Master's Thesis

The Impact of Gender Norms on Gender Gap in Leadership:

Focusing on Voice Pitch Analysis

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Abstract

We examine to what extent gender norms affect voice patterns of women in leadership positions by analyzing voice pitch. Motivated by studies that show links between women's vocal behaviors and gender stereotypes, we investigate whether gender inequalities are related to the gender gap in voice pitch. We hypothesize that women from countries with traditional gender norms will speak in higher-pitched voices than men and that the gender gap in voice pitch will be more pronounced compared to countries with less restrictive gender norms. Using 578 voice samples from 58 countries from 2019 to 2020, we find a statistically robust pattern that the gender gap in average voice pitch increases in countries with less gender equality.

JEL Classification: J16, J24, J71

Keywords: fundamental frequency, gender gap, gender norms, leadership, voice pitch

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I. Introduction

On July 26, 2016, at the Democratic National Convention (DNC) in Philadelphia, Hillary Clinton became the first women in U.S. history to be nominated as the presidential candidate of a major political party[1]. As a news article entitled "Hillary Clinton Breaks the Glass Ceiling" suggests, news outlets hailed her nomination as a historic achievement for women (McCaskill 2016). However, shortly after her acceptance speech declaring her victory that night, a recording of Hillary Clinton's public speech from 1969 – when she was still a 22-year-old student at Wellesley College – went viral on the internet. It was impossible to ignore the dramatic difference in her voice, as young Hillary's soft and lilting tone was almost unrecognizable compared to present-day Hillary's significantly deeper sound. Both the media and political observers criticized the evolution of her voice (Jones 2016a), pointing out that one of the most prominent women in U.S. politics had changed her voice to sound "more like a man" (Jones 2016b). Hillary Clinton is not the only example of women in leadership adjusting their speech patterns to sound more masculine. The first female British Prime Minister, Margaret Thatcher, took private speech trainings with a coach at the Royal National Theatre (Cameron 2005) after being criticized for her naturally high pitch and nasal tone. The result of the lessons was a firmer and more powerful voice with substantially lowered pitch and a slower speech pace.[2]

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[1] Henderson, N.-M. (2016, June 8). Hillary Clinton's historic moment. CNN. https://edition.cnn.com/2016/06/06/politics/clinton-first-woman-nominee-democratic-primary/index.html.

[2] Voice analysts speculate that Thatcher likely damaged her vocal folds as a result of her artificially lowered voice (Karpf 2006).

Women taking such deliberate actions to lower the register of their voices likely reflects a persistent sexism governing gender norms in the male-dominant society, where much lower and deeper masculine voices fitg the archetypal image of a social leader. Considering the biological differences between the sexes – with a woman's average voice pitch being about an octave higher than a man's average pitch – voice pitch can be a contributing factor to the smaller number of females in leadership positions.[3] In addition to individual changes over time, cross-generational changes in women's voices have also been identified, as young women today speak at a significantly lower pitch than women in the 1940s. Pemberton et al. (1998) find an audible difference in women's voices when they compared audio recordings of Australian women aged 18 to 25 from 1993 and 1945.[4] The study suggests some possible sociocultural explanations for this change, speculating that the rise of women to more powerful positions in recent years led them to adopt lower-pitched voices to project the more serious or mature image that is often demanded in professional workplaces. Also, the social transformation of gender norms, which dictate the standards for an appropriate and acceptable pitch for men and women, may have generated the downward trend in women's voice pitch in the Australian population. Sorokowski et al. (2019) also suggest that there is within-individual variation in voice pitch, citing evidence that people lower their pitch when asked to provide expert advice.

[3] In 2020, women hold only 7.4% of leadership positions in Fortune 500 companies (Zillman 2020). In the U.S., women account for 38% of first-level managerial positions while accounting for 48% of entry-level positions (McKinsey & Company 2020).

[4] Compared to the archival recordings of women's voices from 1945, the average pitch of speaking fundamental frequency of young Australian women in 1993 dropped by 23 Hz – from an average of 229 Hz (approximately an A# below middle C) to 206 Hz (approximately a G#).

Their experiments show women lowering their voices more than men when speaking in a professional context.[5] However, what makes it even harder for women to pursue leadership position is the gender stereotype, which will impact people to consider low-pitched voice to be masculine, and high-pitched voice to be feminine. To a certain extent, women who speak in high-pitched voice are regarded as more natural and more likable. In short, we find the clash of two perceptions; the idea of the right voice for leadership and the idea of the right voice for women. These factors create a dilemma, or an environment with a double-standard for women pursuing leadership, and strict gender stereotype may hinder women to speak in low pitch.

Building on these previous studies, this paper conducts empirical analyses to gauge the impact of gender norms on women's behaviors in terms of expressing leadership by observing one of the most distinctive features in vocalization: the fundamental frequency of voice. Our focus on the voice pitch stems from numerous studies that show how social construction of gender bias accounts for gender differences in vocalization and other research suggesting that both men and women who speak in low-pitched voices are more likely to obtain leadership positions. However, to the extent of our knowledge, previous studies do not directly examine the extent to which women adjust their voice pitch in response to the level of gender equality in their society. We hypothesize that women in countries with higher gender parity will use lower-pitched voices compared to women in countries with lower gender parity.

[5] The average woman's mean voice pitch lowered by 33 Hz, while the average man's pitch lowered by 14 Hz.

We compile a cross-country dataset of 58 countries containing 578 voice samples from 68 broadcasting programs between 2019 and 2020. We use an open-source phonetics software called Praat (version 6.1.38) to calculate average, minimum, and maximum voice pitches for each speaker. Our dataset also includes information on the speaker's gender, date of the broadcast, and the type of program. Using the 2020 Global Gender Gap Index (GGI) from the Global Gender Gap Report published by the World Economic Forum, we measure the overall level of gender disparity among countries. We then divide countries into three equally sized groups by GGI, resulting in top, middle, and bottom gender equality groups.

Using an ordinary least squares (OLS) model, we measure the gender differences in average, minimum, and maximum voice pitches across these three gender equality groups while controlling for month, year, program type, and country fixed effects. The month and year fixed effects capture any potential time trends common across broadcasting services. The program type fixed effect captures the possibility that some programs may innately impact the vocal behaviors of the individual cast members. The country fixed effect captures specific country characteristics.

For our baseline results, we find that the gender gap in the average voice pitch decreases by 12 to 18 Hz for the top and middle gender equality groups in comparison to the bottom gender equality group. For example, in our sample, the average voice pitch in the bottom gender equality group is 145 Hz for men and 219 Hz for women, which creates a gender gap of 74 Hz. However, the gap decreases to 56 Hz in the middle group and 62 Hz in the top group. These differences translate to a 24% decrease

in the voice pitch gender gap between male and female speakers in countries with average gender equality and a 16% decrease in countries with the highest gender equality. Evan after controlling for detailed characteristics, including the time of the broadcast, program type, and country, the estimated coefficients for the gender gap in average voice pitch are robust and significant at the 1% level.

These results provide suggestive evidence that gender norms play a critical role in the gender disparity of social leadership. Previous studies on voice pitch find that a deep and low-pitched voice can contribute to an individual's success in a professional career,[6] and the voice pitch of male leaders is closely related to their success in the labor market.[7] If these findings apply to our setting, then the average voice pitch difference among female CEOs can result in up to a 12.48% difference in total annual compensation.

This paper contributes to the literature by being the first to conduct a cross-country analysis of the gender gap in voice pitch and to show a significant effect of gender norms on the vocal behavior of women. Our findings support the importance of gender parity for greater representation of women in the world of leadership. That said, our empirical analysis has several limitations. First, we cannot completely rule out the possibility that voice pitch may be correlated with socioeconomic traits of an

[6] Both men and women who speak in comparably low-pitched voices are regarded to be more competent, stronger, and more trustworthy. In selecting leaders, humans prefer leaders with lower-pitched voices, regardless of their gender. (Klofstad et al. 2012). Tigue et al. (2011) find that in an election, candidates' voice pitch plays an important role in voting behavior and that there is a preference to vote for men with lower-pitched voices, regardless of their political stance.

[7] Mayew et al. (2013) document a significant economic impact of voice pitch in the competition for labor market success among male CEOs, where a 1% decrease in voice pitch is correlated with a 1.37% increase in the size of the firm they manage and a 0.52% increase in their annual income.

individual that we cannot measure in this study. Also, there are arguments that suggest the vocal behaviors of media professionals being heavily conditioned by the gender norms of a society. Therefore, such trained speech patterns may not accurately represent the common language patterns of the public. Additionally, due to data limitations, our study only focuses on the pitch, a single acoustic parameter of voice, but an additional multi-parametric analysis with vocal intensity, jitter, shimmer, or Harmonic-to-Noise Ratio (HNR) would likely yield more productive results. Exploring wider mechanisms of vocal behavior will be necessary to fully understand the vocal adjustments that women make in response to gender stereotypes. We leave these tasks for future research.

The remainder of this paper is organized as follows. Section 2 explains the related studies in vocal acoustic analysis, the perception of leadership in human voice qualities, and the association of gender stereotypes with women's speech behaviors. Section 3 describes the data and the sample we use, the methodology, and the empirical framework. Section 4 reports our results, and Section 5 presents the discussion and concluding remarks.

II. Related Studies

Vocal Acoustic Analysis

There are many acoustic parameters used in voice analysis, but the most referenced ones in the literature are 1) fundamental frequency, 2) jitter, 3) shimmer, and 4) Harmonic-to-Noise Ratio (HNR) (Teixeira et al. 2013). The fundamental frequency is

the lowest frequency of an audible sound, and in the context of human voice, it is perceived as voice pitch (Kreimen and Sidtis 2011). The fundamental frequency, or F0, is measured in Hertz (Hz), meaning human speech is defined by the vibration rate of the vocal folds during a given time period while pressured air flows out from the lungs (Pisanski et al. 2016). Because of the variations in physical properties, such as the length, the mass, and the tension of the vocal cords, from person to person, the F0 differs widely across individuals, both within and between genders. The average fundamental frequency of an adult woman is 200 Hz, and for an adult male, it is 125 Hz (Takefuta et al. 1972), creating the average of 75 Hz gap between gender.

Jitter and shimmer allow us to observe more specific variations occurring in the fundamental frequency. Jitter is the parameter of frequency variation from cycle to cycle, and shimmer presents the amplitude variation of the sound wave (Zwetsch et al. 2006). Jitter is measured in percentage and generated mainly by the lack of control in vibrating the vocal folds. Shimmer is measured in decibels (dB), as it refers to the intensity of vocal emission, and associated with noise emission and breathiness of a voice (Haydée et al. 2005). Lastly, Harmonic-to-Noise Ratio (HNR) is a measure that estimates the amount of noise in the voice signal (Ferrand 2002). Despite being commonly used as acoustic measures of voice, the amount of jitter, shimmer, and HNR in a voice may not be important factors when assessing a listener's perception of voice quality (Kreimen et al. 2002)

Among the various measures of voice acoustic analysis, the variance in the average fundamental frequency is widely considered to be the major difference between male and female voices (Pépiot and Arnold 2021). Hence, in this study,

fundamental frequency is used to analyze gender differences in vocal behavior in regard to gender norms.

Perception of Leadership in Human Voice Qualities

Studies on the relationship between body size and vocal characteristics suggest that low-pitched vocalization is more likely to occur from a larger and taller individual (Puts et al. 2012). Even when physical information about a speaker is not available, listeners often associate low frequency vocalization with a large body size (Pisanski et al. 2017). What is worth noting is that listeners also correspond low voice pitch with the image of intelligence and dominance (Hughes et al. 2014). Regardless of one's actual ability, such positive portrayals would give a comparative advantage in professional workplace. Due to the biophysical differences between gender, it is naturally an uneven playing field for women in the labor market competition.

Gender Norms and Women's Vocal Patterns

The impact of gender norms on voice pitch can be observed in cross-cultural comparisons. Bezooijen (1995) finds that the relatively high-pitched voices of Japanese women compared to those of Dutch women is associated with different gender stereotypes in the two countries. Japanese society considers high-pitched voices as more attractive for females, whereas Dutch society considers medium- or low-pitched voices as a positive trait for females. These unequal perceptions of the ideal voice pitch for men and women is often reflected by a larger gender pay gap in some

countries.[8] Mayew et al. (2013) reveal a strong correlation between men's voice pitch and their income. Their findings show that male chief executive officers (CEOs) with deeper voices manage larger companies, receive higher salaries, and enjoy longer tenures.[9]

However, a low-pitched voice in the work environment may not always be an advantage for women. Jones et al. (2008) stress men's strong preference for feminine features in women's voices, as men were almost always attracted to women's voices with a higher than an average pitch. Karpf (2006) mentions how women consciously or unconsciously speak in a higher, softer, and quieter voice to prevent difficult conversations and to avoid being counted on to make difficult decisions.[10]

When a low-pitched voice amplifies the image of dominance for an individual, it becomes a natural disadvantage for women. While both men and women are likely to choose leaders with lower-pitched voices, whether the individual is a man or a woman (Klofstad et al. 2012), the biological differences between men and women trigger an inevitable gender gap in voice pitch because women's voices are less likely to be perceived as the voice of a leader. Starcheski (2014) suggests a strong gender bias in people's perceptions of female voices. People with higher pitched voices are often regarded as insecure, less qualified, and less dependable. This suggests that because women in general have higher-pitched voices than men, the voice pitch could

[8] In Japan, women do more than 70% of unpaid work and caregiving. Despite recent progress, the country still has the third highest gender pay gap among OECD member countries (OECD 2017).

[9] The analysis of speech samples from 792 male CEOs suggests that a drop in voice pitch of 22 Hz brings increased compensation of USD 187,000 a year. (Mayew et al. 2013)

[10] Contradicting standards in evaluating women's voice can be another double bind that women must face in the business environment (Karpf 2006).

contribute to fewer number of women holding leadership positions than men. Thus, we hypothesize that women in countries with strong gender norms use higher pitched voices than women in countries with more flexible gender norms.

III. Data and Empirical Framework

III.1 Data

We compile a dataset with voice samples of 578 men and women from 58 countries. The materials for the analysis were collected from 68 programs aired on TV, radio, podcast or YouTube channels from 59 broadcasters during the period from February 2019 to December 2020. Audio samples were gathered directly from the program archives available on a broadcaster's official website, podcast, or YouTube channel. Speech fragments of cast members with a duration of less than 20 seconds were extracted from a program episode using Ocenaudio (version 3.10.4), a multi-platform audio editor. We then measured the voice acoustics of each sample using Praat (version 6.1.38), an open-source phonetics software (Boersma and Weenink 2018).

Broadcaster Selection

Public broadcasters, like the British Broadcasting Corporation (BBC) in the UK and the Italian broadcaster Radiotelevisione Italiana (RAI), are some of the most influential media organizations in the world (Hanretty 2011). One of the self-ascribed roles of a national or public broadcaster is the establishment and maintenance of a national identity within a country (Van Den Bulck et al. 1996).

State-run or public broadcasting services were prioritized in the process of selecting broadcasters to obtain speech samples. Out of 58 countries, we identified a total of 42 national or public broadcasters that provide access to their past program archives via their official website and/or podcast channels. For countries with no available access to past program collections for national/public broadcasters, we located a corporate broadcasting service with archives as the second-best option.[11] We obtained samples from corporate broadcasting services for 7 countries. For Chile and Jordan, where neither public nor corporate broadcasters provide archive services, broadcasting services hosted by public institutions (national universities or the parliament) were chosen. For Armenia, Moldova, Morocco, the Philippines, Saudi Arabia, Serbia, and Uruguay, where none of the above-mentioned services were readily attainable, we selected private broadcasting services from podcast channels in each country. The podcast selection criteria were (1) whether the channel was ranked at the top of the country's podcast charts in Spotify or iTunes and (2) whether the channel's physical location and the nationality of the host corresponded to the appropriate country.

Program Selection

Most state-run and public broadcasters air hourly news programs during the day, making the news the most available type of content to collect samples from. Regular news programs, which tend to follow a more traditional news reporting method, have

[11] We use the definitions and concepts of broadcast media set offered by UNESCO (2005) and UNDP (2004) to differentiate state, public, and commercial broadcasting services.

an additional relative advantage over other types of broadcast programs because they provide a more articulate and clear delivery of the announcer's voice without other sound effects that could hinder accurate analysis of voice acoustics. Also, news announcers deliver news reports with standardized language that reflects a nation's cultural characteristics, including the gender norms shared by the society. We found a total of 49 news programs with archives from 45 countries. For the other 13 countries, interviews or talk show programs were chosen as an alternative source to obtain sound samples.

Speech Segmentation and Sampling

As stated above, our dataset was extracted from broadcasting materials of various durations and program categories in either audio or video format. We imported these samples into Ocenaudio, a cross-platform audio editing software that can import both video and audio media formats regardless of the length or size of the files.

By browsing through each program episode, we hand-selected and extracted speech fragments from male and female cast members that had minimal interference from external noise. The selected speech fragments have a mean duration of 16.400 seconds. The selected speech segments were then exported individually into MP3 audio files at a sampling rate of 44.1 kHz with 16-bit amplitude quantization. Our final dataset includes speech samples from 289 individual men and 289 individual women, categorized by the speaker's gender, the language being spoken, the broadcasting date, the title and type of program, and the broadcaster.

These samples were extracted from 49 news, 11 interview, and 8 talk show programs aired on TV, radio, podcast, or YouTube channels from February 2019 to December 2020 through 59 different broadcasting services.

Acoustic Analysis

For measuring the acoustics of the speech samples, we used the Praat phonetic analysis program (version 6.1.38). Praat is an open source, multi-platform computer software package for speech analysis in phonetics. The program can edit and measure the duration, pitch, intensity, and formants of sounds. For each of the 578 selected samples, we measured the duration and the average, minimum, and maximum acoustic fundamental frequency (F0, perceived as pitch) in Hz. Parameters were set to a pitch floor of 75 Hz and a pitch ceiling of 2,500 Hz, with all other values remain in the default setting. In our sample, the pitch of men and women's voices ranged from 66 to 2,014 Hz and 66 to 2,027 Hz, respectively.

Gender Equality Measures

We follow Guiso et al. (2008) and Fryer and Levitt (2013) to measure a country-specific gender equality and use the Gender Gap Index (GGI) from the Global Gender Gap Report published in 2020. The GGI measures the relative position of women in a society by measuring the gap between men and women in economic opportunities, economic participation, educational attainment, political achievements, and health (World Economic Forum. 2020). We then classify countries into three equal-sized gender equality groups – top, middle, and bottom – based on GGI.

III.2 Summary Statistics

Before explaining our model, we will briefly describe the summary statistics of our voice samples. Table 1 displays the summary statistics of our samples divided by gender equality group: all samples (column (1)), the top gender equality group (column (2)), the middle gender equality group (column (3)), and the bottom gender equality group (column (4)).

In column (1) of Table 1, we show that we collected a total of 578 voice samples from 58 countries, and 50% of the samples came from women. The samples are speech fragments from individuals who appeared in 68 broadcasting programs from 59 broadcasting services between 2019 and 2020. More than 60% of our samples are from public broadcasting services, and 72% were speech clips of announcers or reporters from news programs. There were 38 different languages used in our samples. The average gender gap in the average voice pitch of all samples is 63 Hz. It is worth noting that, in our data, the bottom gender equality group in column (4) shows the widest gap in the average voice pitch between men and women at 74 Hz. The gap shrinks to 56 Hz in the middle gender equality group, and the top gender equality group shows a gender gap in the average voice pitch of 62 Hz.

III.3 Empirical Framework

To estimate the impact of gender inequality on voice pitch, we use the following regression model:

$$Y_{i,p,m,t,c} = \alpha + \beta_1 female + \beta_2 female \times 1(c \in GGI\ middle)$$
$$+\beta_3 female \times 1(c \in GGI\ top) + \gamma_p + \delta_m + \theta_t + \mu_c + \varepsilon_{i,p,m,t,c} \quad (1)$$

where $Y_{i,p,m,t,c}$ is the voice pitch of speaker i from broadcast program p aired in month m of year t from country c. We examine three outcome variables: the average, minimum, and maximum voice pitch of speaker i from broadcast program p aired in month m of year t from country c. $Female_i$ is a dummy variable that is equal to one if the speaker i is a woman. Variables $female \times 1(c \in GGI\ middle)$ and $female \times 1(c \in GGI\ top)$ are the interaction terms between a female indicator and gender equality group indicators for GGI middle- and top-ranking countries, respectively. Parameters γ_p, δ_m, θ_t, and μ_c capture program, month, year, and country fixed effects. Variable $\varepsilon_{i,p,m,t,c}$ captures unexplained random shocks and is assumed to be heteroskedastic.

Our hypothesis is that β_1, which captures the voice pitch difference between men and women, will always be positive since women tend to have voices with a higher F0, or higher pitch, than men due to biological differences. The parameters of interest in our regression are β_2 and β_3, which measure the voice pitch gender gap in the middle and top gender equality groups relative to the voice pitch gender gap in the bottom gender equality group. Our hypothesis suggests that the coefficients β_2 and β_3 should be negative and statistically significant, indicating that countries with higher gender equality have less of a gender gap in voice pitch between men and women.

IV. Results

Table 2 presents the results linking gender inequality with gender gap in voice pitch. Consistent with our assumption, the female dummy variable has positive and significant effects on a speaker's voice pitch for all specifications. The first row in

Table 2 reports the difference in the voice pitch of women compared to men in the bottom gender equality group. In our baseline results in column (1), we find a 74.451 Hz gender gap in average voice pitch. These findings are in accordance with previous studies on the gender gap in mean fundamental frequency (Takefuta et al., 1972). The overall positive relationship between average voice pitch and the female indicator remain consistent and statistically robust when we include time, program, and country fixed effects (see columns (4) and (7) of Table 2).

Our baseline results, reported in column (1), show that there is less of a gender gap in average voice pitch in the middle and top gender equality groups – by 18.292 Hz at the 1% level and 12.365 Hz at the 5% level, respectively. The estimates are all statistically significant and negative, which implies that the gender gap in average voice pitch is reduced in countries with higher gender equality. These results remain stable when we control for time-, program-, and country-level characteristics. Column (4), which includes month, year, and program fixed effects, reports regression results nearly identical to the baseline – 18.557 Hz reduction in gender gap for the middle gender equality group and 12.688 Hz reduction for the top gender equality group. Column (7) presents even more robust results by including country fixed effects in the regression specification. We find that there is less of a gender gap in average voice pitch for the middle and top gender equality groups by 19.617 Hz and 13.463 Hz, respectively.[12] Both estimates are significant at the 1% level. These results are not statistically different from the baseline results, confirming that the results remain

[12] However, as the P-values in Table 2 show, the differences in pitch between the middle and top gender equality group is not different at statistically significant level.

robust. These findings suggest that gender equality is a significant variable for women's speech patterns on a transnational level.

V. Concluding Remarks

This research examines the impact of gender norms on women's speech patterns in assuming leadership. Using an OLS regression, we find that the gender gap in average voice pitch is wider in the countries with higher gender inequality compared to the countries with lower gender inequality. These results are consistent with empirical patterns observed in previous studies. These results provide suggestive evidence that gender norms play a critical role in the gender disparity of social leadership. This paper contributes to the literature by being the first to conduct a cross-country analysis of the gender gap in voice pitch and the first to show that gender norms have a significant effect on the vocal behavior of women. Our findings suggest that gender parity is an important factor in promoting greater representation of women in the world of leadership.

There are a few important caveats to these conclusions. First, we cannot completely rule out the possibility that voice pitch may be correlated with certain socioeconomic traits of an individual that we cannot measure in this study. Also, some argue that the vocal behaviors of media professionals are heavily conditioned by the gender norms of a society. Therefore, such trained speech patterns may not accurately represent the common language patterns of the public. Additionally, due to data limitations, our study only focuses on pitch, a single acoustic parameter of voice. An additional multiparametric analysis would likely yield more productive results.

Exploring a wider range of mechanisms of vocal behavior will be necessary to fully understand the vocal adjustments that women make in response to gender stereotypes. We leave these tasks for future research.

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Table 1. Summary Statistics

	All (1)	GGI Top (2)	GGI Middle (3)	GGI Bottom (4)
No. of Countries	58	20	20	18
No. of Observations	578	200	198	180
Female speakers (%)	50	50	50	50
No. of Broadcasting Services	59	20	20	19
- Public[1]	39	17	14	8
- Corporate[2]	7	1	2	4
- Individual[3]	8	2	2	4
- National[4]	3	1	0	2
- Other[5]	2	0	1	1
No. of Programs	68	22	22	24
- News[6]	49	19	17	13
- Interview[7]	11	1	1	9
- Talk show[8]	8	2	4	2
No. of Languages[9]	38	13	17	14
Broadcast Year				
- 2020	550	192	188	170
- 2019	28	8	10	10
Voice Pitch (Hz)				
1) Men				
a) Average[10]	137.071	132.415	134.435	145.143
b) Minimum[11]	77.017	75.504	77.724	77.921
c) Maximum[12]	550.582	537.693	565.811	548.150
2) Women				
a) Average[10]	200.171	194.502	190.594	219.594
b) Minimum[11]	82.245	78.618	82.290	86.227
c) Maximum[12]	580.835	566.923	597.993	577.418

Note: This table provides the specifications of voice samples used in acoustic analysis. Columns (2), (3), and (4) present the top, middle, and bottom gender equality groups, respectively, which are divided into three equal-sized groups. The unit of observation is an individual speaker. See further sample details in Section III of the main text.

[1] A media system established through a legislative framework that exhibits substantial programming autonomy.

[2] A media system under private ownership accompanied by some degree of state regulation.

[3] A digital format media downloaded or streamed online to a computer or mobile device.

[4] A media system under direct supervision of state authorities.

[5] A media system operated by non-profit or non-governmental organizations.

[6] A regularly scheduled media program in which professional anchors report on current events.

[7] A media program in which a host asks structured questions about specific topics to a single guest.

[8] An interview program with multiple guests.

[9] Languages spoken by an individual speaker

[10] We measure the average pitch of each sample and take the average across individuals within a sample.

[11] We measure the minimum pitch of each sample and take the average across individuals within a sample.

[12] We measure the maximum pitch of each sample and take the average across individuals within a sample.

Table 2. Gender Gap in Pitch

	Baseline			FE: Time, Program			FE: Time, Program, Country		
	Average	Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Female	74.451***	8.306***	29.268	74.458***	8.046***	38.116	75.285***	8.571***	34.167
	(4.453)	(2.012)	(42.274)	(4.584)	(2.004)	(40.872)	(4.099)	(1.891)	(25.340)
× GGI: Middle	-18.292***	-3.741	2.914	-18.353***	-3.644	-13.872	-19.542***	-4.306	-3.655
	(5.650)	(2.790)	(69.632)	(5.781)	(2.754)	(67.866)	(5.221)	(2.654)	(38.689)
× GGI: Top	-12.365**	-5.191**	-0.038	-12.523**	-4.833**	-8.989	-13.400***	-5.339**	-4.643
	(5.578)	(2.240)	(68.271)	(5.690)	(2.244)	(67.805)	(5.130)	(2.109)	(33.540)
Observations	578	578	578	578	578	578	578	578	578
R-squared	0.624	0.083	0.003	0.633	0.114	0.056	0.733	0.272	0.778
Mean Dep.	169.025	79.632	565.709	169.025	79.632	565.709	169.025	79.632	565.709
P-value	0.2207	0.5037	0.9695	0.2290	0.5750	0.9492	0.1662	0.6185	0.9783

Note: The unit of observation is an individual speaker by gender. Each column corresponds to a separate regression. Columns (1), (2), and (3) show the baseline results estimates with average, minimum, and maximum pitch as an outcome variable, respectively. Columns (4), (5), and (6) include month, year, and program fixed effects. Columns (7), (8), and (9) include month, year, program, and country fixed effects. Female measures the difference between women and men's voice pitch in the bottom gender equality group. × GGI: Middle measures the interaction between gender and the middle gender equality group. × GGI: Top measures the interaction between gender and the top gender equality group. P-value is the statistical difference between × GGI: Middle and X GGI: Top. * Significant at 10%; ** Significant at 5%; *** Significant at 1%.

Appendix 1. Data Sources

Panel A. GGI Top Group

	Country	Broadcaster	Classification	Program Title	Type	Language	Year	Source
1	Belgium	RTBF	public	Soir Première	News	French	2020	Homepage
2	Canada	CBC	public	News at Issue	News	English	2020	Homepage
3	Denmark	DR	public	P1 Morgen	News	Danish	2020	Homepage
4	Estonia	ERR	public	Uudistesaated	News	Estonian	2020	Homepage
5	Finland	YLE	public	Yle Uutiset selkosuomeksi	News	Suomi	2020	Homepage
6	France	Radio France	public	Le journal de 8H00	News	French	2020	Homepage
7	Germany	Deutschlandradio	public	Nachrichten, Deutschland heute	News	German	2020	Homepage
8	Iceland	RUV	public	Heimskviður	News	Icelandic	2020	Homepage
9	Ireland	RTE	public	The Week in News	News	English	2020	Homepage
10	Latvia	Latvijas Radio	public	Politikas podkāsts	Interview	Latvian	2020	Homepage
11	Mexico	Radio Formula	corporate	Paola Rojas en Fórmula	News	Spanish	2019	Podcast
12	Moldova	Sunt Bine Podcast	individual	Sunt Bine Podcast	Health	Romanian	2020	Podcast
13	New Zealand	RNZ	public	Morning Report, Afternoons with Jesse Mulligan	News	English	2020	Homepage
14	Norway	NRK	public	Dagsnytt 18	News	Norwegian	2020	Homepage
15	Philippines	UsapangEcon	individual	Usapang Econ	Business	Filipino	2019	Podcast
16	South Africa	SAfm	public	First Take SA	News	English	2020	Homepage
17	Spain	RTVE	public	BOLETIN RNE	News	Spanish	2020	Homepage
18	Sweden	Sveriges Radio	public	Sammanfattning av dagens nyheter	News	Swedish	2020	Homepage
19	Switzerland	SRF	public	Nachrichten von 18:00 Uhr	News	German	2020	Homepage
20	United Kingdom	BBC	public	Global News Podcast	News	English	2020	Homepage

Appendix 1. Data Sources (Cont.)

Panel B. GGI Middle Group

	Country	Broadcaster	Classification	Program Title	Type	Language	Year	Source
21	Australia	ABC	national	The World Today	News	English	2020	Homepage
22	Austria	ORF	public	Ö1 Journale	News	German	2020	Homepage
23	Chile	Universidad de Chile	public institution	Palabra Publica	Interview	Spanish	2020	Podcast
24	Czech Republic	Czech Radio	public	Radiožurnál	News	Czech	2020	Homepage
25	Israel	KAN	public	השעה הבינלאומית עם ערן סיקורל	News	Hebrew	2020	Homepage
26	Italy	RAI	public	GR1 Hourly News	News	Italian	2020	Homepage
27	Lithuania	LRT	public	Žinios	News	Lithuanian	2020	Homepage
28	Luxembourg	RTL Télé Lëtzebuerg	corporate	RTL Newsflash, RTL Journal, RTL Background	News	Luxembourgish	2020	Homepage
29	Netherlands	NPO	public	Met het Oog op Morgen	News	Dutch	2020	Homepage
30	Poland	Polskie Radio	public	Mija Tydzień	News	Polish	2020	Homepage
31	Portugal	RTP	public	Noticiário Nacional	News	Portuguese	2020	Homepage
32	Romania	Radio Romania	public	Agenda Globală	News	Romanian	2020	Homepage
33	Russia	VGTRK	public	Принцип действия	News	Russian	2019	Homepage
34	Serbia	MSDSS Podcast	individual	Možemo samo da se slikamo	Culture	Serbian	2020	Podcast
35	Singapore	CNA	corporate	House Party for Two, The Climate Conversations	Interview	English	2020	Homepage
36	Slovakia	RTVS	public	Slovensko dnes	News	Slovak	2020	Homepage
37	Slovenia	RTVSLO	public	Danes do 13:00	News	Slovenian	2020	Homepage
38	Thailand	MCOT	public	ฟังหูไว้หู	News	Thai	2020	Homepage
39	United States	VOA	public	VOA Newscast	News	English	2020	Homepage
40	Uruguay	dobcast	individual	Dobcast	Interview	Spanish	2020	Podcast

Appendix 1. Data Sources (Cont.)

Panel C. GGI Bottom Group

	Country	Broadcaster	Classification	Program Title	Type	Language	Year	Source
41	Armenia	Armenia in Armenia	individual	Armenia in Armenia	Interview	Armenian	2020	Podcast
42	Brazil	EBC	public	EBC Radios News	News	Portuguese	2020	Homepage
43	China	CNR	national	Voice of China	News	Chinese	2020	Homepage
44	Egypt	Cairo Business Radio	corporate	CBR Assessment Center, Start Up, Bitesize, Construction Market, What's Next	Lecture	Arabic	2020	Podcast
45	Ghana	Multimedia Group Limited	corporate	Joy FM Afternoon News	News	English	2020	Podcast
46	India	All India Radio	public	Afternoon News, Evening News	News	Hindi	2020	Homepage
47	Indonesia	RRI	public	Syiar Ramadhan	Talk	Indonesian	2020	Homepage
48	Japan	NHK	public	NHK Radio News	News	Japanese	2020	Homepage
49	Jordan	The Parliament of Jordan	public institution	The Parliament	News	Arabic	2020	Podcast
50	Malaysia	BFM	corporate	BFM Current Affairs	News	English	2019	Podcast
51	Morocco	9addat Podcast	individual	9addat, The Tajriba Experience	Careers	Darija	2020	Podcast
52	Pakistan	Radio Pakistan	public	Radio Pakistan Official News Bulletin	News	Urdu	2020	Homepage
53	Saudi Arabia	Azzbda Podcast	individual	Azzbda	Personal Journal	Arabic	2020	Podcast
54	South Korea	KBS World	public	KBS World Radio News	News	Korean	2020	Homepage
55	Sri Lanka	SLBC	public	Sinhala News	News	Sinhala	2020	Homepage
56	Tunisia	Radio Tunis	public	Tunisian Radio Podcast	Arts	Arabic	2020	Homepage
57	Turkey	FOX	corporate	Fox News	News	Turkish	2020	Homepage
58	Vietnam	Voice of Vietnam	national	Voice of Vietnam	News	Vietnamese	2020	Homepage

국문 초록

젠더 규범이 리더십의 성별 격차에 미치는 영향:

음성 피치 분석을 중심으로

본 논문은 음성 신호의 피치를 분석하여 젠더 규범이 리더십 지위에 있는 여성의 발화 패턴에 어느 정도 영향을 미치는지 연구한다. 우리는 여성의 음성과 젠더 고정관념의 연관성을 보여주는 기존 연구에 근거하여 성 불평등 수준과 남녀 간의 음성 피치 격차 사이의 상관관계를 조사한다. 우리는 전통적인 젠더 규범을 가진 나라들의 여성들이 젠더 규범이 상대적으로 약한 나라의 여성들보다 더 높은 피치의 목소리로 말할 것이며, 그로 인해 남녀 간의 음성 피치의 격차도 더 두드러질 것이라 가정한다. 2019 년부터 2020 년간 58 개국 68 개 방송 프로그램에서 추출한 578 개 남녀 음성 샘플을 사용하여, 우리는 평균 음성 피치의 성별 격차가 성 평등이 덜한 국가에서 증가한다는 사실을 통계적으로 확인했다.

JEL 분류: J16, J24, J71

핵심용어: 기본 진동수, 성별 격차, 성별 규범, 리더십, 음성 피치

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