
Vehicle Expenditure					0.176 **	2.56	0.172 **	2.40
Personal Income							-0.034	-0.36
GDP per capita							0.052	0.55
Gas Expenditure	0.049	0.80	0.024	0.39	-0.010	-0.18	-0.011	-0.20
Transportation Exp.	-0.122	-1.44	-0.155 *	-1.89	-0.248 ***	-3.34	-0.248 ***	-3.32
Year 2008	-0.036 ***	-5.04	-0.032 ***	-4.47	-0.004	-0.41	-0.005	-0.42
Year 2009	-0.014	-0.82	-0.020	-1.20	-0.004	-0.20	-0.004	-0.20
Year 2010	-0.024 *	-1.70	-0.026 *	-1.84	-0.017	-1.21	-0.018	-1.14
Year 2011	-0.061 ***	-4.09	-0.053 ***	-3.62	-0.045 ***	-3.34	-0.045 ***	-3.03
Year 2012	-0.077 ***	-5.59	-0.068 ***	-4.90	-0.066 ***	-5.12	-0.066 ***	-4.43
Intercept	2.935 ***	4.8	3.472 ***	5.3	3.925 ***	6.1	3.772 ***	3.2
State Fixed-effects	Yes		Yes		Yes		Yes	
Observations	294		294		294		294	
Adjusted R ²	0.98		0.98		0.98		0.98	

Table 7: Model for Loss Ratios and Expense Ratio

The dependent variable is the first difference of the log of loss ratios and expense ratio. Explanatory variables are also the first difference of the log of variables. Variables of our primary interest are Auto Loan defined by real auto loan debt balance per capita and House Price defined by annual real house price index. Results shown are from fixed effects regressions by income groups. All models include intercept, country fixed-effects, 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	Loss Ratio		LLAE Ratio		Expense Ratio		Combined Ratio	
	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat
ΔInsurance Price	0.719 **	2.29	0.739 **	2.43	0.006	0.05	0.634 ***	2.54
ΔMarket Competition	-0.190	-0.74	-0.217	-0.85	0.013	0.22	-0.179	-0.84
ΔAuto Loan	-0.109	-0.49	-0.115	-0.55	0.106	1.06	-0.081	-0.47
ΔAuto Loan (-1)	-0.149	-0.77	-0.117	-0.60	-0.033	-0.47	-0.101	-0.61
ΔHouse Price	-0.102	-0.73	-0.118	-0.86	-0.042	-0.80	-0.109	-0.98
ΔHouse Price (-1)	-0.426 **	-2.67	-0.428 ***	-2.71	0.156 *	2.01	-0.339 **	-2.56
ΔVehicle Expenditure	0.211	1.07	0.206	1.07	-0.097	-1.20	0.152	0.95
ΔVehicle Expenditure (-1)	-0.042	-0.18	-0.044	-0.18	0.005	0.06	-0.039	-0.20
ΔPersonal Income	0.055	0.10	0.120	0.22	0.182	1.35	0.121	0.26
ΔPersonal Income (-1)	-0.881 **	-2.68	-0.898 ***	-2.71	0.472 ***	3.73	-0.688 **	-2.44
ΔGDP per capita	-0.001	0.00	-0.003	-0.01	-0.011	-0.11	0.007	0.03
ΔGDP per capita (-1)	0.077	0.27	0.126	0.45	-0.153 *	-1.73	0.085	0.35
ΔPersonal Expenditure	0.788	1.28	0.757	1.19	-0.457 **	-2.35	0.589	1.08
ΔPersonal Expenditure (-1)	0.280	0.77	0.245	0.65	-0.792	-1.65	0.066	0.23
ΔGas Expenditure	-0.051	-0.25	0.010	0.04	0.118 **	2.05	0.018	0.10
ΔTransportation Exp.	0.440	1.57	0.408	1.49	0.102	1.49	0.374	1.61
Year 2009	-0.168	-1.38	-0.152	-1.24	0.043	1.49	-0.124	-1.21
Year 2010	-0.182 ***	-3.13	-0.190 ***	-3.28	0.001	0.05	-0.160 ***	-3.30
Year 2011	-0.111 **	-2.30	-0.123 **	-2.60	0.001	0.03	-0.103 **	-2.64
Year 2012	-0.173 ***	-3.16	-0.172 ***	-3.17	0.023	0.89	-0.142 ***	-3.08
Intercept	0.110 **	2.1	0.112 **	2.19	-0.017	-0.78	0.092 **	2.14
State Fixed-effects	Yes		Yes		Yes		Yes	
Observations	245		245		245		245	
Adjusted R ²	0.07		0.08		0.14		0.08	