WP/19/08

Simulation of Automobile Insurance Market in the Presence of Premium Regulation

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We develop an agent-based simulation of the motor vehicle insurance market, characterized by heterogeneous and bounded rational insurers in a monopolistically competitive market and the existence of multifinance firm as an intermediary between insurer and customer, as well as the existence of price regulation intervention in term of lower and upper premium rate regulation. Insurance products are also differentiated by non-price characteristics over which buyers have preferences to select the insurer. The model simulates the premium and claim losses of insurance firms, who collect premiums from clients in return for ensuring them against a standard right skewed insurance risks. The model generates plausible time series of profits and losses and recovers stylized facts, such as the insurance cycle and the emergence of asymmetric, long tailed firm size distributions. We demonstrate that cycles in loss ratios under the price regulation environment is less volatile than in the market when there is no price regulation. Although the competition in premium rate is still exist in the regulated market, simulation results demonstrates that the price regulation can somewhat reduce competition intensities in premium rates when the regulation is adaptive to the premium dynamics in the market.

JEL Codes: C63, G22, G28, L10, L50.
Keywords: Insurance cycle, monopolistic competition, premium regulation, agent-based model.

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This paper is part of the 2019 research project funded by Otoritas Jasa Keuangan (OJK). The authors thank the participants at OJK Research Seminar in August 24-25, 2019 for their valuable comments and suggestions. The findings and interpretations expressed in this paper are entirely those of the authors and do not represent the views of OJK. All remaining errors and omissions rest with the author

1. Introduction

Insurance penetration in Indonesia of less than 2% is comparably low to the rest of the world that stands at 6.09% (Statista, 2019). Such low penetration has been persistent in Indonesia raises question of its underlying reasons. One popular argument is the lack of financial inclusion in Indonesia which drives low insurance penetration. Significant effort to improve the inclusion has been undertaken by Financial Services Authority with significant results improves the bank account ownership from under 20% in 2011 to around more than 60% in 2017 (Globalfindex, 2017) raises more curiosity of the fundamental cause on the low insurance penetration.

Such low persistent insurance penetration in the increasing percentage of bank account ownership as a proxy for financial inclusion motivates us to study the insurance industry in Indonesia. In this research we limit our study to cover only automobile insurance. Within the approach, a granular map of the insurance business is produced via information gathered from regulator and business players in a focused group discussion setting. Interestingly, the setting in insurance business in Indonesia comprises of insurance firms, multifinance companies, banks and automobile dealers. They are intertwined to create specific characteristics of insurance industry in Indonesia. In sum, insurance firms mostly sell insurance products to their customer via intermediaries, i.e. multifinance companies in collaboration with automobile dealers. Most insurance firms claimed that the existing channel is effective to sell insurance product in a considerably low insurance penetration. The insurance firms argue that their cost to educate customer for insurance awareness could be passed on to the multifinance company and automobile dealers by selling packaged insurance product embedded in the automobile price. To sweeten the deal, multifinance companies offers attractive pricing for consumer credit compared to if the customer paid in cash.

On the regulatory side, The Indonesian Financial Services Authority (OJK) regulates the lower and upper bound of gross premium for automobile insurance product to minimize fierce price competition. The regulation is motivated by the previous fact that insurance firms were setting low premium that rationally almost impossible for the firms to operate profitably in the long term. It has been quite effective to curb such destructive behavior for the past 5 years. With changing business environment in general, the prolonged efficacy of such regulation is in question.

The unique characteristics of insurance industry in Indonesia warrant an approach which is able to accommodate the complex interaction among the participants in the industry. The purposes of our study are twofold: to analyze the complex interaction among business participant in the insurance industry in Indonesia using Agent-based Modeling and to analyze the effectiveness of lower and upper bound premium policy to curb the fierce premium competition in the industry.

Previous studies on the effect of regulation on insurance market performance lays on the empirical approach (see for example Regan, Laureen & Tennyson, Sharon & Weiss, 2008, and

Peng, Li and Chi Liu, 2016). This approach is simple and can deliver some important empiricalinsights to policy maker. However this approach is usually based on the classical economic models that assume that all players in the industry can be represented by single agent or firm. All agents in this class of models assumed having the same attribute and objective (homogenous expectation). Under this approach, we cannot reveal how the state of competition and cycle in the market can propagate from interaction between firms and economic agents. This is because under the classical economic approach, we cannot capture the interaction between firms in the market. The limitations of models of this type are well-known in the literature (see, e.g., Powers and Ren, 2003). To overcome this problem, we utilize the agent-based model (ABM) approach that captures adaptation and interaction between agents in the market and their impact to the system equilibrium.

In this paper we build an agent-based simulation model that includes insurance customers, insurance firms, and intermediaries (multifinance firm). Insurers offer market competitive price of a vehicle insurance coverage to customer. Then customer select a firm that offer the lowest total cost comprising of premium rate and non-price costs. Insurance firms are assumed to offer the market premium rate in the given price interval that determined by regulator. It is assumed that all insurers obey the regulation. Loss events happen at random and lead to claims cost for insurer. It is assumed that insurers are able to pay all claims. The model reproduces a wide range of known stylized facts about the vehicle insurance sector under premium regulation, generating stationary dynamics for the insurance system, a long-tailed firm size distribution for insurance firms and a realistic-looking insurance cycle.

2. Relevant Literature

In this section, we will discuss the relevant literatures that drive our study. We will discuss in Section 2.1 state of the art of analytical models for the insurance sector. Sections 2.2 and 2.3 review the applications of previous models, the modeling of the insurance cycle (Section 2.2) and the investigation of the effect of regulation on insurance systems (Section 2.3). We discuss empirical findings that may be used for calibration in Section 2.4. How these stylized facts are reflected in the model design is explored in more detail in Section 3.

2.1. Analytical Models of Insurance Market

There are in general two approaches have been employed in the literatures to model and analyze the dynamic in insurance market. The first approach utilizes non agent-based analytical models. Contributions from this approach often take an equilibrium approach based on game-theory and common assumptions of frictionless markets and rational decision-making. All agents in this class of models assumed having the same attribute and objective (homogenous expectation). Hence, all agents can be represented by single representative agent. While this can offer some basic guidance on modeling specific elements of insurance markets, their value for system-level analysis and for predictions is limited due to strong assumptions. One example is the hypothesis of the “square-root rule of reinsurance” proposed by Powers and Shubik (2006). They derive the optimal relation of the number of reinsurers to that of insurers as following a square-root function of the size of the system. While the empirical relationship is indeed sub- linear, studies (Venezian et al., 2005; Du et al., 2015) cannot confirm the exact square-root nature. Other examples include Plantin’s (2006) model of the reinsurance market. This paper aims to prove that reinsurance is necessary for a functioning insurance sector and is profitable as a business model under normal conditions. Under rationality assumptions some insurance firms will become reinsurers if the reinsurance sector is not sufficiently large, neglecting dynamics and frictions. The limitations of models of this type are well-known in the literature (see, e.g., Powers and Ren, 2003). These limitations can potentially be overcome by agent-based models.

Contributions using agent based model analysis have been conducted for example by Owadally et al. (2015) and Owadally et al. (2018). They consider pricing effect in non-life insurance. Risk modeling, systemic effects, and catastrophes are side-aspects in this model. Data used to validate the model is taken from the motor insurance sector of the UK, where catastrophic damages at system-scale are unlikely. The study considers various pricing strategies and is able to recover a realistic insurance cycle with direct local interactions (as opposed to a centralized market) being a major factor. They conclude that the insurance cycle cannot be solely driven by repeated catastrophic shocks.

Maynard (2016) investigates whether the use of scientific models can improve insurance pricing. An agent-based approach is used to evaluate how useful those forecasts are in systems with competing insurance firms. To remove interference from other effects, the number of companies is limited to two and the forecasting strategies are fixed, which makes it possible to investigate survival time and commercial success in a controlled setting.

Dubbelboer et al. (2017) explores the dynamical evolution of flood risk and vulnerability in London. This agent-based model is used to study the vulnerability of homeowners to surface water flooding, a major source of catastrophe risks in the United Kingdom. The model focuses on the role of flood insurance, especially in the public-private partnership between thegovernment and insurers in the UK, and the UK’s flood re-insurance scheme *Flood Re*, which has been introduced as a temporary measure for 25 years starting in 2014 to support the development of a functioning flood re-insurance sector in the country.

In contrast to these approaches, we aim to construct a more comprehensive, generic, and flexible agent-based model of the insurance sector, as introduced in Section 3.

2.2. Insurance Cycle

Insurance cycles are a phenomenon of property-liability insurance markets, whereby level of profitability, prices and coverage are observed to rise and fall periodically (Harrington, Niehaus and Yu, 2014; Weiss, 2007; Lyons et al., 1996). There are two periods involved in the cycle. The first is “soft period” and the second is “hard period”. In soft period, premium tends to be low, capital base is high, and competition is high. Premiums continue to fall as insurers offer insurance coverage at low rates. Established businesses are forced to compete for risk losing business in the long term. As a result of this unsustainable development over time, less stable companies are driven out of the market which decreases competition, whilst larger companies' capitals are reduced; hence premiums rise rapidly. In this situation, the hard period begins to occur. During this period, the market hardens and underwriters are less likely to take on risks due to the risk of becoming insolvent. The lack of competition and high rates once again makes the market profitable, thereby attracting more companies to join the market whilst existing businesses begin lowering rates again to compete. This causes market saturation and continuation of insurance cycles.

Insurance cycle can be propagated by many causes. However, there is no consensus in the literature on the causes of the insurance cycle. One major strand of literature believes that capital constraint of insurance firm due to natural disasters and large catastrophes are the main driving force of insurance cycle (Winter, 1988, 1994; Gron, 1994; Cummins and Danzon, 1991; Niehaus and Terry, 1993). Such events are believed to trigger the transition from soft period to hard period. After a catastrophic event, the insurance industry receives a substantial amount of claims which depletes the capital of most insurers while driving those that are less capitalized out of business. The surviving ones reconsider their underwriting criteria, are more reluctant to take risks, and premiums start rising as a consequence. Such events strain insurers' reserves, causing them to seek to shift the cost of capital shocks to policyholders by raising premiums and cutting coverage.

Other literatures proposed that irrational forecasting methods (Brockett and Witt, 1982; Venezian, 1985) and information delays (Cummins and Outreville, 1987) can be a possible cause for cycles. In some models, solvency constraints may be explicit and imposed by regulation. In other models, such as the financial quality hypothesis model, where it is assumed that insurance demand falls with worsening insolvency risk, these constraints may be implicit (Harrington and Danzon, 1994; Cagle and Harrington, 1995).

An alternative explanation for insurance cycles is that they are caused by variations in interest rates. Since the insurance premium is based on the expected discounted value of future claims and expenses, prices will vary inversely with interest rates. Doherty and Kang (1988) and Fields and Venezian (1989) show that interest rates cycle might explain the profitability cycle in the insurance industry. Doherty and Garven (1995) state that interest rate changes will significantly affect the surplus of an insurer whose assets and liabilities are not duration- matched, thereby generating a capital shock. In the presence of capital constraints, a negative shock will lead to prices increasing, while a positive shock explains falling prices.

Solvency is also an important component of the risky debt hypothesis by Cummins and Danzon (1997). A firm with greater capital, and hence lower insolvency risk, is more attractive to insurance consumers and it can price policies more highly than a comparable firm with lower capital. Capital shocks with solvency constraints again drive insurance cycles, but in the opposite direction compared to the capital constraints model.

Other contributions on the cause of cycle in insurance market are Owadally et al. (2015) and Owadally et al. (2018). Using the ABM analysis, these papers show that insurance cycle can emerge from price effects and dynamic interaction between firms, without any catastrophe events. These papers find that cycles in insurance markets can arise without such catastrophec shocks because of the structure of an imperfectly competitive market and the bounded rationality of insurers.

2.3. The Impact of Premium Regulation

The regulatory intervention through the setup of premium reference for the insurance company could create a distortion on the premium setting mechanism within a competitive market. For example, time-delay in the approval process of reference insurance premium can affects the insurer's ability to response changing market environment, which can be caused by fluctuating claim experience, inflation, and exchange rate. Therefore, due to the inability of the insurance company to response to such changes in the market by making an adjustment on its premium, there is a tendency that loss ratio in such type of insurance market will be more volatile compare to those in the competitive market.

Moreover, other study shows that the premium regulation which was initially intended to increase the insurance participation through lower insurance premium, tends to increase the overall cost of insurance. From the customer's perspective, such regulation distorts the relationship between the insurable risks with the insurance premium, thus reduce the incentives for the customer to engage in risk-reducing behaviors. Moreover, from the insurer's perspective, such regulation also affects its profitability and therefore reduce its incentive to establish a long term investment which could enhance the insurer's future efficiency (Regan, Laureen & Tennyson, Sharon & Weiss, 2008).

A study which analyzes the effect of premium regulation among the European countries also shows that countries which implement premium regulation with the intention to protect insurance companies from the risk of insolvency, tend to have higher insurance premium compared to the less premium-regulated countries. (Finsinger and Schmid, 1994).

Another study also concludes that deregulation can lead to lower level of premium in the insurance market. In this case, within a jurisdiction which requires the implementation of a uniform premium reference, the insurance company can rely solely on the operating efficiency in order to acquire profit. However, in a less regulated jurisdiction, an insurance company has to improve their competitiveness by setting the proper insurance premium based on a credible underwriting database, to be able to maintain or even increase their profitability (Peng, Li and Chi Liu, 2016)

The regulatory policy to set a single premium for a market tends to create a condition in which insurers will compete in terms of expenses, including the acquisition expense, in order to attract the marketing partner to help the insurer to acquire larger market share (Ippolito, 1979).

Other than the effect of premium regulation on the level of premium and loss ratio, the intensity of premium intervention in a particular jurisdiction can also affect the market share of different type of insurers. In this case, the market share of the group of insurers which has the ability to engage in the pricing competition tends to be smaller within the non-competitive jurisdictions. Therefore, it can be concluded that such jurisdiction tends to hamper the ability of this specific group of insurers to take advantage of price competition in order to increase their market size (Witt and Urrutia, 1983).

3. Model Description

3.1. Agents and Their Interaction

We assume that Indonesia motor vehicle insurance industry comprises of three types of agents: insurance customers, insurance firms, and multifinance firm. Insurance firms offer an insurance product in the market with competitive price. As part of the financing tersm and conditions from multifinance firm, customers which purchased their motor vehicles through financing scheme have to buy insurance product to cover the risks of loss on their automobile. It is assumed that customers do not have knowledge to select the insurance firm. Thus, MF will help the customer to choose the insurance firm which can provides the appropriate insurance coverage.

Insurance contracts oblige the customer to make one premium payment in advance, which entitle them to claim reimbursements for insured damages under the conditions as per the policy wording. The insurance product offered by insurance firms is the same in terms of potential benefit and other product characteristics (such as loss deductible, maximum loss, and other characteristics). Although the insurance coverage offered by insurance firms are similar through the use of standardized policy wording, there are different characteristics between one firm and another which add the value of insurance product to the customers. Some examples of these characteristics are the efficiency of claim service, the speed of claim process and the availability of authorized (or unauthorized) service shop in variety area.

Interaction between customers and insurance firms in the market are modeled in a simple way. We assume that the market operates in discrete time, similar to Taylor (2009). It is assumed that in the beginning of each underwriting year, each insurer offers its own unique market-competitive premium for a given vehicle insurance contract to all customers. Every customer of multifinance firms that own insurable risks approach one insurer with the help of MF. Every multifinance firm calculates the “total cost” of purchasing insurance and the acquisition fee from every insurer. The total cost includes both the insurance premium from a particular insurer and a non-price “cost” that reflects the distance between the customer's preferences and the insurer's characteristics. The non-price cost of a customer is lower when the characteristics of a particular insurer's products are closer to matching customers' personal preference or product specification than other competitors. The acquisition fee is a commission which is paid by the insurer to multifinance firm in exchange for the service as the insurance product distribution channel. Based on the estimated total costs and acquisition fee, customers select the lowest-cost insurer, and the whole market is balanced between supply and demand. Insurers collect premiums after being selected by their customers at year-start. During the year, customers' total claims are randomly generated and paid by insurers at year-end (deductibles are ignored, or assumed to be identical for all customers). Insurers update their underwriting results after paying claims. Based on performance, insurers decide what their competitive price per unit of risk will be in the next period. The market process then recommences at the beginning of the next period. Beyond some basic assumptions which are also made by both Taylor (2009) and Maynard (2012), we also assume that the market is monopolistically competitive, rather than perfectly competitive. It is compulsory for each customer to renew his/her insurance policy in each time period. Finally, we assume that the market where insurance product is traded is operating under the intervention of premium rate regulation. The premium regulation is in the form of lower and upper bound of gross premium rate that insurance firm may offer in the market. Each insurance firm is assumed to obey the regulation by offering the premium rate in the market at the predetermined premium rate released by regulator.

3.2. Pricing Rule of Insurance Firm

Every insurer offers a single price to all customers at the beginning of every year. The competitive price that each insurer offers is determined by considering two aspects. The first aspect is actuarial considerations and the second aspect considering underwriting judgment. The first aspect is actuarial consideration and the second aspect is pertaining to underwriting judgment. The actuarial principle of premium calculation, as set out by Kaas et al. (2008, p. 203- 227), Booth et al. (2005, p. 439) and Hart et al. (2007, p. 213) for instance, states that the price of insurance coverage, should have component of pure premium P^*_{jt} and risk loading gL_{jt}. Hence, the actuarial premium rate is

$$P_{jt} = P^*_{jt} + gL_{jt}$$

The pure premium component represents the insurer's expected claim cost in the following year. It is a weighted average of the insurer's own average past claims and the average industry-wide claim in the past year. This weighted average involves a “credibility factor" or weighting parameter z (where $0 < z < 1$). The larger z is, the greater the weight placed by the actuary on the insurer's own claim experience. The average past claims of the insurer is itself usually an exponentially weighted moving average of past claims, giving more weight (according to a parameter w) to claims in the recent past than in the distant past.

The risk loading component gL_{jt}, with a positive value g being a loading factor, expresses additional price that insurance firm want to charge to customer for compensating his/her riskier potential claims. Here, L_{jt} representing some measure of risk or volatility of claims experienced by an insurer in the given underwriting year. It is usually computed by standard deviation of claims in the given year (as suggested in Kaas et al., 2008 for example). Thus based on actuarial principle, the riskier claims experience leads to a higher premium rate.

Based on the actuarial premium rate that is calculated using actuarial approach, in the next stage, the underwriter determines the competitive price which can be offered to the customers. Determination of the competitive market price involves adjustment to the actuarial based premium rate by considering estimated customers' sensitivity to the price change of the insurance product. Hence the final price offering to the customer has been adjusted by a given markup m_{it} to the actuarial price.

$$P_{jt} = (P^*_{jt} + gL_{jt})e^{m_{jt}}$$

Underwriters assumed do not want prices to change too rapidly as this could alienate customers, so the underwriter calculates an arc price-elasticity of demand from the quantities of contracts sold in the previous two years and the prices at which they were sold. As a consequence, the final mark-up adjustment m_{jt} is calculated by updating their previous mark-up estimate using a weighted average (following Hirschey and Pappas, 1996, p. 639 for example).

$$m_{jt} = \beta \hat{m}_{jt} + (1-\beta) m_{j,t-1}$$

where $\hat{m}_{jt}$ is crude estimate of m_{jt} and $0 < \beta < 1$. The smaller β is, the more gradual the price change is from year to year. Following the general example given by Hirschey and Pappas (1996, p.639), we assume that insurer calculates a crude estimate of mark-up using the estimate of crude elasticity of demand in the given period $(t, t+1]$.

$$\hat{m}_{jt} \approx -(\hat{\epsilon}_{jt})^{-1} = -\frac{(P_{j,t-1}-P_{j,t-2})/(Q_{j,t-1}+Q_{j,t-2})}{(Q_{j,t-1}-Q_{j,t-2})/(P_{j,t-1}+P_{j,t-2})}$$

where $\hat{\epsilon}_{jt}$ is the crude estimate of demand elasticity faced by insurer j.

The final attribute of insurers is that they have a certain level of wealth or capital which changes over time as they sell more or less insurance coverage. A useful strategy, to achieve greater heterogeneity, is to endow each insurer with a random amount of capital (Gulyas, 2002), but the choice of a suitable distribution is then arbitrary, so we elect to initialize the model with all insurers having the same amount of capital. Simulation experiments indicate that this makes little difference in the long-run

3.3. The Rule of Selecting Insurer by Multifinance Firm

Multifinance firms are modeled in a very simple way. They own insurable risks which they attempt to insure. These insurable risks are in the form of damages due to traffic accident or losses on the automobiles which are purchased through financing or credit scheme. They approach one insurer per time step and accept the current market premium if the insurer offers to underwrite the contract. Each MF selects the policy at the beginning of each time period. The terms and conditions of all insurance policies are the same. These include: a fixed contract period, identical inception and renewal dates (e.g. at the beginning of every year), etc. As stated in the previous section, MFs act on behalf of customers. After all of the MFs are offered insurance at the price P_{jt} by insurer j, at the beginning of each year, MF k then calculates the total cost IC_{jkt} their customer should spend for buying insurance from insurer j as follows:

$$IC_{jkt} = P_{jt} + \gamma D_{jk}$$

where D_{jk}represents the distance along the shorter arc from the MF's location to the insurer's location on the circular landscape (Figure 2), and γ denotes a cost (or disutility) per unit distance. Insurers and MF are autonomous and self-directed agents. To measure the perceived distance of insurance firm by MF, we place insurers and MF on an abstract circular simulation landscape, as shown in Figure 3. Each insurer and MF is distributed along circumference according to uniform distribution. The insurer's location on the circle denotes a particular set of attributes: perceived reliability, advertising methods, branding, target demographics, distribution channels, payment methods, perceived efficiency of claims service, and etc. The proximity of a MF to an insurer is interpreted as a greater affinity for the insurer and its product. We also assume that neither MF nor insurers change their locations. Therefore, our analysis focuses on price competition, and location plays a role of segmenting the whole market into local competition (Salop, 1979). Insurers and MF are fixed in the circular space so that their attributes and preferences do not change. The differing location of insurers means that they are heterogeneous.

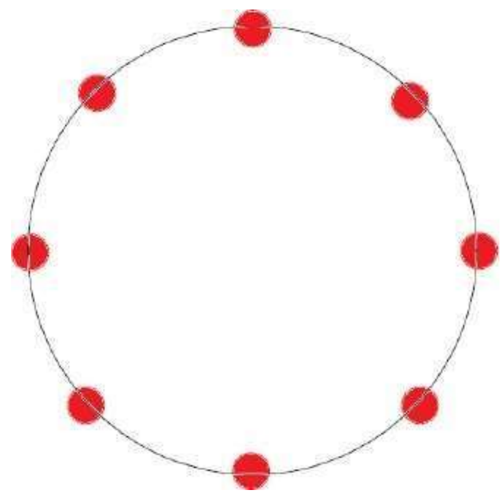


Figure 3.1. A circular simulation landscape showing eight insurers and a large number of multifinance firm customers uniformly distributed along the circle.

Beside total cost that its customer should spent, multifinance firm also calculates the acquisition fee which can be provided by the insurance firm as commission for each insurance sales made by the MF. The acquisition fee is a given percentage θ_j, for $0 < \theta_j < 1$, of gross premium P_{jt} of insurer j at time t. A simple ranking algorithm is then used to assign MFs to insurers. Every MF ranks all insurers from the lowest total cost to the highest and from the highest to the lowest acquisition fee. A MF chooses two insurers with the lowest total cost and the highest acquisition fee, from the MF's point of view, unless this insurer has reached full capacity, in which case the MF chooses an insurer with the next lower total cost. An insurer reaches full capacity if it uses all of its existing capital to support its insurance business. An insurer's total capacity in each time period depends on its existing level of capital and the required solvency ratio, and it defines the maximum total gross premiums that an insurer can take in each time period.

3.4. The Rule of Selecting Multifinance Firm by Customer

Each customer selects the financing product at the beginning of each time period. The terms and conditions of one product are the same for every customer. These include: a fixed contract period, identical inception and renewal times (e.g. at the beginning of every year), two parties only, etc. After all customers are offered financing product at the interest rate I_{kt} by MF k, at the beginning of each year, customer l then calculates the total cost TFC_{klt} of obtaining financing from MF k as follows:

$$TFC_{klt} = I_{kt} + \delta J_{kl}$$

where J_{kl}represents the distance along the shorter arc from the customer's location to the MF location on the circular landscape (Figure 3), and δ denotes a cost (or disutility) per unit distance. The distance J measures how far a MF from the customer points of view. It represents such attributes beyond interest rate, for example the ease of installment payment methods, the speed of service, support in insurance claim arrangements, and etc. To have a measurement of the distance of MF from customer, we assign customer and finance firm in the circumference of a circle in a random way. A simple ranking algorithm is then used to assign customers to multifinance firms, based on the rule that customers wish to find the financing from the multifinance firm with the lowest total cost. Multifinance firm and customers are fixed in the circular space so that their attributes and preferences do not change. The differing location of insurers means that they are heterogeneous.

During a given year (t, t + 1), claims are randomly generated and independent from customer to customer. The size of claim is Gamma-distributed with shape parameter A_G and scale parameter B_G, while their frequency is given by a Bernoulli distribution with parameter q: see Kaas et al. (2008, p. 32) and Hart et al. (2007, p. 130) for more details.

At the end of every year, the total claims paid out by insurers are added up, and likewise for the total premiums received for the year. A loss ratio, the ratio of total claims to total premiums over all the firms in the industry, is then calculated.

4. Simulation setup

We follow a few steps to test and select our simulated data. (1) We use different claim samples that are generated from same distribution parameters to run different lengths of simulations (e.g. test 100, 500, 1000, 2500, and 5000 time periods). (2) We compare the average results of key variables (e.g.: market premium, loss ratio and profit, etc) from each simulation with same time periods, together with their statistics. (3) We find that a time length of 500 periods and more gives us stable results under different claim samples, since our claim distribution has a low coefficient of variation and therefore stable claim samples. This means that we can use a single simulation (e.g. a particular claim sample time series) over (at least) 500 time periods to analyze our model.

We simulate the market behavior over the periods t = 1, . . ., 500 using the model describe in Section 3 and the parameter values given in Table 1. These parameter values are chosen so as to create a reasonable representation of the real-world automobile insurance industry in the Indonesia. We run simulation in two cases. The *base case* involves simulation using a set of parameters under the scenario of nonexistent price regulation in the insurance market. In the second case, the whole procedure is then repeated with the existence of price regulation in the form of lower and upper limit on premium rate.

For each simulation case, we generate key variables like market premium rate, total claim, loss ratio, etc, both for each insurer and for average in the market. Based on these simulation results, we analyze the dynamic character of the insurance market.

Tabel 1. List of Parameter and their values

Claim Model

Claim Probability q: 0.5%
Shape parameter of Gamma distribution A_G: 100
Scale parameter of Gamma distribution B_G : 1
Sum Insured : 117 (95% Percentile of Gamma claim size dist)

Location Model
Circle Diameter : 1
γ (distance cost unit from MF to insurer) : 0.5% (at the beginning condition, the closest insurer total cost is a half of farest total cost)
δ (distance cost unit from customer to MF) : 0.5% (at the beginning condition, the closest insurer total cost is a half of farest total cost)

Premium Model
g (Risk Loading Factor, pengali standard deviasi klaim): 0.01
β (Weight for updating elasticity for markup adjustment): 0.3
w (Weight for updating klaim experience for calculating claim expectation): 0.2
z (credibility factor to calculate updated premium): 0.2
Initial premium rate : 0.5% (it is set equal to claim probability)
Min Elasticity 0
Max Elasticity 1

5. Results and Discussion

In this section, we show the main results of our model and illustrate the dynamics of the motor insurance market. First we elaborate the results from market without premium rate regulation. The detailed discussions are included in the next several subsections, but a key summary as follows:

- Claim experience and market premium: We generate a sample of motor vehicle claims for each customer at each time period, so the overall market losses are stable over time. This simplification helps us to capture the dynamic cyclical behavior of price and loss ratio that are due to insurers' interactions, rather than being driven by major market losses.

- Loss ratio: Casual inspection reveals that there are cyclic patterns over both short and long periods in the market loss ratio, as well as in the loss ratios of individual insurers. However, individual insurers' results are more volatile than the overall market and different insurers have different cycle periods. This may reflect local market competition involves in the process.
- Mark-up pricing adjustment dynamics: The mark-up adjustment has a direct impact on the market competitive price of an insurer, it is worth looking at its pattern over time. Not surprisingly, both short and long term average results of current estimated mark-up such as in Equation (3.5) exhibit cyclic patterns.
- Cyclic market behavior: The autocorrelation function and partial autocorrelation function suggest that market loss ratios, premiums and profits over time follow an AR(2) process.

Figure 5.1 shows one simulation over 500 time periods of claim experience, insurers' offered prices, and premiums paid, all averaged over the market. According to rational expectations theory, insurers' prices should follow the claim pattern over time in response to new information about risk in a fully competitive market (Cummins and Outreville, 1987). However, in monopolistic competition, the interaction of insurers plays a key role in the determination of market competitive price. Therefore, it is not surprising that prices in our simulation behave differently from claims. The thick dark line is the market average claim experience, which is stable over time. The blue line is the market average premium revenue, which is cyclic and more volatile than claim. The green line is the average of all insurers' offered prices, which is higher than market average premium since customers prefer and select the lowest possible prices. This figure only provides an initial snapshot about the prices and claims in our simulation over time. More detailed results will be discussed later when we analyze the cyclic patterns of simulated loss ratios.

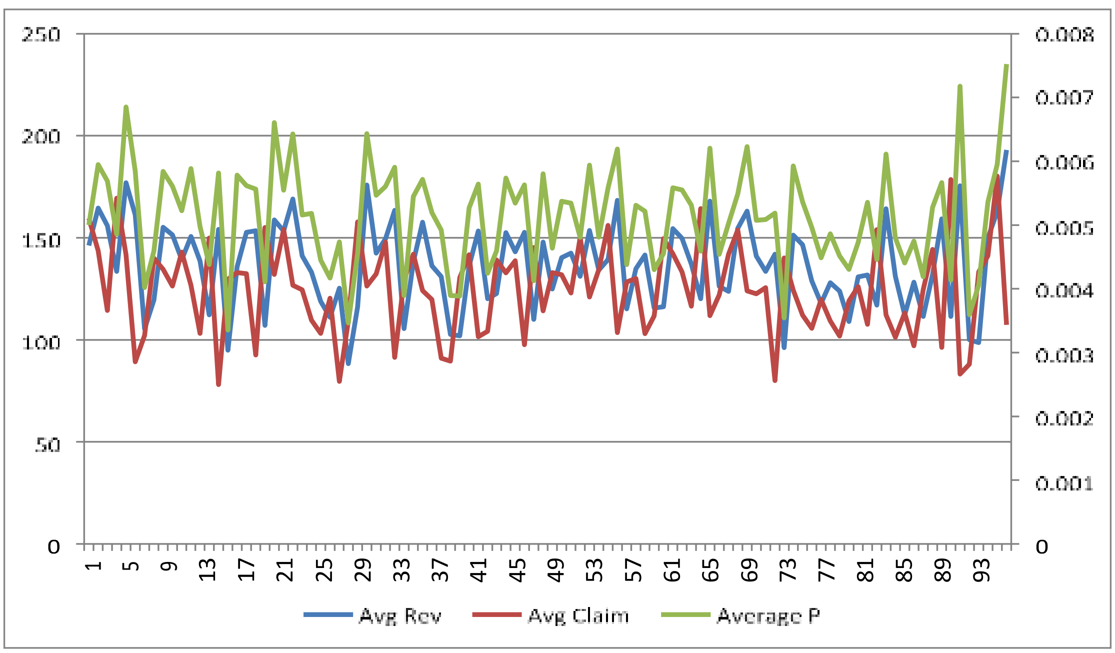


Figure 5.1. Time series of average revenue, average claim, and average premium rate

Analysis into the histograms of market average losses and market average premiums in one simulation over 500 time periods shows that they are distributed differently. Average claims in the market are approximately normally distributed over 500 time periods as expected by the Central Limit Theorem, while the market average revenue premiums are clearly non-normally distributed. Therefore, it is easy for insurers to reduce prices to attract customers, but it is difficult for them to increase prices to compensate their poor claim experiences and retain customers at same time.

Our simulated loss ratio is a ratio of claims paid to premiums collected at each time period, so it should follow a similar pattern to premiums assuming non-CAT claims. Figure 5.2 shows the market loss ratio, which depicts the performance of the overall market, over the first 100 time periods. A casual observation of the chart seems to indicate a cyclic pattern.

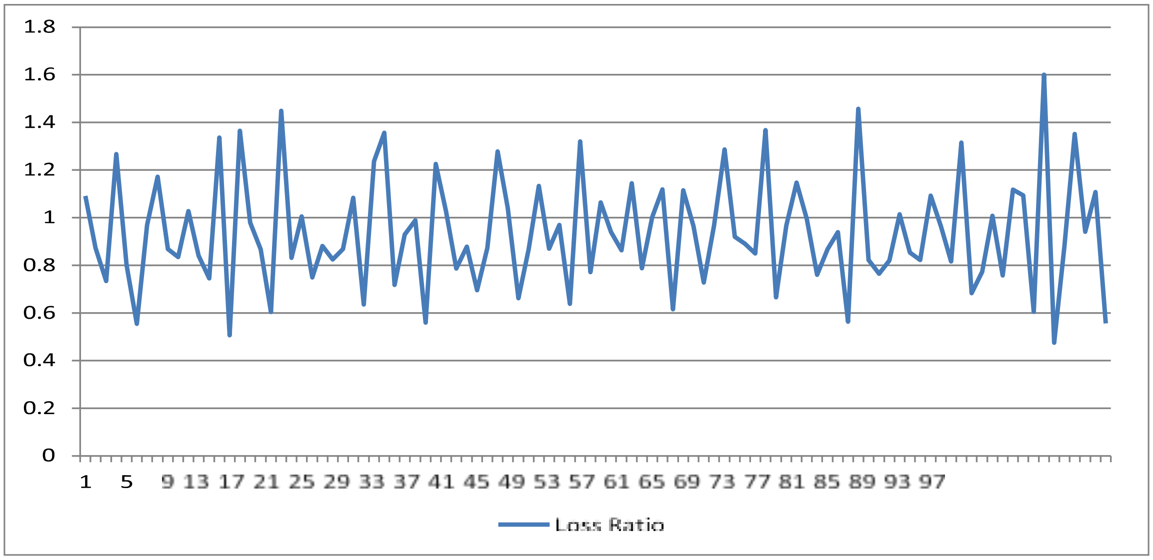


Figure 5.2. Loss ratio : market performance over 500 period

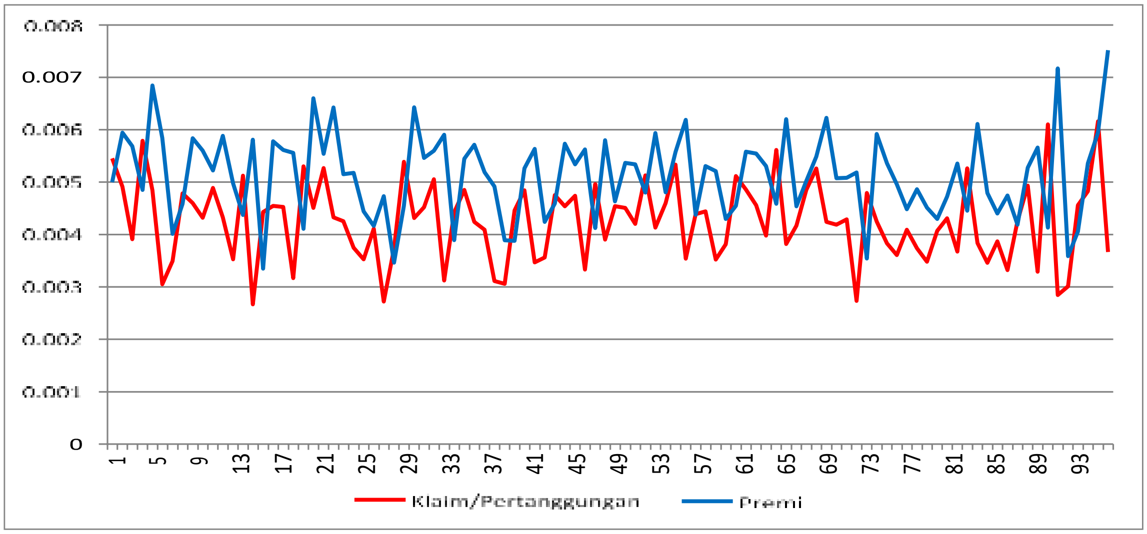


Figure 5.3. Premium rate and claim to sum insured ratio (%)

Figure 5.3 displays time series of premium rate and ratio between claim and sum insured. This figure suggests that premium rate is more volatile than the movement of claim to sum insured ratio

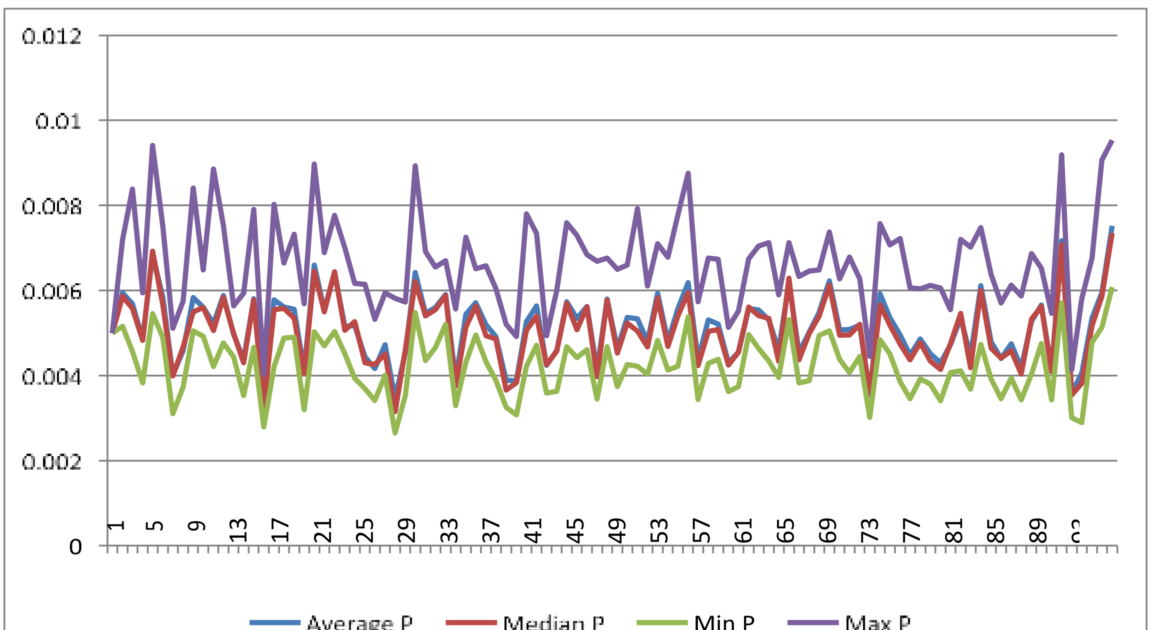


Figure 5.4. average, median, minimum, and maximum premium rate

Under the unregulated premium scenario, the minimum premium rate is less volatile than maximum rate. It at least indicates that insurance firm prefers to offer lower price in the market.

Based on the autocorrelation function (ACF) and partial autocorrelation function (PACF) suggest that market loss ratios, premiums and profits over time tend to follow an AR(2) process.

Sample: 1 100
Included observations: 100

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.441	-0.441	20.003	0.000
		2	-0.110	-0.377	21.255	0.000
		3	0.148	-0.122	23.570	0.000
		4	-0.084	-0.133	24.322	0.000
		5	-0.017	-0.118	24.353	0.000
		6	0.079	-0.021	25.024	0.000
		7	-0.046	-0.022	25.254	0.001
		8	-0.009	-0.021	25.262	0.001
		9	-0.040	-0.108	25.439	0.003
		10	0.087	0.012	26.301	0.003
		11	-0.100	-0.098	27.457	0.004
		12	-0.039	-0.176	27.637	0.006
		13	0.177	0.025	31.306	0.003
		14	-0.099	-0.001	32.480	0.003
		15	-0.021	-0.008	32.531	0.005
		16	0.125	0.098	34.442	0.005
		17	-0.147	-0.026	37.092	0.003
		18	0.033	-0.025	37.225	0.005
		19	0.005	-0.100	37.228	0.007
		20	-0.063	-0.166	37.733	0.010
		21	0.076	-0.078	38.478	0.011
		22	0.095	0.126	39.649	0.012
		23	-0.128	0.030	41.831	0.009
		24	-0.044	-0.070	42.094	0.013
		25	0.100	0.012	43.449	0.012
		26	-0.157	-0.256	46.829	0.007
		27	0.185	0.004	51.621	0.003
		28	-0.111	-0.161	53.367	0.003
		29	0.080	0.014	54.292	0.003
		30	-0.076	-0.060	55.128	0.003
		31	0.036	-0.000	55.322	0.005
		32	0.022	0.015	55.396	0.006
		33	-0.084	-0.065	56.481	0.007
		34	0.068	-0.039	57.200	0.008
		35	0.111	0.041	59.150	0.007
		36	-0.178	-0.036	64.227	0.003

Now, we discuss the results of simulation under the intervention of lower and upper limit premium regulation. The initial value of the lower and upper premium rate are 0.5% and 2%. The lowest rate is assumed to be equal with claim probability and the upper rate is the double of initial premium rate plus maximum margin.

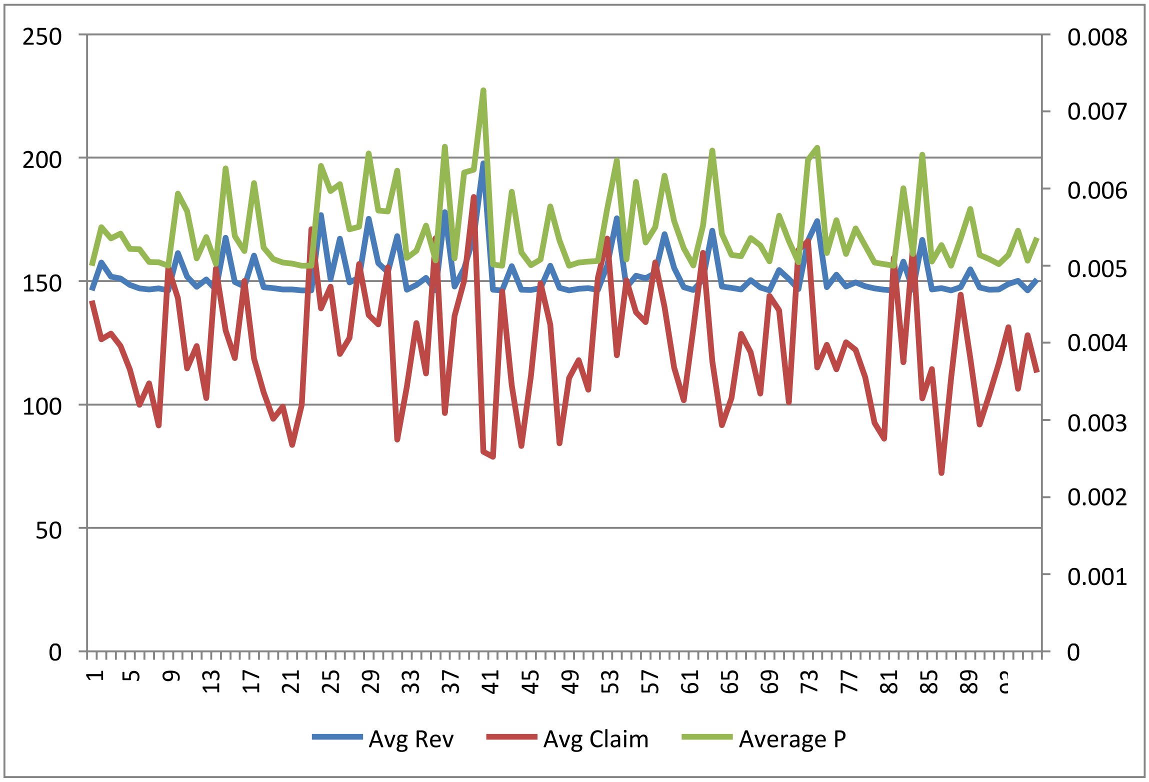


Figure 5.6. Time series of average revenue, average claim, and average premium rate under rate regulation intervention

Figure 5.6 suggests that under premium rate regulation intervention, average rate is less volatile than claim and revenue. Similar pattern occurs when there is no price regulation. It explains that it is easier for the insurers to reduce prices to attract customers, while it is more difficult for them to increase prices and retain customers to cover their poor claim experiences. However, as suggested in figure 5.7., the volatility of premium rate in the regulated premium scenario is lower than the volatility in the non-regulated one. It means that the price regulation is still effective in limiting the fluctuation of premium rate.

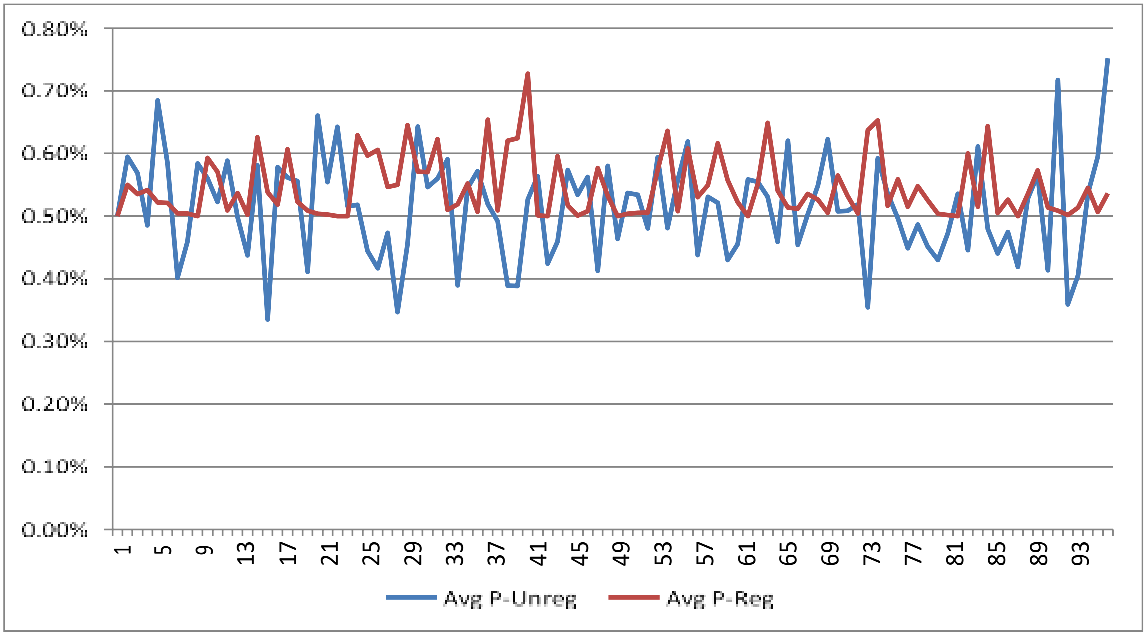


Figure 5.7. average premium rate in the present and not present of regulation

Figure 5.8 explain that loss ratio in the presence of price regulation is less volatile than in the condition of nonexistent price regulation.

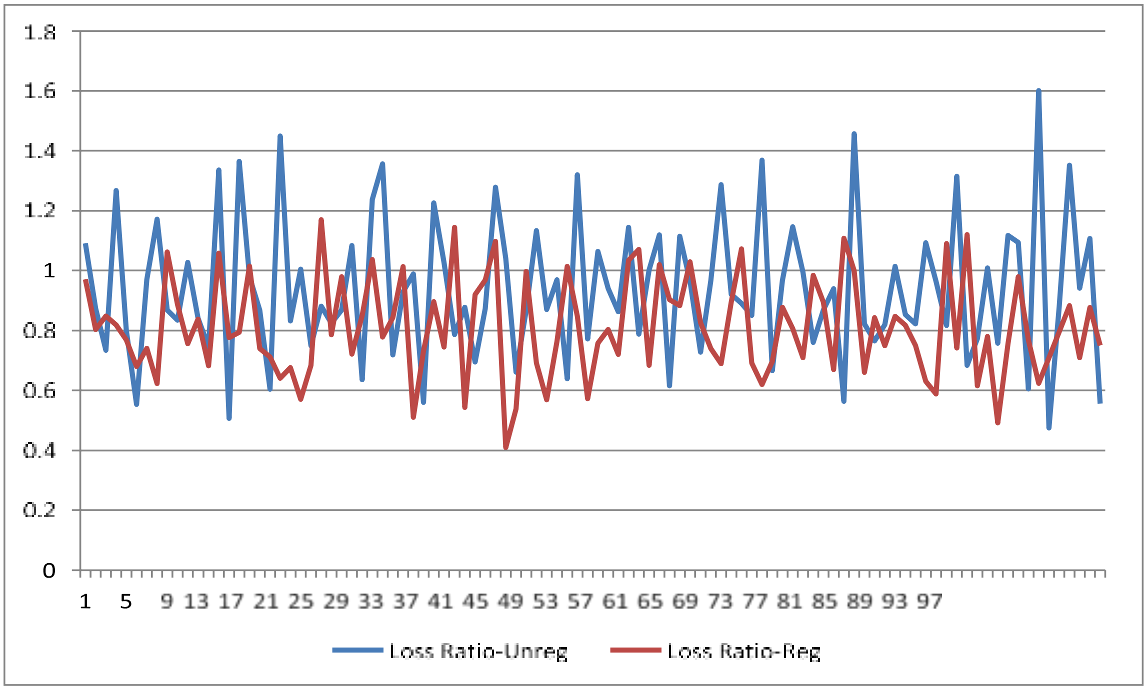


Figure 5.8. comparison of loss ratio under price regulation and no price regulation

Under premium rate regulation, minimum market premium rate tends to be flat, not fluctuate as much as the rate under the unregulated scenario. Insurance firms tend to offer premium rate that is close to the minimum limit regulated by government.

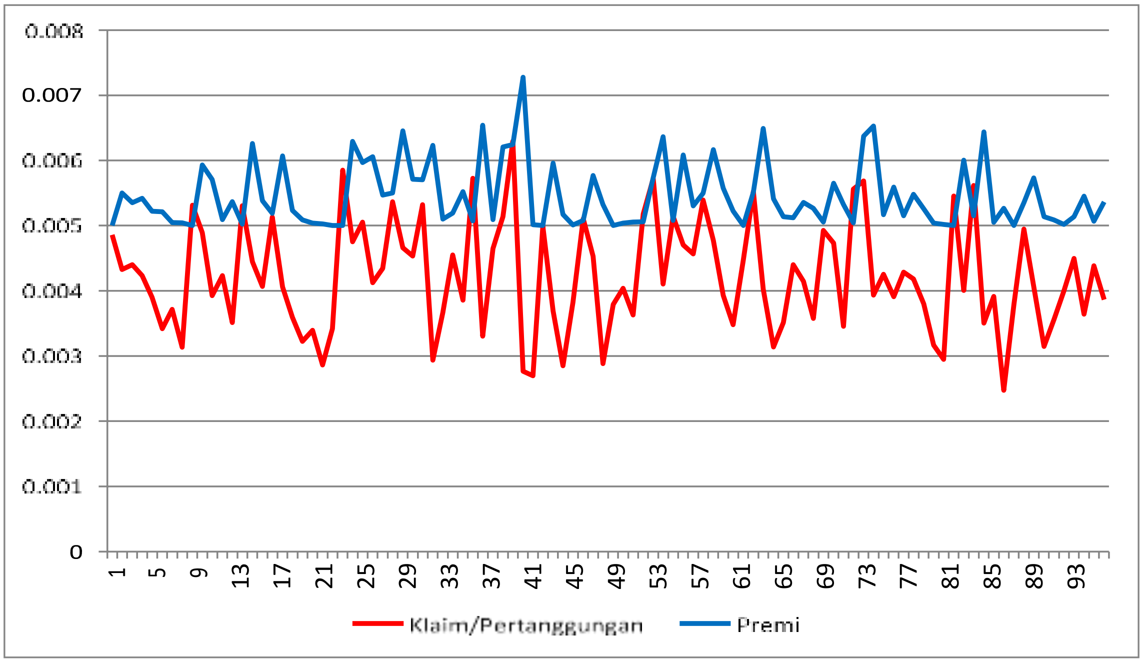


Figure 5.9. Premium rate and claim to sum insured ratio (%) under price regulation intervention

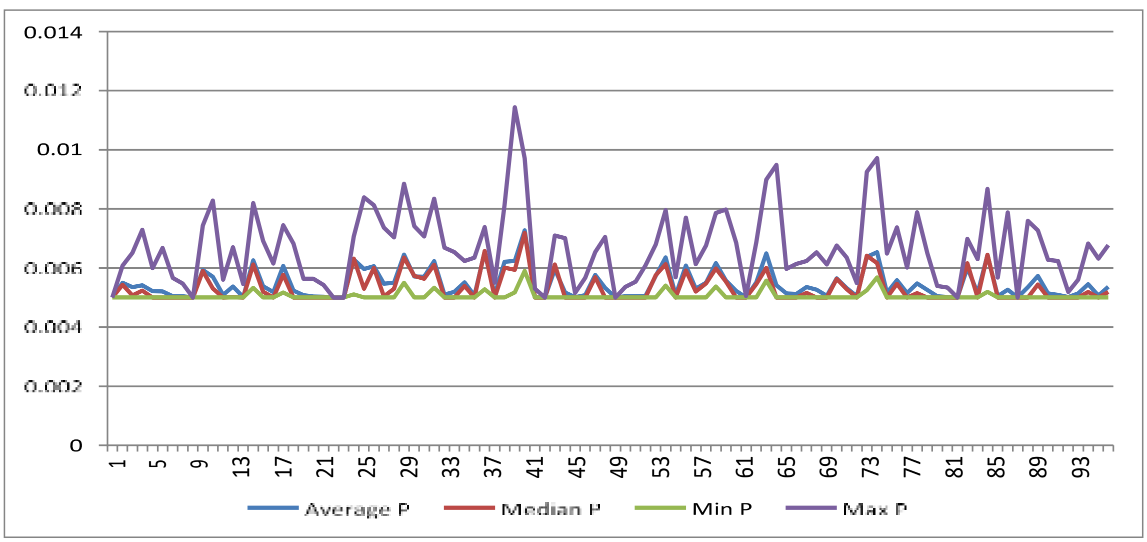


Figure 5.10. average, median, minimum, and maximum premium rate under price regulation

Sample: 1 100
Included observations: 100

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.101	-0.101	1.0458	0.306
		2	-0.138	-0.150	3.0325	0.220
		3	-0.013	-0.046	3.0515	0.384
		4	0.016	-0.013	3.0770	0.545
		5	0.041	0.034	3.2532	0.661
		6	-0.124	-0.119	4.9135	0.555
		7	0.041	0.025	5.0964	0.648
		8	-0.039	-0.068	5.2665	0.729
		9	-0.148	-0.166	7.7312	0.561
		10	0.015	-0.041	7.7574	0.653
		11	0.044	-0.001	7.9842	0.715
		12	0.040	0.015	8.1652	0.772
		13	-0.047	-0.028	8.4219	0.815
		14	-0.071	-0.081	9.0124	0.830
		15	0.070	0.007	9.5939	0.844
		16	0.049	0.034	9.8818	0.873
		17	0.081	0.090	10.681	0.873
		18	-0.097	-0.084	11.844	0.855
		19	-0.226	-0.251	18.282	0.504
		20	0.177	0.104	22.288	0.325
		21	0.012	-0.005	22.307	0.382
		22	-0.093	-0.103	23.439	0.377
		23	0.099	0.103	24.733	0.364
		24	-0.002	-0.000	24.734	0.420
		25	0.042	0.034	24.973	0.464
		26	-0.108	-0.044	26.588	0.431
		27	0.061	-0.016	27.112	0.458
		28	0.138	0.055	29.826	0.372
		29	-0.137	-0.053	32.511	0.298
		30	-0.009	0.017	32.524	0.344
		31	0.073	0.070	33.318	0.355
		32	0.019	-0.020	33.372	0.400
		33	-0.125	-0.115	35.754	0.340
		34	-0.005	0.050	35.757	0.386
		35	-0.018	-0.093	35.808	0.430
		36	-0.038	-0.033	36.038	0.467

ACF dan PACF Loss Ratio

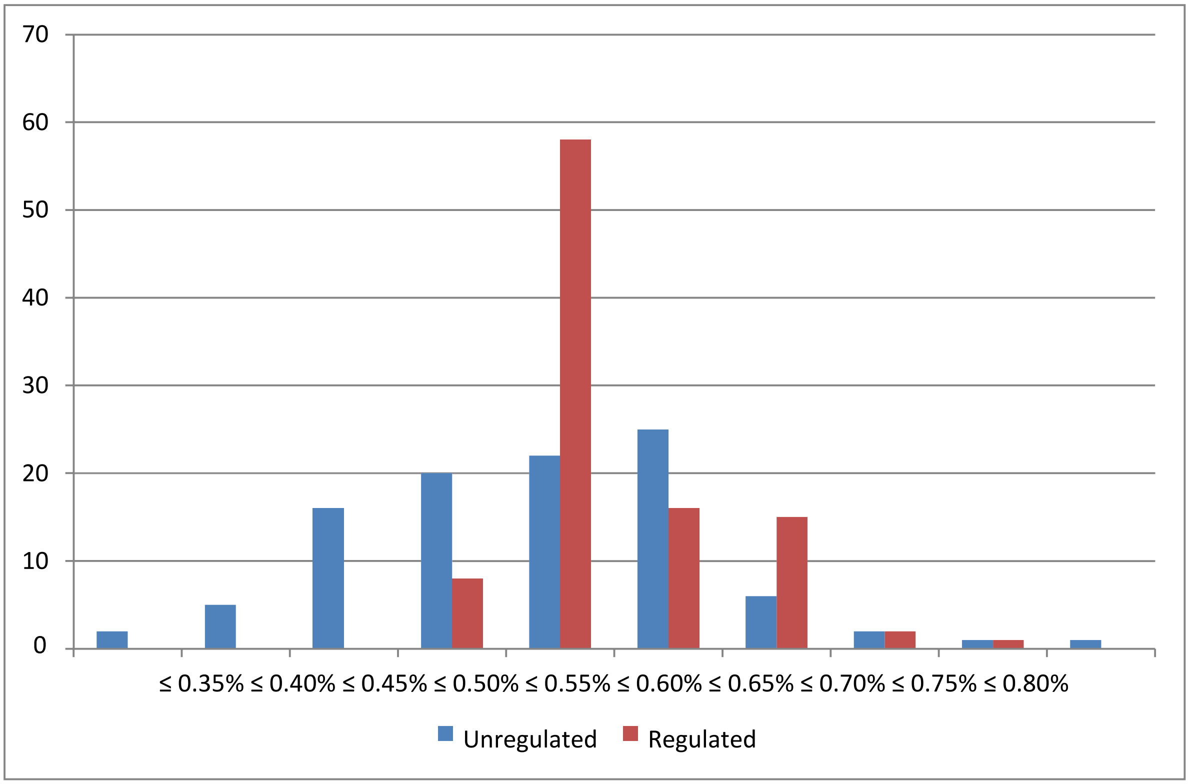


Figure 5.11. Histogram of Premium rate under premium regulation and no premium regulation

Figure 5.11 suggests that the histogram of average premium rate under the unregulated premium scenario is more left skewed compared to the regulated scenario. It means that the tendency of pricing war in the premium regulation environment is less intense compared to the unregulated environment.

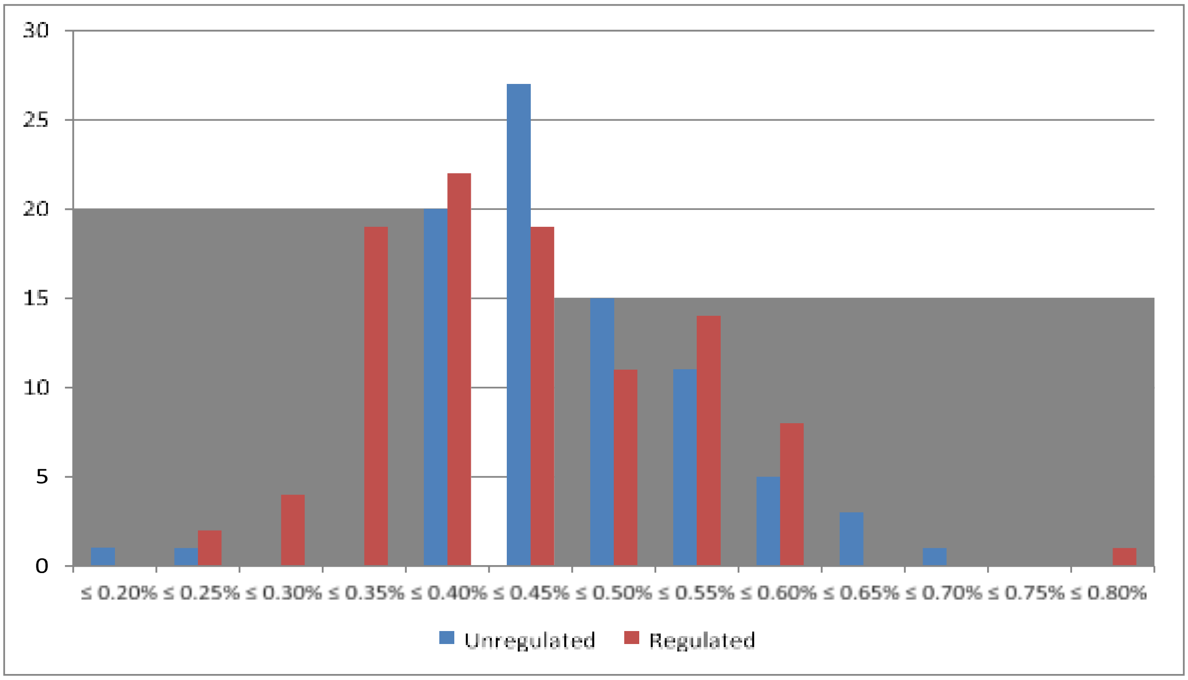
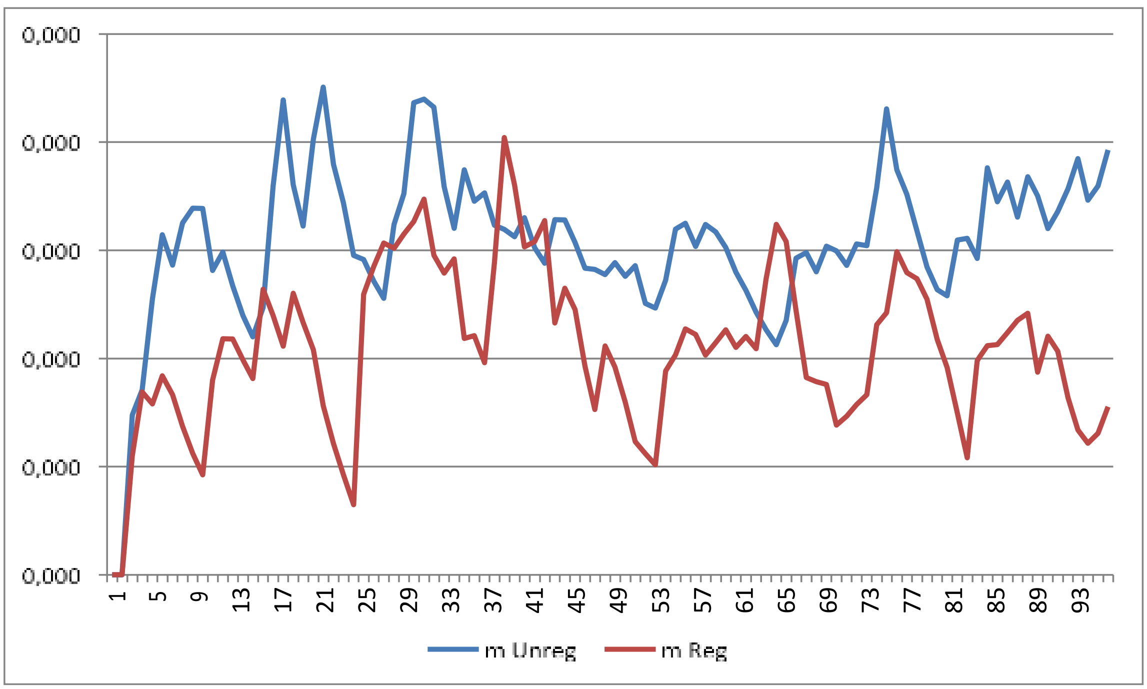
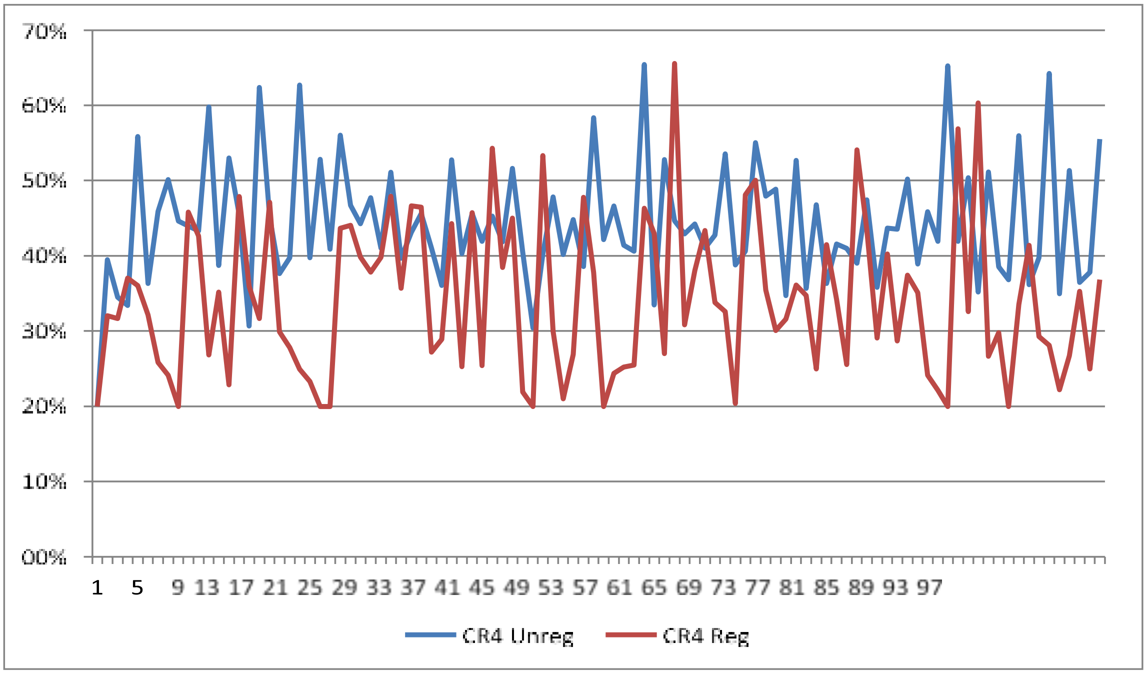


Figure 5.12. Histogram of Claim as % of sum insured



Mark-up adjustment Unregulated vs Regulated



CR4 Unregulated vs Regulated

Concentration ratio for four largest insurance firms in the market tends to be lower when the market is intervened by premium rate regulation. Regulatory intervention in the form compulsory range of premium forces each insurer to have a better knowledge about the range of premium rate offered by insurers in the market. Hence, the distribution of market share for each player is more spread.

6. Conclusion

In this paper, we presented an agent-based model (ABM) of auto insurance market, with the aim of understanding the dynamics which may generate insurance cycles. Unlike other models and theories of insurance cycles, our model excludes exogenous factors driving cycles, and yet we found that cycles emerge in terms of loss ratios. While we could not dismiss the role of exogenous factors such as capital shocks and interest rate fluctuations in promoting and maintaining insurance cycles, our ABM showed that cycles can arise endogenously if insurance markets are modeled as competitive, but not perfectly competitive. In particular, we made use of an economic location model to capture product differentiation and non-price preferences. In our model, insurers competed against each other and priced their products by calculating a premium based on past experience, and then adjusting through cost-plus or mark-up pricing. This provided a realistic description of actuarial and insurance practice.

Our model also assumes that there are multifinance companies acting as intermediaries for the insurer to obtain customers. Multifinance has knowledge about insurer and can help customer to find the right insurer for their risk coverage. We calibrated our model using Indonesia motor vehicle insurance data. Simple time series analysis showed that cycles were present in the simulated insurance loss ratios from our ABM, and that these cycles were comparable to those in the actual data. Our ABM showed that the monopolistically competitive nature of non-life insurance markets, with their differentiated products and with boundedly rational behavior of insurers and customers, may inherently create cycles, without requiring external factors. Simulation also show that regulation intervention in the form of range lower and upper of premium rate regulation can somewhat reduce the volatility of premium rate and market loss ratio performance.

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