The Externality of Driving Luxury Cars

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Abstract

Due to a striking difference in repair cost between foreign and domestic car in Korea, the foreign car drivers increased the property damage liability insurance costs of domestic car drivers. That is, driving foreign car creates negative externalities. We estimate auto accident externalities of driving luxury cars (more specifically foreign cars) by running a two part model (TPM) using individual level panel data on insurance claims and insured's characteristics. We find that negative externalities do exist in all of our specifications. To be specific, a 1% increase in foreign cars raises the property damage liability cost by 3-5.5% which indicates externality in severity. Each foreign car driver increases the property damage cost by USD 37-78 per year on average, depending on the specification. The nationwide increased liability cost is USD 27-48 million per year In Korea, this cost is currently shared by all drivers including the majority of domestic car drivers.

Key Words: Negative Externalities; Luxury Car; Auto Accidents; Tort Liability

1. Introduction

Two vehicles get into an accident. Under the tort system, the at-fault driver pays for the losses of both cars. Where a comparative negligence is applicable, the degree of negligence contributed to the accident is determined and each driver pays for their portion of losses. This comparative negligence tort system is adapted in many countries including Korea. This comparative negligence is considered to be quite fair and has been well accepted adjusting auto accident losses until recent. However, the increasing number of luxury cars generates a

debate questioning the fairness of the system.

If the repairing costs of two cars involved in an accident are fairly similar, the comparative negligence works well. However, when the values of properties vary significantly, this may not be the case. Consider an accident between an expensive and cheap car. Let's assume that the driver of the luxury car was 90% at-fault and the driver of the cheap car was only 10% at-fault for not doing excellent defensive driving. Both cars had minor scratches but the repair costs resulted to be $5,000 and $100 respectively. Now the driver of the luxurious car must pay $90 to his counterparty, and the driver of the cheap car needs to pay $500. If the repair cost of the luxury car had equaled that of the cheap car that is, $100, the driver of the cheap car would have only needed to pay $10. Suppose that all of a sudden your vicinity becomes full of luxury cars. The drivers of cheap cars do not really do anything bad but the liability costs of the cheap car driver increases as a result of increased luxury cars around. However, one's personal preference for luxury cars does not involve an increase in liability cost for others. The aforementioned example illustrates a negative externality from driving luxury cars which the tort system is not designed to address.

Repairing costs of cars vary to some extent but this seems to be a universal phenomenon observed in most countries. However, the price discrepancy becomes a problem in countries like Korea and China where the repair costs between domestic and foreign cars differ exceedingly. For example, in Korea, the repair cost of foreign cars is more than five times higher on average than that of domestic cars of similar size.[2] This striking difference is mostly caused by the costs of expensive parts of foreign cars. The abnormal gap between foreign and domestic cars is a dramatic issue in China. According to Chinese government, the

[2]Table A1 and A2 in Appendix shows the repairing cost difference of domestic and foreign cars and the repairing cost of domestic cars by car type.

sum value of individual parts is 12 times more expensive than the price of the car itself. In August 2014, Chinese authorities fined Volkswagen and Chrysler according to the anti-trust law for imposing higher prices in China for both vehicles and replacement parts. The exorbitant costs for spare car parts in Korea and China compared to other countries, lies in the fact that many automakers in these two countries insist replacement parts to be sold only through authorized dealers. This kind of monopolistic behavior raises the price of repairing costs of foreign automakers. Of course, it is not only the repairing cost that differs. Excessive rental and vehicle prices of foreign luxury cars also burdens drivers and insurers.

As a result, the insurance premiums of foreign cars are more expensive than that of domestic cars. Korean Insurance Development Institution recently announced that own car property damage coverage rate will be adjusted in 2015 and this will increase the rate of foreign cars by 11% on average. Some may consider that the increase in coverage solves the externality problem. However, it does not address the negative externality issue of foreign cars because the raise only applies to the property damage of own cars.

Along with the dramatic speed of economic development, the size of automobile market in Korea also grew very fast during the last few decades. Number of cars increased from 53,000 in 1980 to 1,940,000 in 2013, which is a 3,660% increase in 30 years. The Korean automobile market was dominated by domestic cars for a long time. However, recently, due to the rapid increase in income and active market opening, the number of foreign cars has been grown rapidly. The number of foreign cars quintupled in eight years; the number of registered foreign cars was 138,000 (1.25% of all registered car) in 2005 and this increased to 724,000 (4.8% of registered car) in 2013. In some districts in Seoul, the ratio of registered foreign cars is more than 20%. The growth in foreign car segment in the overall automobile market is expected to accelerate even further since the FTA with EU and the

United States came into effect, granting price competitiveness to foreign cars.

As shortly mentioned above, repairing foreign cars is much more costly than domestic cars and this may affect the decision of purchasing foreign cars. However, this cost is not fully borne by the owner of the vehicle but is shared by all other drivers on the road through the liability costs under the tort system. Therefore, the expensive repair cost may not fully provide an incentive to hinder the purchase of luxurious cars. This results in increased liability costs of all other drivers. Such situation arouses controversy since usually wealthy people tend to purchase foreign cars. That is, personal decisions of affluent people may burden people with relatively lower income in a circuitous route.

Does this negative externality of driving luxury car really exist in practice? That is, did the liability cost really increase? It is, in fact, not that obvious. Due to driver's awareness of high repair costs of foreign cars, drivers may show defensive driving as an effort to reduce losses. For example, drivers may try to hold distance from luxury cars on the road or in parking lots. Such behavior may help foreign cars not to increase accident severity, or may even reduce accident frequency.

Our paper is not the first research examining the accident externalities of driving. Vickrey (1968) discussed accident externality from driving. Through examining two groups of California highways he found out that higher traffic density leads to substantially higher accident rates. Vickrey's work was further extended by Edlin and Kraca-Mandic (2006) who attempted to provide better estimates of the aggregated accident externality from driving. Huang, Tzeng, and Wang (2013) used individual-level data in Taiwan and showed the negative externality exists. All of the studies focus on the quantity of driving.

However, there is no work examining the magnitude and the sign of the externality from driving luxury cars despite of its significance and the controversy it raises. The purpose

of this paper is to empirically examine the existence of negative externality of driving luxury cars and estimate the extent of it. We estimate the relationship between the foreign car ratio and the accident frequency and severity using two part model.

The liability cost is measured by insurer costs in this study. Figure 1 shows the positive relationship between insurer costs of property damage liability per accident (claim severity) and the foreign car ratio of a given region in 2013. This positive correlation indicates possibly existing negative externality from driving luxury cars.

[FIGURE 1 ABOUT HERE]

Difference in foreign car ratio is not the only possible explanation for the relationship shown in Figure 1. In order to address alternative reasons such as differences in car types, road conditions, and demographics, we run multivariate regressions with panel data from 2009-2013 controlling for region and year fixed effect, and individual level variables that are known to affect accident frequency and severity. We also include density, following previous researches on driving externality.

We find that negative externalities do exist. The claim severity of property damage liability increases significantly, as foreign car ratio increases whereas accident frequency stays unaffected. As severity increases and frequency is not affected, the total effect of foreign car on liability loss is positive. In Seoul, which has the highest ratio of foreign cars, we estimate that foreign cars increase auto liability costs by 3,798 won (appx. USD 3.8) to 6,694 won (appx. USD 6.7) per driver per year depending on the specification. This corresponds to a total annual increase of 11,474,627,742 won (appx. USD 11 million) to 20,224,106,926 won (appx. USD 20 million) in loss. The total increase in costs nationwide

reaches over USD 27-48 million. Our conclusion is robust to all specifications.

In the next part we suggest the framework for luxury car accident externality. The data are presented in section 3. Section 4 presents the main results of regressions. The robustness of results is discussed in section 5. Section 6 concludes.

2. The Framework

Let N be the number of total cars on road and let F be the number of foreign cars. The ratio of foreign cars is F/N. When considering a car accident, the probability of encountering a foreign car will be F/N the expected liability cost of a given driver i can be illustrated as follows:

$$c = c_1 \times \frac{N-F}{N} + c_2 \times \frac{F}{N} = c_1 + (c_1 - c_2) \times \frac{F}{N} = \alpha_1 + \alpha_2 \times \frac{F}{N} \qquad (1)$$

where c_1 represents the average liability when the other car is domestic car and c_2 is the average liability when your other party drives a foreign car. (c_1-c_2) is the increased cost due to the foreign car on roads. We expect the cost of property damage liability per accident to be strictly positive for α_2. The effect on accident frequency is however, uncertain. If high costs of repairing foreign car encourages drivers to drive more cautiously, accident frequency and foreign car ratio may have negative relationship. The combined effect of all of these on total liability cost is, therefore, ambiguous.

3. Data

Our data was obtained from one of the largest insurance companies in Korea. The individual-

level insurance data contains auto insurance claim records, coverage choice, premium, and rating factors. Rating factors includes variables such as policyholder's age, gender, car age, type of car, capacity, and registered. The claim records can be used as a proxy for accident information including accident frequency and severity.

In order to examine the effect of foreign car on liability cost, we obtained foreign car ratio of 16 administrative regions in Korea from The Ministry of Land, Infrastructure and Transportation. Table 1 shows the 16 district and the registered foreign car ratio in 2009 and 2013. The cross sectional and time series difference of foreign car ratio during the sample period is quite significant; in 2013, the foreign car ratio of Seoul area is about 7% and the foreign car ratio of Gyeongbuk region is only 1.36%. Moreover, during the sample period, the foreign car ratio increased more than 350% in Daegu area whereas the increase rate only comes to 10% in Busan area.

[TABLE 1 ABOUT HERE]

Unfortunately, information on foreign car registration is somewhat contaminated by car registration fee difference across regions. In order to attract more vehicles to be registered and collect more tax, Gyeongnam province reduced its tax rate significantly in 2008. Since vehicle registration requires a valid address in the given area, for personally owned cars, registration region mostly corresponds with the region of residence. However, the policy leaved loopholes for auto lease firms. Many auto lease firms opened up a little office in Gyeongnam and registered their cars there. Gyeongnam province even opened up a vehicle registration office in Gangnam district, Seoul where the foreign car ratio is the highest in Korea for convenience. Inchoen, which is very close to Seoul, followed Gyeongnam's

strategy, they lowered tax rate in 2011. As a result, Gyeongnam, which is not a metro city but a country area, has very an extremely high foreign car ratio and especially an unusually high business vehicle ratio as is shown in Table A3 in Appendix II. The foreign car growth rate in Gyeongnam drops substantially in 2011 when Inchoen lowered the tax rate. From 2012, we can see that the foreign car growth rate is unusually high and the business vehicle registration surges in Incheon.

Because of this contamination, we adapt a few strategies to minimize noise created by this tax issue. First, we discard Gyeongnam data, which we consider to be unsound due to the aforementioned reasons. Second, we calculate a modified foreign car ratio as follows and apply the modified ratio in further analyses. We first assume that Gyeongnam's true foreign car ratio is close to Gyeongbuk, which shares the most similarities in geographical, cultural, political, and economical aspects. Then, we estimate the number of foreign cars driven in Seoul but registered in Gyeongnam by subtracting the number of registered foreign cars in Gyeongbuk from the number of registered foreign cars in Gyeongnam. Then we add back this number to the number of foreign cars in Seoul. For Inchoen, we assume the foreign car growth rate is 40% in 2012 and 2013 and estimate the true foreign cars driven in Incheon. Again, we add back the difference to Seoul for year 2012 and 2013. As a robustness check, we run regressions with original foreign car ratio without Gyeongnam for whole years and Inchoen in 2012 and 2013. The results remain the same. Additionally, we run regressions using Gangnam district dummy variable as an alternative measure for foreign car. The procedure of Gangnam regression is detailed in section 6 robustness checks.

From year 2009 to year 2013, we obtained 17,597,536 individual level panel observations. We also delete Sejong which is a small special administrative city at the border of three other regions because the lack of information during the former years. After the

deletion of Sejong and Gyeongnam province, we have 16,124,423 observations. The sample has 15,324,560 observations after the deletion of missing variables. Only a quarter of the policies in 2013 data have completed one year information because the termination date of the other 3/4 were not arrived when we attained the data. Therefore, we discard these observations when we analyze total loss and claim frequency. After the deletion of part of 2013 observation, we have 14,061,546 observations. For the analysis of per accident severity, we only analyze the observations with positive liability property damage claims. In this part we include all data of 2013 year data because per accident severity is not affected by the fact the accident information does not contain the full year information. The number of observation of this sample is 1,534,388. Table 2 shows the definitions for all variables used in the study.

[TABLE 2 ABOUT HERE]

We control for region and year fixed effect in the regression analysis. In addition, we add density as a control variable as is suggested by Vickrey(1968), Edlin and Kraca-Mandic (2006), and Huang, Tzeng, and Wang (2013). Density is defined as the yearly average km driven divided by the average length of lanes in each region following Edlin and Kraca-Mandic (2006). The average driven km of each district is obtained from the Korean Transportation Safety Authority and the average length of lanes is from Korean Statistical Information Service.

[TABLE 3 ABOUT HERE]

Summary statistics are presented in Table 3 and 4. Panel A of Table 3 presents summary statistics of dependent variables and continuous explanatory variables. The probability of property damage liability claim is about 11% in our sample. The average claim size was approximately USD 1,000. Figure 2 shows the distribution of claim severity. The distribution is skewed and is far from normal distribution. For regression analyses, we log-transform the severity. The log severity is close to the normal distribution as is shown in Figure 3.

Panel B. of Table 3 presents the correlation between continuous variables and dependent variables. The correlation between foreign car ratio and density is quite high at 0.57. Although we have a very large number of observations, the foreign car ratio and density variables only vary at the level of region and year. Due to the concern of possible multicollinearity issue, we run regressions with and without density variable. In this univariate relationship, the correlations between severity and foreign car ratio and between frequency and foreign car ratio are positive. The correlation between density and severity is negative and the correlation between density and frequency is negative. All correlations are significant at 1% level.

[FIGURE2 ABOUT HERE]

Table 4 provides summary statistics of rating variables. All of the variables in this table are categorical rating variables. Percentage shows the percentage each category accounts for. Mean loss is the average loss reflecting both frequency and severity of claims. Claim probability and claim severity shows the average claim frequency and average per accident claim amount for each categorical variable. Accident severity and frequency is lowest for the age group 30 to 40, car age older than 15, small capacity cars, age limit of 35

year old or higher, driving experience more than 4 years, couple only coverage option, low mileage option, no traffic violation group, and higher BMS coefficient group (bonus group).

Gender, foreign car, and sports car show the opposite effect on frequency and severity. Male drivers tend to have higher accident severity but lower frequency. Male drivers are possibly more aggressive but skillful at the same time, so they tend to have fewer accidents but given an accident the severity tends to be higher. Foreign car has a negative sign in frequency but positive in severity. Foreign car drivers tend to drive more carefully but once they have an accident, the severity is higher. This also applies to sports cars. A possible explanation for this is that the total driven mileage of a sports car may be lower in comparison with others since they are generally used as a second car for leisure purposes. As a result, sport cars may have lower accident frequency but higher severity.

4. Methodology

4.1. Two-part model

The goal of our paper is to estimate the effect of foreign cars on the liability claims. Because loss data only have positive numbers when accidents occur and claim is reported, the loss data has a large proportion of zeros. The liability losses can be considered as having two separate data generating processes: one for the accident frequency and the other for the severity if claims. One simple approach for large proportion of zeros is running the well-known Tobit model with lower censored boundary at zero. Tobit model assumes that there is a latent variable y_i^* which has the following linear regression model:

$$y_i^* = X_i'\beta + \epsilon_i \qquad (2)$$

We observe $y_i = \max(y_i^*, lb)$, where lb is the lower boundary of observations. In our case, lb corresponds to zero. Tobit regression allows estimating the unbiased marginal effect of X on the latent variable y_i^* and y_i in many cases. This, however, is inappropriate because Tobit regression assumes that a single latent variable determines both the magnitude of severity and the frequency of losses, which may not be the case. For example, more skillful but aggressive male drivers may have lower accident frequency but higher severity given an accident than female drivers.

Cragg(1971) suggests a two-part model which separates two data generating processes using insurance examples. This methodology has been used in health care and insurance literature (Mullahy, 1998; Bowers et al., 1997). Two-part model takes the simple probability rule and divides insurance claim into frequency and severity. So the expected claim is

$$E[y|x] = \Pr(y > 0) \times E(y|y > 0) \qquad (3)$$

Where y is the claim amount and x is set of explanatory variables. The first part, Pr(y>0) can be estimated using a binary regression model such as probit or logit. The second part E(y|y>0) can be estimated using OLS or GLM regression. When the dependent variable is count variable, the second part can be estimated using count regression models and two part model is called as Hurdle model. Unlike Tobit, the coefficients in these two regressions are not necessarily the same.

We adapt the Two-part model. The first part contains the frequency regression using logit model and the second part includes the severity regression using OLS with robust error

adjustment. The total marginal effect is estimated from the equation (4).

4.2. First part: the effect of density on loss frequency

Our five year panel data includes the number of claims filed by policyholders. We run a logit regression with dependent variables being zero if there is no claim and one if there is a claim.[3]

The model is expressed as following:

$$\text{Number of claims} = \text{Logit}\left(\alpha_t \quad + Foreign_{i,t}\beta_f + X_{i,t}\beta_x + Z_{i,t}\beta_z\right) \quad (4)$$

The βs are the corresponding coefficients and X_i is the vector of information on each insured, including characteristics of both the policyholder and the vehicle and Z_i represents the vector of region information. In order to control fixed effects of year, year dummies are included. A significant and negative β_f means that more foreign vehicles in region cause fewer accidents. Out of concern of multicollinearity, we run regressions with and without density. In this claim frequency regression, we expect the density variable to have positive and significant coefficient as is shown in the previous driving externality literature.

4.3. The effect of foreign car ratio on loss severity

In order to examine the externality of driving foreign car on the loss severity we use the OLS

[3] As we can observe the number of reported auto insurance claim, we also consider either poisson or negative binomial regression. Negative binomial regression fits better when modeling over-dispersed count outcome variables, which is the case of our sample. We additionally run negative binomial regression. The results of negative binomial regression are almost the same as the one with logit regression. Results are available upon requests.

regression with robust errors as below:

$$\text{E[Per Claim Loss Amount | Claim]} = \alpha_t \quad + Foreign_{i,t}\beta_f + X_{i,t}\beta_x + Z_{i,t}\beta_z \qquad (5)$$

$X_i$is the vector of variables on each insured, including characteristics of both the policyholder and the vehicle including vehicle registered region dummy variable. Z_i represents the vector of region information. A positive β_f means that claim severity is higher in regions where more foreign cars are driven. Year dummies are included to control for year-fixed effects. Edlin and Kraca-Mandic (2006) and Huang, Tzeng, and Wang (2013) had conflicting results in the relationship of claim severity and density. Edlin and Kraca-Mandic noted that high density reduces claim severity. They found negative but insignificant coefficients in US data. Huang, Tzeng, and Wang, on the other hand, found positive relationship between claim severity and density in Taiwan. We expect that higher density reduces the severity given an accident because the higher density may reduce the driving speed.

5. Empirical results

Table 5 reports the effect of driving foreign cars on liability claim frequency and severity. The coefficients of foreign car ratio are insignificant in frequency regressions but significantly positive in severity regressions. The results confirm our hypothesis that foreign cars increase the severity of property damage liability. The claim frequency is unaffected.

[TABLE 5 ABOUT HERE]

The results of density are noteworthy. Our frequency results show that density has a positive but insignificant impact, suggesting possible negative driving externalities as is found in Edlin and Kraca-Mandic (2006) and Huang, Tzeng, and Wang (2013). However, the severity is rather lower in areas with high density. This result is consistent with Edlin and Kraca-Mandic (2006) but opposes the results of Huang, Tzeng, and Wang (2013). Conflicting results are not so strange, though, because the negative externality of density may vary in different locations. When the density is too high, higher density may reduce frequency. It is also possible to have lower severity in high density area if better planned roads are constructed as demanded, or safer conditioned roads attract more drivers, high density may yield lower frequency and severity. Therefore, the verification of driving externality is left to empirical studies.

The results of other control variables are mostly significant and have expected signs. Most individual characteristic variables have the same sign in both severity and frequency regression implying that high risk drivers tend to have both more and heavier accidents . A few variables show the opposite sign as is already shown in the data section. The multivariate regression results are mostly consistent with the univariate comparison in Table 5. The only difference is the age variables. This could be due to the fact that the age limit options and age variables are highly correlated and the age variable shows incremental information after controlling for the age limit coverage. Among all variables, bonus-malus coefficient had by far the highest Chi-square in the frequency regression followed by driving experience of one year. It suggests that there are much of unobserved or unused information in auto insurance rating, and those are well captured in the bonus malus coefficients. In severity regression, capacity1 and bonus-malus coefficient had the highest t value.

After running two-part model, the marginal effect of a continuous variable x_i on y

can be estimated as follows.

$$\frac{\partial E(y)}{\partial x_i} = \frac{\partial(Pr(y>0)\times E(y|y>0))}{\partial x_i} = Pr(y>0)\times\frac{\partial E(y|y>0)}{\partial x_i} + E(y|y>0)\times\frac{\partial Pr(y>0)}{\partial x_i} \qquad (6)$$

As the frequency is unaffected in our analysis, the second term in equation (6) can be ignored and we modify the marginal effect as below because there can be more than one accident per year.

$$\frac{\partial E(y)}{\partial x_i} = [\sum_{i=1}^{N} i \times Pr(y=i)] \times \frac{\partial E(y|y>0)}{\partial x_i} \qquad (7)$$

Table 7 shows the estimates of increased liability losses. In Seoul, the region of highest foreign car ratio, foreign cars increased property damage costs by 3.07-5.42%. This corresponds to 61,025 won (USD 61) per accident and 3,798 - 6,694 won per driver in Seoul annually. In a region with lowest foreign car ratio, Gyeongbuk, the estimated externality cost is about 515-898 won per driver.

[TABLE 6 ABOUT HERE]

A typical way to address negative externality is levying Pigouvian tax. Pigouvian charge may induce people to choose domestic cars or provide incentives to reduce the repair costs of foreign cars. If Pigouvian tax is charged, the revenue would be around 27-48 billion won (USD 27-48 million) and each foreign car drivers will be charged about 38,000-66,000 won. Alternatively, insurers may charge higher liability insurance premium for foreign car drivers and subsidize domestic car driver's premium with the additional revenues. That is,

liability insurance premium can be raised by 38,000-66,000 won (USD 38-66) for foreign car drivers and domestic car driver's insurance premium can be cut by 1,400-2,500 (USD 1.4-2.5) per person annually. This means 21%-37% premium increase for foreign car drivers and 0.8%-1.5% decrease for domestic car drivers.

6. Robustness Checks

6.1. Gangnam district regression

The registered foreign car ratio data is somewhat contaminated because of vehicle registration tax issue detailed in data section. In order to reduce the noise created by this issue, we have created a modified foreign car ratio. Out of concern that our modified ratios are still somewhat inaccurate, we examine the effect of foreign cars in an alternative way.

In Seoul, the capital city of Korea reside about 20% of Korean population in 2014. Also, the foreign car ratio is the highest in this region. There are 25 districts in Seoul. These districts are pretty homogeneous compared to other regions in Korea in terms of population distribution, hospital costs, and etc., but wealth distribution and foreign car ratios within in Seoul vary quite significantly. Among the 25 two - Gangnam gu and Seocho gu, are theso-called "Gangnam" area, also being spotlighted in the famous singer Psy's "Gangnam Style". . Gangnam area can be considered as Seoul's Beverly Hills. Housing prices are notoriously high and the foreign car ratio is known to be the highest among all districts in Korea.

Due to data restriction, we do not have an access to the foreign car ratios of 25 districts in Seoul. So we instead make a dummy variable for Gangnam. Our strategy is to run regressions with this dummy variable using observations of Seoul and test whether the per claim severity is higher in these areas. Figure 3 shows the average foreign car ratio calculated from our database. The foreign car ratio in Figure 3 might be biased if foreign car owners

show preference for the certain insurance company we gained our data from. However, if the preference is a stable factor and does not differ across time and districts, our estimates in figure 3 will be relatively plausible.

Because the number of foreign cars increased explosively in this area during the sample period we also run regressions year by year and examine whether the coefficient of Gangnam dummy changes or not. We hypothesize that the per claim severity of the property damage liability is larger in Gangnam area and the difference increases over time. For frequency, we conjecture that accident frequency is higher in this region as it has higher density. We expect that the accident frequency difference between Gangnam and non-Gangnam does not change over time if foreign car ratio does not affect the accident frequency as is found in the previous section.

[TABLE 7 ABOUT HERE]

Table 7 presents the result of Gangnam regressions. The results are consistent with our hypotheses. The property damage severity is higher compared to other districts in Seoul. As predicted, property damage severity monotonically increases over time in Gangnam area, supporting the foreign car effect. Frequency is also higher in Gangnam, which reflects the density effect. Time trend is not found in frequency regression.

6.2. Censored Losses

Since we used claims as a proxy of actual accidents our data is prone to variable truncation issues. First, very minor accidents may not be observable due to the so-called bonus hunger behavior. Although we do not have an issue with deductibles because the deductible only

applies to the own car's property damage, not the liability losses, some people may not report small accidents because their auto insurance premium will increase as a result of a claim. This is less likely to be an issue in Korea because Korea adopts a somewhat unique national bonus-malus system which reflects the severity of an accident. Korea's bonus-malus system does not penalize accidents which only involves minor property damages. So it is known that most of the accidents are reported. Consistent with this, we do observe quite a few observations with property damage severity below 200,000 won (appx. USD 200); 7 % of property damage liability losses are below 200,000 won in our sample.

Another possible problem is that the loss exceeds the limit of liability coverage. For property damage liability, there are ten options to choose from. The coverage choice is shown in Figure 4. Most drivers chose 100,000,000 won (appx. USD 100,000) as a limit in 2009 and about 60% opt for a coverage of higher than 200,000,000 won (appx. USD 200,000) in 2013. This dramatic change is probably due to the foreign car ratio increase. Auto insurance agencies explicitly mention on their websites “We recommend higher limits due to the increased number of foreign cars.” In addition, cases of accidents with extra ordinarily expensive property damage liability costs were publicized through SNS and media, encouraging people to change their limits.

This, in fact, may bias our results. If the coverage change coincides with foreign car ratio, which is likely if policyholders behave rationally, and property damage liability losses are often truncated due to the limit, foreign car ratio and the claimed loss severity may have a positive relationship even without any actual cost changes due to foreign cars. Out of this concern, we first examine the possibly censored losses. About 5% of people chose the mandatory coverage of 10,000,000 won. Among over the 1.5 million property damage liability losses, in 84 cases the size of loss equaled the limit of property damage and 68 out of

84 cases had the lowest limit of 10,000,000 won. So the impact of censored loss seems to be minor.

To address censored data issue, we conduct regressions excluding those who selected 10,000,000 won limit. This new sample includes 20 censored cases out of over 1.5 million claims. In addition, we run Tobit regression with an upper limit of 10,000,000 using the full sample. The results of these two regressions are presented in Table 8. Results remain mostly unchanged in both specifications.

[TABLE 8 ABOUT HERE]

7. Conclusions

This article examines the externalities of driving luxury cars. We examine the effect of foreign car ratio on property damage liability claims in a sample of 14,061,546 individual level panel data between 2009 and 2013 in Korea.

Using the two-part model, we find significant evidence that driving foreign cars generates negative externality in Korea. We find that foreign cars increase per claim severity of property damage liability and have insignificant effect on the frequency. The combined effect increases liability costs of all drivers. Specifically, on average, in Seoul, the region of highest foreign car ratio, foreign cars increased property damage costs by 3.07%-5.42%. This corresponds to 61,025 won (USD 61) per accident and 3,798 - 6,694 won per driver in Seoul annually. This result is robust to numerous specifications such as censored regression and small sample regression. The same negative externality was found when we run an alternative regression using Gangnam dummy variable for Seoul sample only.

The results suggest that foreign car owners cause negative externality and this cost is

currently shared by the majority of domestic car drivers. As foreign car owners are generally wealthier than domestic car driver, this is a quite controversial issue in Korea. According to a project perception survey by KAIDA (Korean Automobile Importers & Distributers Association) in 2008, 56 percent of people show negative public opinion on foreign car owners. 24 percent of foreign car owners have a fear of personal harm or loss due to this negative perception (KAIDA, 2008). Mass media partly aggravates such negative perception by often publicizing the unfairness of liability losses when having an accident with foreign cars.

Regulators are aware of this fact and try to resolve the issue. In order to reduce the increased property damage costs, insurers currently consider offering a similar sized domestic car as a rental car when foreign car is under repair, using alternative parts instead of the authentic dealer provided parts in order to lower repair costs, and etc. Some even argue to move on no-fault system. Considering the current negative perception and the fear of harm that foreign car owners have, no-fault system does not seems to be a good solution because this may create large moral hazard issue. Unless Korean government finds a way to reduce the repair cost disparity between foreign cars and domestic cars to a reasonable level, the social stress caused by the negative externality will keep increasing.

Our research focuses on the negative externality caused by luxury cars in Korea. This, however, is not limited in Korea. For example, China faces the same issue. Many other countries whose domestic car manufacturers compete with foreign brands may have the same repair cost structure, thus suffer from similar kind of negative externalities. Although the level of repair cost can be much smaller in other countries, luxury cars on road about anywhere in the world are just more expensive to repair, causing the same issue. This kind of negative externality also does not need to be limited to cars. Expensive properties around

may increase the liability risk. An expansion and application of this idea can be numerous.

References

Bowers, Newton L., Hans U. Gerber, James C. Hickman, Donald A. Jones and Cecil J. Nesbitt, 1977, Acturial Mathematics, Society of Actuaries, Schaumburg, IL.

Cragg, John G., 1971, Some statistical models for limited dependent variables with application to the demand for durable goods, Econometrica 39(5), 829-844.

Edlin, A. S., and P. Karaca-Mandic, 2006, the Accident Externality from Driving, Journal of Political Economy, 114(5): 931-955.

Huang,R.J, L.Y.Tzeng, and K.C. Wang, 2013, Heterogeneity of the accident externality from driving, Journal of Risk and Insurance

Korea Automobile insurance repair research and training center, 2011, available at: http://www.kidi.or.kr/about/about06_view.asp?no=371&Cur_Page=1&s_kw=%BC%F6%B8%AE%BA%F1&select2=0

Mullahy, John, 1998, Much ado about two: Reconsidering retransformation and the two part model in health econometrics, Journal Health Economics 17, 247-281.

Parry, I. W. H., M. Walls, and W. Harrington. 2007. Automobile Externalities and Policies, Journal of Economic Literature, 45(2): 373-399.

Vickrey, W., 1968, Automobile Accidents, Tort Law, Externalities, and Insurance: An Economist's Critique, Law and Contemporary Problems 33(summer): 464-487.

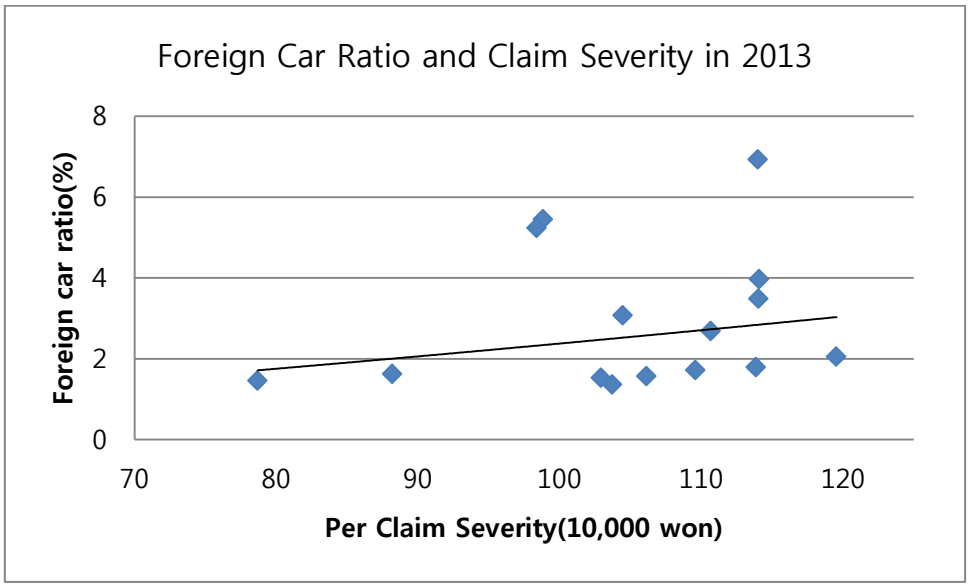

Figure 1. Foreign car ratio and claim severity

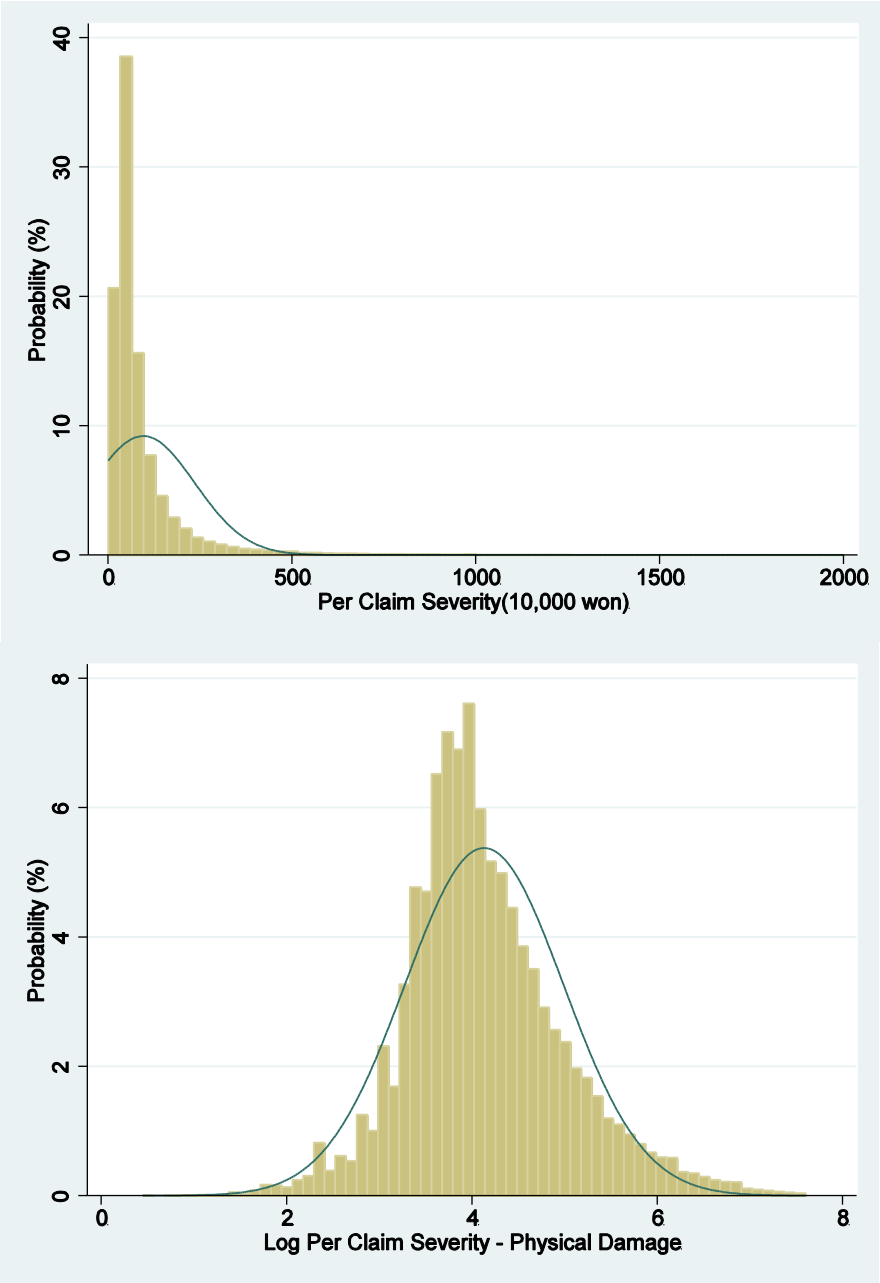

Figure 2. Claim Severity Distribution

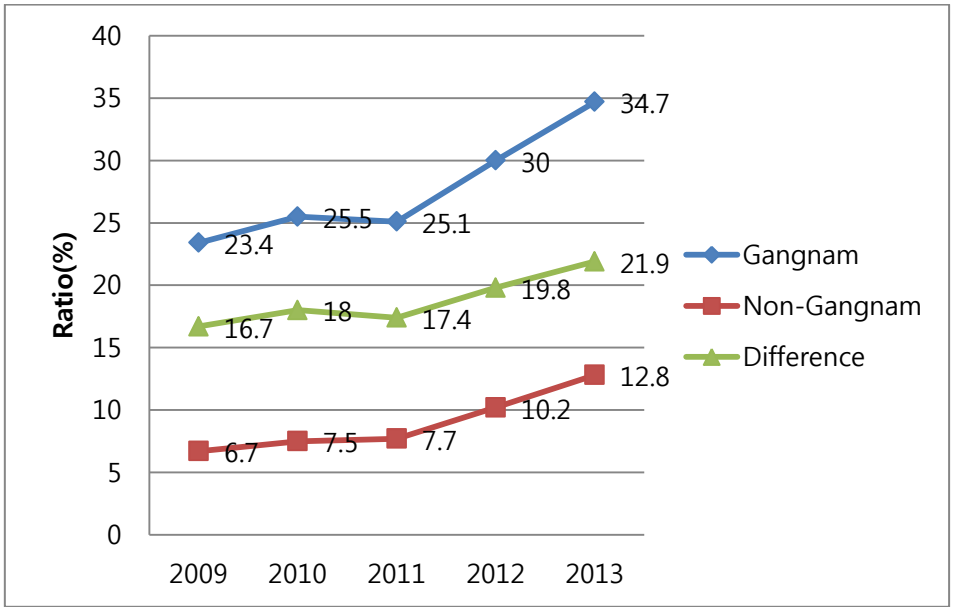

Figure 3. Foreign car ratio change in Seoul

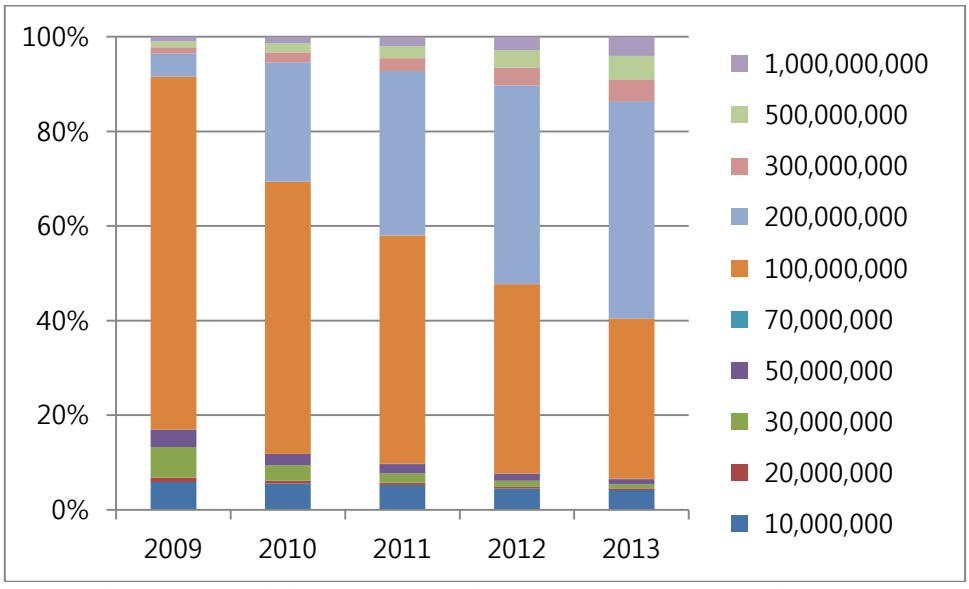

Figure 4. Change in Liability: Property damage Coverage Distribution (unit: won)

Table 1. Foreign Car Ratio by State/Year

	Number of Registered Foreign Cars			Percentage of Registered Foreign Cars to All Registered Cars(unit: %)		
	2009	2013	% Increase	2009	2013	% Increase
Seoul	120,643	205,676	70.48%	4.08%	6.93%	69.85%
Busan	55,655	64,319	15.57%	4.97%	5.45%	9.66%
Daegu	10,548	54,376	415.51%	1.16%	5.23%	350.86%
Inchon*	9,108	45,229	396.59%	1.01%	3.97%	293.07%
Gwangju	6,675	17,478	161.84%	1.36%	3.07%	125.74%
Daejon	5,713	16,354	186.26%	1.04%	2.68%	157.69%
Ulsan	2,822	7,960	182.07%	0.66%	1.62%	145.45%
Gyeonggi	68,207	157,675	131.17%	1.70%	3.48%	104.71%
Gangwon	3,786	9,960	163.07%	0.64%	1.53%	139.06%
Gyeongbuk	5,785	16,409	183.65%	0.54%	1.36%	151.85%
Gyeongnam*	29,803	66,131	121.89%	2.29%	4.44%	93.89%
Chungbuk	4,128	11,533	179.38%	0.70%	1.72%	145.71%
Chungnam	5,984	15,968	166.84%	0.75%	1.79%	138.67%
Jeonbuk	5,031	16,015	218.33%	0.74%	2.05%	177.03%
Jeonnam	4,507	12,587	179.28%	0.65%	1.57%	141.54%
Jeju	1,057	4,808	354.87%	0.44%	1.46%	231.82%

Table 2.Variables and their definitions

Variables	Definition
Dependent Variables	
Claim	The number of claims filed by the policyholder
Per claim amount	The per claim amount (in ten thousand won)
The insured's characteristics	
Foreign car ratio	Foreign car ratio of each district (number of foreign cars/number of registered cars)
density	The average kilometers driven per year in each area divided by lanes
age1525	1 if age in years between 15 to 25
age2530	1 if age in years between 26 to 30
age3040	1 if age in years between 31 to 40
age4060	1 if age in years between 41 to 60
crage05	1 if age of car in years between 0 to 5
crage10	1 if age of car in years between 10 to 15
crage15	Base category
capacity1	1 if capacity is categorized as small
capacity2	1 if capacity is categorized as medium
capacity3	1 if capacity is categorized as large
foreign	1 if car is of foreign brand
sportscar	1 if car is categorized as sportscar
foreign	1 if car is of foreign brand
male	1 if insured is male
expr1	1 if driving experience is 1 year
expr2	1 if driving experience is 2 years
expr3	1 if driving experience is 3 years
expr4	1 if driving experience is 4 years
limit_couple	1 if special contract on couple is included
limit_one	1 if special contract on one person is included
limit_two	1 if special contract on two person is included
agelimit1	Base category (no special contract on age)
agelimit2	1 if special contract on age over 20 is included
agelimit3	1 if special contract on age over 24 is included
agelimit4	1 if special contract on age over 26 is included
agelimit5	1 if special contract on age over 30 is included
agelimit6	1 if special contract on age over 35 is included
agelimit7	1 if special contract on age over 43 is included
agelimit8	1 if special contract on age over 48 is included
lowmile	1 if special contract on low miles driven is included
violation	1 if violation is observed
bms	Bonus Malus coefficient. 11 is the starting class. 1-10 are malus (panelty) and 12-25 are bonus (discount) classes

Note: Base variables are age60up, crage15, capacity4, domestic, non-sportscar, exp4up, no limit or family only, no age limit, non-lowmile, non-violation

Table 3. Summary statistics of dependent and continuous variables

Panel A. Summary statistics

Variable	N	Mean	Median	Std Dev	Maximum	Minimum
Dependent variables						
Number of Claim	14,061,546	0.11	0	0.34	12	0
Claim Severity	1,352,755	99.32	53.5	182.56	26178	1
Continuous explanatory variables						
Foreign car ratio	14,061,546	2.67	2.06	1.76	6.93	0.44
Density	14,061,546	4.33	5.32	1.94	6.68	0.89

Panel B. Correlations between continuous variables

	Frequency	Severity	Foreign Car Ratio	Density
Frequency	1			
Severity	-0.0040***	1		
Foreign Car Ratio	0.0059***	0.0184***	1	
Density	0.0115***	-0.0121***	0.5652***	1

Table 4. Summary Statistics of Rating Variables

Category	Variable	Percentage(%)	Mean Loss (10,000 won)	Claim Probability (%)	Claim Severity (10,000 won)
Age	age1525	1.06	18.30	13.85	114.54
	age2530	6.53	13.30	11.27	106.15
	age3040	27.62	9.48	8.99	97.05
	age4060	54.10	10.14	9.46	98.46
	age60up	10.69	10.09	9.39	98.52
	crage05	40.47	10.89	9.70	102.12
	crage10	31.65	11.21	10.34	99.04
	crage15	22.15	8.82	8.50	95.05
	capacity1	34.34	9.28	9.36	90.79
	capacity2	30.66	10.76	9.80	100.10
	capacity3	15.90	10.67	9.00	108.71
	capacity4	19.10	11.70	10.00	105.30
	sportscar	0.73	11.64	7.00	146.09
	nonsports	99.27	10.41	9.60	99.06
	foreign	5.25	10.17	7.60	123.73
	domestic	94.75	10.43	9.70	98.26
	male	76.09	10.12	9.20	100.39
	female	23.91	11.36	10.66	96.34
	expr1	6.05	16.73	13.73	105.19
	expr2	4.84	12.76	11.10	103.82
	expr3	4.79	11.66	10.38	102.24
	expr4	4.29	10.80	9.90	99.92
	expr4up	80.30	9.70	9.10	98.08
	limit_others	17.19	12.14	10.63	103.55
	limit_couple	33.20	9.61	9.50	92.70
	limit_one	37.89	9.90	8.70	102.07
	limit_two	3.33	11.01	9.98	100.18
	agelimit1(all)	0.34	19.68	15.49	109.73
	agelimit2	1.81	17.80	14.37	109.56
	agelimit3	2.66	14.85	12.43	107.26
	agelimit4	12.61	12.77	11.05	104.67
	agelimit5	19.47	10.25	9.45	99.34
	agelimit6	27.21	9.05	87.40	95.54
	agelimit7	13.67	9.31	8.91	96.34
	agelimit8	22.23	10.31	9.50	98.97

lowmile	3.65	8.54	8.30	95.69
non-lowmile	96.35	10.49	9.64	99.43
violation	3.16	11.82	10.03	107.54
non-violation	96.84	10.37	9.58	99.03
bms(1~10)	7.23	14.75	12.20	107.07
bms(=11)	13.78	14.03	11.84	104.25
bms(12~18)	48.58	10.25	9.57	97.86
bms(19~25)	30.39	8.02	7.99	94.31

Table 5.Two Part Model Regression

	Frequency (Logit)		Severity (OLS)	
Model #	(1)	(2)	(3)	(4)
ForeignRatio	-0.001	0.001	0.0060***	0.0034*
	[0.0021]	[0.0025]	[0.0015]	[0.0018]
density		0.0075		-0.0104***
		[0.0051]		[0.0037]
age1525	-0.3581***	-0.3581***	-0.0215***	-0.0215***
	[0.0094]	[0.0094]	[0.0074]	[0.0074]
age2530	-0.3141***	-0.3141***	-0.0334***	-0.0334***
	[0.0057]	[0.0057]	[0.0045]	[0.0045]
age3040	-0.2846***	-0.2846***	-0.0503***	-0.0503***
	[0.0039]	[0.0039]	[0.0030]	[0.0030]
age4060	-0.1624***	-0.1624***	-0.0170***	-0.0170***
	[0.0032]	[0.0032]	[0.0024]	[0.0024]
crage05	-0.0454***	-0.0454***	-0.0350***	-0.0350***
	[0.0051]	[0.0051]	[0.0037]	[0.0037]
crage10	0.1140***	0.1140***	-0.0123***	-0.0123***
	[0.0035]	[0.0035]	[0.0026]	[0.0026]
capacity1	-0.0884***	-0.0884***	-0.1143***	-0.1143***
	[0.0029]	[0.0029]	[0.0022]	[0.0022]
capacity2	-0.0376***	-0.0376***	-0.0584***	-0.0584***
	[0.0027]	[0.0027]	[0.0020]	[0.0020]
capacity3	-0.1404***	-0.1404***	-0.0320***	-0.0321***
	[0.0033]	[0.0033]	[0.0025]	[0.0025]
male	-0.0635***	-0.0635***	0.0295***	0.0295***
	[0.0022]	[0.0022]	[0.0016]	[0.0016]
bms	-0.0407***	-0.0407***	-0.0075***	-0.0075***
	[0.0003]	[0.0003]	[0.0002]	[0.0002]
foreigncar	-0.3445***	-0.3444***	0.0560***	0.0559***
	[0.0050]	[0.0050]	[0.0040]	[0.0040]
sportscar	-0.2632***	-0.2632***	0.0922***	0.0921***
	[0.0122]	[0.0122]	[0.0112]	[0.0112]
limit_couple	0.0412***	0.0412***	-0.0529***	-0.0529***
	[0.0030]	[0.0030]	[0.0023]	[0.0023]
limit_one	-0.1320***	-0.1320***	-0.0139***	-0.0139***
	[0.0030]	[0.0030]	[0.0023]	[0.0023]
limit_two	-0.0641***	-0.0641***	-0.0203***	-0.0203***
	[0.0054]	[0.0054]	[0.0042]	[0.0042]
agelimit1	0.5149***	0.5149***	0.0797***	0.0796***
	[0.0132]	[0.0132]	[0.0101]	[0.0101]
agelimit2	0.3974***	0.3974***	0.0637***	0.0636***
	[0.0069]	[0.0069]	[0.0053]	[0.0053]
agelimit3	0.2131***	0.2131***	0.0283***	0.0283***
	[0.0062]	[0.0062]	[0.0048]	[0.0048]
agelimit4	0.0715***	0.0715***	0.0013	0.0013
	[0.0044]	[0.0044]	[0.0034]	[0.0034]
agelimit5	-0.0857***	-0.0857***	-0.0307***	-0.0307***
	[0.0038]	[0.0038]	[0.0029]	[0.0029]
agelimit6	-0.1179***	-0.1179***	-0.0330***	-0.0330***
	[0.0031]	[0.0031]	[0.0024]	[0.0024]

agelimit7	-0.0978***	-0.0978***	-0.0150***	-0.0150***
	[0.0033]	[0.0033]	[0.0025]	[0.0025]
lowmile	-0.1339***	-0.1337***	-0.0406***	-0.0407***
	[0.0054]	[0.0054]	[0.0035]	[0.0035]
violation	0.0643***	0.0643***	0.0465***	0.0465***
	[0.0051]	[0.0051]	[0.0042]	[0.0042]
lntotcarval	0.0671***	0.0671***	0.0271***	0.0271***
	[0.0019]	[0.0019]	[0.0015]	[0.0015]
expr1	0.2924***	0.2925***	0.0424***	0.0424***
	[0.0039]	[0.0039]	[0.0030]	[0.0030]
expr2	0.0889***	0.0889***	0.0173***	0.0173***
	[0.0044]	[0.0044]	[0.0034]	[0.0034]
expr3	0.0358***	0.0358***	0.0022	0.0022
	[0.0044]	[0.0044]	[0.0035]	[0.0035]
expr4	-0.0046	-0.0046	-0.0027	-0.0027
	[0.0047]	[0.0047]	[0.0036]	[0.0036]
Observations	14,061,144	14,061,144	1,534,388	1,534,388
R-squared	0.0107	0.0107	0.019	0.019

Note: Region and year fixed effect included but not shown due to space.

Table 6. Yearly Externality Cost of Luxury Car for Selected Regions, 2012

Region	Foreign Car Ratio	Model	Percent Severity Increase	Increased cost per accident	Increased cost per driver	Total Cost Increased in Region	Cost increased by one foreign car in region
Seoul	8.65%	w/o density	5.42%	61,025	6,694	20,224,106,926	78,722
		w/ density	3.07%	34,620	3,798	11,474,627,742	44,665
Daejun	2.68%	w/o density	1.65%	18,051	2,025	1,235,250,000	75,532
		w/ density	0.94%	10,321	1,158	706,380,000	43,193
Gyeong buk	1.36%	w/o density	0.83%	8,557	898	1,087,166,850	66,254
		w/ density	0.48%	4,901	515	622,672,050	37,947
Whole Region	3.73%	w/o density	2.30%	22,963	2,482	48,026,700,000	66,475
		w/ density	1.31%	13,111	1,417	27,418,950,000	37,951

Table 7. Robustness Checks - Gangnam Regression

	Frequency		Severity	
Model #	(1)	(2)	(3)	(4)
Gangnam	0.0793***	0.0665***	0.0748***	0.0494***
	[0.0054]	[0.0126]	[0.0046]	[0.0107]
2010Gangnam		0.0083		0.0122
		[0.0173]		[0.0147]
2011Gangnam		-0.0085		0.0316**
		[0.0173]		[0.0146]
2012 Gangnam		0.0253		0.0298**
		[0.0168]		[0.0143]
2013 Gangnam		-0.0115		0.0505***
		[0.0231]		[0.0147]
age1525	-0.2648***	-0.2744***	-0.0271	-0.027
	[0.0232]	[0.0245]	[0.0192]	[0.0192]
age2530	-0.2492***	-0.2417***	-0.0420***	-0.0420***
	[0.0119]	[0.0127]	[0.0102]	[0.0102]
age3040	-0.2568***	-0.2516***	-0.0479***	-0.0479***
	[0.0081]	[0.0086]	[0.0068]	[0.0068]
age4060	-0.1326***	-0.1274***	-0.0250***	-0.0251***
	[0.0065]	[0.0069]	[0.0054]	[0.0054]
crage05	-0.0088	0.0136	-0.0336***	-0.0342***
	[0.0108]	[0.0116]	[0.0088]	[0.0088]
crage10	0.1187***	0.1350***	-0.0098	-0.0103*
	[0.0077]	[0.0082]	[0.0062]	[0.0062]
capacity1	-0.1520***	-0.1501***	-0.1078***	-0.1077***
	[0.0065]	[0.0069]	[0.0054]	[0.0054]
capacity2	-0.0697***	-0.0681***	-0.0573***	-0.0571***
	[0.0058]	[0.0062]	[0.0048]	[0.0048]
capacity3	-0.1091***	-0.1140***	-0.0384***	-0.0384***
	[0.0068]	[0.0073]	[0.0057]	[0.0057]
male	-0.0960***	-0.0941***	0.0119***	0.0118***
	[0.0046]	[0.0049]	[0.0038]	[0.0038]
bms	-0.0513***	-0.0511***	-0.0065***	-0.0065***
	[0.0005]	[0.0006]	[0.0004]	[0.0004]
foreigncar	-0.3175***	-0.3277***	0.0597***	0.0589***
	[0.0076]	[0.0084]	[0.0068]	[0.0068]
sportscar	-0.2992***	-0.2955***	0.1126***	0.1126***
	[0.0210]	[0.0223]	[0.0211]	[0.0211]
limit_couple	0.0115*	0.0181***	-0.0566***	-0.0566***
	[0.0062]	[0.0067]	[0.0052]	[0.0052]
limit_one	-0.1618***	-0.1674***	-0.0181***	-0.0180***
	[0.0063]	[0.0067]	[0.0053]	[0.0053]
limit_two	-0.0619***	-0.0666***	-0.0279***	-0.0280***
	[0.0110]	[0.0116]	[0.0092]	[0.0092]
agelimit1	0.5104***	0.5071***	0.0861***	0.0863***
	[0.0335]	[0.0349]	[0.0282]	[0.0282]
agelimit2	0.4167***	0.4036***	0.0390***	0.0392***
	[0.0171]	[0.0180]	[0.0139]	[0.0139]
agelimit3	0.2898***	0.2930***	0.0246**	0.0247**
	[0.0141]	[0.0149]	[0.0117]	[0.0117]

agelimit4	0.1640***	0.1598***	0.0038	0.0039
	[0.0091]	[0.0096]	[0.0077]	[0.0077]
agelimit5	-0.0073	-0.0024	-0.0299***	-0.0299***
	[0.0080]	[0.0086]	[0.0067]	[0.0067]
agelimit6	-0.0601***	-0.0527***	-0.0341***	-0.0342***
	[0.0067]	[0.0071]	[0.0056]	[0.0056]
agelimit7	-0.0670***	-0.0664***	-0.0139**	-0.0141**
	[0.0073]	[0.0078]	[0.0061]	[0.0061]
Lowmile	-0.2479***	-0.1913***	-0.0378***	-0.0380***
	[0.0081]	[0.0098]	[0.0066]	[0.0066]
Violation	0.1157***	0.1058***	0.0359***	0.0358***
	[0.0125]	[0.0131]	[0.0107]	[0.0107]
Lntotcarval	0.0364***	0.0375***	0.0338***	0.0341***
	[0.0041]	[0.0044]	[0.0036]	[0.0036]
expr1	0.3150***	0.3148***	0.0297***	0.0296***
	[0.0077]	[0.0082]	[0.0064]	[0.0064]
expr2	0.0762***	0.0757***	0.0140*	0.0139*
	[0.0088]	[0.0095]	[0.0074]	[0.0074]
expr3	0.0295***	0.0211**	-0.0124	-0.0125
	[0.0090]	[0.0097]	[0.0077]	[0.0077]
expr4	-0.0027	0.0001	-0.0176**	-0.0175**
	[0.0096]	[0.0103]	[0.0080]	[0.0080]
Year 2010	0.0483***	0.0465***	0.0758***	0.0739***
	[0.0064]	[0.0069]	[0.0053]	[0.0058]
Year 2011	0.0172***	0.0169**	0.1409***	0.1358***
	[0.0063]	[0.0069]	[0.0053]	[0.0057]
Year 2012	0.0856***	0.0722***	0.1815***	0.1767***
	[0.0064]	[0.0070]	[0.0053]	[0.0058]
Year 2013	-0.1114***	-0.0655***	0.2094***	0.2012***
	[0.0067]	[0.0095]	[0.0056]	[0.0061]
Observations	3,116,622	3,116,622	295,626	295,626
R-squared			0.016	0.016
Chi-square	30,700	25,241		

Table 8. Robustness Check - Small Sample

	Small		Tobit		Gangnam	
	Linear	Quadratic	Linear	Quadratic	Small	Tobit
Model #	(1)	(2)	(3)	(4)	(5)	(6)
ForeignRatio	0.0062***	0.0037**	0.0060***	0.0035**		
	[0.0015]	[0.0018]	[0.0015]	[0.0018]		
density		-0.0104***		-0.0104***		
		[0.0038]		[0.0037]		
Gangnam					0.0497***	0.0490***
					[0.0108]	[0.0106]
2010Gangnam					0.0099	0.0122
					[0.0148]	[0.0146]
2011Gangnam					0.0314**	0.0321**
					[0.0147]	[0.0145]
2012Gangnam					0.0302**	0.0300**
					[0.0144]	[0.0142]
2013Gangnam					0.0500***	0.0508***
					[0.0148]	[0.0146]
age1525	-0.0193**	-0.0192**	-0.0214***	-0.0213***	-0.02	-0.0265
	[0.0075]	[0.0075]	[0.0073]	[0.0073]	[0.0195]	[0.0191]
age2530	-0.0335***	-0.0335***	-0.0332***	-0.0332***	-0.0413***	-0.0418***
	[0.0046]	[0.0046]	[0.0045]	[0.0045]	[0.0103]	[0.0102]
age3040	-0.0507***	-0.0507***	-0.0503***	-0.0503***	-0.0484***	-0.0480***
	[0.0031]	[0.0031]	[0.0030]	[0.0030]	[0.0068]	[0.0068]
age4060	-0.0172***	-0.0172***	-0.0170***	-0.0170***	-0.0247***	-0.0254***
	[0.0024]	[0.0024]	[0.0024]	[0.0024]	[0.0055]	[0.0054]
crage05	-0.0363***	-0.0364***	-0.0347***	-0.0347***	-0.0351***	-0.0339***
	[0.0038]	[0.0038]	[0.0037]	[0.0037]	[0.0089]	[0.0088]
crage10	-0.0126***	-0.0126***	-0.0121***	-0.0121***	-0.0107*	-0.0102
	[0.0026]	[0.0026]	[0.0026]	[0.0026]	[0.0063]	[0.0062]
capacity1	-0.1147***	-0.1147***	-0.1136***	-0.1136***	-0.1079***	-0.1069***
	[0.0022]	[0.0022]	[0.0022]	[0.0022]	[0.0055]	[0.0054]
capacity2	-0.0589***	-0.0589***	-0.0580***	-0.0580***	-0.0573***	-0.0566***
	[0.0020]	[0.0020]	[0.0020]	[0.0020]	[0.0049]	[0.0048]
capacity3	-0.0329***	-0.0329***	-0.0319***	-0.0319***	-0.0391***	-0.0380***
	[0.0026]	[0.0026]	[0.0025]	[0.0025]	[0.0057]	[0.0056]
male	0.0293***	0.0293***	0.0295***	0.0295***	0.0127***	0.0119***
	[0.0017]	[0.0017]	[0.0016]	[0.0016]	[0.0038]	[0.0037]
bms	-0.0076***	-0.0076***	-0.0075***	-0.0075***	-0.0067***	-0.0065***
	[0.0002]	[0.0002]	[0.0002]	[0.0002]	[0.0004]	[0.0004]
foreigncar	0.0554***	0.0553***	0.0551***	0.0551***	0.0597***	0.0583***
	[0.0040]	[0.0040]	[0.0040]	[0.0040]	[0.0068]	[0.0067]
sportscar	0.0938***	0.0938***	0.0887***	0.0887***	0.1117***	0.1078***
	[0.0115]	[0.0115]	[0.0110]	[0.0110]	[0.0215]	[0.0207]
limit_couple	-0.0527***	-0.0527***	-0.0527***	-0.0527***	-0.0554***	-0.0563***
	[0.0023]	[0.0023]	[0.0023]	[0.0023]	[0.0052]	[0.0052]
limit_one	-0.0144***	-0.0144***	-0.0141***	-0.0141***	-0.0174***	-0.0184***
	[0.0024]	[0.0024]	[0.0023]	[0.0023]	[0.0053]	[0.0053]
limit_two	-0.0212***	-0.0212***	-0.0202***	-0.0202***	-0.0267***	-0.0281***
	[0.0043]	[0.0043]	[0.0042]	[0.0042]	[0.0093]	[0.0092]
agelimit1	0.0850***	0.0850***	0.0792***	0.0791***	0.0954***	0.0844***

	[0.0102]	[0.0102]	[0.0100]	[0.0100]	[0.0284]	[0.0278]
agelimit2	0.0646***	0.0646***	0.0632***	0.0631***	0.0424***	0.0380***
	[0.0054]	[0.0054]	[0.0053]	[0.0053]	[0.0140]	[0.0138]
agelimit3	0.0277***	0.0277***	0.0278***	0.0278***	0.0252**	0.0245**
	[0.0049]	[0.0049]	[0.0048]	[0.0048]	[0.0118]	[0.0117]
agelimit4	0.0012	0.0012	0.0008	0.0008	0.0049	0.0031
	[0.0035]	[0.0035]	[0.0034]	[0.0034]	[0.0078]	[0.0077]
agelimit5	-0.0309***	-0.0309***	-0.0309***	-0.0309***	-0.0291***	-0.0302***
	[0.0030]	[0.0030]	[0.0029]	[0.0029]	[0.0068]	[0.0067]
agelimit6	-0.0337***	-0.0337***	-0.0330***	-0.0330***	-0.0335***	-0.0346***
	[0.0024]	[0.0024]	[0.0024]	[0.0024]	[0.0057]	[0.0056]
agelimit7	-0.0149***	-0.0149***	-0.0151***	-0.0151***	-0.0138**	-0.0144**
	[0.0025]	[0.0025]	[0.0025]	[0.0025]	[0.0062]	[0.0061]
lowmile	-0.0406***	-0.0407***	-0.0402***	-0.0403***	-0.0391***	-0.0375***
	[0.0035]	[0.0035]	[0.0034]	[0.0034]	[0.0067]	[0.0066]
violation	0.0440***	0.0440***	0.0463***	0.0463***	0.0382***	0.0363***
	[0.0042]	[0.0042]	[0.0041]	[0.0041]	[0.0109]	[0.0107]
lntotcarval	0.0277***	0.0277***	0.0268***	0.0269***	0.0342***	0.0338***
	[0.0015]	[0.0015]	[0.0015]	[0.0015]	[0.0036]	[0.0036]
expr1	0.0427***	0.0427***	0.0426***	0.0426***	0.0291***	0.0298***
	[0.0031]	[0.0031]	[0.0030]	[0.0030]	[0.0064]	[0.0064]
expr2	0.0169***	0.0169***	0.0172***	0.0172***	0.0135*	0.0139*
	[0.0034]	[0.0034]	[0.0034]	[0.0034]	[0.0075]	[0.0074]
expr3	0.0025	0.0025	0.0021	0.0021	-0.0142*	-0.0126*
	[0.0035]	[0.0035]	[0.0034]	[0.0034]	[0.0077]	[0.0076]
expr4	-0.0029	-0.0029	-0.0026	-0.0026	-0.0186**	-0.0173**
	[0.0036]	[0.0036]	[0.0036]	[0.0036]	[0.0081]	[0.0080]
Observations	1,508,402	1,508,402	1,534,388	1,534,388	291,695	295,626
R-squared	0.019	0.019			0.016	
F-Value			601.8	589.9		121.1

Appendix I. Car Repair Cost

(Table A1) Repair cost of foreign and domestic cars

	Foreign				Domestic				
	Taurus	camry	320d	Average(A)	Grandeur HG	K7	Alpheon	Average(B)	(A/B)
parts	1277	811	513	867	148	133	133	138	6.3
Cost of labor	144	348	589	360	70	76	59	68	5.3
painting	178	294	215	229	81	76	48	68	3.4
total	1599	1453	1317	1456	299	240	275	275	5.3

Source: Korea Automobile insurance repair research and training center (2011)

(Table A2) Repair cost of car types

	displacement (1000cc)	brand	model	Vehicle Price (10,000)	Repair cost front	back	total
Subcompact	1.0	KIA	Allnewmorning	1,015	816	455	1,271
Compact	1.4	Hyundai	Accent RB	1,240	1,186	678	1,864
	1.6	GM Korea	aveo	1,406	1,113	326	1,439
		KIA	allnewpride	1,640	981	479	1,460
		Hyundai	I30	1,845	1,009	585	1,594
		Hyundai	velostar	1,790	1,279	413	1,692
		Hyundai	AvanteMD	1,520	1,229	946	2,175
Mid-sized	1.7	Hyundai	I40	2,695	1,518	742	2,260
	2.0	GM Korea	Malibu	2,514	1,224	532	1,756
SUV	2.0	GM Korea	orlando	2,463	1,045	574	1,619
		ssangyong	Korando C	2,455	2,336	830	3,166

Source: Korea Automobile insurance repair research and training center (2011)

Appendix II . Foreign car ratio adjustment

	Year	Number of Registered Foreign Cars	Foreign Car Ratio	Percentage Business car newly registered	Number of Foreign Car Growth	Modified Foreign Car Ratio
Gyeongnam	2013	66,131	4.44%	0.7506	6.83%	1.36%
	2012	61,902	4.21%	0.8502	14.85%	1.08%
	2011	53,896	3.72%	0.9272	38.32%	0.87%
	2010	38,964	2.82%	0.9296	30.74%	0.68%
	2009	29,803	2.29%	0.9373	-2.06%	0.54%
Seoul	2013	205,676	6.93%	0.1659	15.55%	8.65%
	2012	178,004	6.59%	0.1779	12.69%	8.26%
	2011	157,956	5.3%	0.2346	13.60%	6.62%
	2010	139,048	4.67%	0.3343	15.26%	5.60%
	2009	120,643	4.08%	0.3524	0.15%	4.81%
Inchon	2013	45,229	3.97%	0.7968	61.74%	3.09%
	2012	27,964	2.66%	0.7537	50.34%	2.38%
	2011	18,600	1.9%	0.5719	46.07%	1.82%
	2010	12,734	1.37%	0.3926	39.81%	1.37%
	2009	9,108	1.01%	0.1559	23.23%	1.01%
Gyeongbuk	2013	16,409	1.36%	0.0979	29.37%	1.36%
	2012	12,684	1.08%	0.1187	28.55%	1.08%
	2011	9,867	0.87%	0.1354	31.23%	0.87%
	2010	7,519	0.68%	0.1239	29.97%	0.68%
	2009	5,785	0.54%	0.1528	31.00%	0.54%
Average of 7 non-city region	2013	12,469	1.64%	0.1862	33.06%	
	2012	9,370	1.28%	0.1635	28.35%	
	2011	7,301	0.99%	0.158	30.31%	
	2010	5,602	0.79%	0.2097	29.52%	
	2009	4,325	0.64%	0.2137	30.18%	

Note: 7 non-city regions are Chungnam, Chungbuk, Gyeongbuk, Junnam, Junbuk, Gangwon, Jeju.