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Examining the Progress of Female Athletes in the Marathon

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Abstract

Unlike other sports such as baseball, basketball, football, and other team sports, the performance of a runner is not affected by the teammates around them or by an opponent's defense. The only person that can impact the runner's performance is the runner. At first glance, it may seem that elite marathon runners only come from African countries, but when digging deeper, the variable that makes an elite runner successful may surprise you. The purpose of this paper is to explore the variables that have the greatest impact on elite marathon runner's performance. In addition to this, this paper attempts to answer the question: Has there been improvement in female runners over a ten-year period? The issue of gender performance in sports has been explored in other sports, but looking at the marathon event specifically will be interesting.

The current paper compares various variables in marathon running during the 2005 World Marathon Majors and the 2015 World Marathon major races. Performance data are from the following races are: Tokyo, Boston, London, Berlin, Chicago, and New York City. Other variables analyzed include: gender, age, number of past marathons run at time of race, and course. To compare courses, there will be a control variable for each course. It is important to focus on elite runners in the biggest races for a couple reasons. First, elite runners tend to have more consistent race performance times as opposed to the casual runner who will see large fluctuations in their time. Second, the choice of World Marathon Major races is being used due to the strict regulations for these races by the IAAF.

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I. Introduction

A marathon is 26 miles 385 yards, the ultimate endurance running race. This also presents the opportunity to measure what factors most impact the performance of distance runners. According to Crane (2014), the name Marathon comes from the legend of Pheidippides, the Greek messenger. The legend states that he was sent from the battlefield of Marathon to Athens to announce that the Persians had been defeated in the Battle of Marathon. It is said that he ran the entire distance without stopping and burst into the assembly, exclaiming the news of victory, before collapsing and dying.

Women's participation in marathons has come a long way since Katherine Switzer illegally ran Boston in 1972 as noted in Wettenstein (2015, April 25). Prior to Switzer running, women were not allowed to participate in marathons. According to the Marathon Report created by Running USA (R.U. 2016, May 25), women have gone from being just 11% of all marathon finishers in 1980 to 42% in 2015. Increased participation leads me to believe that performance will also increase for the female athlete. Currently, the marathon distance is dominated by African runners who have a long history of success and winning at the event. Personally, this topic is interesting to me because I am also a marathon runner and I am interested to see how elite athlete's performance has changed over time. I think this topic will be interesting to other readers because by the end of my study they will be able to see what variables most effect the performance of elite runners in the marathon distance.

Unlike other sports such as baseball, basketball, football, and other team sports, the performance of a runner is not affected by the teammates around them or by an opponent's defense. The only person that can impact the runner's performance is the runner. At first glance, it may seem that elite marathon runners only come from African countries, but when digging deeper, the variable that makes an elite runner successful may surprise you. The purpose of this paper is to explore the variables that have the greatest impact on elite marathon runner's performance. In addition to this, this paper attempts to answer the question: Has there been improvement in female runners over a ten-year period? The issue of gender performance in sports has been explored in other sports, but looking at the marathon event specifically will be interesting.

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II. Literature Review

To start, one must answer the question: what classifies a runner as elite? Rosen (1981) provides an explanation of the superstar phenomenon. This is not the only possible way of explaining why superstar athletes are paid so much. According to Rosen (1981), one point that makes the labor market unique for superstars is that, unlike other traditional labor markets, the superstar labor market is not homogenous. As an example: I and Olympic Gold Medalist Matthew Centrowitz can both run a mile, but the fact that he can run it in a much shorter time makes him more valuable in the labor market, and thus he is paid more. Rosen (1981) would argue this example shows that superstar athletes such as Centrowitz are paid high amounts because they are in the labor market which values these skills and the talent difference allows for imperfect substitution.

Rosen (1981)'s argument is quantified by Steinberg (2005. Rosen (1981) suggests that marathon performance could also be a result of the appearance fees garnered by elite athletes in World Marathon Major races. To attract top running talent, race directors are spending more and more money on what they pay elite athletes to run in their races. Thus, showing that Rosen (1981)'s argument is true in that superstar athletes get paid more due to their unique talent. Elite runners will run faster if they know that more prize money is on the line and will train harder if they know that a World Marathon Major race is coming up which offers more prize and appearance money than other races. As an example, Bethea (2015) explains that in 1986, the Boston Marathon awarded prize money to the top male and female finishers. At the time, sixty thousand dollars and a Mercedes Benz was awarded to the top male finisher and thirty-five thousand dollars and a Mercedes Benz to the top female finisher. Since then, the number of course records set by both male and female competitors has reached a combined seven times, and the race's prize money has also gotten bigger each year. In 2015, the winners each received a hundred and fifty thousand dollars, making it the second most prize money given to a marathon winner in the world, behind Dubai which awards two-hundred thousand dollars.

Some studies attempt to trace improvements in performance of elite running athletes over time, but these studies have been in track and field. Liu (2004) argues that it is better to use season best performance data in track and field for analysis and prediction of future performance. He argues that world record performance data tend to be discontinuous due to how seldom a world record is broken in track and field. Season best data on the other hand will always provide data because within each season there will be at least one season best. Liu and Schutz (1998) analyze the trends in season best performances in track and field using linear and exponential empirical models.

Other literature seeks to find the limits of athletic performance such as Deakin (1967). Since it can be assumed that athletic performance has bounds, it must also have a limit to future performance. When looking at this study, it can also be inferred that the performance of both men and female athletes will eventually reach a limit. It could be argued that this could be due to physiological limits of the human body in combination with other factors. One study of interest was done by Dyer (1982) which seeks to examine the athletic performance gap between men and women across all sports. Evidence presented suggests that women are catching up to men in physicality due to changes in training and diet. As women start to train more and more like their male counterparts, women's performances will increase. Dyer (1982) also suggests that women are starting to outperform men in gymnastics and platform diving due to the advantages having a

smaller body type has in both sports. Also, if mating is selective, there could also be genetic changes that affect performance of male and female athletes that Dyer (1982) did not account for.

III. Economic Theory

Most literature reviewed the closing gender performance gap between male and female track and field athletes using a limit or convergence theory. However, the economic theory that will be used to explore the research question previously discussed in this paper will be human capital theory using a production function. There are two elements of the production function: inputs and outputs. It is generally accepted that the inputs of the production function equation will have some impact on the output of the same equation. Specifically relating to this topic, there will be one production function. The reason for using one production function that combines both female and male performances is to estimate the performance effect of being female after controlling for other inputs. Furthermore, the factors that impact the marathon performance may be different for a male than what affects the performance of a female runner.

In terms of human capital theory, we will be exploring the notion that the more on-the-job training a worker gets, their performance should be greater. In this case, the more training an athlete performs, the greater their performance will be. According to Acemoglu (2012), human capital corresponds to any stock of knowledge or characteristics the worker has (either innate or acquired) that contributes to his or her "productivity". This definition is broad, and this has both advantages and disadvantages. The advantages are clear: it enables us to think of not only the years of schooling, but also of a variety of other characteristics as part of human capital investments. These include school quality, training, attitudes towards work, etc. Using this type of reasoning, we can make some progress towards understanding some of the differences in an athlete's running performance. When looking at my topic, the more marathons one has run, it is assumed that they will continue to get better and better with performance. Age is also an important determinant of human capital since it too is linked to training for races. However, as we age, our physical capabilities depreciate. Thus, at some point the advantages from experience that comes from competing in marathons is more than offset by the reduction in physical capabilities related to aging. Therefore, based on human capital theory presented above, it is believed that the performance gap between men and women over the ten-year period of study will shrink.

IV. Database

There will be one source that this study will be drawing data from, which includes data of male and female athletes. This data will include performance time, age, number of past World Marathon Majors run, and gender. Official data will be taken from the International Association of Athletics Federations (IAAF, 2015). This is the international governing body for all professional distance runners as well as track and field athletes. This database is appropriate because it is the official governing body for elite athletes that compete in World Marathon Major events. All data they have must be correct and up to date. By using this data, this project is feasible because the testable hypothesis will be answered based on the empirical model that will be used.

V. Empirical Model

Bringing these things together leads to this study's empirical model. The model being used to test the hypothesis generated from the economic theory is a multiple regression analysis. This is the most effective model to test the hypothesis because there is a specific output being examined and input variables that affects the output. The regression equation will be modeled as:

$$Race\ Time = \alpha + \beta 1(AGE) + \beta 2\left(AGE_{SQUARED}\right) + \beta 3(FEMALE) + \beta 4(VENUE) + \beta 5(YEAR\_2015) + \beta 6(FEMALE\_2015)$$

Table 1 provides definitions of all variables included in the regression along with the expected sign. The dependent variable in this equation will be Race Time in Minutes. This study will be controlling for all variables except Year_2015 and Female_2015 because the primary interest will be the comparison of female and male runners.

Table 1: Variables and Descriptions

Variable Name	**Description**	**Expected Sign**
Dependent		
Minutes_Time	Race Performance converted to minutes.seconds	
Independent		
London	Control Course	Omitted
Tokyo	1 = Tokyo, 0 = Not Tokyo	Positive
New_York	1 = New_York, 0 = Not New_York	Positive
Boston	1 = Boston, 0 = Not Boston	Positive
Chicago	1 = Chicago, 0 = Not Chicago	Positive
Berlin	1 = Berlin, 0 = Not Berlin	Positive
Female	1 = Female, 0 = Not Female	Positive
Year_2015	1 = Year and year is 2015, 0 = Not Year_2015 (2010)	Negative
Female_2015	1 = Female and year is 2015, 0 = Not Female_2015	Negative
Age	How old the runner is the year of the race	Positive
Age_Squared	Squared value of runner's age	Positive

The first variable contributing to the production function will be Age. This is very important because the older a runner gets, the better they will presumably become, but there will come an age where athletic performance begins to plateau and eventually start to decline. In the case of elite marathon running, it is assumed the best runners from both genders will have an age between 30-35. To accommodate this, the equation will also include Age_Squared to show a more realistic representation of the effect of age throughout a runner’s career. Age should be a variable with greater impact than other variables because as a runner gets older, there comes a point when their running performance begins to decline.

Since experience is a valuable determinant of performance, it is hypothesized that performance will improve as the number of races run increases, ceteris paribus. The more marathons a runner has run in the past may have an impact on how well they perform. The preparation of a marathon runner who has run one or two marathons will be much different than a runner racing their first marathon, even at the elite level, because they know what areas they can improve upon from their first marathon and what their strengths and weaknesses are.

The next variable will be Venue, with each course set as a dummy variable. This variable will show the effect of venue on performance and if certain courses have better performances. Per the IAAF (2015), there has been the most World Records set on the London course and for that reason it will be omitted from the regression as the control venue.

Next, there will be two dummy variables, Year_2015 and Female_2015. Year_2015 is a dummy variable with the reference group being 2010. Likewise, Female_2015 is a dummy variable with the reference group being male athletes. Both are important to measure the improvement or decline in performance across gender and over time.

These variables together will show the transformation women have made from the year 2010 to 2015. This is done by taking the product of Year_2015 and Female_2015 to create an interaction term. The result of this interaction term which will be a coefficient which will estimate the relative improvement that elite female marathoners have made relative to elite male marathoners between 2010 and 2015. Finally, my last variable will be athlete gender, defined as Female. The role of gender will be critical in this paper because my goal is to see if there have been performance improvements among female athletes relative to male athletes over the course of five years.

VI. Results

The main purpose of the empirical model described above is to determine if there has been a closing of the performance gap between male and female runners between the year 2005 and 2010 with the use of statistical regression. Overall, the result presented in TABLE 2 suggests that the empirical model well fit the data, showing R-Squared value of 0.889. This tells us that the regression equation explains about 89 percent of the variation in the dependent variable. The two variables that we are focusing on the most out of the regression are Female_2015 and Year_2015. These variables will show the performance of female runners from 2010 to 2015 and the performance of all elite runners from 2010 to 2015 respectively. The interaction term explained earlier is also expected to be negative to show the improvement women have made between 2010 and 2015 relative to men. Looking at TABLE 2, we also see the results of the regression. These results show that each of the Venue variables are significant on the performance time of athletes. In addition to this, the coefficients to being Female and the interaction variable of being Female and the year being 2015 were significant and had the expected signs.

On the other hand, the year and age of runner were not significant. The reason for age not being significant is because all the elite marathon runners, both male and female, are around the same age and after a certain age the runner will recognize a decline in their athletic ability and retire from the sport, dropping out of the sample. The most surprising results shows the performance gains of female runners from 2010 to 2015. Male athletes have showed a fractional improvement of 0.55 minutes during that time which equates to about 33 seconds. What is more staggering is that female athletes have improved 3.47 minutes during the same time which equates to about 3 minutes and 28 seconds.

Looking back at the economic literature and other periodicals, these results are consistent. First, as noted by Acemoglu (2012), humans are expected to evolve physically and mentally over time as seen throughout human history. The physical improvements made over time noted by Acemoglu can also be seen in this study through the performance improvements of the elite marathon runners. Second, as noted by Deakin (1967), there is a limit to human performance and that can also be reasonably be assumed in this study as well that women will not continue to make exponential improvement every five years forever. Finally, as noted by Dyer (1982), women athletes are closing the performance gap with men and that can also be seen in this study through the almost three-and-a-half-minute improvement women have made compared to men. Ultimately, the results of this regression analysis show that the hypothesis was correct in predicting the

performance gap between male and female runners is closing. As noted above, this result is in line with economic theory that supports this finding.

Table 2: Regression Results

Variable	Beta Coefficient	Sig. Value	
London	116.491	0.000	***
Tokyo	6.143	0.000	***
New_York	3.397	0.000	***
Boston	2.534	0.001	***
Chicago	2.357	0.002	***
Berlin	1.473	0.055	*
Female	19.99	0.000	***
Year_2015	-0.549	0.375	
Female_2015	-3.469	0.000	***
Age	0.631	0.185	
Age_Squared	-0.007	0.343	
R^2	0.894		
Adjusted R^2	0.889		
Std. Error	3.369		

*** Significant at the .01 Level
** Significant at the .05 Level
* Significant at the .1 Level

VII. Conclusion

While sports fans enjoy the performances of both male and female runners, the evidence in this paper suggests that the performances of females in the marathon running distance are catching up to the performance of males. Some of the reasons for this performance improvement could be due to changes in training, diet, and general improvement in athleticism in females. More recently, participation in NCAA athletics has seen a sharp increase due to the passage of Title 9 which granted equal participation opportunities for athletes of all genders. Title 9 could also be a reason for the improvement in females due to the increased training and participation opportunities for female athletes. As noted in Dyer (1982), changes in training play the most important role in the improvement women athletes have shown relative to men over history. Many variables could play a part in this improvement. Future research should try to include more than the elite athletes in the sample pool and use runners of all ages for the World Marathon Major races. This will make the findings more applicable to the running population and eliminate the problem of elite athletes retiring or dropping out of competition after a certain age. Another useful extension of this paper could be to develop more independent variables that could play into race performance such as temperature, elevation of race, and grade of the land or how mountainous it is. Finally, research could further explore the reasons for the closing gap and estimate whether the gap is likely to continue to narrow. Combining both additions to the study could provide meaningful insight into the marathon event for decades to come.

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