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Abstract

This paper uses truncated count model with endogeneity and simulated maximum likelihood estimation technique to estimate gender differences in moral hazard in health care insurance. We use the dataset which consists of invoices for all outpatient services from a regional hospital in Croatia. Our theoretical model predicts that higher risk aversion is associated with smaller moral hazard effect. If women are more risk-averse than men, then the moral hazard effect due to health insurance should be lower in women than in men. Whereas the overall results show a statistically significant evidence of moral hazard for the general population, we found economically small but statistically significant larger moral hazard in women than in men.

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1 Introduction

Average lifespans in the developed countries more than doubled in the 20th century due to increases in welfare, improvements in health care, decreases in child mortality and the advent of antibiotics and improved hygiene, yet the difference in life expectancy between sexes still persists. Women experience higher stress, more chronic diseases, more depression, more anxiety and are more likely to be victims of violence. Women earn less than men, and in many countries they don't have the same human rights as men. Despite all these facts, they live longer than men. This is the case without a single exception, in all countries (Assari, 2017).[1]

Both biological and social aspects of being a woman or a man explain the differences in life expectancy. For example, estrogen benefits women because it lowers "bad" cholesterol and increases "good" cholesterol, which reduces cardiovascular risk. On the other hand, testosterone increases blood levels of the bad cholesterol and decreases levels of good cholesterol. This puts men at greater risk of hypertension, heart disease and stroke. Testosterone also puts men at risk behaviorally. It increases aggressiveness, and results in higher death rate from accidents and homicide. Many men define unhealthy and risky behaviors as masculine, while they see health care use and health-promoting behaviors as feminine (Assari, 2017).

Distinction in life expectancy is an important factor in explaining the difference in overall health care consumption between genders but it is not the only one. The gender differences in health care consumption are well documented in the medical literature. The comparisons and computed differences are usually based on medical records such as discharge rates, hospitalization, etc., without controlling for socioeconomic characteristics of patients. This paper investigates gender difference in health care consumption and seeks to explain it by the gender differences in moral hazard due to widespread use of health insurance. Moral hazard has been blamed for the rapid increase of health care expenditure as more people become insured and as insurance coverage become more comprehensive.

[1] For instance, the life expectancy for women in the U.S. is 81.2 years compared to 76.4 for males.

The literature on gender difference in health care consumption can be grouped into two clusters: medical sciences and social sciences (economics). Different sexes are vulnerable to different kinds of diseases or require different kinds of medical treatments in different age cohorts. As a result of genetic differences, men have higher infant mortality (Naeye et al., 1971). Also, men are more susceptible to infections and diseases generally in their early age due to the genetic immunological disadvantages (Washburn, Medearis and Childs, 1966; Michaels and Rogers, 1971). During the prime of adult life, the gender differences in health care utilization are more pronounced because of child-bearing. Nathanson (1977) investigated hospital discharge rates by sex and conditions in Canada and United States. Hospital discharge rate, as a measure of hospital utilization, looks at the number of patients who leave a hospital after receiving care. The study found the total discharge rate for women is about one third larger than that of men in both countries. However, after excluding discharge rates related to obstetrical conditions, discharge rate of women is only one tenth larger than that of men in Canada and one twentieth larger in US. In addition, men and women have different hormonal balance. Some researchers believe hormonal factors are responsible for lower rates of coronary heart disease among women prior to the menopause (Moriyama, Krueger and Stamler, 1971) and it may also explain women's low susceptibility to certain cancers following the menopause (Lilienfeld, Levin and Kessler, 1972). To reduce the confounding variability in background characteristics, Gold et al. (2002) did a study on older different-sex twins. They found men have more life-threatening and cardiovascular conditions than women.

From the economics perspective, at least four major explanatory frameworks (and the combinations thereof) can be constructed to explain gender differences in health care utilization: (1) preferences towards health, (2) life style, (3) opportunity cost of time and (4) risk aversion. Preferences and attitudes towards health are arguably different in women and men. Verbrugge (1985) found that women are more sensitive to their health needs. They pay more attention to coming symptoms and are more willing to address them. Bertakis et al. (2000) found that after controlling for health status and socio-demographic characteristics, women still have higher medical expenses for all categories of charges except hospitalizations. Using 2008 Medical Expenditure Panel Survey, Vaidya, Partha and Karmakar (2012) found that men are significantly less likely to utilize preventive care services (e.g., flu shots, blood pressure and cholesterol check-ups, dental exams) than women. Men are more likely to have a physical exam if it is required for work or insurance purposes rather than voluntarily (Andersen and Anderson, 1967).

The second explanation relies on the gender differences in life styles. For example, in many cultures it is more socially acceptable for men to smoke and drink. Men are more likely than women to use almost all types of illicit drugs (SAMHSA, 2014) and illicit drug use is more likely to result in emergency department visits or overdose deaths for men than for women. Also, traditional male occupations require more physical endurance and are more likely to result in injuries. The health statistics in U.S. show the average annual injury-related visits to hospital emergency departments for men are larger than for women. In the period of 2007-2008, men's injury-related visits amounted to 16,640,000, whereas those of women amounted to 14,688,000. In the 18-44 age cohort, the disparity is the most pronounced. Men of this age cohort had 7,173,000 injury-related visits, while women had 5,823,000 (National Center for Health Statistics, 2010, 2011).

The third possible explanation for the differences in health care utilization could be explained by the difference in the opportunity cost of time. Higher opportunity cost of time could make a visit to a doctor relatively more costly and could ultimately deter a sick person to seek medical attention in cases that are perceived as less serious. Gilleskie (2010) analyzed the gender differences in work absenteeism and medical care decisions during an episode of acute illness. Based on the 1987 National Medical Expenditure Survey data, she found that men are more responsive to variations in sick leave and health insurance coverage than women. A change from no sick leave coverage to covered sick leave induced a 45% increase in illness-related absences in men, but only an 11% increase among women. A change from no insurance coverage for physician visits to free physician visits increases medical care consumption by 20% among men and 15% among women. Reducing these benefits also has smaller effect on the absenteeism and medical care consumption of women than men.

Finally, in this paper we argue that the gender differences in health care consumption could be systematically related to the gender differences in risk aversion or risk assessment. There are two pathways whereby risk preferences could influence health care utilization. First, it is rather straightforward to see that the relationship between the propensity to engage in risky behavior and the level of health care utilization should be positive. For example, Harris, Jenkins and Glaser (2006) investigated gender differences in risk assessment in health related domain of activities by presenting survey participants with scenarios such as not wearing a seatbelt when being a passenger in the front seat, not wearing a helmet when riding a motorcycle or exposing yourself to the sun without using sunscreen. All these activities if engaged in should lead to increased health care utilization either momentarily or in the longer run. The authors found that women have greater perceived likelihood of negative outcomes and lower propensity toward risky choices. Very similar results were found also by Weber, Blais and Betz (2002).

The second, more subtle, relationship between risk-aversion and health care consumption is established via health insurance. Given that most people carry some level of insurance coverage, a straightforward theoretical link between health care utilization and risk-aversion is established through moral hazard. One of the fundamental result from the standard asymmetric information model (principal-agent) establishes an increasing relationship between risk-aversion and moral hazard, where the latter is defined as the welfare difference between the first-best and the next-best contracting outcome where the first-best is not attainable because of the unobservable agent's action. However, if the agent is risk-neutral, then the asymmetric information problem is inert and the first-best outcome generally obtains. Interestingly enough, the use of the term *moral hazard* is not standard in the literature. In the context of health insurance, moral hazard is used to measure how consumers' choices change once insurance partially or completely insulates them from the actual cost of medical care (Pauly, 1968). Central to this definition of moral hazard is the price elasticity of demand for health care services: the more elastic the demand curve, the higher the moral hazard effect.[2] The central objective of this paper is to establish the link between the two concepts by exploring the relationship between price elasticity of demand for health care services and risk-aversion.

The existing literature on the subject of gender differences in risk aversion seem to favor the conclusion that women are more risk averse than men, for instance when it comes to financial decision making (Arano, Parker and Terry, 2010; Charness and Gneezy, 2012; Eckel and Grossman, 2002; Bajtelsmin and Van Derhei, 1997; Jianakoplos and Bernasek, 1998), risk associated with alcohol and drug use (Spigner, Hawkins and Loren, 1993) and risk associated with insurance for loss (Powell and Ansic, 1997). There are also studies that found no significant gender difference in risk aversion, such as the study by Gneezy, Leonard and List (2009) for less developed societies (Maasai society in Africa and Khasi society in South Asia). In another study Flynn, Slovic and Mertz (1994) found that white men perceived risk as much more acceptable than did white women but the perception of risk between nonwhite men and women were quite similar. Schubert et al. (1999) compared the gender difference in the abstract gambling experiment and in the contextual investment or insurance experiment. They found different risk propensities between genders in abstract gambles, but no gender differences in contextual experiments.

The most comprehensive comparative study of the literature in this area is Nelson (2015). She found that the statement about women being more risk averse is not supported by the actual empirical evidence. Quantitative measures of substantive difference (Cohen's d) and substantive overlap (Index of Similarity) were applied to the data on men's and women's risk distributions used in 35 studies in economics, finance and decision making literature. Cohen's d is a measure of the substantive magnitude of a difference, it expresses the difference between means in standard deviation units. She also proposed the Index of Similarity to measure the overlap of any

[2]This definition of moral hazard is also referred to as *ex post* moral hazard. It focuses on consumers' behavior after an insurance related incidence has occurred. In contrast, *ex ante* moral hazard refers to "hidden actions" of consumers before the incident occurs (Bajari et al. 2014).

discrete distribution. This index can be intuitively interpreted as the proportion of the women and men that are identical, which means their characteristics or behaviors exactly match up with someone in the opposite sex group. The results show fewer statistically significant differences but more overlapping than has been commonly claimed in the literature.

Finally, in conducting this research, another challenge we face comes from the data. We use the dataset which consists of invoices for all outpatient services from a regional hospital in Croatia during a four month period in 2009. Because the data contains only users of medical services, we do not have any information about people who didn't show up at the hospital in the period covered by the data. To address this problem, we rely on a truncated count model with endogeneity and a simulated maximum likelihood estimator. After adjusting for the sample selection in the estimation, we found a statistically significant evidence of moral hazard for the general population and statistically significantly larger moral hazard effect for women than for men which is indicative of women being less risk-averse than men.

2 A Theoretical Framework

The use of term *moral hazard* to describe the responsiveness of health care spending to insurance coverage goes back to Arrow (1963). In line with the concept of *hidden action or ex ante moral hazard*, this literature has argued that health insurance may induce people to exert lower effort in maintaining their good health (Ehrlich and Becker, 1972). The conventional definition of moral hazard used in health economics literature, however, is tied to the concept of price elasticity of demand for health care services, or ex post moral hazard. Since the demand function is typically downward sloping, the more elastic the demand (the smaller the elasticity coefficient), the higher the moral hazard effect because the reduction in price caused by health insurance coverage will push the quantity consumed further to the right along the quantity axis. Two extreme cases are determined by an infinitely elastic (horizontal) demand curve causing infinitely large moral hazard and a perfectly inelastic (vertical) demand function causing zero moral hazard.

To establish a sought after relationship between the above definition of moral hazard used in the health economics literature and risk-aversion, we start with a model of a possibly risk-averse economic agent who maximizes his or her utility function by choosing health care m and a composite commodity c, subject to a budget constraint. The utility function is additively separable in aggregate consumption and health care, each in the constant relative risk aversion (CRRA) functional form:

$$U(c, m_; \theta, \gamma) = (1-\theta) lnc + \theta \frac{m^{1-\gamma}}{1-\gamma} \tag{1}$$

where $\gamma > 0$ is the risk-aversion coefficient describing the consumers' risk attitude towards the health care consumption. The larger the coefficient, the more risk averse the person with respect to the variation in health care consumption. This specification of the utility function is a simplified version of the utility function from Bajari et al. (2014) where we assume the risk-aversion coefficient for aggregate consumption equals 1.[3] Assuming that risk-aversion related to health care consumption is higher than in the case of general consumption yields $\gamma > 1$.

Following in the health insurance literature footsteps, our model does not consider the potential impact of insurance on underlying health status. Instead, $\theta \in [0, 1]$ is a parameter which can be interpreted as measuring the importance an agent places on health care and aggregate consumption: the higher the value of θ, the higher the utility of health services and the lower the utility of other consumption. The asymmetric information problem associated with moral hazard would be more accurately described as one of *hidden information* rather than hidden action and is manifested in consumers knowing their value of θ but the insurers do not observe θ. Utility function here is conditional on an individual's choice of insurance, however, we do not explicitly model the insurance choice because we are not interested in selection issues but only in moral hazard. The marginal rate of substitution (MRS) between the optimal choice oh health

[3]Similar specification of the utility function has also been used by Paulson, Townsend and Karaivanov (2006).

care conditional on an individual's coverage choice and the other good is sufficient to uncover the relationship between the price elasticity of demand for health services and risk-aversion.

A consumer's budget constraint requires that his expenditure on aggregate consumption and health care must not be greater than his income minus the insurance premium:

$$c + \alpha m \leq y - p, \tag{2}$$

where prices are normalized to unity, y is income, p is the insurance premium and α is the co-payment rate, i.e., the percentage of the cost that patients have to pay out of pocket which depends on the insurance coverage. The more generous the insurance coverage, the smaller is α which a consumer needs to pay out of pocket.

Since the utility function is strictly increasing, the budget constraint will bind at the optimal bundle and the first order conditions for the maximization of utility (1) subject to budget constraint (2) are as follows:

$$\frac{\partial \mathcal{L}}{\partial c} = (1-\theta)\frac{1}{c} - \lambda = 0,$$
$$\frac{\partial \mathcal{L}}{\partial m} = \theta m^{-\gamma} - \lambda\alpha = 0,$$
$$\frac{\partial \mathcal{L}}{\partial \lambda} = y - p - c - \alpha m = 0.$$

The standard optimization result shows that the marginal rate of substitution between aggregate consumption and health care consumption equals to the ratio of prices. However, the price of health care that a consumer faces is only the co-payment portion α of the actual price. As a result, the relative price of medical services to aggregate consumption is equal to α and the MRS becomes:

$$MRS = \frac{\theta}{(1-\theta)}\frac{c}{m^{\gamma}} = \alpha. \tag{3}$$

Since a patient only needs to pay $\alpha < 1$ portion of the actual health care cost, the price ratio between health care and aggregate consumption is biased towards favoring health care and against general consumption. This *excess* of health care consumption is a standard measure of moral hazard associated with insurance.

Substituting $c = y - p - \alpha m$ into Equation (3) gives:

$$\frac{\theta}{(1-\theta)} \frac{y - p - \alpha m}{m^{\gamma}} = \alpha. \tag{4}$$

which can be used to derive the expression for the price elasticity of demand for health care η using implicit differentiation:

$$\eta = \frac{\partial m}{\partial \alpha} \frac{\alpha}{m} = -\frac{1 + \frac{\alpha m}{y-p-\alpha m}}{\gamma + \frac{\alpha m}{y-p-\alpha m}} < 0. \tag{5}$$

The nonzero elasticity of demand for health care gives rise to the existence of moral hazard. The more elastic the demand for health care (smaller η), the larger the moral hazard effect.

From Equation (5) we can see that the measure of elasticity, hence the magnitude of moral hazard, depends on the risk aversion coefficient γ. The relationship between price elasticity of demand and risk aversion is obtained by computing its derivative with respect to γ:

$$\frac{\partial \eta}{\partial \gamma} = \frac{1 + \frac{\alpha m}{y-p-\alpha m} + (\gamma - 1)\frac{\alpha(y-p)}{(y-p-\alpha m)} \frac{ln(m)}{\alpha + \frac{(y-p-\alpha m)\gamma}{m}}}{\left(\gamma + \frac{\alpha m}{y-p-\alpha m}\right)^2} > 0 \tag{6}$$

which shows that the price elasticity of demand for health services is positively related to risk aversion meaning that more risk averse individual will have less elastic demand for health services and hence smaller moral hazard effect.

The proof that $\frac{\partial \eta}{\partial \gamma} > 0$ depends on two non-restrictive conditions: $\gamma > 1$ and $y - p > 1 + \alpha$. The first one is satisfied automatically by the model set-up and the second is quite weak because $y - p$ can easily be larger than $1 + \alpha$ given that $0 < \alpha < 1$.[4] The obtained result is intuitively

[4]A detailed derivation of Equation (6) and the proof that its sign is positive is relegated to the Appendix.

obvious. A highly risk averse patient will seek medical attention regardless of the price, so her demand for health care is inelastic leading to smaller moral hazard. On the other hand, less risk-averse individual would tend to ignore minor health problems when faced high cost of medical care, hence her demand function would be elastic giving rise to larger moral hazard.

3 Institutional Framework and Data Description

The health care system in Croatia is dominated by a single public health insurance fund: the Croatian Institute for Health Insurance (HZZO). The HZZO offers two types of insurance: the compulsory insurance and the supplemental insurance. The compulsory insurance, which is funded by a 15% payroll tax, covers two kinds of medical care services: one with full coverage, the other with a system of co-payments. Full coverage medical care services are provided to children up to 18 years of age and pregnant women and for everybody else for life threatening types of illnesses such as infectious diseases, psychiatric care, surgeries, cancers, mandatory vaccinations, etc. All other health services (including but not limited to primary care, hospitals stays and prescription drugs) are subject to a system of co-payments. The patients are required to pay 20% of the full price of medical care, with the largest out-of-pocket cost share amount set at 3,000.00 HRK per invoice.[5]

The supplemental insurance is a voluntary insurance that can be acquired by a person 18 years or older, having compulsory insurance, by signing a contract with the HZZO. Certain categories of citizens are entitled to the supplemental insurance free of charge, i.e., their premiums are covered from the state budget. The list of people entitled to free supplemental insurance includes, among others, the full time secondary school and college students. For those not entitled to free supplemental coverage, the premia range from 50 to 130 HRK per month depending on

[5]The figures are reflective of the year 2009 which is the year covered by the dataset. The exchange rate for the local currency, Croatian Kuna (HRK), as of June 20, 2009 was 1USD=5.19 HRK. A more detailed description of the health insurance system in Croatia can be found in Liu, Nestic and Vukina (2012) and Zheng and Vukina (2016).

whether the insured is active or retired and income. A person having the supplemental insurance is entitled to full waiver of all medical expense co-payments mentioned before.

The original data set consists of all invoices for all outpatient services from a small hospital in Croatia during the period from March 1 to June 30, 2009.[6] The data set consists of 105,646 observations. Each observation reflects the invoice for one hospital visit. The data contains the following set of variables: a numeric code for the type of hospital service provided, compulsory health insurance number, supplemental insurance number (if the patient has one), period covered by the supplemental insurance, numeric code for categories entitled to supplemental insurance free of charge, eligibility category for compulsory insurance (k_1–employed, k_2–farmers, k_3–pensioners, k_4–unemployed, k_5–living on social welfare, k_6–self-employed and other), cost of hospital service, part of the cost covered by compulsory insurance, part of cost covered by supplemental insurance, part of cost covered by participation (co-payment), date of birth and sex of the patient.

In this paper we focus only on the supplemental insurance and its impact on health care utilization. For this reason, patients who visited the hospital only because of the illnesses that are fully covered by the compulsory insurance are excluded. This leaves us with only with non life threatening diagnoses which makes the data set particularly suitable for studying the effects of insurance on medical care consumption. To avoid unnecessary complications with different treatments of insurance decision, we also deleted patients that are entitled to supplemental insurance for free. The rest of the sample has two groups of patients: those who bought the supplemental insurance ($Bought$) and those who did not buy it (No). The working data set consist of 14,991 patients.

We compared the gender composition within age cohorts between our sample and the Croa-

[6]The hospital in question is one of the general medicine regional hospitals in Croatia which provides all typical services such as internal medicine, surgery, anesthesiology, pediatrics, psychiatry, neurology, obstetrics and gynecology, radiology, pathology and emergency care at a fairly basic level. All complicated cases are typically referred to one of the larger medical centers in the capital Zagreb. The name and the location of the hospital are suppressed for confidentiality reasons.

tian 2011 Census data for the county that this hospital serves. Results are displayed in Table 1. The gender composition in the population is different than in our data which clearly points to a selection issue. In the two youngest cohorts: $18-35$ and $36-50$, there are more men than women in general population but there are more women than men in the data. This is a raw indicator of the fact that women in these age groups use hospital services more than men. In the oldest two cohorts: $51-65$ and $66+$, the share of women in the general population is higher than men and so is the case in the sample but in the $51-65$ age group the percentage of males visiting the hospital is lower than their representation in the general population (43.8% vs. 49.4%) whereas there are more women visiting the hospital than their share in the general population (56.3% vs. 50.6%). The situation is reversed in the oldest cohort where the percentage of men that visited the hospital is higher than their share in the general population (44.1% vs. 36.5%) where less women visited the hospital than their share in the general population (55.9% vs. 63.5%). This result is also reflective of the fact that women live longer.

The summary statistics of the data by insurance type and gender are given in Table 2. As can be seen, women have significantly more hospital visits than men in the $Bought$ group; the difference is 0.15 visits per person. At the same time women have less visits than men in the No group but the difference is not statistically significant.

The summary statistics of the data by insurance type and employment status are given in Table 3. We denote employed, farmers and self-employed as the $Active$ group and pensioners, unemployed and living on social welfare as the $Inactive$ group. $Active$ group has significantly more hospital visits than $Inactive$ group in both $Bought$ and No subgroups. The difference amounts to 0.27 visits per person in the $Bought$ group and 0.58 visits in the No group. This finding is interesting and somewhat unexpected because it clearly runs contrary to the opportunity cost of time explanation for the differences in health care utilization.

Finally, we looked at the reasons why people come to the hospital. Top ten diagnoses that are subject to co-payments are summarized by gender in Table 4. As it turns out, the list of diagnoses for which people seek medical attention is quite similar for both sexes. Both men and women record outpatient physical therapy and medical biochemistry as top two reasons for coming to the hospital whereas other components of the top ten diagnoses list overlap with somewhat different rank. The only differences between men and women are traumatic injuries (probably job related) and urology (probably prostate screening) on the men side and clinical cytology (probably breast cancer tissue tests) and ultrasound (probably pregnancies related) on the women side.

4 Estimation

Our objective is to determine how the moral hazard effect related to health insurance differs by gender. There are several challenges in empirically examining this issue. First, health care utilization and insurance status are jointly determined. Second, our measure of health care utilization, the number of visits to the hospital, is a discrete (count) variable. Third, we only observe the data for people who actually made at least one visit to the hospital and hence our sample is a selected one. The implemented empirical approach addresses all these difficulties. It builds upon both the count model with endogeneity used by Zimmer and Trivedi (2006) and Deb et al. (2006) to study the effect of health insurance on health care utilization and the truncated model without endogeneity outlined in section 17.3 of Wooldridge (2002).

Formally, let z_i denote the number of hospital visits, I_i the insurance status and x_i the vector of socioeconomic characteristics for individual i. We only observe (z_i, I_i, x_i) when $z_i > 0$. For estimation, we need to derive the likelihood function or density of the endogenous variables (z_i, I_i) conditional on x_i and $z_i > 0$:

$$\begin{aligned} f(z_i, I_i|x_i, z_i > 0) &= \frac{f(z_i, I_i, z_i > 0|x_i)}{f(z_i > 0|x_i)} = \frac{f(z_i, z_i > 0|I_i, x_i)f(I_i|x_i)}{f(z_i > 0|x_i)} \\ &= \frac{f(z_i|I_i, x_i)f(I_i|x_i)}{\Pr(I_i = 1|x_i)f(z_i > 0|x_i, I_i = 1) + \Pr(I_i = 0|x_i)f(z_i > 0|x_i, I_i = 0)}, \end{aligned} \tag{7}$$

where the last equality follows from the fact that $f(z_i, z_i > 0|I_i, x_i) = f(z_i|I_i, x_i)$ as for the observed z, z_i belongs to the set $z_i > 0$.

To use (7) for estimation, we need to specify $f(z_i|I_i, x_i)$ and $f(I_i|x_i)$. As z_i is a count variable, we specify $f(z_i|I_i, x_i)$ to follow a Poisson distribution with mean m_i. m_i is further specified to depend on the individual's age, age squared, gender, insurance status and h:

$$\begin{aligned} m_i &= \exp(\beta_0 + \beta_1 age_i + \beta_2 age_i^2 + \beta_3 male_i + \beta_4 I_i + \beta_5 h_i \\ &\quad + \beta_6 age_i * I_i + \beta_7 age_i^2 * I_i + \beta_8 male_i * I_i + \beta_9 h_i * I_i), \end{aligned}$$

where h_i represents any of the factors that affect the individual's insurance and health care utilization choices that are unobserved by the econometrician. This could include, but not limited to, latent (general or expected) health status and degree of risk aversion. We assume it follows a standard normal distribution. I is the insurance indicator which equals 1 if individual i has supplemental insurance and 0 if he does not. The remaining RHS variables in the m_i equation are the cross-products of previously mentioned variables and the insurance indicator.

With these assumptions, $f(z_i|I_i, x_i)$ can be shown to be

$$\begin{aligned} f(z_i|I_i, x_i) &= \int f(z_i|I_i, x_i, h_i)\phi(h_i)dh_i \\ &= \int \frac{m_i^{z_i}\exp(-m_i)}{z_i!}\phi(h_i)dh_i, \end{aligned} \tag{8}$$

where $\phi(\cdot)$ is the density function for the standard normal distribution. Similarly, the probability of observing an individual with insurance visiting a hospital, $f(z_i > 0|x_i, I_i = 1)$, can be derived as

$$\begin{aligned} f(z_i &> 0|x_i, I_i = 1) = \int f(z_i > 0|x_i, I_i = 1, h_i)\phi(h_i)dh_i \\ &= \int \left[1 - \Pr(z_i = 0|x_i, I_i = 1, h_i)\right]\phi(h_i)dh_i \\ &= 1 - \int \exp(-m_i(I_i = 1, x_i))\phi(h_i)dh_i, \end{aligned} \tag{9}$$

where $m_i(I_i = 1, x_i)$ is the same as m_i defined above except that I_i in m_i is replaced by one. And the probability of observing an individual without insurance visiting a hospital, $f(z_i > 0|x_i, I_i = 0)$, can be derived as

$$f(z_i > 0|x_i, I_i = 0) = 1 - \int \exp(-m_i(I_i = 0, x_i))\phi(h_i)dh_i, \tag{10}$$

where $m_i(I_i = 0, x_i)$ is the same as m_i defined above except that I_i in m_i is replaced by zero.

Next, we specify the conditional density for the insurance variable, $f(I_i|x_i)$. Let I_i^* denote individual i's tendency to purchase health insurance and assume it is determined by the following equation:

$$I_i^* = \gamma_0 + \gamma_1 age_i + \gamma_2 male_i + \gamma_3 active_i + h_i,$$

which depends on the individual's age, gender, working status and h defined above. Active is a dummy variable that equals one if the individual is employed, self-employed or a farmer, and zero otherwise (i.e., inactive as defined earlier). In models with endogeneity, identification of the parameters in the main equation of interest (the number of visits equation m in our case) via nonlinear functional forms is feasible in principle, however, more robust identification relies on nontrivial exclusion restrictions or instrumental variables. Therefore, we need at least one variable that is correlated with the insurance choice but is, conditional on other exogenous variables in the model, uncorrelated with the number of hospital visits. Given the limited number of variables in our dataset, we use the active variable as our only indentifying instrument. This is in line with Olson (2002) and Deb et al. (2006), both of which use employment characteristics to instrument for health insurance.

Finally, similar to many studies in the health economics literature (e.g. Zimmer and Trivedi, 2006; Deb et al., 2006), the unobserved latent factor variable h affects both the insurance decision as well as the health care utilization decision and hence is the source of the endogeneity of the insurance variable in the health care utilization equation. An individual has insurance, that is, $I_i = 1$ if $I_i^* > 0$ and doesn't have insurance otherwise. Therefore, the probability for the individual to have insurance is

$$\begin{aligned} \Pr(I_i &= 1|x_i) = \Pr(I_i^* > 0|x_i) \\ &= \Phi\left(\gamma_0 + \gamma_1 age_i + \gamma_2 male_i + \gamma_3 active_i\right) \end{aligned} \tag{11}$$

and the probability of no insurance is simply

$$\Pr(I_i = 0|x_i) = 1 - \Pr(I_i = 1|x_i), \tag{12}$$

where $\Phi(\cdot)$ is cumulative density function for the standard normal distribution. Finally, we have

$$f(I_i|x_i) = \Pr(I_i = 1|x_i)^{I_i} \Pr(I_i = 0|x_i)^{1-I_i}. \tag{13}$$

Substitution of (8)-(13) into (7) yields the likelihood function for our maximum likelihood estimation. Several terms in (7) have integrals that can be computed using the simulation method. Hence, the estimation method used is the simulated maximum likelihood estimation method. Specifically, we compute (8) using

$$f(z_i|I_i, x_i) = \frac{1}{J}\sum_{j=1}^{J}\frac{(m_i^j)^{z_i}\exp(-m_i^j)}{z_i!},$$

where m_i^j is identical to m_i defined above with the only difference that h_i is replaced by h_i^j, a random draw from the standard normal distribution. J is the number of simulations used in estimation set to be 1000. Other terms with integrals in the likelihood function are computed in the same way.

4.1 Gender Difference in Moral Hazard

With the estimated coefficients, we can compute the moral hazard effect and the gender difference in moral hazard. First, the moral hazard effect of insurance on the expected health care utilization is defined as:

$$\Omega = E(y|I = 1, x, h) - E(y|I = 0, x, h). \tag{14}$$

However, (14) cannot be computed because h is not observed. One solution to this problem is to compute Ω that is unconditional on the latent health status h, but still conditional on other socioeconomic characteristics:

$$\widetilde{\Omega} = E(y|I = 1, x) - E(y|I = 0, x), \tag{15}$$

which can be approximated using

$$\widetilde{\Omega} = \frac{1}{N}\sum_{i=1}^{N}\left[\frac{1}{J}\sum_{j=1}^{J} m_i(I_i = 1, x_i, h_i^j) - \frac{1}{J}\sum_{j=1}^{J} m_i(I_i = 0, x_i, h_i^j)\right]. \tag{16}$$

Same as before, h_i^j is a random draw from the standard normal distribution, J is the number of simulations (1000) and N is the number of individuals in the sample. Based on this approach, the gender difference in unconditional moral hazard between men and women becomes:

$$\begin{aligned}
&\widetilde{\Delta} = \widetilde{\Omega}(male = 1) - \widetilde{\Omega}(male = 0)\\
&= \tfrac{1}{N}\textstyle\sum_{i=1}^{N}\left[\tfrac{1}{J}\sum_{j=1}^{J} m_i(I_i = 1, male_i = 1, h_i^j, x_i') - \tfrac{1}{J}\sum_{j=1}^{J} m_i(I_i = 0, male_i = 1, h_i^j, x_i')\right]\\
&-\tfrac{1}{N}\textstyle\sum_{i=1}^{N}\left[\tfrac{1}{J}\sum_{j=1}^{J} m_i(I_i = 1, male_i = 0, h_i^j, x_i') - \tfrac{1}{J}\sum_{j=1}^{J} m_i(I_i = 0, male_i = 0, h_i^j, x_i')\right],
\end{aligned} \tag{17}$$

where x' includes all other control variables in m except the gender variable.

An alternative approach to computing the moral hazard is to evaluate the effect at the means of the right-hand side variables, that is,

$$\bar{\Omega} = m(I = 1, \overline{x}, \overline{h}) - m(I = 0, \overline{x}, \overline{h}), \tag{18}$$

where $\overline{h} = 0$ by definition and $\overline{x}$ is the sample mean of the socioeconomic characteristics in the sample. Based on this approach, the gender difference in moral hazard between men and women is

$$\begin{aligned} \bar{\Delta} &= \bar{\Omega}(male = 1) - \bar{\Omega}(male = 0) \\ &= \left[m(I = 1, male = 1, \overline{x}', \overline{h}) - m(I = 0, male = 1, \overline{x}', \overline{h})\right] \\ &\quad - \left[m(I = 1, male = 0, \overline{x}', \overline{h}) - m(I = 0, male = 0, \overline{x}', \overline{h})\right], \end{aligned} \tag{19}$$

where $\overline{x}'$ is the sample mean of x'.

Finally, the standard errors of all measures of moral hazard are computed from the variance-covariance matrix of the coefficient estimates using the delta method.

5 Empirical Results

The estimation results are presented in Table 5. Almost all estimated coefficients are highly significant and have predictable signs. As there are interaction variables in the model, the interpretation of the coefficients becomes complicated. The effect of supplemental insurance on health care utilization increases with the individual's age at a decreasing rate. Also, this effect is lower for men than for women. This result is unexpected given our theoretical prediction above. Finally, this effect is also lower for those individuals with higher value of the unobserved factors. If the h variable mainly represents the latent status of the individual, then the latter result is consistent with the idea that demand is more inelastic for individuals with worse health because they need to use health care with or without insurance.

The right-hand-side panel of Table 5 reports the results of the insurance equation estimation. We see that the propensity to purchase the insurance increases with age, it is smaller for men than for women and it is smaller for the active group than for the inactive group. This last result is interesting because it runs counter to what we originally believed. We expected that active people would have higher probability of having the supplemental insurance because for some of them it comes, by default, as a part of the compensation package. However, self-employed and farmers are not very likely to purchase the supplemental insurance, whereas on the other hand, pensioners are very likely to have the supplemental insurance because of the reduced premium.

The central results of the paper are obtained by computing the expressions (16) and (17) and (18) and (19). First, relying on the unconditional approach we use (16) to compute the moral hazard effect using all observations in the data and then compute the average moral hazard effect as the average across all individuals in the sample. Next, we use (17) to compute the difference in moral hazard between men and women. These results are presented in Table 7 as Option 1. As seen from the table, the moral hazard effect amounts to 1.33 visits and is statistically significant. This means that the difference in number of hospital visits which is solely attributable to having versus not having the health insurance amounts to only 1.33 visits per 4 months period. Again, we need to emphasize that not having insurance here only means no supplemental insurance because all citizens of Croatia are always insured by the compulsory insurance. The bottom row in the table shows that gender difference in moral hazard is negative and statistically significant which means that moral hazard in women is larger than in men. Assuming the women are more risk averse than men, which most of the empirical literature on the subject seems to be showing, this finding is opposite from what the theory would predict.

Second, we computed the moral hazard and the gender difference in moral hazard using the sample means of the independent variables from the visits equation using expressions (18) and (19). This was done in two ways. The first set of results are listed in Table 7 as Option 2 (Sample means) and is based on using the estimated means of the corresponding variables from the data sample; see first column of numbers in Table 6. The second set of results, listed in Table 7 as Option 2 (Census means), is obtained using the means of the corresponding variables from the Croatian 2011 Census for the county which this hospital serves; see second column in Table 6. The results are qualitatively similar to those obtained in Option 1, but the magnitudes of the moral hazard and the gender differences in moral hazard are smaller than in Option 1. In both versions of Option 2 the moral hazard effect is again positive and significant. People who bought the supplemental insurance have 0.54 or 0.68 hospital visits per 4 months period more than people who do not have the insurance. When it comes to gender differences in moral hazard, the results show that women have about 0.07 visits per 4 months period (or about 0.2 visits per year) more than men, and the effect, while economically insignificant, is still statistically significant.

6 Conclusion

The lack of the consistent explanation for the empirically observed gender differences in health care consumption serves as strong motivation for an innovative empirical research in this area. More importantly, to the best of our knowledge, the economics literature appears to be completely silent when it comes to explaining the gender differences in health care consumption by a possible gender differences in the magnitude of asymmetric information effects. Since asymmetric information problems, be they of moral hazard or adverse selection nature, have been recognized as one of the important drivers of health care costs, if men and women are different with respect to how they respond to incentives, then knowing what those differences are, could be important for correct pricing of insurance policies.

However, differential pricing of insurance policies with respect to gender, as of now, is not allowed by law. The Patient Protection and Affordable Care Act (also known as Obamacare) prohibits “gender rating” (Arons, 2012). Women cannot be discriminated against in the health insurance market, with higher premiums, lost maternity coverage and denials of coverage for gender-related pre-existing conditions. However, this can all change if Congress and the new President Trump's administration manage to repeal and replace Obamacare with less consumer protection inclined legislation. The results of this research could provide important insights about possible cost of such regulatory requirements and potential budget savings that an alternative program could generate.

The main challenge that we faced in this research is that we only have observations on people who were users of heath care services within a given time period. As a result, the sample selection issue needed to be dealt with. We used truncated count model with endogeneity and simulated maximum likelihood approach to estimate gender differences in moral hazard in health care utilization relying on the hospital invoices data for non life-threatening diagnoses. Because of the lack of information on non-users who did not show up at the hospital, we derived the conditional likelihood density to adjust for this sample selection issue in the estimation and our results should be representative at the population level.

In the theory part of the paper we showed that the price elasticity of demand for health services is positively related to risk aversion meaning that more risk averse individuals will have less elastic demand for health services and hence smaller moral hazard effect. The exhaustive survey of the literature on the differences in risk-aversion between men and women is not entirely conclusive but the papers finding that women are generally more risk-averse than men dominate. Contrary to these empirical results, our estimation results show that women exhibit higher moral hazard effect than men which would indicate lower risk-aversion than men. The result, although economically quite small, is nevertheless statistically significant. This finding is very interesting because to the best of our knowledge, in studies assessing the risks attitudes of men versus women in different content domains (financial, health/safety, recreational, ethical, social, etc.), only the social domain is unique in that either no gender differences are found or when they are found, it is women who report greater propensity to engage in risky behaviors and perceive overall greater benefit and less risk in doing so (Johnson, Wilke and Weber, 2004;

Weber, Blais and Betz, 2002).[7] Perhaps, future studies will show that social interactions are not the only area where women feel less risk averse than men.

Finally, it would be very interesting to find out whether the obtained results are country specific. Does the fact that Croatia has a health system which has been inherited from the socialist past and, essentially, has not been meaningfully modified in line with market oriented reforms that were carried out in other sectors of the economy, matter? To investigate whether these findings would survive if such a model were to be estimated for example with the U.S. data remains a challenging task of future research[8].

[7]From the survey in Harris, Jenkins and Glaser (2006), situations defining the risk attitudes in the social context are: admitting that your tastes are different from those of your friends; disagreeing with your father on a major issue; defending an unpopular issue that you believe in at a social occasion; arguing with a friend about an issue on which he or she has a very different opinion; asking someone you like out on a date whose feelings about you are unknown; raising your hand to answer a question that a teacher has asked in class.

[8]In the US, health insurance for working-age adults is mainly offered by private insurance companies. As a result, different individuals have different plans and the plans can differ from one another significantly. The publicly available survey datasets on health insurance and health care utilization such as the Medical Expenditure Panel Survey (MEPS) often do not provide details on plan characteristics and as a result, disentangling the price effect from the quality effect is a challenging task.

Table 1: Population of the County: Census and Sample

	Census			Sample		
Age group	Total	Male	Female	Total	Male	Female
Total 18+	96,852	47.82%	52.18%	14,991	43.48%	56.52%
18-35	26,605	52.61%	47.39%	2,995	47.61%	52.39%
36-50	24,085	50.77%	49.23%	3,979	39.51%	60.49%
51-65	25,070	49.40%	50.60%	4,505	43.75%	56.25%
66+	21,092	36.53%	63.47%	3,512	44.11%	55.89%

Table 2: Hospital Visits by Insurance Category and Gender

Sample	Male		Female		Difference (M-F)
	Visits per patient	N	Visits per patient	N	Visits per patient
Bought	3.2309***	5,202	3.3801***	7,309	-0.1492**
	(0.05)		(0.05)		(0.07)
No	2.0068***	1,316	1.9545***	1,164	0.0524
	(0.06)		(0.06)		(0.08)

Notes: The numbers represent means or the differences between means.
Standard errors are in the parentheses. *** indicates 1 % significance level and ** 5 % significance level.

Table 3: Hospital Visits by Insurance Category and Employment Status

Sample	Active		Inactive		Difference (A-I)
	Visits per patient	N	Visits per patient	N	Visits per patient
Bought	3.4579***	6,124	3.1840***	6,387	0.2739***
	(0.05)		(0.05)		(0.07)
No	2.0655***	2,121	1.4903***	359	0.5753***
	(0.05)		(0.06)		(0.12)

Notes: The numbers represent means or the differences between means.
Standard errors are in the parentheses. *** indicates 1 % significance level.

Table 4: Top 10 Diagnoses Subject to Co-payment by Gender

	Men		Women	
Diagnoses subject to co-payment (top 10)	Outpatient physical therapy	7.84%	Outpatient physical therapy	13.12%
	Medical biochemistry	3.20%	Medical biochemistry	5.07%
	Radiology	2.62%	Clinical cytology	3.40%
	Traumatology	2.32%	Radiology	3.14%
	Ophthalmology	2.31%	Dermatology and venereology	3.01%
	Otorhinolaryngology	1.92%	Ophthalmology	2.93%
	Urology	1.81%	Physical medicine and rehabilitation	2.35%
	Dermatology and venereology	1.78%	Otorhinolaryngology	2.30%
	Orthopedy	1.34%	Ultrasound	2.20%
	Physical medicine and rehabilitation	1.32%	Orthopedy	1.66%
Other diagnoses		15.34%		19.02%
Total		41.80%		58.20%

Table 5: Estimation Results

Independent Variable	Dependent Variable: z_i		Dependent Variable: I_i	
	Coefficients (β)	Std. Err.	Coefficients (γ)	Std. Err.
Age_i	0.3900***	0.07	0.1910***	0.01
Age_i^2	-0.0353***	0.01		
$Male_i$	0.2863***	0.07	-0.1370***	0.04
$Active_i$			-0.6980***	0.02
I_i	0.0340	0.24		
h_i	1.5618***	0.04		
$Age_i * I_i$	0.6173***	0.07		
$Age_i^2 * I_i$	-0.0530***	0.01		
$Male_i * I_i$	-0.3175***	0.07		
$h_i * I_i$	-0.1856***	0.04		
Constant	-2.9982***	0.25	0.1766**	0.07
Model Statistics:	Log-likelihood: 14083			

Notes: Coefficients are estimated by the simulated maximum likelihood method.
*** indicates 1 % significance level and ** 5 % significance level.

Table 6: Means of the Socio-Economic Variables: Sample and County Census

Variable	Sample Mean	Census Mean
Age_i	5.1604	4.9234
Age_i^2	29.4264	24.2399
$Male_i$	0.4348	0.4782
$Active_i$	0.55	0.4175
I_i	0.8346	-

Notes: Age variable is divided by 10.
Numbers reflect people 18 and older, except for active population in Census where the number reflects people older than 15.

Table 7: Moral Hazard and Gender Difference in Moral Hazard

	Option 1	Option 2 (Sample Mean)	Option 2 (Census Mean)
Moral Hazard	1.3339***	0.5367***	0.6873***
	(0.0289)	(0.0137)	(0.0160)
Gender Difference	-0.2069***	-0.0652***	-0.0746***
	(0.0406)	(0.0127)	(0.0138)

Notes: Standard errors are in the parentheses. *** indicates 1 % significance level.
Standard errors are calculated using Delta method.

7 Appendix

7.1 Derivation of equation (6):

From Equation (5) it follows that:

$$\frac{\partial\eta}{\partial\gamma} = \frac{1 + \frac{\alpha m}{y-p-\alpha m} + (1-\gamma)\frac{\alpha(y-p)}{(y-p-\alpha m)^2}\frac{\partial m}{\partial\gamma}}{\left(\gamma + \frac{\alpha m}{y-p-\alpha m}\right)^2}. \tag{20}$$

To derive $\frac{\partial m}{\partial\gamma}$, use Equation (4) to obtain:

$$\begin{aligned}
-\alpha\frac{\partial m}{\partial\gamma} &= \frac{1-\theta}{\theta}\alpha\left(m^\gamma ln(m) + \gamma m^{\gamma-1}\frac{\partial m}{\partial\gamma}\right)\\
&= \frac{y-p-\alpha m}{m^\gamma\alpha}\alpha\left(m^\gamma ln(m) + \gamma m^{\gamma-1}\frac{\partial m}{\partial\gamma}\right)\\
\frac{\partial m}{\partial\gamma} &= -\frac{(y-p-\alpha m)ln(m)}{\alpha + \frac{(y-p-\alpha m)\gamma}{m}}. \qquad (21)
\end{aligned}$$

Finally substituting Equation (21) into Equation (20) gives the desired result in Equation (6).

7.2 Proof of $\frac{\partial\eta}{\partial\gamma} > 0$ result:

First, notice that the denominator of Equation (6) is clearly always positive so the sign of the equation will be determined by the sign of the numerator that can be rewritten as:

$$\begin{aligned}
&= \frac{(y-p-\alpha m)\left(\alpha + \frac{(y-p-\alpha m)\gamma}{m}\right) + \alpha m\left(\alpha + \frac{(y-p-\alpha m)\gamma}{m}\right) + (\gamma-1)\alpha(y-p)ln(m)}{(y-p-\alpha m)\left(\alpha + \frac{(y-p-\alpha m)\gamma}{m}\right)}\\
&= (y-p)\left(\alpha + \frac{(y-p-\alpha m)\gamma}{m}\right) + (\gamma-1)\alpha(y-p)ln(m)\\
&= \left[\left(\alpha + \frac{(y-p-\alpha m)\gamma}{m}\right) + (\gamma-1)\alpha ln(m)\right](y-p)\\
&= \left[\alpha m + (y-p-\alpha m)\gamma + (\gamma-1)\alpha m ln(m)\right]\frac{y-p}{m}. \qquad (22)
\end{aligned}$$

Because $(y-p)/m > 0$, and the sign of (22) depends on the sign of the term in the bracket which is clearly always positive if $\gamma > 1$ and $m \geq 1$. However, when $\gamma > 1$ and $0 < m < 1$, the third term in the bracket becomes negative because now $ln(m) < 0$ and in order for the whole expression in the bracket to stay positive, the sum of the first two terms must be larger in absolute value than the negative last term. This is the case only as long as $y - p > 1 + \alpha$. To see this notice that $m * ln(m)$ has a minimum of approximately - 0.368 when $m = 0.368$ and therefore:[9]

$$\begin{aligned}\Big[\alpha m + (y-p-\alpha m)\gamma + (\gamma-1)\alpha m ln(m)\Big] &> \alpha m + \gamma(y-p-\alpha m) - (\gamma-1)\alpha \\ &> \gamma(y-p-\alpha m-\alpha) + \alpha(m+1). \qquad (23)\end{aligned}$$

Now, the only thing to show is that (23) is positive. Because $\alpha(m+1) > 0$, the first term in (23) need to be positive which will be the case if $y - p > 1 + \alpha$ because

$$\begin{aligned}y - p - \alpha m - \alpha &> 1 + \alpha - \alpha m - \alpha \\ &> 1 - \alpha m > 0,\end{aligned}$$

since $0 < \alpha < 1$, $0 < m < 1$, which completes the proof.

[9]The stationary point of $m * ln(m)$ is obtained as $\frac{d[m*ln(m)]}{dm} = ln(m) + 1 = 0$ which gives $m = exp(-1) = 0.368$ and is a local minimum because $\frac{d^2[m*ln(m)]}{dm^2} = 1/m > 0$.

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