Economics Bulletin

Volume 44, Issue 3

Risk-taking and performance in marathon running: do pace setters matter?

Jamie Emerson
Salisbury University

Theresa Manns
Salisbury University

Abstract

After many years of using pace setters, the Chicago Marathon eliminated professional pacers for elite runners for the 2015, 2016, and 2017 races, and then reinstated the use of pace setters beginning with the 2018 race. Publicly available data was collected pertaining to the three Chicago Marathon races that did not use pace setters and for the three races subsequent to the reinstatement of pacers. For the same years, data was also collected for the New York Marathon, a World Majors Marathon that did not use professional pace setters for elite runners in any race years under consideration. Difference-in-differences estimations were used to determine the impacts of professional pace setters on the performance of elite male marathon runners. Results indicate that use of professional pacers does improve the race times of the fastest elite runners while making the race appear less competitive by creating more separation between the runners earlier in the race.

Citation: Jamie Emerson and Theresa Manns, (2024) "Risk-taking and performance in marathon running: do pace setters matter?", *Economics Bulletin*, Volume 44, Issue 3, pages 771-780
Contact: Jamie Emerson - jdemerson@salisbury.edu, Theresa Manns - tamanns@salisbury.edu.
Submitted: May 08, 2023. **Published:** September 30, 2024.

1. Introduction

The question of how pace setters can impact different types of competitions has long been of interest to various groups. The importance of pacing strategies has been studied in many areas, from early research in psychology (Triplett (1898)) to more recent research in exercise science (Hanley (2015), Hanley (2016), Muñoz-Pérez, et. al. (2022)), to name a few. In addition, economists have used sports data to investigate the impacts of peers (peer effects) on performance in different sports settings, such as golf (Guryan, et. al. (2009) and Brown (2011)), swimming (Yamane & Hayashi (2015)), and running (Hill (2014a), Hill (2014b), and Emerson & Hill (2018)). The potential impacts of pace setters likely involve both psychological and physical aspects. Further, the utilization of pace setters has the potential to affect marathon running performance due to impacts related to both pacing strategies and peer effects.

Interviews with elite marathon runners and coaches can provide some additional insights into how running in a marathon with professional elite pace setters differs from running in a marathon without professional pace setters. For example, elite marathon runner Meb Keflezighi and his coach, Terrence Mahon, provided the following insights concerning pace setters (Cacciola, 2011):

> A pacemaker's primary job is to keep a flat, even tempo. That's the key to running efficiently, according to Terrence Mahon, who helps coach Keflezighi. Keeping a consistent pace helps runners be economical. Pacemakers also eliminate mental fatigue. Said Keflezighi: "You can just relax for about half the race because you know nobody's going to make a move."

Some additional examples are provided from (Monti, 2015):

> “My only paced race was Berlin and you’re right: it’s totally different,” the fastest American woman entered here (Boston), Shalane Flanagan, told Race Results Weekly in an interview. “I went in and I didn’t have to think. I didn’t have to use my brain. I literally just went in, locked in to my pacesetters, and just hung on for this train ride as long as I could.” “I will say I enjoy, kind of like this match-up, like a boxing fight, when you come to an unpaced race,” Flanagan, 33, continued. “It’s more exciting for the fans, and I think it is more exciting as a competitor. You have to come out, and there is strategizing, there’s thinking. It’s a lot more exhausting. But, overall, I think it yields a much more entertaining race.”
> “When you see the races with pacemakers, you can run one speed and you have to perform one thing,” (Ethiopian Gebre) Gebremariam explained in an interview. “But Boston and New York, they haven’t pacemakers, you have to run five, six races within one race. You have to use your mentality when you run in such kind of races. It’s a huge difference.”

And finally, (Huber, 2015):

> In recent years, some luminaries of professional marathoning, including American legend Bill Rodgers, have complained that the use of pacemakers dulls the actual racing component in the early stages of marathons; elites can just tuck in behind those tasked with generating the tempo and wait. While this can, under the right conditions, produce world record times, it diminishes the likelihood of exciting tactical moves by runners in the first half of the race.

As demonstrated above, elite coaches and runners understand that race strategies, mental fatigue, tactical (strategic) interactions, etc., are different in marathon races that utilize professional elite pace setters compared to races without professional pace setters. This paper investigates differences in elite male athlete performance for marathon races with professional elite pace setters and marathon races that do not utilize professional pace setters.

The Chicago Marathon eliminated the use of professional pace setters for elite male runners beginning with the 2015 race. The decision to eliminate pace setters was made, at least in part, to create more excitement in the marathon race. According to Carey Pinkowski, the Chicago Marathon race director for the 2015 Chicago Marathon (Hersh, 2015): "Without the rabbits, the leaders need a much greater level of concentration. That will allow us to see more tactics, strategy, and competition throughout the race." The Chicago Marathon continued the "experiment" of running the race without professional pace setters for the elite male runners for each of the 2015, 2016, and 2017 races. The use of professional pace setters for elite male runners was reimplemented for the 2018 race. The 2019 and 2021 Chicago Marathons also included professional pace setters for the elite runners[1]. These professional elite pace setters are paid to lead runners through the first half (or slightly longer) of the race at a steady, predetermined pace.

This natural experiment involving the differing use of professional elite pace setters during the 2015 – 2021 Chicago Marathon races provides an opportunity to study the effects of the changing race policy of employing professional elite pace setters.

2. Data

Data on marathon race times was collected from the Bank of America Chicago Marathon website (https://chicago-history.r.mikatiming.com/2021/) and the TCS New York City Marathon website (https://results.nyrr.org/races). Finishing times as well as times through the halfway point of the marathon were collected for the top 15 male finishers for the 2015 – 2021 Chicago Marathon and New York City Marathon races[2]. For this sample of top elite male marathon runners, data on athlete ages and previous personal best times for marathon and half marathon races was obtained from the World Athletics website (https://worldathletics.org/athletes). Tables 1A and 1B provide summary statistics for personal best times (*pb*) and age for the races prior to the policy change and the races after the policy change.

Based on these basic summary statistics, the top 15 male finishers in the Chicago Marathon races and the New York Marathon races appear to have similar characteristics, in terms of previous personal best times and age profiles. The average previous personal best times are in the 2:10 range for each of these marathons both before and after 2018. Since we are interested in investigating how professional pace setters influence marathon race performance (and strategies), we restrict our analysis to runners who are most likely to utilize the professional pace setters as pacing reference throughout the first half of the races. Since the professional pace setters are employed to lead the fastest groups of runners through the half-marathon point (or a little longer) at a fast, steady pace that is determined prior to the start of the race, we focus our

[1] The 2020 Chicago Marathon and New York Marathon races were cancelled due to the COVID-19 pandemic.

[2] Both the Chicago and New York City marathons are part of the World Marathon Majors. The men's Chicago Marathon course record of 2:03:45 was set in 2013 and the men's New York City Marathon course record of 2:05:06 was set in 2011.

analysis on top 15 finishers. Runners with slower marathon personal best times are unlikely to utilize the professional pace setters for much, if any, of the race.

Table 1A: Summary statistics Chicago Marathon races – top 15 finishers

	Mean	Std. Dev.	Min.	Max.
Before (2015, 2016, 2017) (observations = 45)				
pb	7805.022 (2:10:05)	259.322	7468 (2:04:28)	8540 (2:22:20)
age	28.933	3.257	23	35
After (2018, 2019, 2021) (observations = 45)				
pb	7801.333 (2:10:01)	341.666	7435 (2:03:55)	8986 (2:29:46)
age	28.844	3.723	22	36

Table 1B: Summary statistics for New York Marathon races – top 15 finishers

	Mean	Std. Dev.	Min.	Max.
Before (2015, 2016, 2017) (observations = 45)				
pb	7856.556 (2:10:56)	268.242	7393 (2:03:13)	8463 (2:21:03)
age	29.867	5.097	20	42
After (2018, 2019, 2021) (observations = 45)				
pb	7798.311 (2:09:58)	256.605	7265 (2:01:05)	8608 (2:23:28)
age	29.733	4.499	22	42

Since heat and humidity can impact performance in marathon running (Ely et. al., 2007 and El Helou et. al., 2012) hourly information concerning temperature and humidity in Chicago and New York City on the days and times of each marathon race was gathered from the website timeanddate.com: (https://www.timeanddate.com/weather/usa/chicago/historic and https://www.timeanddate.com/weather/usa/new-york/historic). The dew point calculator from calculator.net (https://www.calculator.net/dew-point-calculator.html) was used to calculate the dew point at several times throughout each race (near the beginning, middle, and end of the male elite races). The dew point and temperature were then added together to determine if the heat and humidity during the race would be expected to impact race pace and performance. Each of these Chicago Marathon races started at 7:30am. The hourly data on temperature and humidity was available for the following times – 7:53am (near the start of the race), 8:53am (before any runners have finished), and 9:53am (just after the top runners finished). The 2015, 2016, 2017, and 2019 New York Marathon races each started at 8:30am. However, the 2018 New York Marathon started at 12pm, while the 2021 New York Marathon started at 8am.

According to Coach Mark Hadley, whenever temperature plus dew point is 111 or higher, it is expected that distance runners would likely need to adjust their pace by 0.5% or more (Hadley, 2013). Tables 2A and 2B present the temperature plus dew point values at different times throughout the Chicago and New York Marathon races. Using the averages for the three values of temperature plus dew point during each race, we expect that runners were most likely to adjust their pacing during the 2017, 2018, and 2021 Chicago Marathon races. Therefore, a dummy variable was created to indicate these races in which temperature plus dew point was high enough to potentially impact the elite marathon runners' performances.

Table 2A: Temperature plus dew point throughout the Chicago Marathon races

	2015	**2016**	**2017**	**2018**	**2019**	**2021**
7:53am	98.05	96.04	111.09	115.07	74.2	132.86
8:53am	103.05	97.21	114.82	115.07	76.94	132.86
9:53am	109.05	100.39	119.97	115.07	77.17	133.97

Table 2B: Temperature plus dew point throughout the New York Marathon races

	2015	**2016**	**2017**	**2019**	**2021**			**2018**
8:51am	105.1	91.7	104.9	76.1	83.1		**12:51pm**	82.2
9:51am	105	90.1	107.2	78.3	80.2		**1:51pm**	84.2
10:51am	106.9	90.4	108.2	80	83.1		**2:51pm**	84.2

3. Methodology

We begin with a brief review of a basic difference-in-differences model for pooled cross sections over time. Difference-in-differences estimation with two time periods and one control group requires estimating an equation of the following form:

$$y_i = \beta_0 + \beta_1 treated_i + \beta_2 after_i + \beta_3 (treated_i * after_i) + u_i \quad (1)$$

where *treated* is a dummy variable taking the value of 1 for the treatment group and *after* is a dummy variable taking the value of 1 during the time period for which the policy change is in effect.

In this basic case, the estimate of β_3 can be interpreted as the difference in the mean values of the dependent variable for the treatment group in the two time periods MINUS the difference in the mean values for the control group in the two time periods. In other words, the estimate of β_3 is called the difference-in-differences estimate and is the parameter of interest for the policy analysis. Finally, a statistically significant difference-in-differences estimate suggests that the policy change had a significant effect on the dependent variable. This basic model can also be extended by including additional covariates in the model to account for the possibility that the use of pace setters could be systematically related to other factors that affect the dependent variable. Please see Wooldridge (2002) for a more detailed discussion of difference-in-differences estimation using pooled cross sections over time.

Since our data set consists of pooled cross sections over time, we use difference-in-differences estimation to address the question of how professional pace setters affect the marathon performance. In other words, we compare the differences in performances before and after the race policy change for the treatment and control groups. For our difference-in-differences analysis, we consider the 2015, 2016, 2017, 2018, 2019, and 2021 Chicago Marathon (treatment group) and New York Marathon (control group) races.

4. Results

We begin by using difference-in-differences to compare race performance for the treatment group of Chicago Marathon runners and the control group of New York Marathon runners for the 2015, 2016, 2017, 2018, 2019, and 2021 races. The 2015, 2016, and 2017 Chicago Marathon races were run without professional elite pace setters while the 2018, 2019, and 2021 Chicago Marathon races were run after professional elite pace setters were reimplemented. The New York Marathon races were all run without professional pace setters. We estimate difference-in-differences models of the following form:

$$performance_i = \beta_0 + \beta_1 chicago_i + \beta_2 after_i + \beta_3 (chicago_i * after_i) + \beta_4 pb_i + \beta_5 heat111_i + \beta_6 age_i + u_i \quad (2)$$

The dummy variable $chicago_i$ is defined as 1 for all runners in the Chicago Marathon races, and controls for any baseline differences between the Chicago and New York Marathon races. For example, since the New York Marathon and Chicago Marathon take place in different cities, there are likely to be inherent differences in marathon performances related to the differing courses, even for the same quality of runners. The dummy variable $after_i$ is defined as 1 for the 2018, 2019, and 2021 marathon races, and controls for differences in the two time periods. For example, it is possible that marathon performances could improve over time, regardless of the pace-setter policy, due to improvements in training, diet, etc. The dummy variable $heat111_i$ is defined as 1 if the value of temperature plus dew point during the race was 111 or greater, indicating that heat/humidity conditions were more likely to negatively impact runners' performances. The variable age_i is the runner's age on the date of the race.

The variable pb_i is the personal best marathon finish time (in seconds) for each runner going into each race. Each marathon race also includes some top finishers who have not yet completed a marathon and, therefore, do not yet have a personal best marathon finish time[3]. Since it is important to also include these debut marathon runners in our analysis, we use the McMillan Running Calculator (www.mcmillanrunning.com) to approximate a predicted marathon personal best time for these debut marathon runners (based on the next longest race completed by these debut runners, which is often a half marathon).

In these models, the estimate of β_3 is the relevant difference-in-differences estimator of interest. In other words, this difference-in-differences estimator provides an estimate of the average treatment effect on the treated (ATET), and represents the impact of the policy change on the performance of the top marathon finishers.

For our analysis, we begin by considering two different dependent variables as measures of performance through the first half of the marathon. The first measure of performance considered, *halfsec*, is the total time, in seconds, that it takes each runner to pass the halfway mark of the marathon. Including *halfsec* as a measure of performance will permit us to address whether professional pace setters result in faster times through the first half of marathon races.

[3] Number of debut marathoners in each race: Chicago 2015 = 1 debut runner; Chicago 2016 = 2 debut runners; Chicago 2017 = 2 debut runners; Chicago 2018 = 0 debut runners; Chicago 2019 = 1 debut runner; Chicago 2021 = 2 debut runners; NY 2015 = 2 debut runners; NY 2016 = 0 debut runners; NY 2017 = 0 debut runners; NY 2018 = 0 debut runners; NY 2019 = 0 debut runners; NY 2021 = 2 debut runners

The second measure of performance considered, *behindhalf*, is defined as the number of seconds the runner is behind the leader time at the halfway point of the marathon. This variable is calculated by subtracting the time of the leader at the half from the time at the half of each runner (*halfsec)* for each race. Although very similar to the variable *halfsec*, the *behindhalf* variable makes it easier to determine how close other runners are to the race leader and provides insights into how competitive the race appears at the halfway point.

Tables 3A and 3B provide summary statistics for these measures of performance through the first half of the marathon. Table 3A presents a comparison of summary statistics for the Chicago Marathon in the time period before the policy change (no professional pacers) with the time period after the policy change (with pacers). Table 3B presents the summary statistics for the New York Marathon for the same two time periods.

Table 3A: Summary statistics Chicago Marathon races – top 15 finishers

	Mean	Std. Dev.	Min.	Max.
Before (2015, 2016, 2017) (observations = 45)				
halfsec	3983.667 (1:06:23)	52.695	3913 (1:05:13)	4157 (1:09:17)
behindhalf	19.333	44.815	0	159
After (2018, 2019, 2021) (observations = 45)				
halfsec	3849.556 (1:04:09)	106.039	3734 (1:02:14)	4078 (1:07:58)
behindhalf	94.222	110.483	0	329

Table 3B: Summary statistics for New York Marathon races – top 15 finishers

	Mean	Std. Dev.	Min.	Max.
Before (2015, 2016, 2017) (observations = 45)				
halfsec	3990.067 (1:06:30)	87.713	3864 (1:04:24)	4249 (1:10:49)
behindhalf	42.067	82.183	0	328
After (2018, 2019, 2021) (observations = 45)				
halfsec	3911.2 (1:05:11)	53.747	3835 (1:03:55)	4061 (1:07:41)
behindhalf	57.533	58.035	0	226

Table 3C presents results of difference-in-differences estimations for models evaluating performance through the first half of the marathon. For each model considered, we focus our attention on the relevant difference-in-differences estimator. These difference-in-differences estimates (ATET) are statistically significant at the 5% level in each of the models presented in Table 3C, indicating that professional elite pace setters significantly improve the performance of the treatment group through the first half of a marathon. The negative ATET in column (1) shows that elite male marathon runners competing in a paced race tend to run faster through the first half of the marathon (more than 1 minute faster) because of the professional pace setters. The positive ATET in column (2) shows that at the halfway point in paced races there is more separation among the elite male marathon runners because of the use of professional pace setters. Overall, these results demonstrate that professional pace setters cause runners to alter their race strategies resulting in significant performance differences through the halfway point of the marathon.

Table 3C: Effects of pacers on first half performance – top 15 finishers

	(1) halfsec	(2) behindhalf
chicago	1.290	-7.720*
	(0.963)	(1.015)
after	-69.229**	25.898**
	(2.009)	(1.506)
chicagoXafter (ATET)	-66.252**	54.393**
	(2.062)	(1.481)
pb	0.162	0.176*
	(0.036)	(0.027)
heat111	6.315**	-13.883***
	(0.330)	(0.128)
age	1.555	1.418
	(0.865)	(0.337)
Constant	2671.516*	-1381.840*
	(260.759)	(199.170)
Observations	180	180
Adjusted R-squared	0.5675	0.4654

Standard errors clustered by *chicago* reported in parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

For the next step of our analysis, we consider two different dependent variables as measures of performance through the full marathon. These measures are similar to the measures used to evaluate performance through the first half. The first measure of performance considered, *endsec*, is the total time, in seconds, that it takes each runner to finish the marathon. The second measure of performance considered, *behindend*, is defined as the number of seconds the runner is behind the winner time at the finish of the marathon. Tables 4A and 4B provide summary statistics for these measures of performance through the full marathon.

Table 4A: Summary statistics Chicago Marathon races – top 15 finishers

	Mean	Std. Dev.	Min.	Max.
Before (2015, 2016, 2017) (observations = 45)				
endsec	8013.667 (2:13:33)	166.925	7760 (2:09:20)	8379 (2:19:39)
behindend	211	154.463	0	499
After (2018, 2019, 2021) (observations = 45)				
endsec	7806.333 (2:10:06)	219.843	7511 (2:05:11)	8282 (2:18:02)
behindend	263.667	209.769	0	710

Table 4B: Summary statistics for New York Marathon races – top 15 finishers

	Mean	Std. Dev.	Min.	Max.
Before (2015, 2016, 2017) (observations = 45)				
endsec	8099.356 (2:14:59)	219.864	7671 (2:07:51)	8556 (2:22:36)
behindend	313.356	231.181	0	730
After (2018, 2019, 2021) (observations = 45)				
endsec	7924.756 (2:12:04)	171.868	7559 (2:05:59)	8245 (2:17:25)
behindend	273.422	177.520	0	610

In Table 4C, we present the results of the analysis using marathon finish times instead of times at the half. For both models summarized in this table, the difference-in-differences estimates (ATET) are statistically significant at the 5% level or better, indicating that professional pace setters significantly impact the performance of the treatment group for the full marathon distance. The negative ATET in column (1) shows that the elite male runners competing in a paced race tend to run faster over the full marathon distance (almost 1 minute faster) because of the pace setters. The positive ATET in column (2) indicates that the elite male runners in a paced race tend to be more spread out at the end of the race, similar to what was seen at the midway point. Together, these results imply that the use of professional pace setters results in faster finishing times, but that perhaps the race finish appears less competitive and dramatic because the separation between the top finishers occurs much earlier in the paced races.

Table 4C: Effects of pacers on marathon performance – top 15 finishers

	(1) endsec	(2) behindend
chicago	-58.708**	-87.149**
	(4.472)	(3.609)
after	-148.628***	-13.474*
	(0.498)	(1.967)
chicagoXafter (ATET)	-55.511***	57.905**
	(0.424)	(1.430)
pb	0.438***	0.449**
	(0.001)	(0.029)
heat111	-3.844	30.295**
	(1.639)	(0.760)
age	3.336	2.323
	(4.275)	(1.981)
Constant	4556.408**	-3283.378*
	(117.908)	(288.859)
Observations	180	180
Adjusted R-squared	0.5327	0.4309

Standard errors clustered by *chicago* reported in parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

5. Conclusion

The Chicago Marathon eliminated the use of professional pace setters for elite male runners for each of the 2015, 2016, and 2017 races. The use of professional pace setters for elite male runners was subsequently reimplemented beginning with the 2018 race. Utilizing the natural experiment involving the differing use of professional pace setters for elite runners during the 2015 – 2021 Chicago Marathon and New York Marathon races, this paper examines the effects of this changing race policy of using professional elite pace setters.

As expected, we find evidence that professional pace setters result in faster times for the fastest finishers through the first half of the marathon. In other words, the lead runners end up revealing their true fitness levels and current capabilities much earlier in races with professional pace setters. In addition, we find that there is more separation between runners in paced races. Overall, our results demonstrate that professional pace setters cause runners to alter their race strategies resulting in significant performance differences through the halfway point of the marathon. The impacts of professional pace setters are also seen through the full marathon distance. However, the gains in faster finishing times are essentially made during the first half, when the professional pace setters are leading the runners at the predetermined pace. The leading runners then work to maintain that faster pace, while strategically interacting with their competitors, after the pacers drop out of the race.

Although the setting of this research is unique, we believe that these results demonstrate how performance may be impacted depending on how different leadership strategies potentially alter the expenditures of both mental and physical energy. For example, in races without professional pace setters, runners contending for top finishes tend to try to conceal their true ability level for as long as possible. This likely results in an increase in early strategic interaction (greater expenditure of mental energy) in races without professional pace setters. However, it is unlikely that an elite runner would be willing to run a sustained faster pace (expenditure of physical energy) early in a race (without professional pace setters) and, in essence, become an unpaid pace setter for the rest of the racers (which would also increase mental fatigue).[4]

However, in paced races, runners who hope to compete for the win are essentially forced to run a much faster pace earlier in the race in order to keep up with the leaders. While this results in less strategic interaction (uses less mental energy) over the first half of the race, it also results in larger expenditures of physical energy, which opens the potential for the need to slow down over the later stages of the race if the increased early physical expenditure is too great.

References

Brown, J. (2011) "Quitters never win: The (adverse) incentive effects of competing with superstars" *Journal of Political Economy*, *119*(5), 982-1013.

Cacciola, S. (2011) "A Runner and His…Entourage? By Ditching Pacemakers, the New York Marathon Puts Tactical Running Above Pure Speed" Retrieved June 18, 2024 from https://www.wsj.com/articles/SB10001424052970204528204577012162053905648

[4] We argue that this is likely to be true even if runners who train together might serve as unofficial pacers for their training partners. Those runners, and their unofficial pacers, are still unlikely to decide to set a faster pace early in the race and transfer the benefits of their unofficial pacers to the other competitors in the (unpaced) race.

Ely, M. R., Cheuvront, S. N., Roberts, W. O., & Montain, S. J. (2007) "Impact of weather on marathon-running performance" *Medicine and science in sports and exercise*, *39*(3), 487-493.

El Helou, N., Tafflet, M., Berthelot, G., Tolaini, J., Marc, A., Guillaume, M., Hausswirth, C., & Toussaint, J. F. (2012) "Impact of environmental parameters on marathon running performance" *PloS one*, *7*(5), e37407.

Emerson, J., & Hill, B. (2018) "Peer effects in marathon racing: The role of pace setters" *Labour Economics*, *52*, 74-82.

Guryan, J., Kroft, K., & Notowidigdo, M. (2009) "Peer effects in the workplace: Evidence from random groupings in professional golf tournaments" *American Economic Journal: Applied Economics*, *1(4)*, 34-68.

Hadley, M. (2013) "Temperature + Dew Point for Pace Adjustments" Retrieved June 18, 2024 from http://maximumperformancerunning.blogspot.com/2013/07/temperature-dew-point.html

Hanley, B. (2015) "Pacing profiles and pack running at the IAAF World Half Marathon Championships" *Journal of Sports Sciences*, *33(11)*, 1189-1195.

Hanley, B. (2016) "Pacing, packing and sex-based differences in Olympic and IAAF World Championship marathons" *Journal of Sports Sciences*, *34(17)*, 1675-1681.

Hersh, P. (2015) "No more bunny hop: Chicago Marathon drops rabbits" Retrieved June 18, 2024 from https://www.chicagotribune.com/sports/olympics/ct-chicago-marathon-drops-rabbits-20150826-story.html

Hill, B. (2014a) "The Heat is On: Tournament Structure, Peer Effects, and Performance" *Journal of Sports Economics, 15*, 315-337.

Hill, B. (2014b) "The Superstar Effect in 100-Meter Tournaments" *International Journal of Sport Finance, 9*, 111-129.

Huber, M. F. (2015) "Pacesetters, You Were Missed at the Chicago Marathon" Retrieved June 18, 2024 from https://www.outsideonline.com/health/running/pacesetters-you-were-missed-chicago-marathon/

Kiel, K. & McClain, K. (1995) "House prices during siting decision stages: The case of an incinerator from rumor through operation" *Journal of Environmental Economics and Management, 28,* 241-255.

Meyer, B., Viscusi, W., & Durbin, D. (1995) "Workers' compensation and injury duration: Evidence from a natural experiment" *American Economic Review, 85,* 322-340.

Monti, D. (2015) "Boston Marathon Sticks to Traditional Racing – No Pacemakers" Retrieved June 18, 2024 from https://www.runnerspace.com/gprofile.php?mgroup_id=90&do=news&news_id=335571

Muñoz-Pérez, I., Lago-Fuentes, C., Mecías-Calvo, M., & Casado, A. (2022) "Pacing and packing behaviour in elite and world record performances at Berlin marathon" *European Journal of Sport Science*, 1-8.

Triplett, N. (1898) "The Dynamogenic Factors in Pacemaking and Competition" *The American Journal of Psychology*, *9(4)*, 507-533.

Wooldridge, J. M. (2002) *Econometric analysis of cross section and panel data*. MIT press.