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Specialization and Performance: Evidence from NCAA 4 × 400 m Relay Times

Candon Johnson [1], Robert Schultz [2] and Joshua C. Hall [3,*]

[1] Food and Drug Administration, Silver Spring, MD 20993, USA; candon2591@gmail.com
[2] Institute for Social Research, University of Michigan, Ann Arbor, MI 48104, USA; schultro@umich.edu
[3] John Chambers College of Business and Economics, West Virginia University, Morgantown, WV 26506, USA
* Correspondence: joshua.hall@mail.wvu.edu

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Abstract: This paper investigates the impact of having open 400 meter (400 m) runners on NCAA relay teams. Using data from 2012–2016 containing the top 100 4 × 400 m in each NCAA Division relay times for each year, it is found that more 400 m specialists lead to an increase in the overall performance of the team, measured by a decrease in relay times. The effect is examined across Division I–III NCAA track teams. The results are consistent across each division. We view this as a test of the role of specialization on performance. Using runners who specialize in 400 m races should increase overall team performance as long as specialization does not lead to an inefficient allocation of team human capital. An additional performance measure is used examining the difference between projected and actual relay times. Divisions I and II are found to perform better than projected with an increase in 400 m runners, but there is no effect found in Division III.

Keywords: specialization; running; peer effects; Division III

JEL Classification: J31; L20

1. Introduction

First developed in Adam Smith's *Wealth of Nations*, specialization theoretically improves upon productivity and output Smith ([1776] 1904). Specialization appears in situations such as a four athlete sports team, but has also been discussed in a larger scale such as regional agglomeration Rotemberg and Saloner (2000). This study investigated the impact of within-team specialization on team performance, specifically 4 × 400 meter (400 m) relay teams within the National Collegiate Athletic Association (NCAA). As costs decrease, specialization increase Rossi-Hansberg (2005). Within sports such as the 4 × 400 m relay, teams will seek to increase the number of open 400 m runners, hereby referred to as 400 m specialists, when feasible in an attempt to increase performance. Thus, we examine how the number of 400 m specialists on a team impacts the overall performance of the team. We posit that 400 m specialists can impact a team in multiple ways that will increase team performance, mainly through comparative advantage and specialization. Having a higher number of 400 m specialists should increase overall performance because they are specifically trained in that event. Additionally, having other400 m specialists on the team could provide peer effects by increasing performance of other runners on the relay team.

The organizational economics literature points out, however, that the link between specialization and performance has a potential downside. In the venture capital context, Stein (1997) argues that organizational diversification is part of a strategy of ensuring efficient allocation of capital across industries. If opportunities are poor in one sector, firms can allocate resources to other industries.

In the context of collegiate track, minimizing specialization gives the coach the flexibility to allocate runners across events to ensure the team's best overall performance at a meet.

Gompers et al. (2009) argue, also in the context of venture capital firms, that a trade-off with being a generalist is that specialists should do better in the area of specialization for two reasons. One, they will have a better knowledge of their area of specialization. Second, within the firm, specialists are more likely to make higher quality investments in their area of specialization. For a 4 × 400 m runner, specialization can lead to improved performance by focusing on the distance, the team aspect (handoffs), and focused attention.

During the 4 × 400 m relay, four athletes from the same team each complete one 400 m lap. The first lap is run in designated lanes, as is the second-until the beginning of the back straight. Thereafter, runners usually battle to hold the inside line. Each runner must carry a baton during his or her leg and hand it to the subsequent runner within the changeover zone, which is sited 10 m either side of what will be the finish line World Athletics (2018). There are several potential rule violations that can disqualify a runner, and, therefore, the team from the race. These include, but are not limited to, throwing the baton to relay teammate, passing the baton outside the 20 m exchange zone, relay members do not run the specified race distance, a runner impedes the progress of another runner after handing off the baton, or a team member runs more than one leg of the relay Podkaminer (2012). The NCAA record for the 4 × 400 m relay is 2:59.00 set by the team from Southern California (Morgan, Benjamin, Shinnick, and Norman) in June 2018 US Track & Field and Cross Country Coaches Association (2018).

In the 400 m dash, competitors run once around a 400 m track. Athletes that run these races are what we refer to as 400 m specialists. They start from blocks, though not required, set in staggered positions and run in lanes World Athletics (2018). Competitors can be disqualified from competition for, including but not limited to, stepping out of designated lane, impeding another runner's lane or committing a false start infraction. The NCAA record for the 400 m run is 43.61, set by Michael Norman (Southern California) in June 2018 US Track & Field and Cross Country Coaches Association (2018).

Unlike the literature in organizational economics (Meijaard et al. 2005; Gompers et al. 2009; Clark and Huckman 2012), we do not focus on overall organization (team) performance. Instead, we focus only on performance in the narrow area of specialization, i.e., the 4 × 400 m relay. We assume that having a higher number of 400 m specialists making up the legs of the relay would lead to a faster time when combining four athletes on a relay. We assume a higher number of 400 m specialists would positively impact team performance in line with theory since specialization should allow individuals to do better than generalists.

However, others have argued that peer effects among specialists may have a dampening effect. The negative role of peer effects in the 4 × 400 m is discussed by Depken and Haglund (2011):

> ... relay teams might naturally improve in performance, that is, have lower times, as average team member quality increases. However, like other team contexts, increasing average team member quality might induce shirking by lower quality team members, jealously, or a 'prima donna' syndrome in other high quality team members, all of which could reduce team productivity, that is, increase relay times.

In the context of this paper, a quality team member is a runner who is a 400 m specialist relative to a runner who is not a 400 m runner. This peer effect literature builds off the seminal work of Alchian and Demsetz (1972) and follow up work by Drago and Turnbull (1988), where group effort is not completely separable from individual effort.

The negative peer effects discussed by Depken and Haglund (2011) may potentially be explained through moral hazard Holmstrom (1982). Under a situation with costly or infeasible monitoring, the moral hazard problem will be more likely to occur. However, moral hazard may be mitigated when each team member's contribution to total output becomes clearly identified. Under the setting of 4 × 400 m relays, each individual's performance is perfectly monitored. Each leg of the relay is separately recorded, thus giving incentive for runners to exert effort in order to remain a member of the relay team.

The literature on peer effects in sports economics has heterogeneous findings depending on the sport and level of competition. Previous research on the topic of peer effects in running events studying the 4 × 400 m relay found that increasing average team member quality did improve overall team performance but at a decreasing rate Depken and Haglund (2011). Guryan et al. (2009) find that golfers saw no difference in quality of overall play based on fellow playing partners. Jane (2015) find that swimmers perform better when his or her competitors are faster. Their research showed positive peer effects as the quality of swimmers increased, dispersed-quality competitors make a swimmer faster. However, in a follow up work, Jane et al. (2018) find positive effects for males from having stronger competitors, but not females. More directly related to our work, however, Jane et al. (2018) find a positive intra-team effect from having faster relay team members for both men and women. Finally, Yamane and Hayashi (2015) find that athletes swim faster when they have swimmers behind them, but tend to swim slower with faster swimmers ahead of them.[1]

The role of comparative advantage and specialization in sport has been tested in the sports economics literature. Baumann et al. (2011) find that soccer players who specialize in taking penalty kicks have no independent effect on success with penalty kicks. Wiersma (2000) find that children are beginning to train and specialize in team and Olympic sports at an earlier age and this has implications for human capital development in the form of motor skills. Simmons and Berri (2009) find that National Football League running backs who specialize in rushing versus receiving see an increase in salary, consistent with productivity being higher.[2]

To preview our results, we find that that teams comprised of more 400 m specialists perform better at track meets. These results are shown across the different divisions within the NCAA from 2012 to 2016: Divisions I–III. Our research contributes to both the sports economics and organizational economics literature. The results showing that an increase in the number of specialists on a team improves performance will apply in general organization as well.

2. Data and Empirical Approach

We hand collected data on the top 100 4 × 400 m relay times for each of Division I–III Schools from 2012 to 2016.[3] All times were run on outdoor tracks that are 400 m in distance during the outdoor track season. Each entry collected included the date the relay was run, meet location, type of meet, the team name, time the relay ran and the difference between the relay teams projected actual relay time. The type of meet contains information on whether the relay was held at a conference meet instead of those held at an invitational or classic relay event. We identify someone as a 400 m specialist if they have a 400 m open time during the year, as opposed to being a 200-m runner that bumps up to the 400 m relay.

The variables are straightforward with the exception of the difference between the projected and actual relay time. For each 4 × 400 m team in our sample, we obtained the best 400 m times for each member. We then used those times to calculate a projected relay time. The actual 4 × 400 m time is then subtracted from this projected time to obtain the difference. Since this measure takes into account

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1 There is also a large literature in the economics of education on peer effects. While this literature presents mixed results, recent literature using the random assignment of students to peer groups in a military setting finds positive effects at the course level but negative effects at the company level Brady et al. (2017). Further research in the economics of running should separate peer effects at the event level from the team level, although the non-randomization of runners to events makes this difficult.

2 There is also a related literature in sports economics on comparative advantage and specialization where the unit of observation is the team or country. For example, Tcha and Pershin (2003) find that higher income countries specialize less in the Olympics. Du Bois and Heyndels (2012) build off the work of Tcha and Pershin (2003) and find geographic differences in specialization. While not a focus of our paper, the reasons for specialization across different levels of competition (Divisions I–III) would be an interesting area of further research. Finally, Georgievski et al. (2019) look at comparative advantage and specialization in the English Premier League and find that low-ranked teams should specialize in defense.

3 Due to the nature of the data, teams are not repeated throughout each year. Thus, we are unable to utilize team fixed effects.

the quality of team members, it provides some insight into whether specialization leads to lower times or whether better teams are more likely to employ specialists.

Table 1 shows the descriptive statistics for the number of 400 m specialists and all other variables, reporting the means for the full sample and each division. The average number of 400 m specialists is approximately 3 in each division.[4] The noticeable differences across divisions are the time in seconds, and difference between projected and actual times. Intuitively, Division II is on average slower than Division I, while Division III is slower than Division II. Division III also performs closer to their expectations than Division I and II. In total, we observe approximately 1500 different relays times for our time period and different NCAA division.

Table 1. Descriptive statistics.

Variable	Full Sample	Division I	Division II	Division III
Time in seconds	192.87	187.41	194.18	197.00
Difference between projected and actual relay time	−0.272	−0.333	−0.308	−0.174
Conference meet	0.284	0.262	0.302	0.287
Number of 400 m Specialists	2.98	3.032	2.992	2.944
N	1501	500	500	501

Note: For the variable difference between projected and actual relay time, in the full sample $N = 1484$; Division I $N = 496$; Division II $N = 497$; Division III $N = 491$.

The effect of 400 m specialists on overall team performance is estimated similarly to the manner in which Depken and Haglund (2011) estimate the effect of runner rank on team performance. We approach our estimation of the effect of 400 m specialists using ordinary least squares (OLS) regression:

$$Performance_{ij} = \beta_1 400\ mSpecialists_{ij} + \beta_2 ConferenceMeet_{ij} + \beta_3 DivisionII_{ij} + \beta_4 DivisionIII_{ij} + \sigma_j + \epsilon \quad (1)$$

The OLS estimation includes the number of 400 m specialists on team i in year j, the NCAA division that the team belongs to, a dummy variable for whether the relay was held at a conference meet (1) or elsewhere (0), and year fixed effect σ_j. Performance is measured using both the relay time in seconds and the difference between projected relay times and actual relay times. In additional specifications, there is an interaction term included interacting the division and number of 400 m specialists to test for difference across NCAA divisions.

Regression results are reported in Table 2. Columns 1 and 2 show the results using relay time in seconds as the dependent variables, while Columns 3 and 4 use the difference between projected and actual performance. It is shown across all specifications that an increase in the number of 400 m specialists increases overall performance, since negative coefficients denoted a faster relay time or faster actual times relative to projected times. Column 1 indicates that teams are slower at a conference track meet, Division II relay teams are slower than Division I teams, and Division III teams are slower than both Division I and II teams. In Column 2, additional variables are added by interacting Division II with the number of 400 m specialists, as well as Division III with the number of 400 m specialists. The results shown in Column 1 remain consistent in Column 2, and there is no difference found when interacting divisions with 400 m specialists. Regressions run by subsampling the data into the different divisions find similar results for the number of 400 m specialists for each division.

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[4] We considered including a variable indicating if any 400 m specialist appeared on the team in the results. However, greater than 98% of teams have at least one 400 m specialist due to meets having both 4 × 400 m relays and 400 m solo events.

Table 2. OLS estimates of 4 × 400 m relay results in NCAA competition.

Variable	Time in Seconds		Time in Seconds		Difference between Projected and Actual Time		Difference between Projected and Actual Time	
Number of 400 m Specialists	−0.423	***	−0.395	***	−0.132	***	−0.193	***
	(−7.34)		(−4.40)		(−5.44)		(−5.23)	
Conference Meet	0.579	***	0.577	***	−0.104	**	−0.102	**
	(4.70)		(4.68)		(−2.56)		(−2.68)	
Division II	6.720	***	6.986	***	0.0224		0.0617	
	(48.69)		(16.92)		(0.52)		(0.33)	
Division III	9.526	***	9.518	***	0.154	***	−0.435	**
	(70.85)		(23.69)		(3.52)		(−2.32)	
Division II–400 m interaction			−0.0887				−0.0140	
			(−0.64)				(−0.25)	
Division III–400 m interaction			0.00346				0.195	***
			(0.03)				(0.03)	
R-squared	0.772		0.772		0.064		0.077	

Note: Robust standard errors in parentheses. **, and *** indicate significance at the 1%, 5%, and 10% levels, respectively. N = 1501 in Specifications (1) and (2). N = 1484 in Specifications (3) and (4). Year fixed effects and intercept are included in each regression but are omitted from results shown to reduce table size.

While these results are consistent with the idea that specialists lead to lower times, they are also consistent with better teams employing more specialists. Better resourced schools might be able to attract enough high-quality runners to allow for specialization. Lower 4 × 400 m relay times associated with having more 400 m specialists could therefore be a sign of better runners in the 4 × 400, not specialization *per se*.

To get at this question, we utilize the difference between projected and actual time as the dependent variable in Columns 3 and 4. Since the projected time uses the fastest 400 m time for each team member during the season, it controls for the quality of team members. Columns 3 and 4 show that teams with higher numbers of 400 m specialists outperform teams with fewer 400 m specialists. The negative coefficient on the number of 400 m specialists in Columns 3 and 4 suggest that teams with more 400 m specialists shrink the gap between their projected and actual time.

It is also shown that there are no difference between Division I and II teams' abilities to outperform projections. When adding the interaction terms, the effect of the number of 400 m specialist cancels out for Division III relay teams. This result is strengthened when subsampling the data into divisions. When subsampling, the effect of 400 m specialists is significant for Divisions I and II, but not Division III. One possible reason for these results is specialization. Using more athletes that specifically train for 400 m events increases team performance.

3. Conclusions

The results found in this study suggest that utilizing more 400 m specialists on a 4 × 400 m relay team will increase the performance of the team. This is measured using time in seconds and the difference between projected and actual relay times. Using OLS, it is shown that there is a decrease in time in seconds as the number of 400 m specialists is increased. This effect is present in all three NCAA divisions. An increase in the number of 400 m specialists also leads to a team outperforming projections more than if the team had a lower number of specialists. This effect is only found in Division I and Division II, not in Division III. The results are attributed to specialized training for the specific event that makes up the legs of the relay.

In finding that specialization in the 4 × 400 m leads to improved 4 × 400 m times, our work contributes to the literature on within-team comparative advantage and specialization in sports economics Baumann et al. (2011); Simmons and Berri (2009). In addition, our findings contribute to the larger literature in organizational economics on within-firm specialization and performance Gompers et al. (2009); Meijaard et al. (2005). Teams that employ more 4×400 m specialists have lower 4×400 m relay times, and this result does not seem to be driven just by better teams being able to afford having more specialists.

Our research suggests at least two other fruitful lines of research. First, similar to the work of Tcha and Pershin (2003) and Du Bois and Heyndels (2012), it would be helpful to know *why* some teams specialize and others do not. Does the level of competition, geographic region, or school endowment matter? A second follow-up should focus on the effect of specialization on *overall* team performance, building off the organizational economics literature that focuses on venture capital Gompers et al. (2009). This would provide greater insight for coaches looking to improve their teams in both the 4×400 m without harming their team overall.

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Abbreviations

The following abbreviations are used in this manuscript:

NCAA	National Collegiate Athletic Association
OLS	Ordinary Least Squares

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