The Impact of Rate Regulation on Claims Evidence from Massachusetts Automobile Insurance

Richard A. Derrig and Sharon Tennyson, Ph. D.

Abstract

Rate regulation has a long history in insurance markets. In many states an important goal of regulation is to reduce price variation across purchasers, and specifically to reduce price levels for high-risk purchasers. That feature of rate regulation leads to price cross-subsidies from low-risk purchasers to high-risk purchasers. Consumers who are charged higher prices in order to finance cross-subsidies to high-risks may be less likely to purchase insurance and to reduce participation in insured activities. These adverse selection effects will lead to a higher proportion of high-risk consumers and a higher proportion of insurance purchased by high-risks.[1] In addition, because cross-subsidies reduce the links between insurance risk and insurance prices, all consumers face reduced incentives for loss prevention and safety investments due to moral hazard.

The article tests the hypothesis that insurance price subsidies lead to higher insurance cost growth. To squarely focus on the impact of regulatory price subsidies rather than that of price regulation more generally, the paper makes use of data from the Massachusetts private passenger automobile insurance market. Cross-subsidies were explicitly built into the rate structure through rules that limit rate differentials and differences in rate increases across driver rating categories. Two approaches were taken to study the potential loss cost reaction to the Massachusetts cross-subsidies that began in systematic form in 1977 and continued through 2007. The first approach compared Massachusetts to all other states on demographic, regulatory and liability coverage levels. Loss cost levels that were 44 to 50 percent above the expected level were found for Massachusetts during the 1978-1995 periods when premiums charged were those fixed by the state and included explicit cross subsidies from low risk drivers to high risk drivers. A second approach considered changing cost levels across Massachusetts by studying loss cost changes by town and relating those changes to subsidy providers and subsidy receivers. Subsidy data for 1999-2007, with underlying accident year data for 1993-2004, showed a significant and positive (relative) growth in loss costs for towns that were subsidy receivers in line with the theory of underlying incentives for adverse selection and moral hazard.

Keywords: Auto Insurance, Subsidies, Adverse Selection, Moral Hazard

1. INTRODUCTION

Rate regulation has a long history in insurance markets. In the United States, regulation arose due to concerns about monopoly pricing if insurers were allowed to pool information for rating purposes, coupled with concerns about price instability and insolvencies if they were not. With the growth of large national insurers and advances in information technology, such concerns have eased and insurance markets are widely considered to be workably competitive. Large numbers of firms operate in most markets and rates of return are within competitive norms. As a consequence, price regulation has become confined to selected markets and state approaches vary significantly.

Rate regulation is most commonly employed in health insurance, automobile insurance, and workers compensation insurance, markets in which insurance is mandatory or universal insurance coverage is thought to be desirable. In many states an important goal of regulation is to reduce price variation across purchasers, and specifically to reduce price levels for high-risk purchasers. For example, some state rate regulations place limits on risk classes, restrict price differences across consumers, and restrict insurers' ability to deny coverage to high-risk purchasers to achieve these goals. These features of rate regulation lead to price cross-subsidies from low-risk purchasers to high-risk purchasers.

Although consumers who receive subsidies should be more likely to purchase insurance, thereby promoting one goal of rate regulation, price cross-subsidies may have many unintended consequences in insurance markets. For example, consumers who are charged higher prices in order to finance cross-subsidies to high-risks may be less likely to purchase insurance and to reduce participation in insured activities. These adverse selection effects will lead to a higher proportion of high-risk consumers and a higher proportion of insurance purchased by high-risks.[2] In addition, because cross-subsidies reduce the links between insurance risk and insurance prices, all consumers face reduced incentives for loss prevention and safety investments due to moral hazard (Shavell, 1982).

These combined adverse selection and moral hazard effects of insurance price cross-subsidies lead to efficiency losses in the insurance market, and will lead inevitably to higher insured losses and thus to higher insurance prices in the long run. This article explores the economic importance of this hidden cost of insurance rate-leveling.

The article tests the hypothesis that insurance price subsidies lead to higher insurance cost growth. To squarely focus on the impact of regulatory price subsidies rather than that of price regulation more generally, the paper makes use of data from the Massachusetts private passenger automobile insurance market, a state with unique regulatory characteristics. During the period of study, insurance prices in this market were determined annually through a state hearing process, and the state-determined rate grid formed the basis for pricing by all insurers in the state. Cross-subsidies were explicitly built into the rate structure through rules that limit rate differentials and differences in rate increases across driver rating categories. Market forces that might work to undermine intended

[2] Harrington and Doerpinghaus (1993) provide a useful exposition of these ideas.

cross-subsidies – including the definitions of driver rate classes and the underwriting criteria used by insurers – are also highly regulated by the Commonwealth. Price subsidies to high risk drivers are thus a hallmark of the Massachusetts regulatory system since 1978, providing an ideal venue for the study. Table 1 lists the timeline of major developments in the regulatory environment in the Massachusetts private passenger auto insurance market.[3]

Table 1
Major Regulatory Changes, 1970-2007
Massachusetts Private Passenger Automobile Insurance

Year	Regulation
1971	No-fault auto insurance effective
1975	State rate-setting extended to all auto coverages
1977	Competitive rate-setting allowed
1978	State rate-setting reinstituted
1989	Automobile Insurance Reform Law effective
1991	Insurance Fraud Bureau began operation
1996	Competitive Discounts and Deviations begin at -7.4%
2006	Competitive Discounts and Deviations stabilize at -1.7%
2007	Competitive rate-setting allowed 4/1/08

We conduct two distinct sets of analysis to present evidence on the relationship between price subsidies and insurance cost growth. In the first analysis, annual state-level data on loss costs per insured car for Massachusetts are compared to those in other states during the time period 1972-1998. This analysis uses variation in Massachusetts' regulations over time to demonstrate that cross-subsidies lead to unusually high loss costs in the state. The empirical results show that loss costs are significantly higher in Massachusetts after the cross-subsidy system is introduced (in 1978) but not before; and that the Massachusetts cost differential decreases during the 1990s after the state passed an insurance reform law (1989) and established an insurance fraud bureau (1991).[4] These reforms led to lower loss costs and induced insurers to offer some drivers premiums below those set by the state, reducing effective cross-subsidies. Table 2 reports the average annual percentage discounts offered by insurers, subject to prior approval, beginning in 1996.

[3] State set Massachusetts PPA insurance rates are expected to come to an end after 30 years as of April 1, 2008, to be replaced by a form of managed competition (Burnes, 2007).
[4] See Weisberg and Derrig (1992) for the effects of the tort reform, Derrig (1997) for the effects of the auto property reform, and Derrig, et al. (2006) for the more recent effects of the Insurance Fraud Bureau.

Table 2
Massachusetts Private Passenger Automobile
Historical Summary of Industry Discounts/Deviations

Year	Average Discount		Annual Change in Discount
1996	-7.4%		
1997	-9.2%		-1.8%
1998	-9.2%		+0.0%
1999	-6.5%		+2.7%
2000	-5.5%		+1.0%
2001	-3.0%		+2.5%
2002	-2.2%		+0.8%
2003	-1.9%		+0.3%
2004	-1.7%		+0.2%
2005	-1.8%		-0.1%
2006	-1.7%		+0.1%
2007	-1.7%	est'd	+0.0%

Source: Automobile Insurers Bureau of Massachusetts

In order to test the hypothesis that price subsidies contribute to cost growth, we undertake a second analysis using data by Massachusetts towns for the time period 1999-2007. This analysis makes use of the variation in subsidies across towns to identify the effects of subsidies on loss cost growth. The empirical results show that loss cost growth is significantly higher among towns in which the average driver receives a premium subsidy.

Section 2 describes the regulated Massachusetts auto insurance system in more detail and documents the extent of price subsidies. Section 3 develops the theoretical arguments regarding incentive effects of regulation and discusses prior research on the impact of insurance regulation and premium subsidies. Section 4 presents our analysis of state-level average annual loss costs for the time period 1972-1998. Section 5 introduces the Massachusetts town level data and presents results of analysis of those data. The final section of the paper provides conclusions and discusses the implications of our findings.

2. MASSACHUSETTS AUTOMOBILE INSURANCE REGULATION

In Massachusetts, regulated automobile insurance rates are determined annually by the state insurance commissioner as the outcome of a public hearing process. The rates determined through the hearing process must be charged by all firms writing in the state – irrespective of differences in operating costs or loss experience – unless an insurer obtains approval from the insurance commissioner to charge lower rates.[5] Massachusetts is the only state that used this form of rate regulation for automobile insurance, until quite recently.[6]

Massachusetts has regulated automobile insurance rates since 1927, but the regulatory features of primary interest to this paper took shape in the late 1970s, after a brief experiment with a more competitive system in 1977. [7] In that year legislation introduced file-and-use rate regulation, which allowed insurers to set their own rates subject to light regulatory review. The new system led to dramatic increases in premiums and reduced insurance availability for some drivers, producing a record number of consumer complaints to the Division of Insurance (Stone, 1977). In response, the state returned to the state-made rates and new legislation and regulatory decisions imposed even further state controls over pricing.[8] The legislature ordered rebates on 1977 premiums for many policyholders, and passed legislation that prohibited premium surcharges to policyholders insured through the residual market facility. In determining the 1978 rates, the insurance commissioner rejected the use of age, gender and marital status as risk classification variables, and required all insurers to utilize the same classification variables (Stone, 1978).

The resulting regulations mandate a common set of rating territories and driver rating classes for all insurers. Rating territories are determined by town and the assignment of towns to territories is determined through a periodic hearing process. Only nine driver rating classes are allowed, with

---

[5]Historically, such deviations were not common; however, most insurers sought significant rate deviations for selected groups of drivers in 1996-2004 as shown in Table 2.

[6] This regulatory system has recently been overturned (see Burnes, 2007) and the state will employ a file-and-use regulation called "managed competition," effective April 2008. The recently adopted change of December 24, 2006, to the California DOI regulation on rating class differentials (10 CCRs2632.8, Factor Weights) provides for indirect subsidies for high-risk towns that will differ by insurer through the suppression of the true cost of location by lowering the "importance" of territory in the final rate differentials.

[7] See Derrig (1993), Yelen (1993), Rottenberg (1989), and Tennyson, Weiss, and Regan (2002) for more discussion of the history and process of Massachusetts regulation. Details on the current regulations are available at the Web site of the state of Massachusetts http://www.mass.gov/.

[8] The state still operates under the law that allows file-and-use regulation. State-set rates were reintroduced due to a provision in the law that allows the insurance commissioner to hold an annual hearing to determine whether competition

drivers classified only by driving experience, drivers' training, and use of car. Experienced drivers are defined as those with more than six years of driving experience. There are an additional six classes consisting of four types of inexperienced drivers, senior citizens, and business-use drivers. Age, gender, and marital status are specifically prohibited from use as rating variables (Mass GL c. 175E, s4(b)). The restrictions on rating classes produce a far coarser rate matrix than used in other states' automobile insurance markets, leading to cross-subsidies in rates across drivers.[9]

Additional cross-subsidies are built into the rates through a systematic leveling process known as *tempering* and *capping*. Tempering restricts the differences in average rate levels across the class-territory rating cells. Capping restricts the average annual increase in rates for any rating cell to be no more than a pre-specified percentage above the average statewide rate increase. Capping thus restricts the change in average rate levels over time for each rating category, reinforcing the cross-subsidies generated by tempering.

A final set of inter-class rate constraints is applied within each territory to assure that the lower risk classes do not pay more than a given percentage of the rate paid by higher risk classes. For example, traditionally the experienced driver rate is set at no greater than 95 percent of the lowest inexperienced driver rate; the business use rate is at least as great as the experienced driver rate, and so forth.[10] The application of these constraints introduces additional, sometimes substantial, cross-subsidies across drivers.[11]

This complex set of restrictions produces significant variation in premium charges relative to those based on costs alone. Some drivers receive substantial premium subsidies, with the remaining drivers paying relatively smaller premium increases. Table 3 summarizes the direction and extent of premium subsidies received and premium subsidies paid, using data for 2004.[12] The table reports the average premium, average subsidy (or surcharge) amount and the percent of class-territory rating

---

is feasible, and to impose state-set rates if it is not. In every year since 1978 competition has been found not to be viable and state-set rates have been imposed. File and use is expected to return for rates effective April 1, 2008 (Burnes, 2007).

[9] Finger, (2006), notes that the standard industry classification plan contains 217 driver classes.

[10] See Docket R98-42, AIB Filing on 1999 rates, August 1998.

[11] For 2007 Boston Compulsory Rates, the inter-class constraints generated half of the average subsidy of 17.6% (AIB, Actuarial Notice 07-1, p.2).

[12]The premiums paid by each individual driver vary from the class-territory average due to experience rating adjustments based on accident experience, the type of car driven, and other factors. Experience rating adjustments are applied through the revenue neutral Safe Driver Insurance Plan (SDIP), which allows for discounts and surcharges to bodily injury liability (BIL), property damage liability (PDL), and collision rates, based upon one's recent driving record. The state also allows premium discounts for anti-theft devices, airbags, low mileage, multiple cars, or use of public transit. These adjustments are applied as percentage changes to the premium, but are relatively modest. The state determines

cells that are subsidized for compulsory insurance coverage. Boston drivers and inexperienced drivers are those most likely to receive a subsidy, but some proportion of drivers in every rating cell receive a subsidy.[13]

Table 3
Direction of Subsidies by Driver Class and Territory Compulsory Insurance Coverage
2004

		Experienced Classes	Inexperienced Classes	Business Classes
Non-Boston Territories	**Average Premium**	$527.15	$1,220.54	$500.67
	Average Subsidy	-$26.00	$138.29	-$46.43
	Cells Subsidized (%)	12.50%	42.71%	6.25%
Boston Territories	**Average Premium**	$813.33	$1,434.04	$751.98
	Average Subsidy	$253.77	$520.09	$32.30
	Cells Subsidized (%)	64.65%	72.73%	36.36%

Source: Authors' calculations using data from Actuarial Notice 04-1, Automobile Insurers Bureau of Massachusetts, 2004. Compulsory coverages are Bodily Injury Liability (20/40), Personal Injury Protection (8,000), Property Damage Liability (5,000) and Uninsured Motorist (20/40)

Within Boston, 72.73% of inexperienced driver rating cells, 64.65% of experienced driver rating cells, and 36.36% of business cells receive a subsidy. Outside of Boston, 42.71% of inexperienced driver rating cells receive a subsidy. In contrast, only 12.5% of experience driver cells and 6.25% of business driver cells outside of Boston receive a subsidy. Both experienced and inexperienced Boston drivers receive substantial premium subsidies (averaging $253.77 and $520.09 respectively), while Boston business classes receive only a modest subsidy ($32.30).

experience rating adjustments and other adjustments, which are subject to prior approval regulation. Premium surcharges to drivers insured through the state's residual market facility are prohibited.

[13] The number of drivers receiving subsidies or paying surcharges differs from the number of insured vehicles in the rating cells, due to cross-subsidies across drivers within class-territory rating cells.

It is natural to ask how the state can sustain an auto insurance market under the regulations described here. Several additional regulations promote the continued supply of insurance in the market. Access to insurance for high-risk drivers is protected by restrictions on insurers' ability to refuse insurance or cancel a policy. There are also strong restrictions placed on insurers' rights to exit the automobile insurance market. An insurer wishing to withdraw from the market must receive regulatory approval and must pay substantial penalties in order to exit the market (Yelen, 1993). Finally, insurance demand is bolstered by a strong compulsory insurance law.

Nonetheless, previous studies have documented a number of distortions to the Massachusetts' market that arise due to regulation (Rottenberg, 1989; Derrig, 1993; Tennyson, 1997; Tennyson, Weiss, and Regan, 2002). Most notably, these studies have found that the supply side characteristics of the Massachusetts automobile insurance market differ from those in comparable state markets, with far fewer insurance providers[14] and fewer national insurers in the state. Residual market size is also greater in Massachusetts, providing another indicator of lack of insurance availability. And, movement toward lower cost distribution systems has been much slower there than in other automobile insurance markets.

3. PREMIUM SUBSIDIES AND DRIVER INCENTIVES

3.1 Economic Theory

If insurance premiums reflect the expected marginal costs of coverage, consumers have appropriate information on which to base their decisions about insurance purchase and also their decisions to purchase or drive a car or both (Harrington and Doerpinghaus, 1993). However, consumers who receive premium subsidies face less than the true expected marginal cost of their decisions with respect to insuring and driving decisions and will be more likely to own a car, to drive and to purchase more insurance. Consumers who pay premium overcharges will have the opposite response, tending to be less likely to drive and to purchase less insurance.

Drivers also make choices about the amounts and types of driving and other actions that are correlated with expected loss costs.[15] These choices will also be distorted by cross-subsidies. Simply put, the Massachusetts rate structure and the cross-subsidies built into the rates reduce the penalties

[14] A total of 19 insurers had (non-specialty) Massachusetts private passenger automobile insurance written premium in 2006.

[15] See Brockett and Golden, (2007), for a discussion of risky behavior by drivers and its relation to credit scores as a proxy measurement of that risk.

for risk-taking. The rate categories are few and will, of necessity, permit cross-subsidies of identifiable subgroups.[16] Policies cannot be cancelled based on loss or accident experience. Higher premium charges due to higher accident costs of any one driver will be partly shared by the driver under a Safe Driver Insurance Plan,[17] partly across all members of the class-territory rating cell, and partly by all subsidy-paying drivers in the remainder of the Commonwealth. Those subsidies will dampen individual incentives to reduce costs. Risky choices may move a driver into the residual market but at no premium differential. These regulatory restrictions will increase the risky choices of all drivers. As a result, average loss costs are predicted to be higher under the Massachusetts regulatory system than otherwise.

Perhaps as important, there may be an additional upward shift in *insured* claims and loss costs due to the greater incentives for claims filing introduced by the rate structure. Consumers consider the marginal costs and the marginal benefits when deciding whether to file a claim. The restrictions on policy cancellation, the relatively small premium penalties for high losses, and the tempering of rate increases across time imply that the future adverse consequences of filing a claim or of filing many claims are lessened. This will increase the propensity of consumers to file claims. The same arguments apply not only to legitimate claims, but also to fraudulent or exaggerated claims.[18] Under Massachusetts law insurers may cancel a policy due to fraud, but the fraud must be proven which may be costly and difficult. These forces underlie the authors' prediction that there will be a greater incidence of fraudulent claiming in Massachusetts.

The prediction of fraudulent claim behavior was observed soon after the 1988 Reform Law provision that raised the monetary threshold to file a tort claim from $500 to $2,000 in claimed medical bills. Weisberg and Derrig (1992) document the increase in numbers and intensity of medical provider visits with the result being a much larger-than-anticipated 1989 proportion of auto injury claims with medical bills in excess of $2,000, the new tort threshold. More recently, Derrig, et

[16] The largest such classification is Experienced Driver, representing about 89% of the 2005 exposure in each rating territory and consisting of all non-business drivers with more than 6 years licensed. By law, the subgroup of drivers 65 and older pay 75% of the rate that the remaining risks pay who will range in age from about 22-64 years.

[17] The Massachusetts Safe Driver Insurance Plan sets forth differentials within each rate class based upon at-fault accidents and traffic violations.

[18] In addition, the no-fault compensation system increases the marginal benefits of building up bodily injury claims. First-party insurance for automobile-related injuries is mandatory in Massachusetts under PIP coverage, which pays a maximum of $8,000 in losses, which can be offset by up to $6,000 through private health insurance. However, injured parties may be eligible for compensation under bodily injury liability (BIL) in addition to PIP if their medical expenses exceed $2,000. BIL claimants may be compensated for medical and wage losses, plus "pain and suffering." This provides significant incentives for fraudulent BIL claiming, and the medical expense threshold for BIL claiming provides significant incentives for PIP claims build-up (Weisberg and Derrig, 1991, 1992; Cummins and Tennyson, 1992, 1996).

al. (2007) discuss auto injury claims with the appearance of fraud and/or buildup[19] countrywide through the Insurance Research Council (IRC) Study of 2002 Claims and in Massachusetts through the developments in the town of Lawrence. In Lawrence, Insurance Fraud Bureau (IFB) activities reduced injury claims per 100 accidents (PDL claims) from 141 in 2002 to 60 in 2004 and claim payments from $48.6 million in 2002 to $19.8 million in 2004. Granted, Lawrence was an exceptional case identified as far back as 1991 (Weisberg and Derrig, 1991), but reductions on a lesser scale in other towns have been realized by IFB efforts since 2004.

The combined effect of the incentive distortions from premium subsidies is to increase the average cost of insurance coverage relative to that under a cost-based system of rates. The extent to which this increases average costs will depend upon the sensitivity of driving, insuring and claiming decisions in relation to insurance prices, and the extent to which cross-subsidies change prices.

3.2 Empirical Evidence

The empirical literature on insurance price cross-subsidies has mainly examined their impact on insurance purchase decisions, with particular focus on adverse selection. Cross-state studies in health insurance find small or insignificant effects on insurance coverage due to state regulations that impose price cross-subsidies (Simon, 2005; Buchmueller and DiNardo, 2002; Monheit, Steinberg, and Schore, 2003). Case studies of New Jersey's community rated program for individual health insurance find more mixed evidence (Swartz and Garnick, 1999; Monheit, Cantor, Koller and Fox, 2004). Studies in automobile insurance find that insurance purchase decisions are sensitive to price cross-subsidies, with low risk drivers reducing insurance purchase (Dahlby, 1983, 1992).

There is a growing empirical literature relating loss cost growth to insurance rate regulation more generally, but rarely has the focus been on cross-subsidies. Using data on state-level average loss costs, studies in both workers compensation insurance and automobile insurance find evidence that rate regulation is associated with higher loss costs.[20] Using data by individual rating classes from eight states, Danzon and Harrington (2001) find that workers compensation loss cost growth is higher for classes with a larger proportion of risks insured in the residual market.

[19] "Build-up" is the term of art for excessive treatment for the injury (if any) sustained in an auto accident with treatment usually provided by a chiropractor or physical therapist.

[20] Barkume and Ruser, (2001), and Harrington and Danzon, (2000) analyze state-level data on workers compensation losses; Weiss, Tennyson, and Regan, (2007) present a similar analysis of automobile insurance losses.

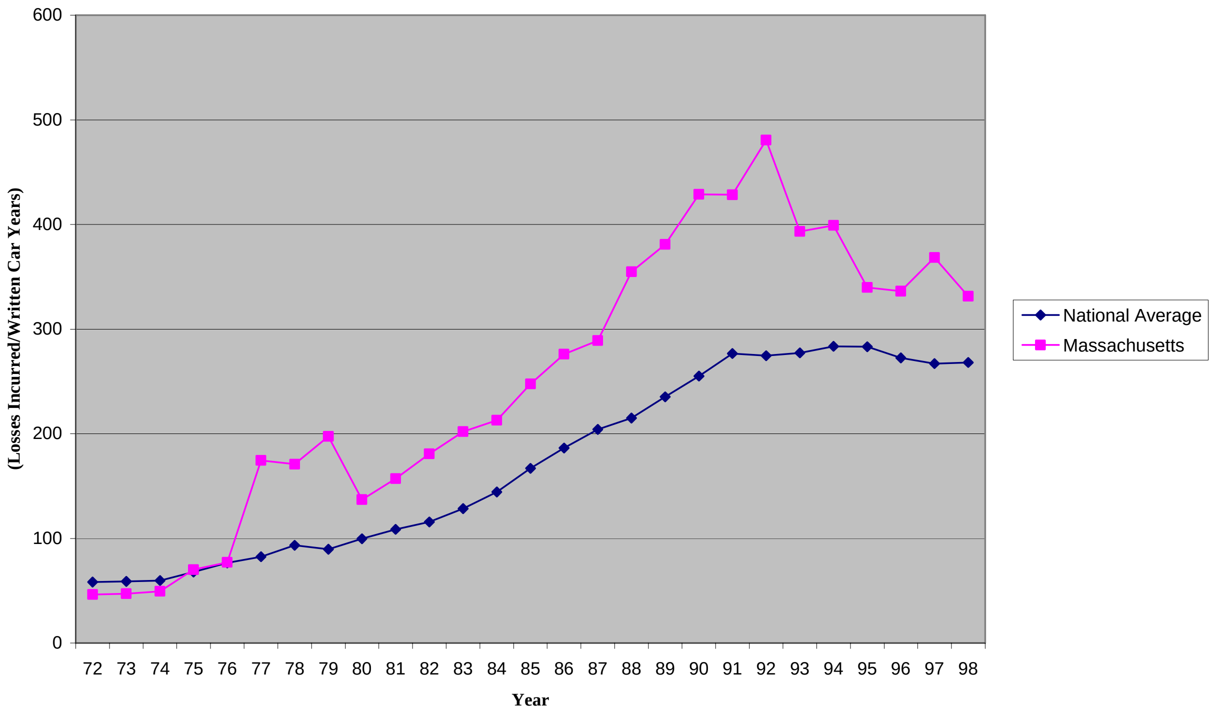
The current study uses data from Massachusetts automobile insurance to examine the relationship between regulatory price cross-subsidies and loss costs. The study adds to existing research by providing a more direct analysis of the relationship between regulatory premium subsidies and loss cost growth than has been possible previously. Taking advantage of the explicit and transparent system of premium cross-subsidies under Massachusetts regulations, we estimate the effects of the subsidies by first comparing loss cost levels in Massachusetts to those in other states before and after the subsidies are introduced; and by comparing loss costs and risk characteristics for Massachusetts towns that receive subsidies to those that do not.

4. REGULATION AND LOSS COST GROWTH IN MASSACHUSETTS

State-level data are used to compare Massachusetts loss costs to those that would be predicted in the absence of the regulations. The data encompass the time period before regulation, the period during the enforcement of the most stringent regulations, and a period during which regulatory stringency was relaxed.

Figure 1 plots Massachusetts annual loss costs over the time period 1972-1998, along with the average losses for all other states. The loss costs reported in the figure are statewide average liability losses per insured car, constructed as total liability losses incurred divided by number of written car years. The liability losses are those reported in the insurers' annual statements and include those paid under all automobile bodily injury insurance, including bodily injury liability, first party personal injury protection (PIP) in no-fault states, medical payments, and uninsured/underinsured motorist coverages; along with losses incurred under property damage liability coverage. Losses not included in the liability data series are first-party property damage losses paid under collision and comprehensive insurance coverages. Liability losses are used in this comparison because liability coverages are compulsory in most states. Thus there is anticipated to be less variation due to differences in insurance purchase in automobile liability insurance losses than in total automobile insurance losses.

Figure 1: Average Annual Liability Loss Costs per Insured Car Massachusetts vs National Average



The figure shows a striking difference between Massachusetts loss costs and those of other states after 1977, and virtually no difference between Massachusetts and other states prior to 1977.[21] The loss cost gap appears just at the time the more stringent regulations are enacted in Massachusetts, and loss cost growth appears to be greater in Massachusetts throughout the 1980s. The distance between Massachusetts and other states is reduced in the 1990s, at a time when the state introduced antifraud measures and when regulatory stringency was relaxed sufficiently that insurers offered discounted rates to select low-risk drivers (Table 2).

Of course, other features of the state may account for the difference in insured loss costs. Massachusetts is a largely urban state with high traffic density, which may contribute to higher rates of accidents. The state population also has high per capita income and high cost of living, which may contribute to higher costs per claim. Moreover, the increase in relative loss costs in Massachusetts in the early 1990s coincides with an increase in the maximum first-party PIP compensation (from $2,000 to $8,000) and compulsory bodily injury liability limits (from

$10,000/$20,000 to $20,000/$40,000 per person and per accident, respectively). This pattern reinforces the idea that factors such as coverage amounts must be controlled for when comparing loss costs across states.[22]

4.1 Regression Analysis

To further explore whether Massachusetts loss costs are higher than expected we estimate a regression model using 1972-1998 annual loss cost data from 50 states, including control variables for time-varying state characteristics as well as state fixed effects. The methodology for modeling the effect of regulation is to examine whether the difference between Massachusetts' loss costs and those of other states is significantly different before and after the regulations that introduced substantial price cross subsidies in Massachusetts.

Because there are many other determinants of loss costs at the state aggregate level, the empirical model includes state characteristics as control variables. The empirical model takes the basic form:

$$L_{st} = \beta_0 + \beta_1 CSYears_t + \beta_2 MA_s CSYears_t + \beta_3 StateRegs_{st} + \beta_4 StateRegs_{st} CSYears_t + \delta' X_{st} + a_s + \varepsilon_{st} \quad (1.0)$$

where subscript s denotes state and t denotes year, and L_{st} is the logarithm of statewide average liability losses per car. The variable $CSYears_t$ is an indicator variable set equal to 1 in the years of cross-subsidy regulation in Massachusetts. The impact of subsidies in Massachusetts is identified by including the interaction of a Massachusetts dummy variable (MA_s) with the cross-subsidy years variable: $MA_s CSYears_t$. If premium cross-subsidies in Massachusetts are a significant determinant of higher loss costs in the state, then – after controlling for other determinants of losses – we expect to find a significant increase in loss cost differences in Massachusetts during the regulatory periods denoted by $CSYears_t$, and thus a significantly positive value for the coefficient β_2. Including the dummy variable $CSYears_t$ for the years in which Massachusetts cross-subsidy regulation occurs means that we are testing for differences in Massachusetts loss costs relative to any nationwide

---

21 Loss costs for 1977 were incurred under a mixed regulatory system that began as open competition then collapsed under an average 14.5% increase and ended with a rate rollback for 1977 and return to fix and establish rates for 1978 (Burnes, 2007).

22 Weisberg and Derrig (1992) argue that this change also increased incentives for claims exaggeration, due to the need to exceed the threshold in order to become eligible to file a bodily injury liability claim. Their analysis shows that PIP claim amounts cluster at the value of the tort threshold.

effects on auto insurance loss costs that occur in those years. We first estimate models in which the regulated period is defined to be all years 1978-1998; we also explore models in which the regulated period is defined as 1978-1995.

$StateRegs_{st}$ is a vector of variables reflecting each state's legal and regulatory environment for auto insurance in state s and year t; included are indicators of a state's use of rate regulation and no-fault auto insurance. Massachusetts has both rate regulation and no-fault throughout the sample period, and so we include these variables and interact them with $CSYears_t$. This specification means that the interaction term $MA_sCSYears_t$ distinguishes the effects of Massachusetts cross-subsidy regulations from these more general regulatory features.

The variable denoted X_{st} is a vector of other time-varying state characteristics. Other state characteristics included in the model are traffic density, defined as total vehicle miles driven divided by total miles of roadway in the state; per capita income in the state; and the statewide average cost per day of hospital stay. All three variables are entered in the model in log form. Higher traffic density should be associated with higher accident rates, and thus is expected to be positively related to loss costs. Both per capita income and hospital costs will affect the costs associated with accidents, holding other charactaristics that affect accident severity constant. Higher per capita income may also be positively associated with insurance purchase amounts, which will affect loss payments. Thus both are expected to be positively related to loss costs.

We also recognize that differences in loss costs across states and time will be affected by differences in insurance purchase amounts. For example, the average insurance coverage limits may vary across states and years, and states with no-fault insurance may provide different coverage limits for compulsory (or optional) first party PIP limits. To partially control for these differences, our models include the minimum required coverage limits (if any) for BIL and PDL coverages in each state and year, and the maximum PIP limits in no-fault (and add-on) states.

The term a_s represents a state-fixed effect, and the term ε_{st} is a stochastic error term. Including state-fixed effects implies that we are testing for differences in Massachusetts' loss costs under the cross-subsidy regulation relative to average loss costs in the state over the sample period. In estimating the model, standard errors are corrected to allow for arbitrary forms of heteroskedasticity and for clustering by state. Clustering takes into account the fact that the regression errors are likely to be correlated within each state across years (Bertrand, Duflo, and Mellainathan, 2004).

Table 4 reports summary statistics of the variables included in the state regression models. The table reports the mean and standard deviation of each variable for the full set of states and for Massachusetts alone. The data confirm the conclusion from Figure 1 that average loss costs in Massachusetts are higher than the national average. However, the data also reveal that traffic density, per capita income, and costs of medical care – factors that could contribute to automobile loss costs – are also higher in Massachusetts. As mentioned previously, Massachusetts is a no-fault state and has a compulsory insurance law; however, Massachusetts' mandatory coverage limits were lower than the national average.

Table 4
Summary Statistics
Annual State-Level Data, 50 States
1972-1998

	All Other States		**Massachusetts**		
Variable	**Mean**	**S.D.**	**Mean**	**S.D.**	
Losses per Insured Car	176.73	111.30	251.06	132.41	**
Traffic Density	0.53	0.40	1.21	0.21	**
Average Cost of Hospitalization	492.72	326.45	618.04	387.05	
Per Capita Income	13,686	6,815	16,728	8,866	
Rate Regulation Dummy	0.60	0.49	1.00	0.00	**
No-fault Dummy	0.27	0.44	1.00	0.00	**
Add-on Dummy	0.19	0.39	0.00	0.00	**
Person Minimum Limit (000)	18.43	6.80	12.59	4.25	**
Property Minimum Limit (000)	9.56	5.19	5.00	0.00	**
PIP Coverage Limit	13,078	45,667	4,000	2,882	**
Add-on Coverage Limit	802.96	2565.85	0.00	0.00	**

Source: Authors' calculations from state-level data. *** indicates Massachusetts mean is significantly different from other-states' average at the 5 percent confidence level.

Table 5
Regression Analysis of Statewide Annual Average Liability Losses per Car
1972-1998

Dependent Variable = Ln(Liability Losses/Written Car Years)

	All Years		**1977-1979 Omitted**	
Explanatory Variable	**CSYears 78-98**	**CSYears 78-95**	**CSYears 78-98**	**CSYears 78-95**
MA x CS Years	0.3781 ***	0.3663 ***	0.4874 ***	0.4051 ***
	0.1543	0.1101	0.0579	0.0519
Reg x CS Years	0.1097 ***	0.0418	0.1311	0.0547
	0.0338	0.0260	0.0820	0.0464
No-fault x CS Years	0.0114	0.0046	0.0038	0.0029
	0.0316	0.0245	0.0682	0.0431
CS Years Dummy	-0.0807 ***	0.0523 ***	-0.0595	0.0657 ***
	0.0291	0.0181	0.0501	0.0249
Ln(Traffic Density)	0.2017 ***	0.2663 ***	0.1566	0.2170 *
	0.0616	0.0636	0.0099	0.1191
Ln(Hospitalization Cost)	0.2927 ***	0.2557 ***	0.2588 ***	0.2116 ***
	0.0786	0.0647	0.0802	0.0681
Ln(Per Capita Income)	0.4876 ***	0.4809 ***	0.5165 ***	0.5416 ***
	0.1057	0.0876	0.1149	0.1057
Rate Regulation Dummy	-0.0889 ***	-0.0206	-0.1115 *	-0.0315
	0.0268	0.0234	0.0614	0.0401
No-fault Dummy	-0.0179	-0.0421	-0.0190	-0.0501
	0.0303	0.0270	0.0380	0.0396
Add-on Dummy	0.0504	0.0319	0.0320	0.0122
	0.0499	0.0498	0.0931	0.0966
Person Minimum Limit	0.0082 ***	0.0087 ***	0.0082 **	0.0086 **
	0.0021	0.0020	0.0034	0.0034
Property Minimum Limit	0.0089 ***	0.0091 ***	0.0115 *	0.0112 *
	0.0027	0.0027	0.0063	0.0065
PIP Maximum	5.0E-07	7.1E-07 **	6.10E-07	8.1E-07 *
	3.3E-07	3.2E-07	4.70E-07	4.7E-07
Add-on Maximum	2.4E-05 ***	2.4E-05 ***	2.50E-05	2.5E-05
	6.7E-06	6.7E-06	1.90E-05	2.0E-05
Intercept	-1.3720 **	-1.1359 **	-1.5147 **	-1.5065 *
	0.5946	0.5149	0.7480	0.8103
State Fixed Effects	Yes	Yes	Yes	Yes
R-squared	0.8742	0.8769	0.8898	0.8936
N	1334	1334	1190	1190

Standard errors appear below the coefficient estimates and are adjusted to allow for arbitrary forms of heteroskedasticity and arbitrary correlation across years within a state. *** indicates statistical significance at the 1% confidence level; ** at the 5% confidence level; and * at the 10% confidence level; all are two-sided tests.

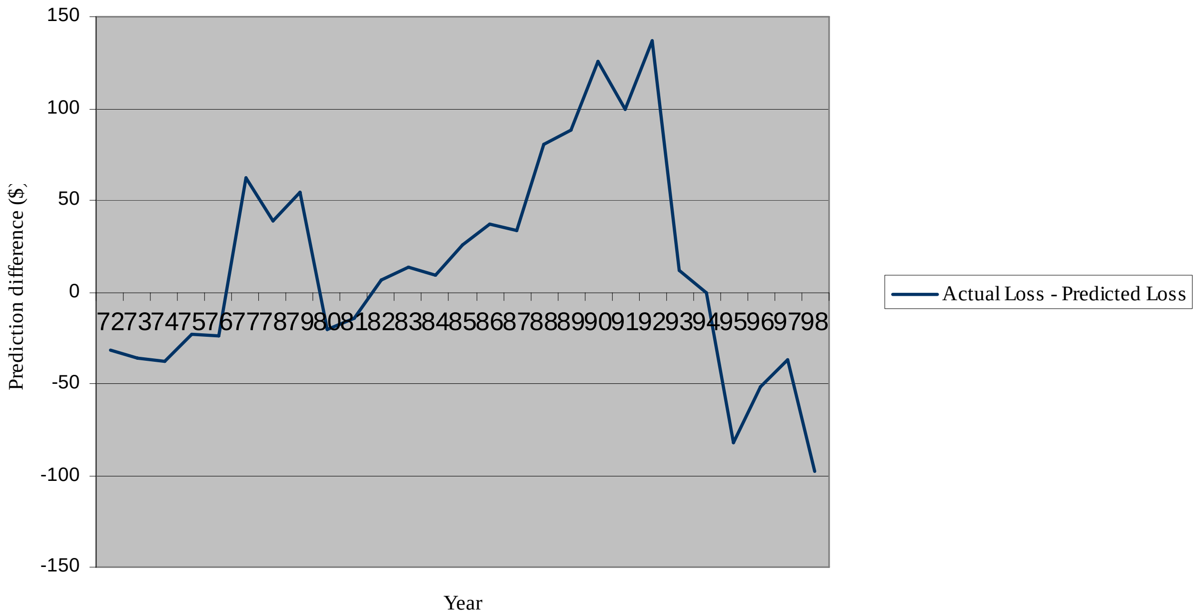
4.2 Estimation Results

The estimation results are shown in Table 5 The first two columns of the table report the estimates obtained using all years of data 1972-1998, and columns three and four report the estimates when the years 1977-1979 are omitted from the dataset (due to concerns that these years are outliers for Massachusetts). Columns 1 and 3 show the estimates when the cross-subsidy years are defined as the entire sample period after regulatory enactment (1978-1998), and columns 2 and 4 show the estimates when the cross-subsidy years are defined as 1978-1995 due to the insurer discounting below state-set rates that began in 1996.

The estimates demonstrate that Massachusetts' loss costs were significantly higher than expected during the period of cross-subsidy regulation, based on other characteristics of the state insurance market. All four specifications show $MA_sCSYears_t$ significant and positive at the 1% confidence level. The two specifications that define the cross-subsidy era as ending in 1995 show more consistent results than those that define the era through 1998. The model estimates using all years of data show about a 44 percent (exp (0.3663)) increase in liability loss costs over the levels experienced in the overall U.S. market with the same demographics and liability coverages. The model estimates about a 50 percent increase when 1977-1979 are omitted.

An alternative estimation approach is to exclude Massachusetts from the sample to obtain the beta coefficients of the model for the 49 other states, and use those beta coefficients combined with Massachusetts data to predict Massachusetts loss costs for each year. Comparing actual Massachusetts loss costs with predicted loss costs from this model then yields the estimated excess loss costs in Massachusetts for each year. Using this approach we find similar results, with loss costs in Massachusetts higher than predicted in the years of cross-subsidy regulation. Figure 2 shows the plot of actual minus predicted loss costs in Massachusetts for each year. The estimated average excess loss cost per year over the years 1978-1995 is 32.14 percent using this methodology.

Figure 2
Actual Losses Incurred vs Predicted Losses from Regression Model



5. RELATING PREMIUM SUBSIDIES TO LOSS COST GROWTH

The state-level data provide evidence that loss costs are higher in Massachusetts under cross-subsidy regulations. More detailed data on insurance costs and premiums by Massachusetts town are used to link these trends more specifically to the incentive effects that arise from premium subsidies. Economic theory predicts that premium subsidies distort incentives in a variety of ways that lead to greater interest in insurance among consumers in subsidized groups, and to more rapid growth in loss costs among subsidized groups. This prediction can be tested with the data available.

5.1 Data by Massachusetts Town

The data on insured loss costs and insured driver risk characteristics by town are obtained from documentation of the biennial Massachusetts regulatory hearings for territory determination. These data include actuarial estimates of the pure premiums and aggregate risk factors for each town. The available data used in our analysis span the time period 1999-2007 for territory determination filings, at two-year intervals. In each case, the filings include four prior accident years of loss data. For example, towns are grouped into rating territories for policies issued as of 4/1/2007 based upon data reported for accident years 2001-2004, each as of 24 months' development. Overall, five datasets are available for this study, reflecting loss experience for the years 1993-2004.

The analysis of town assignments to rating territories has two major elements. First, the relative loss potential of each town is estimated. Second, towns having similar estimates of loss potential are grouped into territories (AIB, 2006). Specifically,

> [The] estimation of each town's loss potential begins with the actual insurance experience (vehicle exposures, claim counts, loss dollars) of each town. The towns' loss cost experiences are dissected into claim frequency and claim severity components and the two compontents are analyzed separately. This information alone is not sufficient, however, since less than complete credibility can be attributed to the actual experiences of the towns. The partially credible actual data must be supplemented by additional information or judgments or both.

In the analysis of town claim frequencies, a mathematical model of frequency potential by town is constructed using data related to the four-year insurance experiences of the towns, and is used to supplement less than fully credible actual town frequency data. The model parameters and quantification of town credibilities are based on an analysis of patterns in loss experience across towns and years (Conger, 1988).

In the analysis of town claim severities, partially credible actual town average cost data are supplemented by data from larger geographic regions (countywide and statewide data). As in the claim frequency analysis, the quantification of town credibilities is based on an analysis of patterns in loss experience across towns, counties, and years.

The result of the claim frequency and severity analysis for each town is used to calculate a loss cost (pure premium) index value for each town as a simple product. The index value expresses the town's loss potential relative to the statewide average. For example, a town index of 1.25 indicates that the per vehicle insurance loss costs for a typical driver in the town are expected to be 25 percent greater than the statewide average.

The town index procedure has been in place with few changes since the early 1980s. The initial credibility procedures were developed by William DuMouchel, a statistician at MIT (DuMouchel, 1984). As a result, the town index for each of the five coverage groups (BIL, PIP, PDL, collision, and comprehensive, all at compulsory or standard deductible levels) is a best Bayesian estimate of the combined four accident year data for each town, normalized for other rating variables, underlying each new territory definition year. We use these town data indices in analyzing the effect of subsidies on the realized accident years 1993-2004 that underlie the territory definition years of 1999-2007.

Some of the town-to-town variation in pure premiums may be captured already by other rating variables. For example, a town with a heavy concentration of inexperienced operators will tend to exhibit a high pure premium, but should not necessarily be put in a high-rated territory, since the classification pricing scheme will already account for this high pure premium (because inexperienced operators are charged higher than average experienced operator rates in each territory). Therefore, the procedure removes from each town's pure premium index the effects of the mix of insured drivers by driver classification as measured by the average class rating factor (ACRF). The ACRF is a town exposure weighted average of relative pure premium by class compared to statewide. The resulting town net pure premium indices are rebalanced to unity within each coverage and provide for a normalized index that measures comparable loss costs by town.

Table 6 provides a comparison of towns that are indicated to receive subsidies and those that are indicated to pay subsidies in the territory definitions for 2005. The table shows that only 19 of the 360 towns in Massachusetts receive a subsidy. On average, these towns have higher pure premium index values (by design). The table also shows that these towns tend to be larger and more densely trafficked, and have a different mix of insured drivers than the subsidy paying towns.

Table 6
Massachusetts Town Data—Characteristics of Towns Receiving Subsidy in 2005

	Subsidy-Receiving (N=19)		**Subsidy-Paying (N=341)**		
	Mean	**S.D.**	**Mean**	**S.D.**	
Pure Premium Index	2.0262	0.5248	0.7267	0.1733	**
Insured Exposures (PDL)	30,346.00	20,889.00	9,969.00	9,933.00	**
Traffic Density	210.10	59.39	93.56	60.38	**
BIL ACRF	1.1150	0.1034	0.9804	0.0330	**
PDL ACRF	1.0538	0.0581	0.9936	0.0255	**

Source: Authors' calculations based on data from AIB. Traffic density = exposures per mile of road. ** indicates means for subsidized and unsubsidized towns are significantly different at the 5 percent confidence level.

5.2 Cost Growth by Town

To provide a preliminary look at the empirical relationships, Figures 3 and 4 compare trends in pure premium growth in the underlying accident year data for high-cost and low-cost towns over the territory definition years 1999-2007 for BIL and PDL insurance coverages, respectively. The data are grouped into high-cost and low-cost with classifications based on each town's overall pure premium index in 1999, using a value of 1.20 or greater to indicate high cost and a value of 1.00 or lower to indicate low cost. Only towns above (or below) the cut-off values in every year of the sample period are included in the figures. The averages for each group of towns are weighted by the number of insured exposures in each town. The data are normalized by setting the 1999 pure premium index for each coverage and each group of towns equal to 1.00, to facilitate comparisons in the average annual growth rates over time.

The figures show a clear upward trend in pure premiums among high-cost towns, and a mirroring decrease in low-cost towns as the overall average is about 1.00. The greater growth in the pure premium index among towns that were high-cost in 1999 is consistent with the hypothesis that subsidies positively affect loss cost growth.

Figure 3: BIL Pure Premium Index Growth

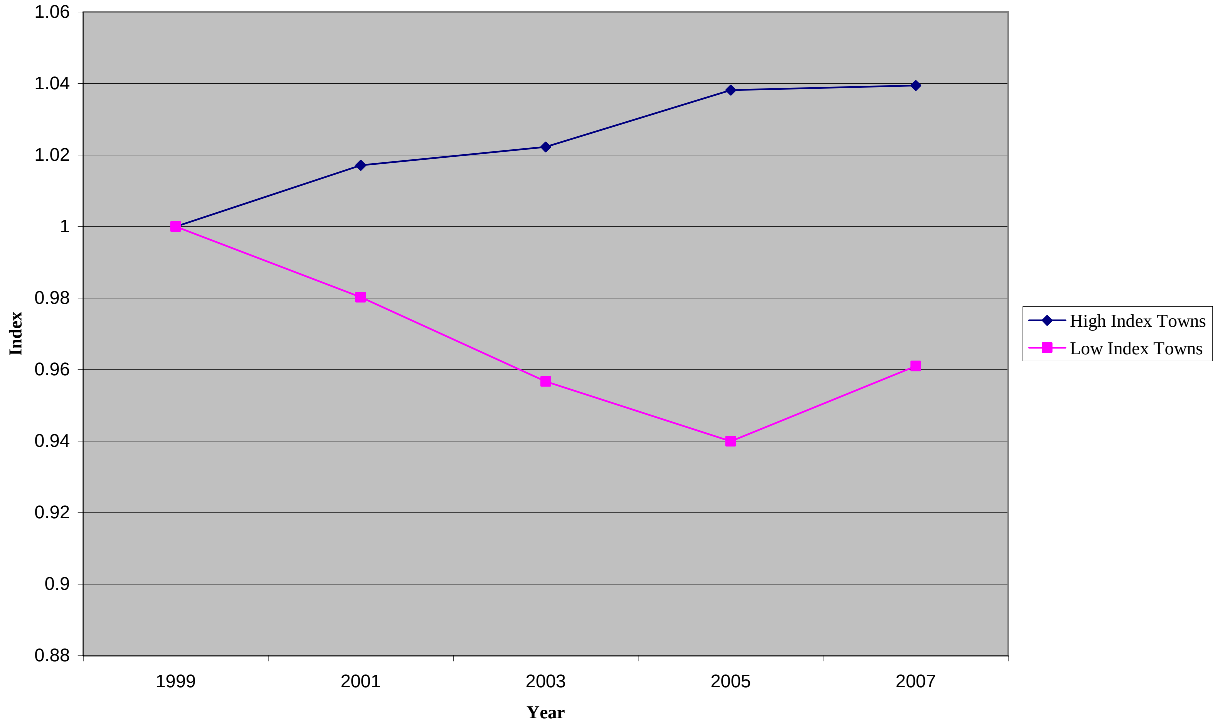
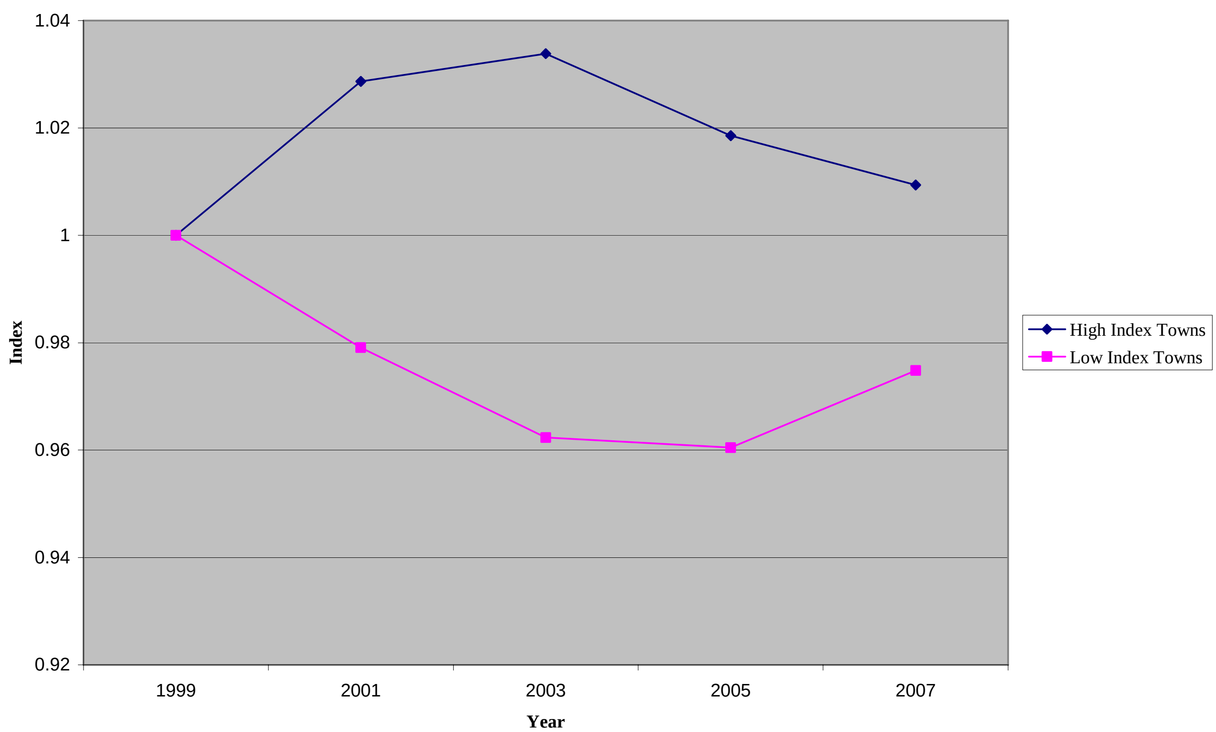


Figure 4: PDL Pure Premium Index Growth



5.3 Regression Analysis

To further explore the relationship between price subsidies and changes in loss costs, simple regression models of the period-to-period changes in pure premiums are estimated. The pure premium regression model takes the following form:

$$\text{Chg}(PP_{it}) = \beta_0 + \beta_1(Subsidy_{it-\tau}) + \beta_2(PP_{it-1}) + \beta_3(Boston_i) + \delta'(Chg\,X_{it}) + T_t + \varepsilon_{it} \qquad (2)$$

where Chg denotes percentage biennial change, subscript i denotes town and t denotes year, and PP_{it} is the pure premium index for town i in year t. The biennial change in the average pure premium index for each town is modeled as depending on the receipt of subsidy in the years during which the loss data were generated, allowing for unspecified differences between Boston-area towns and other towns, and after controlling for changes in other relevant characteristics of each town. The lagged value of the pure premium index is included in the model to allow for the tendency for loss costs to regress toward the mean, and year indicators T_t are included to allow for loss shocks that are common to all towns in a year. The term ε_{it} is a stochastic error term. In estimating the model standard errors are corrected to allow for arbitrary forms of heteroskedasticity and for clustering by town. Clustering takes into account the fact that the regression errors are likely to be correlated within each town across years.[23]

The hypothesis to be tested is that pure premium growth is positively related to the receipt of a subsidy in the years in which the loss data are generated. The period indicator for the subsidy variable is denoted by t-τ to make clear that the relevant period is not the previous territory definition year but rather the years in which the current pure premium data were generated. For example, the 2007 pure premium index is based on loss data from 2001-2004. Because the loss data years overlap for our territory definition years, we use the the subsidy values generated from the two earliest years (using either 2001 or 2002 or both year's subsidy status to analyze the impact on 2007, for example). We obtain the subsidy status and percentage subsidy received by town and year by matching each town to its assigned territory in each year that the underlying loss data were generated.

[23] We do not have enough time series observations to estimate models specifically corrected for autocorrelation.

The model is estimated separately for each of the five auto insurance coverages. The control variables included in the models are the percentage change in the ACRF, the percentage change in the number of cars insured for compulsory coverages, and the change in traffic density in each town. These variables measured using data from the most recent loss data year, for example 2004 data are used for the 2007 pure premium index year.

A second set of models analyzes changes in the average class rating factors (ACRF). These models provide a test of the hypothesis that subsidies lead to greater entry of high-risk drivers into the insurance pool. The model estimated is

$$\text{Chg}(ACRF_{it}) = \beta_0 + \beta_1(Subsidy_{it-\tau}) + \beta_2(ACRF_{it-1}) + \beta_3(Boston_i) + \delta'(ChgX_{it}) + T_t + \varepsilon_{it}, \qquad (3)$$

using the same notation defined for the previous model. The ACRF models are estimated for each of the five automobile insurance coverages separately. Changes in the ACRF may reflect either changes in the demographics of a town or changes in the characteristics of insured drivers in the town (irrespective of changes in town demographics). To capture changes in demographic characteristics that may lead to changes in the propensity to purchase insurance, the control variables include the change in the average age of cars and the change in the percentage of luxury cars registered, as well as the change in traffic density, for each town. As in the pure premium models, we also allow for unspecified differences between Boston-area and other towns.

5.5 Estimation Results

Summary statistics for the variables included in the Massachusetts town regression models are reported in Table 7, and the estimation results are presented in Tables 8, 9, 10, and 11. Tables 8 and 9 report estimates for the pure premium models, and those for the ACRF models are reported in Tables 10 and 11. In each case the first table of estimates use the lagged subsidy status indicators for each town, while the second table reports estimates using the lagged percentage subsidy amount for each town. The subsidy is measured as a percentage of the true cost-based premium for the town, and the subsidy percent variable is set equal to zero in towns that do not receive a subsidy.

Table 7
Summary Statistics
Annual Town-Level Data, Massachusetts
2001-2007 Index Years

Variable	N	Mean	S.D.
Pct change BIL PP Index	1439	0.0006	0.1588
Pct change PIP PP Index	1439	-0.0191	0.1351
Pct change PDL PP Index	1440	-0.0048	0.0524
Pct change COLL PP Index	1439	-0.0056	0.0635
Pct change COMP PP Index	1440	0.0210	0.0963
Lag BIL PP Index	1440	0.7476	0.4503
Lag PIP PP Index	1440	0.7203	0.5688
Lag PDL PP Index	1440	0.8404	0.2344
Lag COLL PP Index	1440	0.8777	0.2644
Lag COMP PP Index	1440	0.8516	0.3896
Pct change BIL ACRF Index	1440	-0.0036	0.0175
Pct change PIP ACRF Index	1440	-0.0048	0.0196
Pct change PDL ACRF Index	1440	-0.0020	0.0130
Pct change COLL ACRF Index	1440	-0.0018	0.0177
Pct change COMP ACRF Index	1440	-0.0011	0.0153
Lag BIL ACRF Index	1440	0.9951	0.0386
Lag PIP ACRF Index	1440	0.9889	0.0463
Lag PDL ACRF Index	1440	1.0000	0.0266
Lag COLL ACRF Index	1440	0.9982	0.0336
Lag COMP ACRF Index	1440	0.9974	0.0452
Subsidy Indicator (lagged)	1440	0.0688	0.2531
Subsidy Percent if subsidized (lagged)	1440	0.0094	0.0453
Pct change Luxury Cars	1433	0.1350	0.2414
Pct change Mean Age of Car	1425	0.0391	0.1023
Pct change Traffic Density	1440	0.0310	0.0454
Boston Dummy	1440	0.2194	0.4140
Pct change Exposures	1440	0.0399	0.0348

Source: Data on PP Indices, ACRF Indices, subsidies, traffic density and insured exposures from AIB; data on luxury cars and mean car age from Massachusetts Division of Motor Vehicles.

The results of estimating changes in pure premium by town are reported in Table 8. The lagged subsidy indicator is positive and significant at the 5% level for PDL coverage and at the 1% level for the remaining four coverages. The estimates support the hypothesis that the growth in pure premiums is positively related to previous subsidies received. This suggests that cost increases are greater in subsidized towns than in unsubsidized towns – consistent with the existence of significant incentive effects on entry into driving and/or riskier driving behaviors created by premium subsidies.

The estimates using subsidy percents rather than subsidy indicators show a positive relationship between larger subsidy percents and pure premium growth for all five coverages. However, the effect of larger subsidies on pure premium growth is statistically insignificant in PD liability coverage, and there are only marginally significant effects (at the 10% confidence level) of larger subsidies on pure premium growth in collision coverage. The estimated effects of larger subsidies are significant at the 1% confidence level for BI liability, PIP, and comprehensive pure premium growth.

Table 8
Regression Analysis of Growth in Pure Premiums by Town
Index Years 2001-2007

Dependent variable = PP Index(t)/PP Index(t-1) - 1

Explanatory Variable	BIL PP		PIP PP		PDL PP		COLL PP		COMP PP	
Lag subsidy indicator	0.0717	***	0.0566	***	0.0112	**	0.0277	***	0.0206	***
	0.0220		0.0184		0.0061		0.0088		0.0134	
Lag pure premium	-0.0598	***	-0.0105		-0.0035		-0.0284	***	-0.0616	***
	0.0192		0.0076		0.0083		0.0101		0.0114	
Pct change exposures	-0.0467		0.0243		-0.0560		-0.1808		-0.0444	
	0.2328		0.1617		0.0797		0.1423		0.1509	
Pct change density	0.3893	*	0.2726	***	0.0686		0.0680		-0.0701	***
	0.1567		1.1E-01		0.0461		0.0456		0.0722	
Boston dummy	0.0010		1.8E-02	**	-0.0050		0.0041		0.0097	*
	0.0134		8.9E-03		0.0039		0.0057		0.0056	
Pct change BIL ACRF	0.3434									
	0.7024									
Pct change PIP ACRF			-0.2124							
			0.3699							
Pct change PDL ACRF					-0.1408					
					0.1835					
Pct change COLL ACRF							0.4936			
							0.3670			
Pct change COMP ACRF									0.2906	
									0.2223	
Intercept	0.0097		-0.0763	***	-0.0145		0.0146		0.0647	***
	0.0211		0.0105		0.0091		0.0148		0.0115	
R-squared	0.0396		0.0794		0.0625		0.0701		0.0841	
F-statistic	2.95	***	19.22	***	7.54	***	7.51	***	8.90	***
N	1439		1439		1440		1439		1439	

Standard errors appear below the coefficient estimates, and are adjusted to allow for arbitrary heteroskedasticity and for arbitrary correlation in errors across years within each town. *** indicates statistically significant at the 1% confidence level ** at the 5% confidence level, and * at the 10% level; all are two-sided tests.

Table 9
Regression Analysis of Growth in Pure Premiums by Town
Index Years 2001-2007

Dependent variable = PP Index(t)/PP Index(t-1) – 1

Explanatory Variable	BIL PP		PIP PP		PDL PP		COLL PP		COMP PP	
Lag subsidy percent	0.5832	***	0.3649	**	0.0328		0.1006	*	0.3504	***
	0.1767		0.1670		0.0355		0.0546		0.1110	
Lag pure premium	-0.0759	***	-0.0162		0.0007		-0.0223	**	-0.0850	***
	0.0213		0.0128		0.0081		0.0106		0.0120	
Pct change exposures	-0.0462		0.0214		-0.0554		-0.1810		-0.0277	
	0.2304		0.1605		0.0795		0.1422		0.1504	
Pct change density	0.3867	***	0.2798	***	0.0727		0.0718		-0.0753	***
	0.1562		0.1087		0.4622		0.0456		0.0712	
Boston dummy	-0.0048		0.0152	*	-0.0045		0.0042		0.0064	*
	0.0141		0.0089		0.0040		0.0059		0.0059	
Pct change BIL ACRF	0.2513									
	0.7074									
Pct change PIP ACRF			-0.2287							
			0.3768							
Pct change PDL ACRF					-0.1370					
					0.1853					
Pct change COLL ACRF							0.5038			
							0.3663			
Pct change COMP ACRF									0.2664	
									0.2221	
Intercept	0.0253		-0.0694	***	-0.0177	*	0.0106		0.0836	***
	0.0219		0.0125		0.0092		0.0152		0.0123	
R-squared	0.0424		0.0782		0.0615		0.0667		0.0913	
F-statistic	3.01	***	21.42	***	7.48	***	6.75	***	13.01	***
N	1439		1439		1440		1439		1440	

Standard errors appear below the coefficient estimates, and are adjusted to allow for arbitrary heteroskedasticity and for arbitrary correlation in errors across years within each town. *** indicates statistically significant at the 1% confidence level ** at the 5% confidence level, and * at the 10% level; all are two-sided tests.

The estimation results relating town subsidy status to changes in ACRF are reported in Table 10. The estimates support the hypothesis that previous subsidies received are significantly related to changes in a town's average class rating factor. The estimated effect is significant at the 1% confidence levels for all five coverages and is greatest in magnitude for BI liability and PIP, even after controlling for changes in other characteristics of towns' auto insurance environments. The estimates reported in Table 11, using percentage subsidies by town rather than subsidy indicators, yield similar conclusions. Consistent with the predictions of theory, these estimates suggest that insurance decisions are sensitive to the receipt of premium subsidies, with subsidies leading to a greater proportion of high-risk drivers in the insurance pool.

Table 10
Regression Analysis of Growth in ACRF by Town
Territory Assignment Years 2001-2007

Dependent variable = ACRF Index(t)/ACRF Index(t-1) - 1

Explanatory Variable	BIL ACRF		PIP ACRF		PDL ACRF		COLL ACRF		COMP ACRF	
Lag subsidy indicator	0.0258	***	0.0326	***	0.0156	***	0.0180	***	0.0142	***
	0.0033		0.0040		0.0022		0.0027		0.0020	
Lag ACRF	-0.0272		-0.0343		-0.0470	**	-0.1256	***	-0.1007	***
	0.0186		0.0222		0.0194		0.0374		0.0209	
Pct change density	7.3E-02	***	7.6E-02	***	4.7E-02	***	5.7E-02	***	7.5E-02	***
	1.9E-02		2.1E-02		1.6E-02		1.9E-02		1.8E-02	
Boston dummy	-2.7E-03	***	-2.1E-03	**	-2.3E-03	***	-2.0E-03	*	-1.4E-03	*
	1.1E-03		1.1E-03		9.0E-04		1.1E-03		8.0E-04	
Pct change luxury cars	3.0E-03		2.3E-03		2.5E-03		-5.9E-03		3.3E-03	
	2.2E-03		2.8E-03		1.7E-03		3.8E-03		3.0E-03	
Pct change mean car age	-3.1E-03		-1.6E-03		-3.7E-03		-8.5E-03	**	-2.4E-03	
	4.2E-03		4.5E-03		3.2E-03		3.5E-03		2.8E-03	
Intercept	0.0186		0.0232		0.0025	**	0.1220	***	0.0930	***
	0.0188		0.0223		0.0011		0.0372		0.0208	
Year fixed effects	Yes		Yes		Yes		Yes		Yes	
R-squared	0.1928		0.2268		0.1341		0.1320		0.1861	
F-statistic	13.14	***	20.21	***	7.81	***	11.32	***	28.88	***
N	1418		1418		1418		1418		1418	

Standard errors appear below the coefficient estimates, and are adjusted to allow for arbitrary heteroskedasticity and for correlation in errors across years within each town. *** indicates statistically significant at the 1% confidence level ** at the 5% confidence level, and * at the 10% level; all are two-sided tests.

Table 11
Regression Analysis of Growth in ACRF by Town
Territory Assignment Years 2001-2007

Dependent variable = ACRF Index(t)/ACRF Index(t-1) - 1

Explanatory Variable	BIL ACRF		PIP ACRF		PDL ACRF		COLL ACRF		COMP ACRF	
Lag subsidy percent	0.1845	***	0.2390	***	0.1061	***	0.1195	***	0.0870	***
	0.0251		0.0344		0.0142		0.0201		0.0136	
Lag ACRF	-0.0689	***	-0.0847	***	-0.0726	***	-0.1501	***	-0.1087	***
	0.0177		0.0232		0.0167		0.0385		0.0220	
Pct change density	7.0E-02	***	7.3E-02	***	4.6E-02	***	5.6E-02	***	7.5E-02	***
	1.9E-02		1.9E-02		1.7E-02		1.9E-02		1.8E-02	
Boston dummy	-4.4E-03	***	-4.3E-03	**	-3.2E-03	***	-2.9E-03	***	-2.0E-03	***
	1.1E-03		1.1E-03		9.0E-04		1.1E-03		8.0E-04	
Pct change luxury cars	3.3E-03		2.6E-03		2.6E-03		-5.7E-03		3.3E-03	
	2.3E-03		3.0E-03		1.8E-03		3.8E-03		3.0E-03	
Pct change mean car age	-3.5E-03		-2.0E-03		-4.0E-03		-8.8E-03	***	-2.8E-03	
	3.8E-03		4.1E-03		3.0E-03		3.4E-03		2.8E-03	
Intercept	0.0618		0.0752	***	0.0686	***	0.1475	***	0.1019	***
	0.0174		0.0227		0.0167		0.0382		0.0218	
Year fixed effects	Yes		Yes		Yes		Yes		Yes	
R-squared	0.2497		0.2931		0.1722		0.1509		0.1942	
F-statistic	14.34	***	21.18	***	8.44	***	11.08	***	28.25	***
N	1418		1418		1418		1418		1418	

Standard errors appear below the coefficient estimates, and are adjusted to allow for arbitrary heteroskedasticity and for correlation in errors across years within each town. *** indicates statistically significant at the 1% confidence level ** at the 5% confidence level, and * at the 10% level; all are two-sided tests.

6. CONCLUSION

Rate regulation in the United States had its origins in the twin concerns of excessive monopoly pricing on the one hand and potential insolvency from inadequate pricing and capital commitment on the other hand. Under the state-by-state regulatory scheme in the United States, rate regulation evolved to address local concerns such as price levels for high-risk insurance consumers, risk classifications (and price differentials) based upon socially unacceptable or controversial characteristics of insurance consumers, and mandatory levels of coverage. That evolution has led to a patchwork of state-specific laws and regulations with varying levels of stringency and enforcement.

Nowhere is this variety more prominent than in private passenger automobile insurance, where rating classifications and regulatory restraints have promoted cross-subsidies among the insured populations. The most common of subsidy-inducing regulatory actions are (1) restriction of risk classification plans and (2) restrictions on pricing for allowed classification. The strict regulation of classification and pricing of Massachusetts private passenger automobile insurance during 1978-2007 serves here as a test of whether the reduction in efficiency from these cross-subsidy-providing restrictions result in excessive cost growth through overuse of the insurance system by high-risk drivers.

Two approaches were taken to study the potential loss cost reaction to the Massachusetts cross-subsidies that began in systematic form in 1977 and continue through 2007. The first approach compared Massachusetts to countrywide on demographic, regulatory, and liability coverage levels. Loss cost levels that were 44 percent above the expected level were found for Massachusetts during the 1978-1995 period, when premiums charged were those fixed by the state. A second approach considered changing cost levels across Massachusetts by studying loss cost changes by town and relating those changes to subsidy providers and subsidy receivers. Subsidy data for 1999-2007, with underlying accident year data for 1993-2004, showed a significant and positive (relative) growth in loss costs for towns that were subsidy receivers. These results are in line with the theory of underlying incentives for adverse selection and moral hazard created by premium cross-subsidies.

Acknowledgment

The authors are grateful for the historical data and assistance provided by the Automobile Insurers Bureau, especially Kim A. Scott, William Scully, and Eilish Browne and to anonymous referees.

7. REFERENCES

[1] Automobile Insurers Bureau of Massachusetts, "Actuarial Notice - 2: Subsidies in the Rates," Various Years, Boston, MA.

[2] Automobile Insurers Bureau of Massachusetts, AIB Recommendations for 2007 Private Passenger Automobile Insurance Territory Definitions, MA DOI Docket R2006-03, May 15, 2006.

[3] Barkume, A. and J. Ruser, "Deregulating Property-Casualty Insurance Pricing: The Case of Workers' Compensation," *Journal of Law and Economics,* 2001, Vol. 44, 37-64.

[4] Bartlett, D.K. III, R.W. Klein and D.T. Russell, "Attempts to Socialize Costs in Voluntary Insurance Markets: The Historical Record," *Journal of Insurance Regulation*, 1999, Vol. 17.

[5] Bertrand, M., E. Duflo and S. Mullainathan, "How Much Should We Trust Differences-in-Differences Estimates," *Quarterly Journal of Economics,* 2004, 249-275.

[6] Blackmon, B.G. Jr. and R. Zeckhauser, "Mispriced Equity: Regulated Rates for Auto Insurance in Massachusetts," *American Economic Review,* 1991, Vol. 81, 65-69.

[7] Brockett, P.L. and L.L. Golden, "Biological and Psychobehavioral Correlates of Credit Scores and Automobile Insurance Loss: Toward an Explication of Why Credit Scoring Works," *Journal of Risk and Insurance*, March 2007, Vol. 74, No. 1, 22-63.

[8] Buchmueller, T. and J. DiNardo, "Did Community Rating Introduce an Adverse Selection Death Spiral? Evidence from New York, Pennsylvania, and Connecticut," *American Economic Review*, 2002, Vol. 92, 280-294.

[9] Burnes, N.S., "Opinion, Findings, and Decision on the Operation of Competition in Private Passenger Motor Vehicle Insurance in 2008," Massachusetts Division of Insurance Docket No. R2007-03, July 16, 2007.

[10] Cohen, A. and R. Dehejia, "The Effect of Automobile Insurance Accident Liability Laws on Traffic Fatalities," *The Journal of Law and Economics*, 2004, Vol. 47, 357-393.

[11] Conger, R.F., "The Construction of Automobile Rating Territories in Massachusetts," *Proceedings of the Casualty Actuarial Society*, 1988, Vol. 71, Part 1, 1-74.

[12] Cummins, J.D., "Property-Liability Insurance: Price Deregulation: The Last Bastion," in *Deregulating Property-Liability Insurance,* J.D. Cummins, ed. (Washington, D.C.: Brookings Institution Press, 2002) 1-24.

[13] Cummins, J.D. and S. Tennyson, "Controlling Automobile Insurance Costs," *Journal of Economic Perspectives*, American Economic Association, 1992, Vol. 6, No. 2, 95-115.

[14] Cummins, J.D. and S. Tennyson, "Moral Hazard in Insurance Claiming: Evidence from Automobile Insurance," *Journal of Risk and Uncertainty*, 1996, Vol. 12, No. 1, 29-50.

[15] Dahlby, B., "Adverse Selection and Statistical Discrimination: An Analysis of Canadian Automobile Insurance," *Journal of Public Economics*, 1983, Vol. 20, 121-130.

[16] Dahlby, B., "Testing for Asymmetric Information in Canadian Automobile Insurance," in *Contributions to Insurance Economics,* Georges Dionne, ed. (Boston: Kluwer Academic Publishers, 1992).

[17] Danzon, P.M. and S.E. Harrington, "Workers' Compensation Rate Regulation: How Price Controls Increase Costs," *Journal of Law and Economics,* 2001, Vol. 44, 1-36.

[18] Derrig, R.A., D.J. Johnston, and E.A. Sprinkel, "Auto Insurance Fraud: Measurements and Efforts to Combat It," *Risk Management and Insurance Review*, 2006, Vol. 9, No. 2, 109-130, Fall.

[19] Derrig, R.A., "Auto Property Damage Cost Containment - A Billion Dollar Decade of Progress in Massachusetts," Automobile Insurers Bureau of Massachusetts Cost Containment and Fraudulent Claims Payment Filing, Docket R97-37, July 1997, Boston, Massachusetts Division of Insurance.

[20] Derrig, R.A., "Price Regulation in US Automobile Insurance: A Case Study of Massachusetts Private Passenger Automobile Insurance 1978-1990," *The Geneva Papers on Risk and Insurance,* 1993, Vol. 18, 158-173.

[21] DuMouchel, W.H., "The Massachusetts Automobile Insurance Classification Scheme," *The Statistician,* 1983, Vol. 32, 69-81.

[22] Finger, R.J., "Risk Classification," Chapter 6 in *Foundations of Casualty Actuarial Science* (Arlington, Va.: Casualty Actuarial Society, 2001) http://www.casact.org/admissions/syllabus/ch6.pdf.

[23] Greene, W.E., *Econometric Analysis*, 4th edition, (Upper Saddle River: Prentice-Hall, Inc., 2002).

[24] Grace M.F., R.W. Klein, and R.D. Phillips, "Auto Insurance Reform: Salvation in South Carolina," in *Deregulating Property-Liability Insurance,* J.D. Cummins, ed. (Washington, D.C.: Brookings Institution Press, 2002) 148-194.

[25] Harrington, S.E., "Automobile Insurance in Michigan: Regulation, No-fault and Affordability," *Journal of Insurance Regulation*, 1991, Vol. 10, 144-183.

[26] Harrington, S.E., "Effects Of Prior Approval Rate Regulation of Auto Insurance," in *Deregulating Property-Liability Insurance*, J.D. Cummins, ed. (Washington, D.C.: Brookings Institution Press, 2002) 285-314.

[27] Harrington, S.E., "The Relationship Between Voluntary and Involuntary Market Rates: Regulation in Automobile Insurance," *Journal of Risk and Insurance*, 1990, Vol. 57, 9-27.

[28] Harrington, S.E. and P.M. Danzon, "Rate Regulation, Safety Incentives, and Loss Growth in Workers' Compensation Insurance," *Journal of Business*, 2000, Vol. 73, 569-95.

[29] Harrington, S.E. and H.I. Doerpinghaus, "The Economics and Politics of Automobile Insurance Rate Classification," *Journal of Risk and Insurance*, 1993, Vol. 60, 59-84.

[30] Insurance Research Council, "Uninsured Motorists," 1999, Malvern, PA.

[31] Keeton, W.R. and E. Kwerel, "Externalities in Automobile Insurance and the Underinsured Driver Problem," *Journal of Law and Economics,* 1984, Vol. 27, 149-179.

[32] Jaffee, D.M. and T. Russell, "Regulation of Automobile Insurance in California," in *Deregulating Property-Liability Insurance: Restoring Competition and Increasing Market Efficiency,* (Washington, DC: AEI-Brookings Joint Center for Regulatory Studies, 2002).

[33] Jaffee, D.M. and T. Russell, "The Causes and Consequences of Rate Regulation in the Auto Insurance Industry", 2002, 81-112, in *The Economics of Property-Casualty Insurance,* D. F. Bradford, ed. (Chicago, IL: University of Chicago Press, 1998).

[34] Ma, Y.L. and J.T. Schmit, "Factors Affecting the Relative Incidence of Uninsured Motorists Claims," *Journal of Risk and Insurance*, 2000, Vol. 67, 281-294.
[35] Monheit, A.C., Steinberg Schone, B., "How Has Small Group Market Reform Affected Employee Health Insurance Coverage?" *Journal of Public Economics,* 2003, Vol. 88, 237-254.
[36] Monheit, A.C., et al, "Community Rating and Sustainable Individual Health Insurance Markets in New Jersey," *Health Affairs,* 2004, Vol. 23, 167-175.
[37] Puelz R., and W. Kemmsies, "Implications for Unisex Statutes and Risk Pooling: The Costs of Gender and Underwriting Attributes in the Automobile Insurance Market," *Journal of Regulatory Economics*, 1993, Vol. 5, 289-301.
[38] Riley, J.G., "Informational Equilibrium," *Econometrica,* 1979, Vol. 47, 331-359.
[39] Rothschild, M. and J.E. Stiglitz, "Equilibrium in Competitive Insurance Markets: An Essay on the Economics of Imperfect Information," *Quarterly Journal of Economics,* 1976, Vol. 90, 629-649.
[40] Rottenberg, S., "The Cost of Regulated Pricing: a Critical Analysis of Auto Insurance Premium Rate-Setting in Massachusetts," 1989, Boston, Pioneer Institute for Public Policy Research.
[41] Shavell, S., "On Liability and Insurance," *Bell Journal of Economics*, 1982, 13-120.
[42] Simon, K. "Adverse Selection in Health Insurance Markets? Evidence from State Small-Group Health Insurance Reforms," *Journal of Public Economics*, 2005, Vol. 89, 1865-1877.
[43] Stone, J.M., "Opinion and Findings on the Operation of Competition Among Motor Vehicle Insurers," Rendered June 1977, Boston, MA., Massachusetts Division of Insurance.
[44] Stone, J.M., "Opinion, Findings and Decision on the Operation of Competition Among Motor Vehicle Insurers," Rendered June 1978, Boston, MA: Massachusetts Division of Insurance.
[45] Swartz, K. and D.W. Garnick, "Can Adverse Selection be Avoided in a Market for Individual Health Insurance?" *Medical Care Research and Review,* 1999, Vol. 56, 373-388.
[46] Tennyson, S., "The Impact of Rate Regulation on State Automobile Insurance Markets," *Journal of Insurance Regulation*, 1997, Vol. 15: 502-523.
[47] Tennyson, S., M. Weiss and L. Regan, "Automobile Insurance Regulation: The Massachusetts Experience," in *Deregulating Property-Liability Insurance: Restoring Competition and Increasing Market Efficiency,* J. David Cummins, ed. (Washington, D.C.: AEI-Brookings Joint Center for Regulatory Studies, 2002).
[48] Weisberg, H.I. and R.A. Derrig, "Fraud and Automobile Insurance: A Report on the Baseline Study of Bodily Injury Claims in Massachusetts," *Journal of Insurance Regulation*, 1991, Vol. 9, 497-541.
[49] Weisberg, H.I. and R.A. Derrig, "Massachusetts Automobile Bodily Injury Tort Reform," *Journal of Insurance Regulation*, 1992, Spring, Vol. 10, 384-440.
[50] Weiss, M., S. Tennyson and L. Regan, "Incentive Effects of Automobile Insurance Rate Regulation on Loss Costs and Accident Frequency," working paper, 2007.
[51] Worrall, J.D., "Private Passenger Auto Insurance in New Jersey: A Three-Decade Advertisement for Reform," in *Deregulating Property-Liability Insurance,* J.D. Cummins, ed. (Washington, D.C.: Brookings Institution Press, 2002) 81-134.
[52] Yelen, S., "Withdrawal Restrictions in the Automobile Insurance Market," *Yale Law Journal*, 1993, Vol. 102, 1431-1455.

Biographies of the Authors

Richard A. Derrig is president of Opal Consulting, LLC in Providence, Rhode Island. He can be reached at Richard@derrig.com.

Sharon Tennyson, Ph.D., is Associate Professor of Policy Analysis and Management at Cornell University. She can be reached at st96@cornell.edu.