Weather, Gender Wage Gap and Intimate Partner Violence

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Abstract According to household bargaining theories of domestic violence, when a woman's relative wage increases, her bargaining power increases, which leads to less domestic violence. This paper suggests that bargaining power can insulate the woman from the effects of weather shocks on the male partner's marginal utility of violence. I exploit the exogenous local variation in temperature at the county level to estimate the effect of weather and the gender wage gap on domestic violence. Specifically, I study the influence of extreme temperature on male-to-female intimate partner violence and how the influence changes with the gender wage ratio.

Keywords Intimate partner violence · domestic violence · expressive violence · violence against women · gender wage gap

JEL Classification J16 · I1 · J12

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Introduction

Intimate partner violence is a very expensive crime. In terms of medical care, mental health care, lost productivity and present value of lifetime earnings[1], the estimated annual cost is $5.8 billion (National Center for Injury Prevention and Control, 2003). In this paper, I exploit the exogenous local temperature and local gender wage ratio at county level to estimate the effect of weather on domestic violence under different women's bargaining power. First, I test the hypothesis of expressive violence theory which predicts that the husband's marginal utility of violence increases when he is agitated by extreme weather. Specifically, I estimate the influence of extreme temperature on male-to-female intimate partner violence and I find that both hot days and cold days increase intimate partner violence. Second, I test the hypothesis predicted by household bargaining theory that as the woman's relative wage increases, her outside option improves, which makes violence more costly for the male and hence less prevalent. My finding shows the woman's relative wage decreases domestic violence which is consistent with the expressive violence hypothesis. Finally, I test the hypothesis that bargaining power insulates the woman from the extreme weather effect. While men's marginal utility of violence increases as the extraordinary weather motivates his aggressive behavior, women with significant bargaining power can make it prohibitively expensive to attack them.

This paper's major contribution is to show that the higher the woman's relative wage (to man's wage), the smaller the effect of extreme weather on intimate partner violence. My findings have important policy implications. It helps to better understand the weather induced risk faced by vulnerable population. It also helps the police, shelter managers, and hospital

[1] The annual estimate of female homicide victim is 1,252 and the present value of lifetime earnings represents the expected value of these homicide victim would have earned if they were to live (National Center for Injury Prevention and Control, 2003).

administrators allocate their resources based on the estimated potential victims derived from weather.

The remainder of the paper is organized as follows. Section I describes the background on domestic violence. Section II presents the data and empirical model. Section III presents the results, and Section IV concludes.

I. Background on Domestic Violence

A. Theories of Domestic Violence

The majority of the economic literature analyzing domestic violence uses a household bargaining model. The household bargaining model analyzes the allocation and distribution behavior within the household. It distinguishes from previous household decision-making models by allowing different utility functions (Manser and Brown, 1980; McElroy and Horney, 1981). Lundberg and Pollack (1993) extend the household bargaining model by providing a noncooperative separate spheres equilibrium. An important result of these theories is that the woman's bargaining power increases as her relative wages increase. As a woman's outside option – in this case, leaving the man and earning her own wages – improves, she becomes less tolerant of violence. If she accepts violence at all, the man must pay more. In addition, as the woman gains more money, her marginal utility of income decreases, meaning she demands even more money to compensate for any violence. Conversely, as the man must pay more for violence, he loses income, and his marginal utility of money increases.

Bloch and Rao (2002) introduce asymmetric information into the noncooperative bargaining model. The husband has private information on his marriage satisfaction, and he uses violence as an instrument, in particular a signal, to convince the bride's family to pay a

larger dowry. In the case where the husband uses violence as a means to control household resources, domestic violence is viewed as instrumental violence. Alternatively, if the husband gains a positive utility by beating his wife and provides her some compensation to keep her in the marriage, then domestic violence is viewed as expressive violence (Tauchen et al., 1991). Using emotional cues to access expressive violence, Card and Dahl (2011) study the effect of unexpected local professional football losses, which serve as emotional cues on domestic violence. They find the unexpected losses increase intimate partner violence. In addition to emotional cues, weather shocks such as extreme temperature can increase domestic violence as well.

B. Studies of Weather and Violence

Previous research has established the connection between weather and violence. The most commonly discussed aspect of weather in this context is temperature. In psychology, the temperature-aggression hypothesis states that uncomfortable temperatures motivates aggressive behavior (Anderson et al., 2000). Baron and Bell (1976) conduct an experiment to examine the influence of temperature on physical aggression. They assign students to receive a positive or negative evaluation from a partner, and students later may respond to the partner by electric shock. They find in certain cases, high temperature can lead to higher physical aggression. Not only temperature increases intra-personal violence, it also increases intra-family violence, especially intimate partner violence. Card and Dahl (2011) show that the intimate partner violence is 8% higher in state with maximum temperature above 80 degrees Fahrenheit.

The other common aspect of weather linked to violence is precipitation. Rainfall directly influences the growth of agricultural products, and therefore rainfall is an important factor contributing to the economy in developing countries relying heavily on agriculture. In order

to smooth consumption, parents may distribute their children's nutrition intake differently by gender (Behrman, 1988). Rose (1999) finds that rainfall deficits decrease the girl's survival rate compared to the boy's survival rate in rural India. In addition to affecting the growth of agricultural products, rainfall also reduces people's desire for outdoor activities. The more time the couples spending indoors with each other, the more a couple is exposed to each other, increasing the chance of a conflict leading to violence (Dugan et al., 1999).

When the couple has different opinions on what to spend, violence is one way to control the household resource allocation. In an economic downturn, scarce resources may exacerbate the couple's arguments, and therefore domestic violence against women could be even more severe. Sekhri and Storeygard (2010) find that rainfall deficits increase the reported dowry deaths in India. As a response of the weather shocks, the dowry payment increases to both above- or below-normal rainfall shocks. This suggests that the husband uses violence as tool to smooth consumption in response to weather shocks.

C. Studies of Woman's Economic Status and Violence

The woman's economic status is an indicator of her bargaining power. One way to measure the woman's economic status is by viewing her employment status. Bowlus and Seitz (2006) build a model incorporating violence, divorce and employment, and they show a negative impact of women's employment on domestic violence using Canadian survey data. Heath (2014) analyzes the data collected in Bangladesh and finds a positive correlation between working women and violence. However, the positive correlation only exists among women with low education or women with an early first marriage.

Another common measurement for the woman's economic status is by viewing her wage. The empirical studies on the woman's wage and violence is inconclusive because using woman's wage as a measurement for her bargaining power is problematic. First, the reverse

causality issue must be addressed. The woman's health condition may affect her productivity and therefore her wage. The average lost productivity per physical assault is about a week and the estimated annual cost is $0.85 billion in the U.S. (National Center for Injury Prevention and Control, 2003). Second, the woman's bargaining power is determined by her wage rate, not her actual wage. A woman may have lower wage simply because she allocates more time on household production (Pollak, 2005). To address this issue, Aizer (2010) uses gender wage ratio to measure the woman's bargaining power and she finds that increases in female-to-male wage ratio decrease the female hospitalization for assault.

II. Data and Empirical Model

A. Data Sources

Crime Data. – The domestic violence data are derived from National Incident-Based Reporting System (NIBRS) complied by the FBI for comprehensive crime studies. NIBRS provides detailed information on crime incidents reported to the police station including information on the offender and the victim. Importantly, NIBRS reports the relationship between offenders and victims by reported incident. There are several advantages to using NIBRS. First, it provides all the reported domestic violence from participating police agencies. It covered a quarter of the U.S. population by year 2006. The other data containing domestic violence such as National Crime Victimization Survey only covers 160,000 persons. Also, it records the relationship between the offender and the victim. I use this information to identify domestic violence. The other common crime data such as Uniform Crime Report (UCR) provides aggregated crime rates disregarding the victim-offender relationship, and therefore the data on family violence is not available.

One critique of using crime report data is that it underestimates the crime rate. Not every victim chooses to notice the police, especially if the crime is committed by one's intimate

partner[2]. The reported crime may vary due to the variation of true crime and the variation of reporting behavior. If the reporting behavior varies with gender wage ratio, say the reporting rate is higher when the female to male wage ratio is higher, then the estimated effect of gender wage ratio on violence is biased towards zero. This potential bias makes the estimates more conservative.

I focus on male-on-female intimate partner violence, and I calculate the violence count at annual county level[3]. There are in total 104 counties in 27 states. Table 1 lists all the counties covered in this analysis. Intimate partner includes spouse, common-law spouse, ex-wife, and girlfriend/boyfriend. The violence count includes the incident count of both aggravated assault and simple assault. Aggravated assault is defined as any physical assault with grievous bodily harm and/or a lethal weapon. Simple assault is defined by any physical assault without grievous bodily harm or lethal weapon.

Weather Data. – The weather data are taken from Global Summary of the Day, compiled by National Climatic Data Center (NCDC). I focus two weather variables which are daily temperature and perception at county level. A *hot* day is defined when a day with the maximum temperature greater than 80 degrees Fahrenheit; and a *cold* day is defined when a day with the minimum temperature is less than 33 degrees Fahrenheit.

Demographic Data. – The annual income per capita is from Bureau of Economic Analysis. The unemployment rate data is from Bureau of Labor Statistics.

B. Econometric Strategy

[2] In the U.S, about 60% of domestic violence were reported to police based on National Crime Victimization Survey (Durose et al., 2005).

[3] In the U.S., about 84% of the intimate partner violence is female from 2009 to 2010 (Catalano, 2012). Also, women are 1.8 times more likely being victim of severe physical violence than men (Breiding et al., 2014).

To better identify the woman's bargaining power, instead of using women's actual wage, I follow Aizer (2010)'s measure of relative wage. There are two major advantages. First, this measure avoids the endogeneity issue of individual wages. Second, it reflects a woman's wage rate or potential wage by estimating the average female wage as a function of local labor demand for females. The average female wage is composed of the proportion of local female labor working in a certain industry and the annual wage in a particular industry in the state except the local county. The average female (or male) annual wage in a county is calculated as equation (1).

$$\bar{W}_{gcry} = \sum_j \gamma_{gcryj} w_{-cyj} \tag{1}$$

where g indicates gender, c county, r race, y year and j industry. γ_{gcyj} is the annual proportion of a certain gender g workers working in industry j for county c in year y[4]. The employment data by industry is from American Community Survey from year 2006 to 2009. w_{-cyj} is the annual compensation in industry j in the state except for county c in year y. The industry compensation[5] data by county is from the Bureau of Economic Analysis. The difference between equation (1) and Aizer (2010)'s measurement of relative wage is that I allow the annual proportion of female (or male) workers working in a certain industry to be time-varying. The benefit of allowing it to be time-varying is to estimate the annual average female (or male) wage more accurately.

I estimate the effect of weather and gender wage ration on domestic violence using the following equation:

[4] I exclude workers with more than high school degree or GED because domestic violence is more severe in low-income family (Zawitz, 1994). Also, I exclude military service workers because they are unlikely to report domestic violence to police station.

[5] Compensation is defined as the sum of wage and salary disbursements and supplements such as social insurance and pension funds.

(1) $DV_{crt} = F(\lambda_{crt}, \theta)$

(2) $\ln(\lambda_{crt}) = \beta_0 + \beta_1 Hot_{ct} + \beta_2 Cold_{ct} + \beta_3 WageRatio_{crt} + \beta_4 Hot \times WageRatio_{crt} + \beta_5 Cold \times WageRatio_{crt} + \beta_6 Rain_{ct} + \beta_7 ViolentCrime_{crt} + \beta_8 DV_{crt-1} + \beta_9 Unemp_{ct} + \beta_{10} Inc_{ct} + \gamma Race_r + \theta County_c + \delta Year_t + \varepsilon_{crt}.$

The observation unit is race-county-year and *r* indicates race, *c* indicates county while *t* indicates year. θ is the over-dispersion parameter, and λ_{crt} is the expected annual count of domestic violence by county c and race r. *DV* is the annual count of physical assault against female intimate partner by county c and race r. *Hot (Cold)* refers to the number of hot (cold) days in a year in the county. *WageRatio* is the ratio of female to male average annual wage using equation (1). *Hot* × *WageRatio* is an interaction term between number of hot days and female to male wage ratio. *Cold* × *WageRatio* is an interaction term between number of cold days and female to male wage ratio. *Rain* is the number of days with any precipitation in a year in the county. *ViolentCrime* is the annual count of non-intimate homicides in a county in a year. It is used to control for the violence trend. DV_{rct-1} is the lags of the dependent variable and is used to control for any other omitted time varying variables. *Unemp* is the annual unemployment rate in the county. *Inc* is the annual per capita income in the county. Race is categorized as white, black, Asian, Hispanic, and others. I include county fixed effects (*County*) to control for the time-invariant characteristic in each county and year (*Year*) fixed effects control the crime variation over time.

C. Summary Statistics

Table 2 shows the descriptive analysis of the estimation sample. The average of physical assaults against female intimate partners per 10,000 people is 6.7 in a county year. The average annual number of days with maximum temperature more than 80 degrees of Fahrenheit is 54 days in a county year. The average annual number of cold days with

temperature lower than 33 degrees of Fahrenheit is 67 days in a county year. The rate of non-intimate homicides is much smaller than the rate of physical assaults against female intimate partners; it is used to control for local violence trends. Finally, the gender wage ratio is defined as average annual female wage divided by average annual male wage by equation (1). The mean of the gender wage ratio is higher than the median. It suggested that the gender wage ratio has a right-skewed distribution. More than half of the observations in the sample have relatively low female wage by a certain county, year and race.

The mean of female physical assault is less than the standard deviation and therefore using Poisson model is inappropriate[6]. I use the negative binomial model which is an alternative model for count model and it is robust to over-dispersion (Aizer and Dal Bó, 2009).

III. Empirical Results

I estimate the effects of extreme weather and gender wage ratio on domestic violence using the empirical strategy in Section II. The dependent variable is the annual count of physical assaults against female intimate partners and the unit of observation is a county-race-year cell. I include county, year and race fixed effects.

Table 3 presents the main results. First, I test the hypothesis of expressive violence theory, which predicts that extreme weather will increase domestic violence. In column 1, the significant and positive coefficients of both hot days and cold days support the hypothesis. On average, an additional hot day in a year increases the rate of female physical assaults by 1.7 %; an additional cold day in a year increases the rate of female physical assaults by 1.2 %. In addition, rainy days increase female physical assaults by her intimate partner. This reflects the predictions of criminologists' exposure theory, which suggests the less time a couple spends together the less they will fight, and vice versa (Dugan et al., 1999). The couple

[6] The expected value of mean for a random variable following Poisson distribution is equivalent to the variance.

spends more time together inside on a rainy day, and this increased interaction leads to violence.

Second, I test the hypothesis of household bargaining model, which predicts that an increase in the woman's wage rate improves her outside option. The woman's higher bargaining power decreases intimate partner violence against her. In column 2, the significant and negative coefficient of female/male wage supports the second hypothesis. An increase in 0.1 of the gender wage ratio increases decreases annual assaults against females by their partners by 2.6%. The effect of gender wage ratio on domestic violence is smaller after controlling for local extreme weather, but is still significant.

Third, I test the hypothesis that the woman's bargaining power cushions the effect of extreme weather on intimate partner violence. The direct effect of gender wage ratio on domestic violence becomes insignificant after controlling for the interaction between gender wage ratio and extreme weather (column 4). This suggests that the increase in female/male wage dampens the effect of extreme cold weather on intimate partner violence. The protection afforded by an increase in the woman's bargaining power appears to manifest itself in the extreme situations where a man's utility of violence has been shocked. This suggests an irregularity of violence among some offenders, where the benefits of violence only exceed the costs when various frustrations add up. However, the wage ratio does not insulate women from the effect of extraordinarily hot weather. In column 5, I include the lagged local intimate partner violence to control for other time varying omitted variable[7]. The interaction term between wage ratio and cold days remain significantly negative. Finally, I include the local non-intimate homicide to control for the violence trend and main results remain.

[7] The autoregressive model with fixed effect is biased for small time period (Baltagi, 2008; Nickell, 1981). I include the lagged dependent variable to show that the omitted variable is not an issue here.

IV. Conclusion

I examine the influence of the gender wage ratio on the effect of extreme weather on domestic violence, specifically physical assault against female intimate partners. The household bargaining model states the increase in the woman's potential wage (or wage rate) increases her well-being at threat point and therefore it increases her bargaining power. This model predicts that the woman's potential wage will insulate her from the effect of extreme weather motivating aggressive behavior. Analyzing the annual count of physical assault against female intimate partners in 104 counties in the U.S. over 2006 to 2009, I find that an increase in female-male wage ratio protects the woman from the husband's aggressive behavior motivated by freezing weather. This finding helps the police agencies, hospitals, shelters, and hot line services to better estimate the potential domestic violence victim and to better allocate manpower during extraordinary weather. Further, promoting gender equal pay is important for limiting intimate partner violence.

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Table 1: Counties Included in the Analysis

County	County	County
Accomack, VA	Galveston, TX	Nez Perce, ID
Ada, ID	Genesee, MI	Pennington, SD
Alamosa, CO	Grand Forks, ND	Plaquemines, LA
Alpena, MI	Greene, OH	Polk, IA
Arlington, VA	Halifax, VA	Potter, TX
Black Hawk, IA	Hamilton, TN	Power, ID
Blount, TN	Hampden, MA	Pulaski, AR
Brown, SD	Harris, TX	Raleigh, WV
Burleigh, ND	Hartford, CT	Randolph, WV
Caddo, LA	Henrico, VA	Roscommon, MI
Calcasieu, LA	Hill, MT	Salt Lake, UT
Caledonia, VT	Houghton, MI	Sebastian, AR
Cascade, MT	Hughes, SD	Sedgwick, KS
Cass, ND	Jackson, OR	Shawnee, KS
Charles Mix, SD	Jefferson, AL	Shelby, TN
Charleston, SC	Kanawha, WV	Sherman, KS
Chippewa, MI	Kent, MI	Spartanburg, SC
Chittenden, VT	Kent, RI	Suffolk, MA
Clay, IA	Lexington, SC	Summit, OH
Clinton, MI	Linn, IA	Tarrant, TX
Cloud, KS	Loudoun, VA	Tom Green, TX
Coos, NH	Lubbock, TX	Tooele, UT
Cumberland, ME	Lucas, OH	Trumbull, OH
Cuyahoga, OH	Marion, OR	Umatilla, OR
Dallas, TX	Marquette, MI	Valley, MT
Dane, WI	Merrimack, NH	Victoria, TX
Davidson, TN	Mesa, CO	Wayne, MI
Delta, MI	Millard, UT	Wayne, WV
Denver, CO	Milwaukee, WI	Wichita, TX
Dubuque, IA	Minnehaha, SD	Williams, ND
El Paso, CO	Missoula, MT	Woodbury, IA
Fairfield, CT	Moffat, CO	Worcester, MA
Flathead, MT	Montgomery, OH	Yellowstone, MT
Ford, KS	Montgomery, TN	Yuma, AZ
Franklin, OH	Muskegon, MI	

Note: The sample years are from 2006 to 2009 except Yuma, AZ covers only year 2006.

Table 2: Summary Statistics for Intimate Partner Violence, 2006-2009

	Mean	Median	Std. Dev.
Female physical assaults/ 10,000 people	6.73	0.85	10.66
Annual hot days	54.00	26.00	60.88
Annual cold days	67.42	38.00	77.54
Annual rainy days	74.83	31.50	82.91
Nonintimate homicides/ 10,000 people	0.08	0.00	0.23
Female/male wage	1.01	0.93	0.53

Note: The data unit is county-race-year.

Table 3: The Impact of Weather and Gender Wage Ratio on Intimate Partner Violence

	(1)	(2)	(3)	(4)	(5)	(6)
Hot days	0.017***		0.016***	0.018***	0.014***	0.013***
	(0.002)		(0.002)	(0.002)	(0.002)	(0.002)
Cold days	0.012***		0.012***	0.014***	0.013***	0.013***
	(0.001)		(0.001)	(0.001)	(0.001)	(0.001)
Rainy days	0.008***		0.008***	0.008***	0.007***	0.007***
	(0.001)		(0.001)	(0.001)	(0.001)	(0.001)
Female/male wage (Wage Ratio)		-0.266**	-0.154**	-0.014	-0.075	-0.080
		(0.120)	(0.072)	(0.089)	(0.086)	(0.085)
Wage Ratio x hot days				-0.001	0.002	0.002
				(0.002)	(0.002)	(0.002)
Wage Ratio x cold days				-0.002***	-0.001***	-0.001***
				(0.000)	(0.000)	(0.000)
Lagged dependent variable					0.001***	0.001**
					(0.000)	(0.000)
Non-intimate homicide						-0.009
						(0.008)
County, year, race fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Per capita income, and unemployment rate	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,866	1,866	1,866	1,866	1,381	1,381

Note: Robust standard errors are clustered by county level. The data unit is county-race-year. *, **, *** denote the significance level at the 10%, 5%, 1%, respectively.