

Original Article

# Voice pitch and the labor market success of male chief executive officers

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## ABSTRACT

A deep voice is evolutionarily advantageous for males, but does it confer benefit in competition for leadership positions? We study ecologically valid speech from 792 male public-company Chief Executive Officers (CEOs) and find that CEOs with deeper voices manage larger companies, and as a result, make more money. After including proxies for other CEO attributes including experience, education and formant position, we document economically significant voice pitch effects. For the median CEO of the median sample firm, an interquartile decrease in voice pitch (22.1 Hz) is associated with a \$440 million increase in the size of the firm managed, and in turn, \$187 thousand more in annual compensation. Deep voiced CEOs also enjoy longer tenures. Although this is a study of association, the results are consistent with recent experimental predictions suggesting a role for voice pitch in leadership selection and also suggest economically meaningful effects of voice pitch reach the upper echelons of corporate management.

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## 1. Introduction

Among males, deep voices are correlated with evolutionary success. Deep-voiced men are judged as more attractive by women (Feinberg, Jones, Little, Burt, & Perrett, 2005), mate more frequently (Hodges-Simeon, Gaulin, & Puts, 2011), and father more children (Apicella, Feinberg, & Marlowe, 2007). Such success has been attributed to perceptions of deep voiced males as more physically and socially dominant (Puts, Gaulin, & Verdolini, 2006; Puts, Hodges, Cárdenas, & Gaulin, 2007; Wolff & Puts, 2010).

But is a deep voice associated with success in economic settings where leadership selection, not mate selection, is the objective? Recent laboratory evidence (Tigue, Borak, O'Connor, Schandl, & Feinberg, 2011; Klofstad, Anderson, & Peters, 2012) suggests such a possibility, whereby deep-voiced individuals are perceived to have greater leadership capacity, and as a result may be more successful in obtaining leadership positions. Perceptions of enhanced leadership capacity generally stem from listeners viewing deep voiced males as more competent, persuasive, confident and trustworthy (Apple, Streeter, & Krauss, 1979; Burgoon, Buller, & Woodall, 1996; Tigue et al., 2011; Klofstad et al., 2012). Whether this laboratory evidence of perceived leadership capacity based on voice pitch is descriptive in actual competition for leadership positions is unknown. To provide initial insight on this issue, we examine whether, and to what extent, a deep voice is associated with labor market success among public company Chief Executive Officers (CEOs).

We measure labor market success with respect to the hiring, compensation, and retention of CEOs. If a male with a deep voice is perceived to have greater leadership capacity, we predict that deeper voiced CEOs will be employed by larger firms who have relatively more physical, financial and human resources to manage. In addition to the prestige and reputational enhancements that stem from operating a large firm, we also consider annual compensation and tenure as additional measures of CEO labor market success. If voice pitch is an honest signal of important leadership traits, we predict deep voiced CEOs will be paid more and retained longer.

## 2. Method

### 2.1. Sample

To identify a set of executives for analysis, we start with a list of male CEOs from the Standard & Poor's 1500 stock index analyzed by Engelberg, Gao, and Parsons (2013). We restrict attention to only male CEOs because of the sexually dimorphic nature of voice pitch (Titze, 1994) and the poor representation of female CEOs among S&P 1500 firms (Bertrand & Hallock, 2001). We intersect the Engelberg et al. (2013) observations with the Mayew and Venkatachalam (2012) CEO speech corpus, which is derived from earnings conference calls archived in the Thomson Reuters *StreetEvents* database ([www.streetevents.com](http://www.streetevents.com)). Earnings conference calls are live public telephonic broadcasts that regularly occur following each fiscal quarter whereby executives begin by making an uninterrupted and pre-scripted presentation followed by a question and answer session with financial analysts. For CEO observations in Engelberg et al. (2013) without a related speech sample from Mayew and Venkatachalam (2012), we

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search the Thomson Reuters *StreetEvents* database and other internet based sources, such as YouTube and company websites, to locate sources of CEO speech. When multiple sources exist we select the one closest in calendar time to the fiscal year-end of the observation. These collection efforts result in identification of ecologically valid CEO speech for 792 unique CEOs, with 216, 551 and 25 of the cross sectional observations having fiscal years ending in 2006, 2007 and 2008, respectively. Male S&P 1500 CEOs exhibit little ethnic heterogeneity, as over 90% of the CEOs are Caucasian.

## 2.2. Measurement of voice pitch

Vocal depth is captured by measuring each CEO's vocal fundamental frequency ( $F_0$ ), which listeners perceive as voice pitch. To estimate each CEO's fundamental frequency, we stream approximately the first 20 s (audio file duration  $M = 21.5 \pm 1.6$ ) of CEO speech and encode in mono directly onto a computer hard disk, using Total Recorder 7.1 Professional Edition software, at 11.025 kHz sampling rate and 16 bit quantization, and save the streamed audio segment as uncompressed .wav files. We focus on the opening statements by the CEO during earnings conference calls, as opposed to responses to analyst questions, in order to capture the natural speaking voice of the CEO. The opening conference call presentation remarks are less prone to purposeful changes in voice pitch resulting from a male CEO attempting to dominate a male analyst during questioning (Puts et al., 2006). Each .wav file is then digitally analyzed using PRAAT acoustics software version 5.2.05 (<http://www.fon.hum.uva.nl/praat/>), via the GSU PRAAT “quantify-Source” add-on tool (Owren, 2008). We calculate  $F_0$  with PRAAT via the autocorrelation method using default system settings and pitch floor (ceiling) values set to 75 (300) Hz, as these are the appropriate boundaries for analyzing speech of adult males (Evans, Neave, & Wakelin, 2006; Puts et al., 2006; Puts, Apicella, & Cárdenas, 2012).

## 2.3. Measurement of labor market outcomes

For our first labor market outcome, we measure firm size using the total assets managed by the CEO. Total assets are measured in millions of dollars at fiscal year-end, obtained from the Standard & Poor's *Compustat* database ([www.compustat.com](http://www.compustat.com)). For our second labor market outcome, we obtain total annual CEO compensation, in thousands of dollars, from the Standard & Poor's *Compustat Execucomp* database. For our third labor market outcome, we calculate CEO tenure by counting the number of days between the reported date the individual became CEO per *Execucomp* and the fiscal year-end date of the observation.

## 2.4. Measurement of control variables

We consider four potential confounding factors: CEO age, education, facial traits and formant position. To control for age effects, we obtain directly from *Execucomp* the age of the CEO in years as of fiscal year-end, and then adjust this value as necessary to capture the age of the CEO as of the date of the audio recording analyzed. We search CEO profiles online in the event CEO age is missing from the *Execucomp* database. To control for education effects, we create an indicator variable that equals one if the CEO has a degree beyond a collegiate bachelor's degree per the *BoardEx* database ([www.boardex.com](http://www.boardex.com)), and zero otherwise.

We also consider the potential confounding effects of facial traits, as prior literature suggests that both face and voice may reveal common information (Feinberg, DeBruine, Jones, & Little, 2008). Given the sexually dimorphic nature of voice pitch, we consider three sexually dimorphic facial traits that identify masculinity (Penton-Voak et al., 2001; Lefevre et al., 2012): the lower face to face height ratio (vertical distance from mean eye height to gnathion/vertical distance from trichion to gnathion), cheekbone prominence (bizygomatic width/

horizontal distance between left and right gonion approximation), and the facial width to lower face height ratio (bizygomatic width/vertical distance from mean eye height to gnathion). Additionally, while not a sexually dimorphic trait (Kramer, Jones, & Ward, 2012; Lefevre et al., 2012), we also consider the facial bizygomatic width to upper facial height (fWHR) because it has been forwarded as a marker of favorable leadership traits stemming from power and dominance among CEOs (Wong, Ormiston, & Haselhuhn, 2011).

We searched Google Images and corporate annual reports for CEO pictures and were able to obtain forward facing pictures suitable for measuring facial traits for 585 of our sample CEOs. Following Carré, McCormick, and Mondloch (2009), each photo was converted to an 8-bit, gray-scale image with a standard height of 400 pixels and morphometric calculations were executed using ImageJ software (Rasband, 2012). The lower face to face height ratio ( $M = 0.65 \pm 0.03$ ), cheekbone prominence ( $M = 1.13 \pm 0.05$ ), and the facial width to lower face height ratio ( $M = 1.13 \pm 0.06$ ) each exhibited no statistically significant association with voice pitch ( $r = -0.047$ ,  $p = 0.255$ ;  $r = -0.056$ ,  $p = 0.178$ ;  $r = 0.046$ ,  $p = 0.272$ , respectively). We also observed no significant association between voice pitch and fWHR ( $r = 0.047$ ,  $p = 0.254$ ), but did observe that the mean and standard deviation of fWHR ( $M = 1.96 \pm 0.14$ ) in our sample of 585 CEOs mimic almost identically the same statistics for the 55 CEOs studied in Wong et al. (2011). None of these facial traits were significantly associated with any of the labor market metrics except for a positive statistical association between CEO tenure and cheekbone prominence ( $r = 0.070$ ,  $p = 0.092$ ) and CEO tenure and the facial width to lower face height ratio ( $r = 0.093$ ,  $p = 0.025$ ). Given the lack of association of a systematic relationship between facial traits with voice pitch or labor market outcomes, we do not include facial traits in our subsequent analysis.

Finally, we control for formant position ( $P_f$ ), a sexually dimorphic acoustic feature introduced by Puts et al. (2012) as an indicator of men's threat potential. Smaller  $P_f$  values indicate more threat potential, and  $P_f$  is negatively correlated with height, weight, arm strength and physical aggression. We measure formant position following Puts et al. (2012) as the average standardized formant value for the first four formants. Formant frequencies for the first four formants are calculated from PRAAT via the GSU PRAAT “quantify-Formants” add-on tool (Owren, 2008), using maximum thresholds of 1000, 2850, 3750 and 4500 Hz for  $F_1$  through  $F_4$ , respectively. Before standardizing, mean  $F_1 = 298 \pm 31$  Hz, mean  $F_2 = 1,329 \pm 78$  Hz, mean  $F_3 = 2,444 \pm 66$  Hz, and mean  $F_4 = 3,502 \pm 132$  Hz. To standardize, we subtract the mean of each formant divided by its standard deviation.

## 3. Results

Table 1 provides descriptive statistics for each measure and reveals that the median sample CEO operates a firm with \$2.4 billion in assets,

**Table 1**  
Summary statistics for variables used in analysis (N = 792).

Variable	Mean	Median	S.D.	Lower Quartile	Upper Quartile
Voice Pitch ( $F_0$ in Hz)	127.123	125.550	17.652	114.550	136.650
Firm Size (Total Assets in \$ Millions)	17,020.680	2,427.624	84,089.110	876.768	9,005.672
Total Compensation (in \$ Thousands)	5,859.811	3,692.913	7,182.007	1,972.427	7,168.113
Tenure (in days)	2,517.638	1,824.000	2,323.114	882.000	3,286.000
Age (in years)	56.521	56.000	6.428	52.000	61.000
Education (equals 1 if advanced degree, 0 otherwise)	0.519	1.000	0.500	0.000	1.000
Formant Position, ( $P_f$ in Hz, standardized)	0.000	−0.010	0.521	−0.308	0.280

is paid \$3.7 million annually, is 56 years old and has led the firm for 1,824 days, i.e., 5 years. The median CEO in our sample exhibits a fundamental frequency of 125.5 Hz, which is consistent with standard values for adult males of comparable age in the general population (Kent, 1994). In all statistical analyses, we use log transformations of labor market outcomes to correct for right skewness (Puts et al., 2012). We also log transform each continuous independent variable such that the regression coefficients can be interpreted as *elasticities* connoting the percentage change in labor market outcomes for a 1% change in each independent variable. Table 2 provides the correlations between each measure.

### 3.1. Voice pitch and firm size

The first scatterplot depicted in Fig. 1 visually reveals a negative vocal pitch–firm size relation. The slope of the scatterplot line in Fig. 1 is  $-1.367$ , as displayed in Column I of Table 3 ( $\beta = -1.367, p = 0.002$ ), implies that a 1% decrease in voice pitch is associated with a 1.367% increase in the size of the CEO's firm. After controlling for CEO age, education and formant position in Column II, this estimate decreases slightly to  $-1.199$  ( $\beta = -1.199, p = 0.008$ ). This effect demonstrates economic significance. In dollar terms, for the median CEO operating the median firm, an interquartile decrease in voice pitch from 114.55 Hz to 136.65 Hz (22.10 Hz) is associated with an increase in firm size of \$440 million, from \$1.869 billion to \$2.309 billion. In comparison to CEO experience, the voice pitch–firm size elasticity of 1.199% is larger in absolute magnitude than the CEO age–firm size elasticity of 0.993%. We also find that voice pitch maintains a negative association with firm size after controlling for formant position, which itself also exhibits a negative and statistically significant relation ( $\beta = -0.428, p = 0.049$ ). Since formant position is inversely related to height, this association is consistent with other research documenting a positive association between height and leadership (Case & Paxson, 2008; Lindqvist, 2012), although these studies do not focus on the upper echelons of corporate management. At a minimum, that both voice pitch and formant position are incrementally associated with firm size suggests that CEOs with more masculine voices, however measured, achieve superior labor market outcomes.

### 3.2. Voice pitch and total annual compensation

The second scatterplot depicted in Fig. 1 visually reveals a negative vocal pitch–compensation relation. The estimated slope of this line displayed in Table 3 Column III implies a 1% decrease in voice pitch is associated with a 0.523% increase in total annual compensation ( $\beta = -0.523, p = 0.028$ ). Economically, the same interquartile decrease in voice pitch by 22.10 Hz implies an increase in annual compensation of \$187 thousand. However, CEO compensation is to a

large extent dictated by firm size (Gabaix & Landier, 2008), consistent with the large positive correlation between firm size and total compensation in our sample ( $r = 0.663; p < 0.001$ ). Introducing firm size as an additional determinant of annual compensation in Column IV of Table 3 reveals that firm size is a statistically significant mediator ( $p = 0.002$ ) of the relation between voice pitch and annual compensation, driving the voice pitch coefficient down to a statistically and economically insignificant  $-0.023$  ( $p = 0.897$ ). This implies that the pay premium for a deep voice occurs primarily because deeper voiced CEOs are employed by larger firms, and there is no additional premium in compensation for a deep voice. In Column V of Table 3 we also include other CEO characteristics as controls, and observe only CEO education plays a role in explaining annual compensation beyond firm size ( $\beta = 0.173, p < 0.001$ ). Unlike the estimation of firm size, formant position exhibits no statistically significant association with compensation either unconditionally ( $r = -0.036, p = 0.314$ ) or after controlling for firm size and other CEO characteristics ( $\beta = 0.056, p = 0.503$ ).

### 3.3. Voice pitch and tenure

The final scatterplot in Fig. 1 shows a negative association between voice pitch and CEO tenure. The estimated slope displayed in Column VI of Table 3 is  $-0.520$  ( $\beta = -0.520, p = 0.026$ ). After controlling for firm size and other CEO characteristics in Column VII of Table 3, the coefficient remains virtually unchanged at  $-0.457$  ( $\beta = -0.457, p = 0.045$ ) and implies a 1% decrease in voice pitch is associated with a 0.457% increase in tenure. In economic terms, if the median CEO at the median firm decreased voice pitch from the upper quartile to the lower quartile (22.10 Hz), tenure would increase by 151 days, or roughly 4/10 of a year. Formant position plays no role with respect to tenure unconditionally ( $r = 0.012, p = 0.733$ ) or after controlling for other factors ( $\beta = 0.005, p = 0.968$ ).

## 4. Discussion

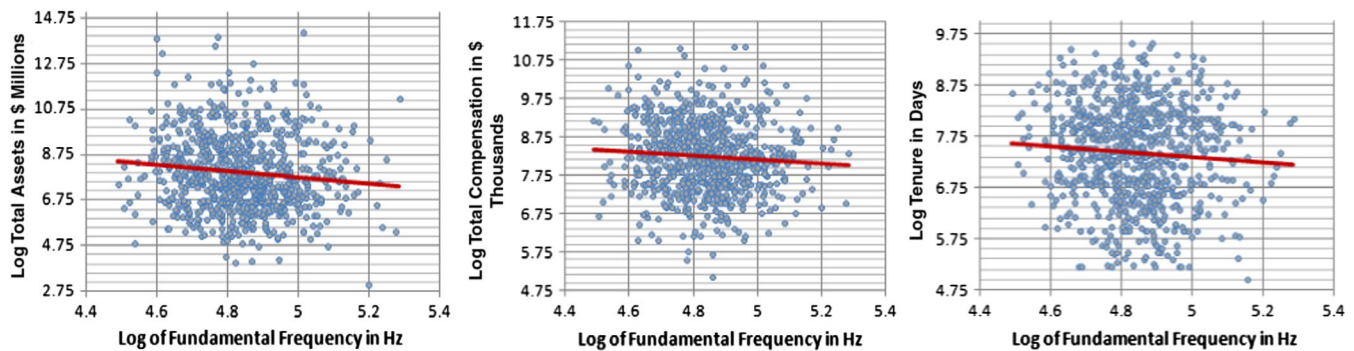
This study is the first to examine the relationship between voice pitch and labor market success among males in a corporate leadership context. We find deep voiced males oversee larger firms, in turn receiving more compensation, and are retained longer. These associations offer external validity for recent experimental evidence suggesting voice pitch matters in leadership selection. Our estimations also provide the first economic quantification of the benefits that accrue to CEOs with deeper voices.

As this is a study of association, we cannot make causal claims and acknowledge the potential for reverse causality and correlated omitted variables. Regarding reverse causality, one possible interpretation of our results is that CEOs of larger firms or of longer tenure are those very

**Table 2**  
Correlation Matrix (N = 792).

	1	2	3	4	5	6
1 Voice Pitch ( $F_0$ in Hz)						
2 Firm Size (Total Assets in \$ Millions)	-0.112 (0.002)					
3 Total Compensation (in \$ Thousands)	-0.078 (0.029)	0.663 (0.000)				
4 Tenure (in days)	-0.074 (0.037)	-0.088 (0.013)	-0.108 (0.002)			
5 Age (in years)	-0.080 (0.025)	0.083 (0.019)	0.082 (0.021)	0.301 (0.000)		
6 Education (equals 1 if advanced degree, 0 otherwise)	-0.068 (0.057)	0.072 (0.043)	0.143 (0.000)	-0.012 (0.745)	0.075 (0.034)	
7 Formant Position ( $P_f$ in Hz, standardized)	0.062 (0.081)	-0.077 (0.030)	-0.036 (0.314)	0.012 (0.733)	-0.020 (0.571)	-0.013 (0.712)

This table displays Pearson correlations, with p-values displayed in parenthesis below the correlation coefficients. All continuous variables are log-transformed to be consistent with the multiple regression estimates in Table 3. The log transformation for  $P_f$  is equal to  $\ln(2 + P_f)$ . We add a constant of 2 to  $P_f$  because the minimum value is  $-1.641$ , which cannot be log transformed.



**Fig. 1.** Scatterplot of CEO voice pitch (measured as the natural logarithm of fundamental frequency) and labor market success, measured as the natural logarithm size of the firm employing the CEO, CEO annual compensation, and CEO employment tenure, respectively. The solid line is the ordinary least squares estimate which reveals that CEOs with lower pitched voices manage larger firms, are paid more, and have longer tenures.

CEOs who have achieved heightened social status (Hodges-Simeon, Gaulin, & Puts, 2010). Individuals achieving heightened social status may subsequently exhibit a permanent and stable downward shift in voice pitch outside of volitional control. We are unable to design a test to rule out this possibility with our current data.

Another possible interpretation is that CEOs at larger firms tend to artificially lower their voice pitch when speaking in public. From a strategic perspective, we view this as unlikely because if there was some benefit to artificially lowering one's voice pitch, all CEOs would do it, rendering such a strategy degenerative. Additionally, the institutional setting we study makes it unlikely that managers could credibly manipulate their voice pitch for two reasons. First, as the firms we study are among the most prominent in the U.S. economy, financial analysts provide intense monitoring and develop intimate relationships with CEOs. These analysts interact regularly and repeatedly with CEOs both publicly and privately, and therefore are familiar with the regular speaking voice of CEOs, which would reduce the credibility of voice pitch manipulation during public presentations.

Second, focusing on the presentation portion of the conference call to capture speech, relative to CEO speech in response to questions, helps diminish the possibility that the CEO is manipulating voice pitch in order to portray dominance as part of an aggressive dialog with a financial analyst (Puts et al., 2006). While avoiding the potential for dialog induced voice pitch changes, an alternative view

is that the rehearsed presentation portion of earnings conference calls may be precisely when CEOs are more likely to strategically manipulate their vocal pitch downward. Under such a scenario, we would expect voice pitch for a given CEO to be lower in the presentation portion of the conference call relative to the question and answer portion. To test this conjecture, we are able to obtain twenty second speech samples for 155 of our sample CEOs from the question and answer session. We find the mean  $F_0$  is 118.51 Hz in the question and answer session, which is statistically lower than the related mean  $F_0$  of 126.83 Hz in the presentation (paired  $t$  test:  $t_{154} = 6.959$ ,  $p < 0.01$ ). This finding is more consistent with CEOs lowering their voice pitch in response to analyst inquiry than to strategic manipulation during the rehearsed presentation portion of the conference call, although it is still possible for some strategic manipulation to occur during the presentation.

To provide additional evidence on the conjecture that our results reflect artificial voice pitch manipulation by some CEOs, we relax our maintained assumption that voice pitch is an honest signal of leadership capacity. In such a setting, some CEOs achieve positions in high status firms by fooling the board of directors with an artificially deep voice. This implies that deep voiced CEOs, who truly possess little leadership capacity, should operate their firms in a less profitable manner compared with other CEOs. Operating profit margin, defined as fiscal year-end earnings before interest and taxes divided by fiscal year sales ( $M = 0.129 \pm 0.17$ ), is negatively associated with  $F_0$  ( $r = -0.098$ ,

**Table 3**  
Regression analysis of the association between voice pitch and CEO labor market success ( $N = 792$ ).

Dependent Variable:	Firm Size (I)	Firm Size (II)	Total Compensation (III)	Total Compensation (IV)	Total Compensation (V)	Tenure (VI)	Tenure (VII)
Intercept	14.603*** (2.180)	9.972*** (2.961)	10.772*** (1.152)	5.432*** (0.885)	4.468*** (1.269)	9.941*** (1.127)	0.046 (1.584)
Voice Pitch	−1.367*** (0.450)	−1.199*** (0.450)	−0.523** (0.238)	−0.023 <sup>a</sup> (0.177)	0.019 (0.178)	−0.520*** (0.233)	−0.457*** (0.228)
Firm Size				0.366*** (0.015)	0.362*** (0.015)		−0.070*** (0.020)
Age <sup>b</sup>		0.993*** (0.467)			0.164 (0.215)		2.545*** (0.275)
Education		0.196* (0.117)			0.173*** (0.049)		−0.056 (0.064)
Formant Position		−0.428** (0.217)			0.056 (0.083)		0.005 (0.118)
Adjusted R <sup>2</sup>	0.0113	0.0214	0.0048	0.4378	0.4456	0.0043	0.1060
Overall F	9.21***	5.67***	4.85**	302.18***	128.05***	4.97**	19.31***

All dependent variables are log-transformed, as are all continuous independent variables. The log transformation for  $P_i$  is equal to  $\ln(2 + P_i)$ . We add a constant of 2 to  $P_i$  because the minimum value is  $-1.6411$ , which cannot be log transformed. This table displays unstandardized regression coefficients. Heteroscedasticity robust standard errors are shown in parenthesis. Significantly different from zero at the \*10% level, \*\*5% level, and \*\*\*1% level, two-tailed.

<sup>a</sup> A test of mediation using the product of coefficients method for large samples following Preecher and Hayes (2008) confirms firm size mediates the effects of voice pitch ( $Z = 3.15$ ,  $p = 0.002$ ).

<sup>b</sup> During a CEO's tenure at a firm, tenure and age increase proportionately, introducing a mechanical positive association between CEO age and tenure. As such, in Column VII, we define CEO age as the age of the CEO as of his hiring as CEO by the firm.



$p = 0.006$ ), as is return on assets, defined as fiscal year earnings before interest and taxes divided by total assets at fiscal year-end ( $M = 0.096 \pm 0.09$ ,  $r = -0.068$ ,  $p = 0.055$ ). While the magnitude of these correlations is not particularly high and statistical significance is marginal for return on assets, the direction of association is more consistent with deeper voiced CEOs operating firms more profitably, not less profitably. A limitation of this analysis is that our corporate performance measures likely contain the influence of factors that are outside of the CEOs' control, such as macroeconomic shocks. Boards of directors, in contrast, have access to more precise measures of performance that more directly relate to CEO actions. Assuming boards of directors rationally utilize such measures and learn of their mistake after hiring an artificially deep voiced CEO, these CEOs should exhibit shorter tenures as boards relieve them of their duties (Brickley, 2003; Dikolli, Mayew, & Nanda, in press). In the data we observe the opposite, which is more consistent with the notion that on average voice pitch is providing an honest signal of leadership capacity in terms of corporate board retention decisions.

Regarding correlated omitted variables, we cannot completely rule out the possibility that voice pitch is correlated with some other observable physical CEO trait we cannot measure. For example, one might conjecture that since a deep voice is commonly *perceived* as an honest signal of body size (Rendall, Vokey, & Nemeth, 2007) and research has documented an association between height and leadership (Case & Paxson, 2008; Lindqvist, 2012), body size is a confounding effect. Whether body size is ultimately a serious threat to our inferences is unclear given the lack of a robust actual (not perceived) association between voice pitch and body size in the literature (Künzel, 1989; Fitch, 1997; Fitch & Hauser, 2002). Additionally, our inclusion of formant position in our specifications indirectly controls for height and weight, but given the relatively low level of correlation between  $P_f$  and these aspects of body size (Puts et al., 2012), we may not have completely removed all potential for body size as a confounding factor. Given corporate leaders are both seen and heard by stakeholders of the firm, future research might examine the conditions under which audio cues like voice pitch and visual cues like body size or even facial features interact to exacerbate or diffuse perceptions of leadership capacity.

**An additional important limitation of this study is that we cannot directly measure the particular aspects of the CEO's job that benefit from having a deep voice.** Do subordinates or other members of management accede more quickly to deep voiced CEOs yielding more efficient decision making, which in turn makes the firm more profitable? Are there indirect channels by which voice pitch assists in CEOs securing labor market success? For example, if in early life a CEO with a deep voice is able to secure more education or gain more experience, our documented effects of voice pitch are understated because we control for these factors in our multivariate regression specifications. Future research will hopefully identify a more precise mapping between vocal pitch and more direct aspects of productivity, as well as when during the life of a CEO a deep voice begins to play an important role.

In terms of effect sizes, while the economic magnitude of voice pitch effects are non-trivial, the proportion of variation in labor market outcomes explained by voice pitch is small. At one level, we do not expect voice pitch to be a first order determinant of, for example, the size of the firm since macroeconomic conditions and business models in place before any CEO is hired are the causal drivers of firm size. Rather, the association we find between firm size and voice pitch represents the outcome of a competitive tournament for top corporate employment (Lazear & Rosen, 1981). Recent research by Tamiya, Lee, and Ohtake (2012) that investigates the association between physical markers (second to fourth digit ratios) and competitive tournament outcomes (professional sumo wrestler winning percentages), documents explanatory power in ranges similar to those found here for voice pitch. One potential explanation for the small explanatory power is that when investigating the role of physical characteristics

among highly selective samples, there is less room for physical characteristics to play a role. Our setting is unquestionably a highly selective setting as we focus solely on CEOs of firms in the S&P 1500 stock index. Since prominent firms from leading industries in the U.S. economy are selected for membership in the S&P 1500 index, we are investigating the role of voice pitch variation among CEOs who already manage the most coveted firms in the U.S. economy. Additionally, our sample CEOs collectively manage over \$13 trillion in assets. Given the sheer magnitude of economic resources entrusted to these CEOs, boards of directors who make the hiring, compensation and retention decisions have strong incentives to carefully seek out and examine all available information about a CEO, which can potentially minimize the usefulness of voice pitch as an information source. Future research might investigate whether voice pitch explains more outcome variation among competitors in less selective populations or identify settings where voice pitch is more likely to be a more prominent source of information. The election of political leaders is one such setting as voters may rely extensively on physical characteristics to guide their decision making (Gregory & Gallagher, 2002; Todorov, Mandisodza, Goren, & Hall, 2005).

Future research might also identify conditions under which a deep voice is relatively more or less important. The leadership capacity view forwards that dominant, autocratic managers might create value by imposing their will on subordinates, thereby securing compliance and coordinated effort. This may be particularly important in times of crisis, much like voice pitch is perceived to be more important for political leaders during wartime (Tigue et al., 2011). We do not have sufficient data to examine voice pitch effects during periods of economic crisis, but view such an analysis as an important area for future inquiry. An alternative perspective is that in some corporate situations, soliciting input and achieving democratic consensus are important. In such situations, dominance may not be a desirable executive trait and a deep voice may be punished, not rewarded.

**In addition to the possibility that different business situations may require a leader with different voice pitch, another important area of inquiry is whether the effects of voice pitch we document differ for female CEOs.** From an evolutionary mating perspective, a high pitched voice is generally *advantageous* for females. Klostad et al. (2012) suggest that this may not be the case in leadership contexts and provide evidence that a deep voice is also advantageous for females seeking leadership positions. **They forward the possibility that voice pitch is a universal indicator of leadership capacity, and given sexual dimorphism in voice pitch, may explain the well documented under-representation of females in leadership positions.** We cannot conduct a direct empirical test regarding the role of voice pitch among female CEOs as we do not have sufficient speech data to do so. However, an indirect investigation can be undertaken by noting that adult females in the population exhibit an average voice pitch of roughly 210 Hz. If voice pitch was the sole determinant of firm size for a female CEO, our estimate from Column A of Table 3 would imply that the size of the firm run by a female CEO with a voice pitch of 210 Hz would be about \$1.5 billion. For the female CEOs listed in the S&P 1500 stock index during our sample period, the median firm size is quite similar at \$1.7 billion in assets. This finding is consistent with the idea that voice pitch acts as a universal indicator of leadership capacity and suggestive that voice pitch may be one explanation for the finding in Bertrand and Hallock (2001) that female executives in the S&P 1500 tend to be employed by smaller firms, and in turn paid less, relative to males.

Collectively, we view our results as advancing the emerging literature on biological economics (Apicella, Dreber, Campbell, Gray, Hoffman, & Little, 2008) by showing that a trait known to indicate success in biological competition is also associated with success in the economic labor market of CEOs. Voice pitch is likely not the only biological trait that matters as it goes without saying that there are likely a myriad of characteristics that influence how the CEO is

perceived. Corporate leaders are exceedingly complex and not easily summarized, be it by scale, tape measure, or microphone.

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## Supplementary Materials

Supplementary data to this article can be found online at <http://dx.doi.org/10.1016/j.evolhumbehav.2013.03.001>.

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