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Abstract: The paper investigates the moderating effect of CEO race on the relationship between CEO masculinity and company performance. The sample includes 260 companies listed on the Bursa Malaysia for the period from 2009 to 2019. Data extracted for 405 unique CEOs from different races (Malay, Chinese, Indian, and others). The paper uses two indicators of CEO masculinity, facial width-to-height ratio (fWHR) and testosterone level (Tsh). The fWHR of CEOs is measured using artificial intelligence (Python code/c).

In addition, a contemporary model is applied to estimate Tsh based on face measures and CEO age. The results indicate that CEO race moderates the relationship between masculinity and company performance. The findings reveal that high masculinity is positively associated with company performance only among the non-Bumiputera group, however, there is no significant evidence among the Bumiputera group. This study uniquely links CEO characteristics and financial performance with neuro finance and biological aspects. Therefore, this study offers novel contributions to literature and implications for investors, board members, policymakers, and academicians.

Keywords: masculinity; testosterone; financial performance; ethnicity; Bumiputera; non-Bumiputera; Bursa Malaysia.

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1 Introduction

In the aftermath of the 2008 financial crisis, large organisations, bankers, and executives were criticised for masculine and their tendencies toward making high-risk decisions before the crisis (Kamiya et al., 2019). Psychological and biological studies indicate those masculine behavioural characteristics (e.g., aggression, deception skills, non-interchange trust, cheating, and sensation seeking), and increased tolerance risk are depicted by male facial composition [facial width-to-height ratio (fWHR)] (Matsumoto and Hwang, 2021; Ormiston et al., 2017). Several studies (e.g., Amin et al., 2022; de Andrés and Arranz-Aperte, 2019; Demirtas and Simsir, 2016; Naeem and Khurram, 2020; Wang and Fung, 2022; Withisuphakorn and Jiraporn, 2017) have been conducted on different aspects of CEO (e.g., culture, gender, age and compensation). However, they ignored the masculine behavioural characteristics of a CEO. Many studies have shown evidence of heterogeneity in individual facial composition regarding social behaviours, especially concerning fWHR (Ormiston et al., 2017; Stirrat and Perrett, 2012). To this end, several researchers have begun to use a facial masculinity measurement in the areas of accounting and finance (Ahmed et al., 2019; Beltman, 2018; Gong et al., 2020; He et al., 2019; Kamiya et al., 2019; Ku et al., 2021; Matsumoto and Hwang, 2021). Gong et al. (2020), He et al. (2019) and Kausel et al. (2018) investigated the relationship between masculinity measured by fWHR and enhanced performance. He et al. (2019) indicate that the performance of male financial analysts may be predicted by fWHR as a dominant trait. Ku et al. (2021) show a negative relationship between fWHR and performance in Korea. Similar outcomes were reported in India by Kohli and Dangi (2017). However, no evidence has been found on the relationship between CEOs' fWHR and firm performance in Europe (Beltman, 2018).

In a similar context, several studies established a relationship between increased testosterone hormone (Tsh) levels and the larger facial composition (high fWHR) (Anderl et al., 2016; Matsumoto and Hwang, 2021). Nofsinger et al. (2020) argue that the impact of the testosterone hormone is evident on financial decisions due to its reflection in human attitudes via the endocrine system. Casto et al. (2020) report a positive relationship between testosterone levels (Tshs) and performance. The testosterone-to-cortisol ratio is favourably connected with loss aversion, which leads to improved overall performance (Nofsinger et al., 2018). Nadler et al. (2017) advocate that more Tsh improves analysts' performance when making economic decisions. Nofsinger et al. (2020) report that Tsh increases portfolio turnover leading to higher significant returns. Further, according to Coates and Herbert (2008), the daily profit of traders can be predicted using morning Tshs. However, Cueva et al. (2015) found instability in the price of assets and additional risk due to taking steroid hormones. They indicate that applying external doses of testosterone increases the disruption of financial markets.

The difference in hormonal traits between racial groups such as Americans, Hispanic as well as Asian groups could be easily understood based on variations in health issues and biosocial outcomes (Kramer, 2020). For example, one study deduced that Tsh levels are lower in white men compared to black men (Ross et al., 1986). Richard et al. (2014) explained more on the disparity between the black-white based on the variation of Tsh. It was affirmed that testosterone is lower for white men than black men with modest to significant variations. On the contrary, Lopez et al. (2013) found significant differences exist for blacks (low Tsh) compared to whites (high Tsh) when controlling statistically for the percentage of body fat and level of physical activity. Ellison et al. (2002) tested salivary Tsh obtained from four populations (Congo, Paraguay, Nepal and USA). They reported that the mean Tsh levels significantly differ among the four considered races. The average Tsh variations were insignificant for the older generation and greatest in younger men. Similarly, Lopez et al. (2013) and Rohrmann et al. (2007) indicated that Hispanic males possessed significantly larger Tsh levels than non-Hispanic males. Wu et al. (1995) indicated that East Asian-Americans possess the highest Tsh, while African-Americans were found to have medium levels, and whites had the lowest value. Jin et al. (1999) advocated that Chinese men had significantly higher circulating Tsh levels than white men. Whittemore et al. (1995) reported that East-Asian people have larger Tsh levels than whites. In the same context, de Jong et al. (1991) revealed that Dutchmen have larger testosterone than Japanese. Jakobsson et al. (2006) declared that Swedish men have higher circulating Tsh levels than Korean. Jin et al. (1999) found that Chinese men have significantly higher circulating Tsh levels compared to white men. Ellis (2017) stated that non-Hispanic whites and Hispanics were similar in Tsh level, but East Asians (Chinese men) had higher Tsh levels than whites. Heald et al. (2003) showed that Pakistani male residents in Britain had lower circulating testosterone than native whites.

Accordingly, the objective of the present study is to investigate the moderating effect of CEO race on the relationship between CEO masculinity and firms' performance. The present study contributes to the strand literature in several ways. First, it utilises a sample of 1,611 observations from Bursa Malaysia between 2009 and 2019. Malaysia is a country with a multiracial population that is governed by the same laws and policies under the same conditions. The race can be identified as Bumiputera and non-Bumiputera. While Bumiputera includes Dayak, Anak Negeri and Orang Asli and counts for 69.6% of the population, non-Bumiputera comprises Chinese (22.6%), Indians (6.8%), and others (1%) (Mahidin, 2021). Malaysia is considered an emerging country representing an interesting case for investigating this issue. Also, this study is motivated by several prior studies, which provided inconsistent empirical results from different countries (USA: Mills and Hogan, 2020; Wong et al., 2011; China: Gong et al., 2020; He et al., 2019; Koreans: Ku et al., 2021; India: Kohli and Dangi, 2017; Europe: Beltman, 2018). Finally, the current study provides a unique contribution to measuring CEO masculinity using fWHR and testosterone hormone levels.

The remainder of the paper comprises five sections. Section 2 discusses the literature review. Section 3 describes the data and methods. Section 4 displays the empirical results and the additional test. Finally, Section 5 presents the implications, and concludes.

2 Literature review

Recently, testosterone therapy has spread widely among some CEOs of companies and Wall Street traders (Perman, 2012). It gives them greater durability to face the risk and provides them more masculine behaviours. In addition, according to data released by the US Government for the top 300 drugs, testosterone had become the 124th most prescribed medication, rising from 276th place between 2006 and 2018 with more than 5.4 million prescriptions issued (Clincalc.com, 2021). Indeed, within the last two years alone, testosterone had climbed 22 places (Clincalc.com, 2021).

The recent combination of neuroscience, psychology and financial sciences which is referred to as 'neuro finance' creates opportunities to better understand the nature of the financial decisions made by leaders in companies that, in turn, affect financial markets (Nouraei et al., 2021). A few papers have started to use a facial masculinity metric in the financial and accounting literature after biology and psychology studies documented that this facial metric predicts variation in masculine behaviours across individuals (Ahmed et al., 2019; Beltman, 2018; Gong et al., 2020; Jia et al., 2014; Kamiya et al., 2019; Ku et al., 2021; Wong et al., 2011). The broad samples used the masculinity metric because it needs only an individual picture (Jia et al., 2014). Despite this, there is a paucity of masculinity studies in emerging markets.

The previous studies confirmed the level of masculinity affects the behaviour of individuals. This matter becomes more difficult if the individuals are in a leadership position such as CEOs because they have the power to make decisions. Perhaps the most directly relevant studies are that confirmed the association between the masculinity of CEOs and misreporting (Jia et al., 2014), also the study of Stirrat and Perrett (2012) that document an association between facial masculinity and the propensity to cheat, where a highly masculine CEO is more likely to make decisions for his own benefit, for example, using earnings management and manipulation practices, regardless of the company's interests than his less masculine counterpart.

In the same context, a willingness to exploit others, and egocentric behaviour as some traits of masculinity (Wright et al., 2012) may cause harm to workers by increasing inappropriate burdens or arbitrarily reducing wages, which will harm the company in the long term. Other masculinity behaviours of CEO such as risk-seeking (Apicella et al., 2014) may encourage a decision to invest in new ventures of a high-risk nature, which may have repercussions later. In addition, CEOs with more masculine may have a better performance as an outcome of their masculine behaviours (Wong et al., 2011). At the same time, being risk-tolerant and aggressive with the competitors might achieve the firm's goals, entering new markets and exploiting opportunities, with positive results.

The current study chose Bursa Malaysia for the institutional setting due to the series of corporate financial scandals such as those affecting the Transmile Group Berhad, Megan Media Berhad, United U-Li Corporation Berhad, OCI Berhad and NasionCom Berhad. There is evidence that the CEOs of these companies have been involved in financial irregularities concerning their annual reports (Mohamad et al., 2012). For example, on 21st June 2019, the High Court of Kuala Lumpur confirmed the trial ruling against Datuk Dr. Mohd Adam Che Harun who is the CEO of Megan Media, imposing a

RM300,000 fine and a six month jail sentence (Hamdan, 2019). Harun falsified the company's financial reports and provided inaccurate information to Bursa Malaysia about the company's financial position which was out by RM1.03 billion in 2007. The consequences of these disclosures were that the share price declined and then in 2008, Megan-Media was declared bankrupt.

Man is distinguished from other creatures by the human brain which is considered to be the most influential centre of intelligence in life. Brain tissue hides the great secret of the distinctive feature of man. Perhaps we may never fully comprehend it (Smith, 1924). The integration of different disciplines by biologists and social scientists helps to understand the many complex issues and, at the same time, it creates new research trends. Biological measures have been used by financial researchers to explain economic behaviour and financial decision-making. Hambrick and Mason (1984) noted that in the main perspective of the upper echelons theory "the organization is a reflection of its top managers." This theory confirms that corporate organisational results are significantly influenced by the characteristics and attributes of executives which, in turn, affect their choices when making decisions.

Testosterone was first discovered by Berthold (1849) but in uncertain and straightforward results. The work continued since this period until the 1930s. Kochakian and Murlin (1936) demonstrated the hormone's effects in terms of increasing nitrogen retention which is a mechanism central to anabolism. Then Kenyon et al. (1940) demonstrated that testosterone propionates anabolic and androgenic effects in eunuchoid men, boys and women. Research in this golden age proved that this newly manufactured testosterone compound or rather the group of compounds (many derivatives) that were developed in the period between 1940 and 1960 were potent multipliers for the health and strength of muscles (De Kruif, 1945).

Testosterone is defined as an anabolic steroid male sex hormone that plays a vital role in developing the reproductive system of male testes and the prostate as well as stimulating secondary male characteristics including body hair growth and increased bone mass and muscle (Mooradian et al., 1987). Also, testosterone is vital for bone health (Bassil et al., 2009) and preventing bone weakness (osteoporosis) (Tuck and Francis, 2008). Therefore, decreased levels of testosterone may lead to fragile bones or even bone loss in men.

Testosterone is a natural hormone secreted in human bodies. It is also used as a medication to treat low Tshs in men (Margo and Winn, 2006) and as therapy for transgender men as a transgender hormone. Testosterone plays a role in breast cancer management in females too (Drugs.com, 2015). Testosterone is sometimes given to older men if the level of natural testosterone declines to compensate for this deficiency. It is also used illegally to increase physical performance in athletes.

Testosterone became one of the androgen medications after it was isolated in 1935 and approved for medical use in 1939 (Fischer et al., 2010). Between 2001 and 2011 in the US, consumption rates have increased threefold (Desroches et al., 2016). It is considered one the most effective, essential and safest medicines available as a generic medication needed in a health system and was added to the World Health Organization (2015) list.

3 Data and methods

3.1 Data

We started with 260 companies as the total sample. This represents 32.74% of the companies listed on the Bursa Malaysia stock exchange as of 31st December 2019, for eleven years from 2009 to 2019. For the purpose of sample selection, a systematic random sampling method was applied. As can be seen in Table 1 panel A, 405 CEOs were recorded in the original sample. We identified CEOs from the companies' websites, annual reports, and the Bursa Malaysia website. We followed Hu et al.'s (2020) approach whereby if the same individual served as both chairman and CEO of a company, he is recorded as the CEO if the listed firm provides an income for him.[1] The study followed the same concept when the same person held the positions of general manager and CEO in the same company (Hu et al., 2020).[2] We referred to the board structure and the responsibilities in the governance report to determine who holds the highest level and who should be reported to. Otherwise, the CEO was considered to be almost always on the payroll as a CEO.

After identifying the names of the CEOs, hand-collected demographic and personal data were obtained including gender, age, race, nationality, educational backgrounds, and the date appointed to their position. Then we excluded 34 female CEOs which led to 12 companies being lost from the sample. The standard practice in the fWHR literature is to exclude women from the selection (Ahmed et al., 2019; Jia et al., 2014; Kamiya et al., 2019).[3] We followed the approach adopted by previous studies to build the face photo database for CEOs. We used the CEO's name and the company's name to obtain high quality photos on Google-images. When a suitable image could not be found, we searched on Google-video for movies that maybe include the CEO in a meeting, conference or even at a party. Then we obtained an image of the CEO's face from the film and included this picture in the database. If we could not find a suitable image in the last phase, we searched on LinkedIn, Facebook, and Instagram to obtain the required photo.

Finally, we could not find pictures for 59 CEOs at 44 companies, so they were excluded. We removed 27 CEOs (from 18 companies) whose photos were non-compliant with the conditions. We identified the best photograph in terms of resolution, whether the CEO was facing the camera and whether he has a neutral expression. We removed 12 CEOs' photos (from five companies) that could not be measured by the python code program. The sample included 273 CEOs from 181 companies. After that, we extracted 2,680 financial-year observations for our original sample from the DataStream database. This gave 1,991 observations for companies after banning the excluded companies. We removed 282 and 98 observations during the matching process due to missing financial data and fWHR, respectively. The final sample became 1,611 observations of CEOs' fWHR for 273 unique CEOs from 181 listed companies from 2009 to 2019 listed on the main market of Bursa Malaysia.

Table 1 panel B classify CEOs of the sample by race. Chinese CEOs were the biggest percentage by 57.14% of total CEOs with 1,079 observations, while Malay CEOs were 88 CEOs as a second group. However, Malay represents the largest share in the board of Bursa Malaysia, according to the Corporate Governance Report on 28th February 2019 (Bursa Malaysia Berhad, 2019). In line with the structure of the Bursa Malaysia board, other races came in third-ranked by 24 CEOs;[4] however, the Indian group had only 21 observations for five CEOs as the last ranking. For the purpose of hypothesis testing, Malays are referred to as Bumiputera, otherwise are others (hereafter known as non-Bumiputera). Following prior studies by Hashim (2012) and Haniffa and Hudaib (2002), Bumiputera refers to only Malays as they form the majority and such categorisation may be useful for the analysis. The sample included 420 and 1,191 observations as Bumiputera and non-Bumiputera, respectively.

Table 1 Sample selection

Panel A: sample selection

Process of sampling	*Companies*	*CEOs*	*Observations*	*No.*
Original sample	260	405	Financial observations	2,860
Less			Less	
Female CEOs	12	34	Excluded due to photos selection	869
Not available photos	44	59	Missing data from DataStream	282
Non-compliant photos	18	27	Excluded when matching with CEO photos	98
Unmeasurable photos	5	12		
Total	181	273	Total	1,611

Panel B: sample by race

Race	*No.*	*%*	*Obs.*	*%*	*Race*	*No.*	*%*	*Obs.*	*%*
Chinese	156	57.14	1,079	66.98	Bumiputera	88	32.2	420	26.07
Malay	88	32.23	420	26.07	Non-Bumiputera	185	67.8	1,191	73.93
Indian	5	1.83	21	1.30	Total	273		1,611	
Others	24	8.79	91	5.64					
Total	273		1,611						

Panel C: sample by industry

Sector	*Comp.*	*Obs.*	*%*	*CEOs*	*%*	*Obs.*	*%*	*Years*	*Obs.*	*%*
Transportation and logistics	28	308	15.47	39	21.55	233	14.52	2019	173	10.73
Property	26	286	14.36	41	22.65	238	14.76	2018	172	10.67
Consumer products and services	21	231	11.6	37	20.44	191	11.85	2017	170	10.61
Technology	21	231	11.6	32	17.68	176	10.92	2016	164	10.17
Industrial products and services	20	220	11.05	28	15.47	190	11.79	2015	161	9.99
Plantation	18	198	9.94	24	13.26	166	10.3	2014	151	9.37
Energy	13	143	7.18	21	11.6	123	7.63	2013	144	8.93
Healthcare	13	143	7.18	14	7.73	101	6.27	2012	132	8.19
Telecommunications and media	11	121	6.08	20	11.05	111	6.89	2011	124	7.69
Utilities	10	110	5.52	17	9.39	82	5.09	2010	118	7.32
								2009	102	6.33
Total	181	1,991		273		1,611			1,611	

Table 1 panel C presents the companies by sector, CEO and year in the sample that have complete data. The largest percentages are 15.47% and 14.36% for the transportation and logistics sector, and property sector, respectively. However, the lowest ratios are 6.08% and 5.52% for the telecommunications and media sector, and utilities sector, respectively. The consumer products and services, technology, and industrial products and services sectors represent similar percentages of between 11% and 12%. The sample included plantation (9.94%) and both the energy sector and healthcare sectors comprised 7.18%. Table 1 panel B illustrates the distribution of CEOs and their observations. The number of CEOs for the property industry was the highest in the sample, presenting 22.65% (41 CEOs), while the lowest was 7.73% (14 CEOs) for healthcare. The distribution of observations across the years was largely similar from 2014 to 2019 at between 9.37% and 10.73% for each year. Meanwhile, it was between 7.32% and 8.93% from 2010 to 2013. Although the lowest sample percentage was 6.33% in 2009, it is greater than the sample of Jia et al. (2014) and Kamiya et al. (2019) which were 0.61% and 0.41%, respectively. This consistency in the distribution during the period indicates a good representation for all years.

3.2 Variables and measures

3.2.1 Procedures for obtaining the facial-width-height-ratio

We follow the approach applied in the empirical literature to obtain fWHR as the primary proxy for masculinity from the photo database (see Figure A1). Adobe Photoshop (Ps) version 20 was used to convert each photo to 8-bit and greyscale (Kamiya et al., 2019) with a focus on the face and 400 pixels as a standard height (Carré et al., 2009). We saved all photos as .jpg files (Jia et al., 2014) after creating a code for each one that refers to the company's and CEO's name and his power period.

The empirical literature used different programs to measure fWHR and these can be classified into two main groups. The first one used manual measurements (human hand) to determine the face distance such as 'ImageJ software' provided by the National Institute of Health (Jia et al., 2014) and 'Adobe InDesign' (Mills and Hogan, 2020). The second group used artificial intelligence to identify the face dimensions such as 'Face++ facial recognition' software (Ahmed et al., 2019) and the 'Python open-source package' (Ku et al., 2021). The current study used a Python/C code developed by Kamiya et al. (2019) because fWHR results have been tested. Kamiya et al. (2019) used ImageJ software and then used Python/C code which was developed to measure fWHR. They compared the results to test the human error and effectiveness of python/C code; the results were consistent.

There are two calculation methods for the fWHR. The first is the distance between the left and right zygion (the cheekbones) which is referred to as the bizygomatic width and this is divided by the vertical distance from the upper lip on the face to the lower point of the eyebrows meeting (facial height) (Kamiya et al., 2019; McCormick et al., 2008; Vorsatz et al., 2021). The current study used this method because we used the same Python code program that has been developed by Kamiya et al. (2019). The second way measures the upper facial height in a slightly different manner in that they measure the distance between the upper lip and the highest point of the eyelids (Jia et al., 2014; Ku et al., 2021; Lefevre et al., 2013).

3.2.2 Testosterone measures

Testosterone is measured in the laboratory in different ways because it is a ubiquity hormone of the body along with blood (Nadler et al., 2017; Stanton et al., 2021), urine (Jiménez et al., 2006) and saliva (Coates and Herbert, 2008; Hodges-Simeon et al., 2016; Kordsmeyer et al., 2019). It is not easy to measure the actual Tsh using samples in organisational environments. Social science has used various proxies because one of the essential features of testosterone is that it leaves behind body marks (Hardy, 2019). Researchers use these in most organisational research because they are visible and measurable. The empirical literature uses three proxies for testosterone: the second finger length (index finger) divided by the fourth finger length (ring finger), which is known as 2D:4D, facial morphometric masculinity (fMM) which is the difference of the calculated degree between the masculinity of the face and a female reference face (Vorsatz et al., 2021),[5] and finally the fWHR which has been discussed above.

Table 2 Variables' definition

Variable	*Symbol*	*Formula/definition*
Dependent variables		
Return-on-assets	*ROA*	A proxy of financial performance
Return-on-equity	*ROE*	A proxy of financial performance
Independent variables		
Facial width-to-height ratio	*fWHR*	= (distance between left and right zygion/vertical distance from the upper lip to the lower point of the eyebrows)
Testosterone	*Tsh*	= expected levels of testosterone according to the equation (1)
Control variables		
Business background	*Businnessbg*	A dummy variable equals one if the CEO holds a degree in business administration and zero otherwise
Size	*Lnassets*	Natural logarithm (total assets)
Square (size)	$Lnasstadj^2$	= *square* (*Lnassets – sample mean of Lnassets*)*
Financial leverage	*Leverage*	= ($Total\ Liabilities_t$ / $Total\ Assets_t$)
Asset turnover	*Asseturnover*	= ($Total\ Revenues_t$ – $Total\ Assets_t$)
Revenue growth	*GrowRev*	= ($Total\ Revenues_t$ – $Total\ Revenues_{t-1}$) / $Total\ Revenues_{t-1}$
Asset growth	*GrowAsset*	= ($Total\ Assets_t$ – $Total\ Assets_{t-1}$) / $Total\ Assets_{t-1}$
Moderating variable		
Race/ethnicity of CEO	*CEO race*	A dummy variable equals one if CEO's race is Bumiputera and zero others.

Notes: *added $Lnasstadj^2$ in our model to explore the nonlinear relationship of performance with size according to method of Davidson and Gist (1996, p.114) to overcome a problem of high collinearity between the variables.

We cannot obtain laboratory Tshs for CEOs because this requires a medical screening procedure, so instead we used one of the proxies. Our study followed the approach of

Ahmed et al. (2019) to measure Tshs. Ahmed et al. (2019) used expected Tshs as a proxy for CEO masculinity and they developed an alternative proxy-based on fWHR and age for CEOs using the clinical data provided in Lefevre et al. (2013)[6] about reactive Tshs on the baseline with age.

The clinical studies noted that age works as a moderator in the relationship between fWHR and Tshs in men (Bird et al., 2016; Hodges-Simeon et al., 2016). In the same context, other clinical research studies have provided evidence of a negative relationship between males' age and Tshs (Feldman et al., 2002). Ahmed et al. (2019) estimated the following regression system to estimate the expected level of testosterone:

$$\sqrt{Testosterone_{it}} = \alpha + \beta_1 + fWHR_i + \beta_2 \log\left(Age_{it}\right) + \varepsilon_{it} \tag{1}$$

where *Testosterone* is the level of testosterone of the CEO (i) in year (t), *fWHR* denotes the fWHR; *Age* is the age of an individual in years and α = 14.53, β_1 = 2.64, and β_2 = –3.21 which are the coefficients that have been estimated using actual clinic data. Table 2 illustrates variables' definition and measurement.

3.3 Model

The present study utilises fixed effect model to estimate the effect of the masculine behavioural traits of the chief executive officers (CEOs) on company financial performance. Basically, the following fixed model is estimated to regress this relationship:

$$Y_{it} = \alpha + \alpha_{0i} + \alpha_{1i} X_{it} + \mu_{it} \tag{2}$$

As s straightforward technique, this form gives each firm its own intercept to establish a set of binary variables, one for each firm, and use them as regressors.

$$Y_{it} = \sum\nolimits_{j=1}^{N} D_{it}\alpha_{0i} + \alpha_{1i} X_{it} + \mu_{it} \tag{3}$$

However, no constant exits in this form hence, the following equation is adopted as an extension of fixed effect model allowing the intercept to vary across time periods:

$$Y_{it} = \sum\nolimits_{j=1}^{N} \alpha_{0i} D_{it} + \sum\nolimits_{j=1}^{T} \alpha_{2i} T_{it} + \alpha_{1i} X_{it} + \mu_{it} \tag{4}$$

Based on these equations, we used the following model to test the direct relationship between performance and CEO masculinity:

$$\begin{aligned} Performance_{it} = \alpha + \beta_1 CEOmasculinity_{it} + \beta_2 CEOrace_{it} + \beta_3 Businessbg_{it} \\ + \beta_4 Lnassets_{it} + \beta_5 Lnasstadj_{it}^2 + \beta_6 Leverage_{it} \\ + \beta_7 Asseturnover_{it} + \beta_9 GrowRev_{it} + \beta_8 GrowAsset_{it} + \varepsilon_{it} \end{aligned} \tag{5}$$

Further, the following model has been estimated to predict the moderation effect of the CEO's race on the relationship between performance and CEO masculinity:

$$\begin{aligned} Performance_{it} = \alpha + \beta_1 CEOmasculinity_{it} + \beta_2 CEOrace_{it} + \beta_3 CEOmasculinity_{it} \\ *CEOrace_{it} + \beta_4 Businessbg_{it} + \beta_5 Lnassets_{it} + \beta_6 Lnasstadj_{it}^2 \\ +\beta_6 Leverage_{it} + \beta_7 Asseturnover_{it} + \beta_9 GrowRev_{it} \\ +\beta_8 GrowAsset_{it} + \varepsilon_{it} \end{aligned} \quad (6)$$

4 Empirical results

4.1 Descriptive statistics and correlation

The variables' descriptive statistics are presented in Table 2. The variables fWHR, Tsh, ROA, and ROE were winsorised by 1%. The average values of ROA and ROE are 4.3% and 7.3% having standard deviation correspond to 0.048 and 0.076, accordingly. The fWHR average value is 1.874 with standard deviation of 0.151 that appear to be in consistent with the outcomes of prior empirical studies whereas it was recorded as 1.86 in the work of McCormick et al. (2008), 1.83 n the sample used by Ku et al. (2021) and 1.91 in Mills and Hogan (2020). The mean testosterone natural logarithm in the present sample is 6.718, with the standard deviation of 0.752. It is in agreement with the outcome of Ahmed et al. (2019) with the mean value, 7.23 (SD = 0.585).

Table 3 Descriptive statistics

Variables	*N*	*Min*	*Max*	*Median*	*Mean*	*Std. dev.*
ROA	1,571	–0.073	0.156	0.041	0.043	0.048
ROE	1,528	–0.105	0.251	0.071	0.073	0.076
fWHR	1,610	1.536	2.202	1.865	1.874	0.151
Tsh	1,610	4.785	9.097	6.654	6.718	0.752
Businnessbackg	1,610	0	1	0	0.384	0.487
Lnassets	1,855	–4.467	4.865	–0.126	0	1.802
$Lnasstadj^2$	1,855	0	23.666	1.579	3.247	4.336
Leverage	1,867	0.005	0.996	0.444	0.439	0.2
Asseturnover	1,866	0	7.158	0.617	0.81	0.755
GrowRev	1,841	–3.197	1	0.048	0.002	0.379
GrowAsset	1,825	–0.814	4.668	0.051	0.11	0.377

The Pearson correlation matrix is illustrated in Table 4. The table shows a significant positive relation between ROA and ROE. The correlation between fWHR and testosterone is positive and significant ($r = 0.736$, $p < 0.001$) which is in line with prior research (Ahmed et al., 2019). The correlation between fWHR and performance (ROA and ROE) is negative and insignificant. Testosterone has a positive correlation with ROA and a negative correlation with ROE. The matrix depicts a strong correlation between performance and most CVs, improving the interpretation of our model employed. There is no evidence multi-collinearity problem as the correlation values between the independent variables are less than 0.70 and the VIF values are in the range of 1.18 and 1.19.

Table 4 Correlation matrix and multi-collinearity diagnostics

Variables	*ROA*	*ROE*	*fWHR*	*Testosterone*	*Bumip*	*Businnessbackg*
ROA	1					
ROE	0.910***	1				
fWHR	–0.016	–0.039	1			
Tsh	0.028	–0.013	0.736***	1		
CEOrace	–0.057**	0.003	0.063**	0.051**	1	
Businnessbackg	–0.141***	–0.128***	0.021	0.113**	0.141***	1
Lnassets	0.055**	0.122***	0.107***	–0.005	0.285***	0.063**
Lnasstesadj^2	–0.041	0.006	0.043*	0.072***	0.160***	0.079***
Leverage	–0.243***	–0.060**	0.018	–0.050**	0.212***	0.085***
Asseturnover	0.195***	0.187***	–0.016	0.034	–0.101***	0.006
GrowRev	0.096***	0.087***	0.021	0.018	–0.014	–0.055**
GrowAsset	0.164***	0.120***	0.020	0.042*	–0.014	–0.060**
	Lnassets	*Lnasstesadj*^{2}	*Leverage*	*Asseturnover*	*GrowRev*	*GrowAsset*
Lnassets	1					
Lnasstesadj^2	0.234***	1				
Leverage	0.380***	0.053**	1			
Asseturnover	–0.155***	–0.135***	0.189***	1		
GrowRev	0.049**	–0.013	0.028	0.085***	1	
GrowAsset	–0.008	–0.018	–0.002	–0.047**	0.102***	1
With fWHR	*VIF*	*1/VIF*	*With testosterone*		*VIF*	*1/VIF*
fWHR	1.013	0.987	*Tsh*		1.042	0.96
CEOrace	1.121	0.892	*CEOrace*		1.124	0.89
Businnessbackg	1.041	0.961	*Businnessbackg*		1.04	0.961
Lnassets	1.568	0.638	*Lnassets*		1.577	0.634
Lnasstadj^2	1.256	0.796	*Lnasstadj*^{2}		1.28	0.781
Leverage	1.295	0.772	*Leverage*		1.293	0.773
Asseturnover	1.167	0.857	*Asseturnover*		1.168	0.856
GrowRev	1.065	0.939	*GrowRev*		1.066	0.938
GrowAsset	1.051	0.952	*GrowAsset*		1.058	0.945
Mean VIF	1.18	.	*Mean VIF*		1.19	.

Notes: *, **, *** indicates significance at the 0.10, 0.05 and 0.01 level, respectively.

Table 5 Univariate tests

Main variables	*Non-Bumiputera*	*Mean*	*Bumiputera*	*Mean*	*Difference*	*St. err.*	*t-value*
fWHR	1,190	1.868	420	1.89	–0.022**	0.009	–2.5
Tsh	1,186	6.696	416	6.784	–0.088**	0.043	–2.05
ROA	989	0.044	356	0.037	0.006**	0.003	2.1
ROE	970	0.072	342	0.072	–0.001	0.005	–0.1

Notes: *, **, *** indicates significance at the 0.10, 0.05 and 0.01 level, respectively.

Table 6 Regression result

	Model 1	*Model 2*	*Model 3*	*Model 4*	*Model 5*	*Model 6*	*Model 7*	*Model 8*
	ROA	*ROE*	*ROA*	*ROE*	*ROA*	*ROE*	*ROA*	*ROE*
fWHR	0.013	0.029			0.050*	0.100**		
	(0.591)	(0.785)			(1.966)	(2.115)		
Tsh			0.012***	0.012**			0.016***	0.018**
			(3.304)	(2.092)			(3.273)	(2.319)
CEOrace #c.fWHR					–0.085*	–0.164**		
					(–1.803)	(–2.372)		
CEOrace #c.Tsh							–0.016*	–0.022*
							(–1.840)	(–1.668)
CEOrace	–0.001	0.007	0.002	0.010	0.155*	0.309**	0.103*	0.148*
	(–0.086)	(0.290)	(0.174)	(0.411)	(1.705)	(2.342)	(1.688)	(1.674)
Businnessbg	0.004	0.007	0.002	0.003	0.005	0.008	–0.000	0.000
	(0.602)	(0.681)	(0.286)	(0.326)	(0.730)	(0.821)	(–0.010)	(0.044)
Lnassets	–0.005	–0.020**	–0.003	–0.018**	–0.005	–0.021**	–0.002	–0.017**
	(–0.948)	(–2.449)	(–0.496)	(–2.121)	(–1.034)	(–2.597)	(–0.447)	(–2.053)
Lnasstesadj^2	–0.003**	–0.004**	–0.003**	–0.004**	–0.004***	–0.005***	–0.004**	–0.004**
	(–2.389)	(–2.183)	(–2.394)	(–1.983)	(–2.714)	(–2.655)	(–2.437)	(–2.013)
Leverage	–0.090***	–0.041	–0.090***	–0.040	–0.089***	–0.039	–0.090***	–0.041
	(–3.499)	(–1.171)	(–3.585)	(–1.162)	(–3.526)	(–1.131)	(–3.627)	(–1.203)
Asseturnover	0.035***	0.033	0.037***	0.033	0.035***	0.033*	0.038***	0.034
	(3.129)	(1.648)	(3.280)	(1.616)	(3.182)	(1.676)	(3.337)	(1.618)

Notes: 1 *, **, ***indicate significance at the 0.10, 0.05 and 0.01 level, respectively.
2 Models (1) and (2) estimate the relationship between fWHR and performance using ROA and ROE, respectively.
3 Models (3) and (4) estimate the relationship between Tsh levels and performance using ROA and ROE, respectively.
4 Models (5) and (6) estimate the moderate effect of CEO race on the relationship between fWHR and ROA and ROE, whereas models (7) and (8) estimate the moderate effect of CEO race on the relationship between Tsh and ROA and ROE.

Table 6 Regression result (continued)

	Model 1	*Model 2*	*Model 3*	*Model 4*	*Model 5*	*Model 6*	*Model 7*	*Model 8*
	ROA	*ROE*	*ROA*	*ROE*	*ROA*	*ROE*	*ROA*	*ROE*
GrowRev	0.007*	0.009*	0.009**	0.012**	0.007	0.009	0.009**	0.011**
	(1.723)	(1.661)	(2.521)	(2.223)	(1.645)	(1.554)	(2.413)	(2.131)
GrowAsset	0.019	0.024	0.018	0.024	0.019	0.023	0.018	0.023
	(1.385)	(1.200)	(1.354)	(1.209)	(1.361)	(1.151)	(1.344)	(1.183)
_cons	0.040	0.020	–0.019	–0.009	–0.028	–0.110	–0.043	–0.044
	(0.958)	(0.298)	(–0.675)	(–0.202)	(–0.585)	(–1.279)	(–1.259)	(–0.804)
FE (year)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
FE (industry)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	1325	1294	1319	1289	1325	1294	1319	1289
r^2	12.5%	7.3%	14.0%	8.0%	12.9%	7.8%	14.4%	8.3%
r^2_a	11.9%	6.6%	13.4%	7.3%	12.2%	7.1%	13.7%	7.5%
F	5.172	3.666	6.817	3.721	5.372	4.032	5.824	3.226
P	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001

Notes: 1 *, **, *** indicate significance at the 0.10, 0.05 and 0.01 level, respectively.
2 Models (1) and (2) estimate the relationship between fWHR and performance using ROA and ROE, respectively.
3 Models (3) and (4) estimate the relationship between Tsh levels and performance using ROA and ROE, respectively.
4 Models (5) and (6) estimate the moderate effect of CEO race on the relationship between fWHR and ROA and ROE, whereas models (7) and (8) estimate the moderate effect of CEO race on the relationship between Tsh and ROA and ROE.

Table 7 Additional test

	Non-Bumiputera				Bumiputera			
	Model 1	*Model 2*	*Model 3*	*Model 4*	*Model 5*	*Model 6*	*Model 7*	*Model 8*
	ROA	*ROA*	*ROE*	*ROE*	*ROA*	*ROA*	*ROE*	*ROE*
fWHR	0.045*		0.064		–0.016		–0.014	
	(1.789)		(1.454)		(–0.503)		(–0.250)	
Tsh		0.016***		0.013**		0.002		0.001
		(4.268)		(1.967)		(0.334)		(0.048)
Businnessbackg	0.016**	0.006	0.031**	0.021	0.007	0.007	0.006	0.006
	(2.021)	(0.668)	(2.167)	(1.397)	(0.940)	(0.934)	(0.450)	(0.440)
Lnassets	–0.002	0.002	–0.024***	–0.020***	–0.006	–0.006	–0.007	–0.008
	(–0.689)	(0.517)	(–4.145)	(–3.493)	(–0.906)	(–0.856)	(–0.570)	(–0.692)
Lnasstesadj^2	–0.002**	–0.002**	–0.003*	–0.002	–0.006***	–0.006***	–0.008***	–0.008***
	(–2.212)	(–2.181)	(–1.781)	(–1.491)	(–3.542)	(–3.480)	(–2.816)	(–2.603)
Leverage	–0.083***	–0.085***	–0.025	–0.023	–0.128***	–0.130***	–0.101**	–0.107**
	(–5.235)	(–5.428)	(–0.893)	(–0.824)	(–5.218)	(–5.260)	(–2.317)	(–2.482)
Asseturnover	0.054***	0.058***	0.040***	0.042***	0.024**	0.023**	0.034**	0.028*
	(7.232)	(7.895)	(4.287)	(4.519)	(2.554)	(2.475)	(2.051)	(1.712)
GrowRev	0.006	0.008**	0.008	0.011*	0.003	0.003	0.001	0.005
	(1.585)	(2.281)	(1.380)	(1.707)	(0.549)	(0.621)	(0.147)	(0.467)

Notes: 1 *, **, *** indicate significance at the 0.10, 0.05 and 0.01 level, respectively.
2 Models (1:4) estimate the relationship between CEO masculinity (fWHR and Tsh) and performance (ROA and ROE) Amang non-Bumiputera Group.
3 Models (5:6) estimate the relationship between CEO masculinity (fWHR and Tsh) and performance (ROA and ROE) Amang Bumiputera Group.

Table 7 Additional test (continued)

	Non-Bumiputera				*Bumiputera*			
	Model 1	*Model 2*	*Model 3*	*Model 4*	*Model 5*	*Model 6*	*Model 7*	*Model 8*
	ROA	*ROA*	*ROE*	*ROE*	*ROA*	*ROA*	*ROE*	*ROE*
GrowAsset	0.015***	0.015***	0.017**	0.017**	0.040***	0.040***	0.051***	0.052***
	(3.588)	(3.526)	(2.289)	(2.374)	(4.825)	(4.778)	(3.459)	(3.549)
_cons	–0.049	–0.072***	–0.075	–0.043	0.140**	0.097**	0.161	0.137*
	(–1.017)	(–2.717)	(–0.915)	(–0.968)	(2.364)	(2.071)	(1.546)	(1.739)
FE (year)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
FE (industry)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	979	975	961	958	346	344	333	331
r^2	0.131	0.155	0.088	0.094	0.221	0.221	0.100	0.105
r^2_a	0.015	0.013	0.066	0.059	0.060	0.059	0.090	0.086
F	15.817	19.105	9.923	10.587	10.137	10.070	3.817	3.974
p	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Notes: 1 *, **, *** indicate significance at the 0.10, 0.05 and 0.01 level, respectively.
2 Models (1:4) estimate the relationship between CEO masculinity (fWHR and Tsh) and performance (ROA and ROE) Amang non-Bumiputera Group.
3 Models (5:6) estimate the relationship between CEO masculinity (fWHR and Tsh) and performance (ROA and ROE) Amang Bumiputera Group.

Table 5 reports the results of the t-tests. Consistent with our hypothesis, the t-tests indicate a statistically significant difference between CEOs' masculinity (fWHR and Tshs) and performance measured by ROA in the racial groups (Bumiputera and non-Bumiputera). However, the mean differences in ROE between the different subgroups are statistically insignificant.

4.2 Regression results

Table 6 presents the estimation of the results using fixed effects regression based on panel data analysis and Hausman test. The results show that fWHR has an insignificant relationship with performance measured by ROA and ROE. This is consistent with Beltman (2018). However, this contradicts Wong et al. (2011) who found a positive and significant relationship between both, whereas Kohli and Dangi (2017) report a negative significant relationship. This difference in findings could be because this research utilised a larger sample size, nearly five times greater than the sample in the previous studies. The findings in this study were also different from those of Ku et al. (2021), which showed that fWHR is negatively correlated with performance.

Nonetheless, the results indicate that testosterone exhibits a statistically significant positive association with performance. While it has a statistically significant association at the level of 1% with ROA, it is significant at the level of 5% for ROE. This indicates that a greater Tsh, as a proxy for the CEO's masculinity, leads to higher performance. This is consistent with a wide variety of laboratory studies (Casto et al., 2020; Nadler et al., 2017; Nofsinger et al., 2020), which confirm a positive and statistically significant relationship between forecasted Tshs and CEO performance.

Table 6 shows the moderating effect of race on the relationship between CEO masculinity and performance. Columns 5 and 6 show in greater detail the increase in the coefficient relationship between fWHR and ROA (ROE) from 0.013 (0.029) to 0.050 (0.100). The relationship of fWHR and race as CV and the moderating variable with ROA and ROE became significant at the 10% and 5% levels, respectively. Regarding Tshs, columns 6 and 7 show a rise in the coefficient relationship with ROA and ROE from 0.012 to 0.016 (0.18) with the same significant levels. These results are consistent with our third hypothesis.

The business background of the CEOs (*Businnessbg*) has no influence on performance, which is consistent with (Jalbert et al., 2002). The results also show that size, measured by *Lnassets* and *Lnasstesadj*[2], exhibits a negative impact across all models except for the relationship between *Lnassets* and ROA, which is insignificant. This is consistent with Chandren et al. (2021) who found a significant relationship between size and performance. This relationship could be due to controlling factors such as growth opportunities, liquidity level, financial risk and firm age (Isik et al., 2017). However, the insignificant relationship between *Lnassets* and ROA is justified by Lee (2009), who indicates that the nonlinear relationship between firm size and performance is governed by other factors such as market share and concentration, capital intensity, and advertising intensity. *GrowRev* has a significant influence on ROA at the level of 1%. *Asseturnover* and *GrowRev* are positively associated with performance at different significance levels. However, the results reveal an insignificant association between *GrowRev* and performance. Finally, *Lvrg* indicates negative values in four models, which is consistent with (González, 2013).

4.3 Additional test

To confirm the validity and robustness of the findings, the statistical analysis was re-run after dividing the sample into two groups based on race (Bumiputera and non-Bumiputera) to explore the relationship of masculinity with performance. Table 7 shows a significant relationship between the masculinity of the CEO and performance within the non-Bumiputera group however, it is insignificant in the case of the Bumiputera group. The results indicate that in the non-Bumiputera group, testosterone has a statistically significant positive association at the levels of 1% and 5% with ROA and ROE, respectively. Further, the results reveal a significant relationship between fWHR and ROA at the level of 10%; however, the relationship between fWHR and ROE was insignificant. The results indicate that the fWHR of a CEO is not linked with company performance and therefore cannot be used as a predictor of performance.

Overall, the results signify that race plays a role in the relationship between masculinity and performance. Our results regarding Tshs between races are in line with prior studies that reported variations in Tshs among various races (Ellison et al., 2002). More specifically, blacks and whites (Ellis and Nyborg, 1992; Richard et al., 2014), Hispanic and non-Hispanic (e.g., Lopez et al., 2013; Rohrmann et al., 2007), and Asians (Koreans, Japanese, Chinese, Indian and others) (de Jong et al., 1991; Ellis, 2017; Jakobsson et al., 2006; Jin et al., 1999).

5 Conclusions

We employ a sample of 1,611 observations from Bursa Malaysia from 2009 to 2019 to examine the moderating effect of CEO race on the relationship between masculinity and company performance. CEO masculinity was measured using the fWHR and testosterone hormone levels. The study used the 'Python open-source package' to measure fWHR and predict testosterone according to the age of CEOs. Employing panel data analysis with fixed effect model, we show that CEO testosterone hormone levels have a positive and significant effect on company performance. We also report that CEOs' fWHR has an insignificant influence on company performance. Our empirical findings provide a clear evidence on the relationship between masculinity and company performance, which could be a reconcile to the conflicting findings by prior studies (e.g., Beltman, 2018; Casto et al., 2020; Chandren et al., 2021; Ellis, 2017; Isik et al., 2017; Kohli and Dangi, 2017; Ku et al., 2021; Nadler et al., 2017; Nofsinger et al., 2020). Moreover, we extend prior research by providing an empirical evidence of the moderating role of CEO race on the relationship between masculinity and company performance. We reveal that high masculinity is positively associated with company performance only in the case of non-Bumiputera group. This signifies that race plays a role in the relationship between masculinity and performance.

Our findings contribute to resolve the controversy in the results of prior studies (e.g., Lopez et al., 2013; Rohrmann et al., 2007; Ellis and Nyborg, 1992; Richard et al., 2014; de Jong et al., 1991; Ellis, 2017; Jakobsson et al., 2006; Jin et al., 1999) related to masculinity and race. Our findings have significant implications for developing countries with different races such blacks and whites, Hispanic and non-Hispanic, and Asians (Koreans, Japanese, Chinese, Indian and others). In addition, our study makes a novel contribution and has valuable implications for investors, board members, policymakers, and academics. It highlights the importance of CEO race and masculinity especially, for foreign companies operating in multi-cultural and races environments. Despite the significant results and high contributions of the present study, there are some limitations and the findings should be interpreted in their context. For example, CEO females are excluded due to those prior studies confirming that fWHR does not apply to females. Further, the sample consists of non-financial firms and the findings may not be the same for all types of organisations. Therefore, future research is suggested to investigate this issue in a pure finance context. Another possible stream for future research is to take into consideration the quality of financial reporting and earnings management.

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Notes

1 Founded only five cases that the one individual occupies the two positions called 'executives chairman' in our sample.

2 There were 45 cases that have two different persons in two positions in the same company, and 21 cases that the one individual occupy the two positions.

3 Biological studies emphasise that fWHR is valid only for men as a measure of masculinity and not valid for women (e.g., Lefevre et al., 2013).

4 Other races included (British, American, Thai, South African, Australian, Japanese, Dutch, Italian, Danish, Taiwanese, Spanish, New Zealand, Turkish and Norwegian CEOs).

5 Testosterone in the male foetus' bloodstream during pregnancy, especially in the period from 12 to 18 weeks, changes the morphology of the body and affects the spinal cord, brain, and the formation of male reproductive organs which exceed females by nine times as well as influences the 2D/4D ratio (Cohen-Bendahan et al., 2005; Lutchmaya et al., 2004). For more details see (Marečková et al., 2011).

6 The clinic data of Lefevre et al. (2013) is available online with their published paper.

Appendix

Figure A1 Procedure for obtaining the facial-width-height-ratio (see online version for colours)