The Impact of Price Controls on Mandatory Automobile Insurance Markets

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[1] jstrauss2@student.gsu.edu I wrote this paper the same day I learnt about partial-equilibrium models in my MA, Economics Microeconomics course at the University of Calgary. The course had plugged along on the basic fundamentals that are necessary, and then in the final weeks it came together quickly.

INTRODUCTION

This paper models an automobile insurance market and attempts to investigate the impact of a price/ premium control. The particular segment of the insurance market under consideration in this theoretical paper is automobile insurance but the arguments might be extended to other insurance market segments as well.

VARIABLES

Y = Quantity of mandatory and identical automobile insurance policies/ risks underwritten by insurer,[2]
P = Price per insurance policy,
$E[\Omega]$ = Expected loss per policy,
$\beta = (\beta_1 + \beta_2 + \beta_3)$ = Operating expenses per policy,
- β_1 = Adjusting costs per policy,
- β_2 = Administrative costs per policy,
- β_3 = Sales costs per policy,

$Var(E[\Omega])$ = Variance of expected loss per policy,
$r = (r^m - \overline{r})$ = Effective interest rate cost for the insurer, assumed positive,[3]
- r^m = Opportunity cost/ market rate of return on capital,
- $\overline{r}$ = Risk free rate of return on capital, the rate that an insurer can earn on capital,

K = Capital reserves of the insurer,
Ψ = Probability of insolvency and $0 \leq \Psi < 1$,
$E[\pi] = Y(P - E[\Omega] - \beta) - rK$ = Expected profit of the insurer,
$\operatorname{var}(E[\pi])$ = Variance of insurer's expected profit.

[2] An example from Canada would be Section A mandatory automobile insurance coverage (see the Standard Insurance Bureau of Canada policy wordings for more information). In most Canadian provinces, the mandatory coverage is $200,000 in third party liability coverage plus basic no-fault accident benefits coverage. Accident benefits coverage provides low-limit (relatively speaking: $10,000 -$50,000) basic no-fault insurance coverage to anyone who may be involved in an accident/ claim with the insured vehicle regardless of fault. The use of mandatory automobile insurance coverage simplifies the discussion because insureds cannot choose portions of the mandatory coverage—they must choose no coverage (and can't drive) or mandatory coverage (and then optional additional coverage if they desire).

[3] The effective rate of interest for the insurer is assumed positive because of solvency regulation which restricts where the capital of an insurer can be invested.

THE MODEL

Assume all consumers have utility functions of the quasilinear form as shown in equation (0.1). Let x_1 be equal to purchase of insurance coverage (modeled as a product) and x_2 be a composite good.

$$U(x_1 x_2) = \phi x_1 + x_2 \tag{0.1}$$

Assume that all consumers can be put into risk classification groups based on their level of risk. The rating variables used to estimate the level of risk include age, gender, marital status, number of years driving, number of claims, number of traffic violations, and any other variables which have significant predictive power. The risk groups are then ranked so that group 1 is the least risky and group n is the most risky. There is no equality in level of risk between any two risk groups; each group is uniquely different in their frequency and severity of loss.

The consumers within each group purchase an aggregate quantity of mandatory automobile insurance policies based on price. It is assumed that the insurance policy to be purchased is a standard and mandatory personal liability automobile insurance policy for the province or state under consideration. As such, consumers cannot buy portions of this mandatory coverage and must either buy the entire product or no product at all.[4] Each risk classification group is comprised of consumers who have different reservation prices from each other but are otherwise homogenous. Aggregate demand is a function of price.

[4] Note, however, that consumers can always buy more than full coverage, but cannot ever buy only a portion of mandatory coverage. For this reason, there is a unique market for the mandatory automobile insurance market. The focus on mandatory insurance markets does not cause loss of generality. The assumption is made for simplifying reasons. This assumption rules out issues related to market signaling through less-than-full insurance coverage.

A sequence of utility functions, equations (0.2), will then exist for a representative consumer for each of the $i = 1, 2, ..., n$ risk classification groups.

$$\begin{aligned} u_1(x_1 x_2) &= \phi x_1 + x_2 \\ &, \\ u_2(x_1 x_2) &= \phi x_1 + x_2 \\ &\vdots \\ u_n(x_1 x_2) &= \phi x_1 + x_2 \end{aligned} \tag{0.2}$$

The utility maximizing problem for each of the $i = 1, 2, ..., n$ representative consumers is shown in equation (0.3). Demand for insurance, $x_1(p_1, p_2)$, is not a function of wealth whereas demand for the composite good, $x_2(p_1, p_2, \omega)$ is a function of wealth, ω. The demand for insurance and the composite good are both assumed to be normal, $\partial x_1(\cdot)/\partial p_1 < 0$ and $\partial x_2(\cdot)/\partial p_2 < 0$.

$$\begin{aligned} &Max: u_i(x_1 x_2) = \phi x_1 + x_2 \\ &s.t.: p_1 x_1 + p_2 x_2 = \omega \end{aligned} \tag{0.3}$$

Insurers are assumed to be less risk averse than consumers. The insurers are profit maximizers who compete on price and are constrained by financial quality regulations.[5] The regulator imposes a constraint on profit maximization where the probability of insolvency must be less than or equal to some predetermined level (a target).[6] It is assumed that the regulator's required solvency level represents the desire of the

[5] Note that the financial quality regulation (probability of insolvency target) can actually be used to find a production function for an insurer as a function of price and probability of insolvency. Starting from the probability of insolvency function, equation(2.1), and rearranging and solving for quantity of insurance policies, Y, a supply function is actually found which is a function of price and the probability of insolvency, Ψ, taking other variables as parameters: $Y(P,\Psi) = \frac{-2K\left(P - E[\Omega] - \beta\right)}{\ln \Psi \operatorname{var}\left(E[\Omega]\right)} + \frac{P - E[\Omega] - \beta}{rK}$

[6] The probability of insolvency/ ruin will be introduced later on in this paper. For further discussion on the probability of ruin, see Kaas, et al, (2001) or Booth, et al, (1999).

consumers for financial quality; each consumer is assumed to desire the same level of financial quality represented by the actuarial concept of probability of insolvency.[7] The regulator enforces adherence to this requirement.

An insurance regulator imposes a constraint so that the probability of insolvency Ψ for each and every insurer must be less than or equal to Ψ^* (equation (2.1) is the probability of insolvency equation). The insurer's profit maximization problem is then shown in equation (0.4). Let $E[\pi]$ be the expected profit the firm hopes to make as an aggregate from the $i=1,2,...,n$ risk groups.

$$\begin{aligned} &Max: E[\pi] \\ &s.t.: \Psi \leq \Psi^* \end{aligned} \tag{0.4}$$

The expected profit for the insurer from one risk group is shown in equation (0.5). Rewriting equation (0.5) to include marginal operating expenses, β, capital, K, the cost of capital, r, and aggregating across the risk groups, the total profit for an insurer is found in equation (0.6).[8]

$$E[\pi] = Y_i \left(P_i - E[\Omega_i] \right) \tag{0.5}$$

$$E[\pi] = \sum_{i=1}^{n} Y_i \left(P_i - E[\Omega_i] - \beta \right) - rK \tag{0.6}$$

[7] Research has been done on what constitutes rational insurance purchasing if there exists some default risk on the part of the insurer (see, for example, Doherty and Schlesinger, 1990; Cummins and Mahul, 2003; Tapiero and Jacque, 1987). Furthermore, the financial quality hypothesis (see Cagle and Harrington, 1995; Cummins and Danzon, 1997) suggests that consumers will pay more for an insurance policy backed by an insurer with a high degree of financial quality than an insurer with a low degree of financial quality.

[8] Although operating expenditures could also be modeled as a combination of fixed and variable costs, it is simple to only consider variable operating expenditures. In reality, this assumption may not be too far fetched, insurers who sell through independent brokers and use independent adjusters pay both of these agents on a marginal basis (per policy sold and per claim adjusted). Likewise, for direct insurers, there are very few fixed costs for the operation of the business itself, although there are fixed capital requirements for both types of insurers (those who sell through the direct method and the independent agent network) that the insurer must meet in order to obtain a license to do business in most provincial jurisdictions.

The probability of insolvency for the firm is a function of capital held at the beginning of the period of time under consideration, expected profit, and the variance of expected profit. The capital of the insurer increases continuously and decreases stepwise; premiums accumulate and claims (relatively larger) are paid when they occur.[9]

It is assumed by the probability of insolvency function that the distribution of potential losses for each automobile insurance policy is an exponential distribution and that the aggregation of the policies represents the overall distribution of potential losses for the insurer as a whole. The probability of insolvency is then the probability of having negative capital.[10] The probability of insolvency for the insurer is shown in equation (2.1) . Let $\sigma = \mathrm{var}\left(E[\pi]\right)$ be the variance of profit for the insurer and let K be the capital held by the insurer at the start of the time period.

$$\Psi = \exp\left\{\frac{-2K\left(E[\pi]\right)}{\sigma}\right\} \tag{2.1}$$

Expanding the probability of insolvency function to include the explicit-form equation (0.6), and expanding the variance of expected profit into the variance of expected losses and the quantity of insurance sold, equation (2.2) is found.[11]

$$\Psi = \exp\left\{\frac{-2K\left(\sum_{i=1}^{n} Y_i\left(P_i - E[\Omega_i] - \beta\right) - rK\right)}{Y^2\,\mathrm{var}\left(E[\Omega]\right)}\right\} \qquad (2.2)^{12}$$

[9] In reality, claims are not generally paid out immediately after an accident. This simplifying assumption does not cause loss of generality or applicability of this model for explaining the impact of price controls on the market.

[10] More precisely, for a finite time model, the probability of insolvency is the probability of having more claims in a period than all premiums received in that period plus the capital held at the start of the period.

[11] $\sigma = \mathrm{var}\left(E[\pi]\right) = Y^2\,\mathrm{var}\left(E[\Omega]\right)$

In order to reach the probability-of-insolvency regulatory target, the insurers are able to use different combinations of prices, operating expenditures, capital, and capital costs. However, because of the homogenous nature of the mandatory automobile insurance policy and the required probability of insolvency target, the insurers are competing on prices and not on service or quality. Assuming that all insurers in the industry have the same β, r, $Var(E[\Omega])$, and the same price, P, the insurers then share the market for mandatory automobile insurance in equal proportions and each have the same amount of capital.[13]

If a price control is introduced which is higher than a market price of P, the price control is non-binding and meaningless.[14] If a price control is less than a market price of P, one of two things will happen depending on the severity of the price control and the degree of commitment that the regulator has towards price controls.

If it is assumed that all insurers have the same β and that β cannot be lowered any more than it already is, the insurers will leave the market if the price cap, $\hat{P}$ is larger than the market price, P. The insurers were already assumed to be earning zero profit through competition so any price below the market price would necessarily imply that the insurers would lose money by remaining in the market.

The more interesting and realistic assumption is that β is different for each insurer and that prices are also different for each insurer in the pre price control regime;

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[12] The variance of expected losses and the quantity of policies in the denominator represent the overall/ total variance of expected losses for the insurer's portfolio of risks underwritten and the total quantity of policies sold (all risk groups).

[13] This outcome is a result of the Bertrand competition assumption.

[14] This paper is not concerned with the rationale for a price control, but rather, the effects of a price control. Although there is evidence of economies of scale in the property and casualty insurance industry in Canada (see, for example, Doherty, N.A. 1981), it is not straightforward that the industry needs price controls if competition is on price and there are two or more insurers.

this assumption requires otherwise homogenous consumers to have different demands for service levels and/ or financial quality levels.[15] Assuming that service level can be represented by the amount of expenditure on operations, β, the price that high-service-level insurers would be able to charge would be higher than it would be for low-service-level insurers.

Assuming that a market equilibrium had been reached where each insurer charged a price and provided a level of service which cleared the market, the results of a price cap below market price are now investigated in the proceeding sections.

Suppose that P^U represents the underwriting price which is also equal to the expected losses for a policy, then $(P^U + \beta + \frac{rK}{Y}) = P$ for each insurer and the insurer does not make any economic profit from any of the risk classification groups while in competition without a price control. If the price cap is lower than the underwriting price, $\hat{P} < P^U$, the insurer will certainly withdraw from the market. However, if the price cap is larger than the underwriting price, $\hat{P} > P^U$ the insurer will not necessarily withdraw from the market. If the price cap is larger than the underwriting price, then the insurance firms with the lowest cost of operations and (by assumption) lowest service levels benefit the most as they will still earn nonnegative profit if $(P^U + \beta + \frac{rK}{Y}) \leq \hat{P}$. However, for a portion of the insurers, the price cap may be less than their market equilibrium price but more than the total of the underwriting price and their cost of capital. If $(P^U + \frac{rK}{Y}) < \hat{P} < P$, the insurer has an incentive to lower β to $\hat{\beta}$ until

[15] For a discussion of how this is possible and related literature on the topic, please see my paper, Strauss, J.D., 2007b, "Equilibrium in Insurance Markets: Price and Probability of Insolvency," unpublished, working paper.

$(P^U + \hat{\beta} + \frac{rK}{Y}) \le \hat{P}$ and the insurer earns nonnegative profit. In this scenario, the overall social welfare is less than it was with market prices because the difference between the two levels of operating expenditures $(\beta - \hat{\beta})$ represents the value destroyed by the price controls. Insurance consumers receive less service choices as a result of price control regulation.[16]

Also of interest is the length of the price control. If the regulator credibly commits to a long-term price control, this will likely be more efficient than a series of short-term price controls spanning the same period of time; insurers will have more incentive to become more competitive as they will be able to profit from their cost-reductions. An insurer with a service level represented by the operating cost of β may be unwilling to lower it if the insurer does not believe that the regulator will credibly stay-the-course of price controls for a *sufficiently* long-enough period of time. The price controls must be long enough in length (known ex-ante) to make an adjustment in distribution structure and/ or service/ quality level affordable and profitable to the firm.

If the insurer believes that the regulator may lift the price controls after a short period of time, the insurer may prefer to maintain its service level and earn negative profit for that short time. This scenario could easily arise in the insurance markets where a high β might represent an independent broker or a career agent's commission for broking and selling insurance products on the insurer's behalf.[17] If the insurer is willing

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[16] It is also likely that heterogeneous consumers would suffer from having fewer choices over price and financial quality of their insurer—this is not discussed in this paper because in reality, most insurance regulators do not allow differentiated levels of financial quality within one insurance market (more choices for informed consumers). Most insurance regulators require all insurers to meet or surpass some standard financial quality guideline.

[17] An independent broker sells insurance for multiple insurance companies. A career agent sells insurance for only one insurance company. In Alberta, examples of companies that sell through the independent

to lower β, the insurer may have to fire/ discontinue valuable relationships with its brokers/ agent's in order to lower operating expenditures. The insurer may have to change its distribution structure and sell, perhaps, via the internet, fax, and telephone. The insurer may be unwilling to do this if it believes that the price cap is not credible over a long-enough period of time. Uncertainty regarding the length of a price control can prevent insurers from changing their cost/ distribution structures.

If an insurer believes that the price control will be lifted after a short period of time, the insurer may be willing to earn negative profit for a short period of time rather than completely restructure its cost/ distribution system. However, the lower prices that the insurer must charge for the duration of the price cap will place the insurer below the financial quality target that the regulator imposes ($\Psi \le \Psi^*$). In order to meet the financial quality target, the insurer must incur extra financial costs by holding more capital. This extra cost can be calculated straightforwardly.[18] Consumer surplus is increased because of the lower prices but producer surplus is lowered by an amount greater than the change in consumer surplus because of the extra cost of holding extra capital to maintain compliance with the financial quality target ($\Psi \le \Psi^*$).

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insurance network include ING, Economical Insurance, Wawanesa, and many others. In Alberta and many other jurisdictions, examples of insurers who employ career agents include State Farm Insurance, Allstate Insurance, and the Cooperators. There is also a third group of insurers who sell direct to consumers and typically bind their insurance policies over the phone and through mail, email, and fax. In Alberta, examples of direct insurers include TD Insurance, TD Meloche Monnex, and others.

[18] To calculate the amount of capital the insurer needs to hold to ensure compliance with a regulatory target of Ψ^*, the probability of insolvency equation is rearranged so that capital is found, $K = \frac{Var(E[\Omega])\ln\Psi^*}{-2Y^{-1}(P - E[\Omega_i] - \beta) - rY^{-2}}$. The amount of extra capital necessary to attain Ψ^* when prices go from P to $\hat{P}$ and the insurer does not alter its cost/ service/ distribution structure is $\Delta K = (K - \hat{K})$ where $\hat{K} = \frac{Var(E[\Omega])\ln\Psi^*}{-2Y^{-1}(\hat{P} - E[\Omega_i] - \beta) - rY^{-2}}$. The total cost of this extra capital is $r\Delta K$.

CONCLUSION

If the regulator chooses a price cap below a market price, the price cap will necessarily impact the service and financial quality levels of the market. If the regulator's *own* utility function (based on consumer surplus, producer surplus, service levels, etc.) places greater weighting on prices and consumer surplus than service and producer surplus, it *may* be rational (from this regulator's perspective) to impose a price control. A price cap that is ex ante long in duration may be preferred to a price cap that is ex ante short in duration but ex post of the same long duration; the uncertainty regarding the continuance of the price cap can create extra inefficiency.

Further research could be done on the topics discussed in this paper; an empirical research project would investigate the change in market structure (average costs, distribution structures, financial leverage, and market concentration) as a result of binding price control regulation.

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