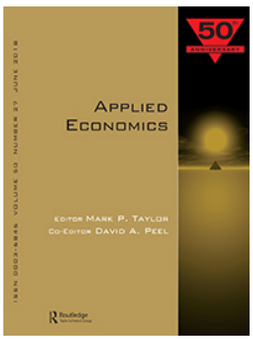

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Evidence on the importance of cognitive ability tests for NFL quarterbacks: what are the relationships among Wonderlic scores, draft positions and NFL performance outcomes?

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ABSTRACT

Employing data on National Football League (NFL) quarterbacks drafted between 2002 and 2012, the authors consider whether factors correlated with a quarterback being more productive in the NFL are the same factors that correlate with an improved draft position. In particular, the authors consider the relevance of scores on the Wonderlic test. Contrary to all prior literature on the subject, the authors find that performance on the Wonderlic test is positively correlated with NFL performance. However, the authors find no clear evidence that Wonderlic scores are correlated with draft position. Beyond this primary finding, the authors reveal many other interesting results that should help researchers better understand a quarterback's progression from college to the NFL.

KEYWORDS

NFL draft; NFL productivity; Wonderlic; football

JEL CLASSIFICATION

L83; M51; Z20; Z22

I. Introduction

One of the most important determinants of a National Football League (NFL) franchise's long-term success is its choices in the annual NFL draft. The selections that a franchise makes on draft day can elevate a team to contender status or lead to a path of perpetual disappointment. This is especially true for the drafting of quarterbacks, which is clearly evident when considering the performance of NFL franchises during the 2016–2017 NFL season. The final four teams remaining in the NFL playoffs – Atlanta Falcons, Green Bay Packers, New England Patriots and Pittsburgh Steelers – all possessed elite quarterbacks by most standards. The starting quarterbacks for all four teams were attained through the NFL draft and all of these quarterbacks have spent their entire professional careers (an average of nearly 13 seasons) playing for the same franchises. Considering the importance of the NFL draft, it is not surprising that franchises are willing to devote significant time and resources to evaluating prospects, particularly at the quarterback position.

Despite the enormous amount of effort put into evaluating talent at the quarterback position by numerous people, forecasting productivity and selecting the best quarterback prospect is neither an exact science nor a simple process. College quarterbacks often start for only one or two seasons, compete against disparate levels of competition and participate in offences that are often far different from traditional NFL systems. With so many factors to consider, which characteristics *should* teams pay close attention to on draft day? In our research, we consider (A) the factors that NFL teams *should* emphasize when drafting quarterbacks, based on past performance of NFL quarterbacks and (B) the factors that NFL teams actually seem to consider, based on selections in prior drafts. By analysing both of these factors simultaneously, we are able to see if there are some factors that NFL franchises are systematically overemphasizing or failing to appropriately include in their considerations.

In the current article, we choose to focus much of our analysis on the Wonderlic test. This cognitive ability test, developed by Eldon F. Wonderlic in 1936, consists of 50 multiple choice questions. A participant's score on this exam is simply the number of correct answers he attains during the 12 min provided. One need only browse the internet to determine that most members of sports media find

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little value in administering the Wonderlic test to potential NFL quarterbacks.[1] More so, previous academic literature offers no evidence that scores on the Wonderlic test are correlated with the NFL productivity of quarterbacks. However, our study offers ample evidence that there is indeed a significant relationship between Wonderlic scores and productivity for NFL quarterbacks. Despite this finding, we show that Wonderlic scores are not significant in determining the draft positions of quarterbacks. Thus, it appears that NFL franchises are failing to account for the value of Wonderlic scores when evaluating and drafting quarterbacks.

II. Literature review

The majority of prior studies on the subject consider the impact of various factors related to a player's collegiate career on either draft position, NFL productivity or both. There is evidence that collegiate productivity, speed, height, body mass index (BMI) and variables measuring a player's performance in various NFL combine drills are significant predictors of when a player will be selected in the NFL draft and, to a lesser extent, his NFL productivity (Treme and Allen 2009; Berri and Simmons 2011; Wolfson, Addona, and Schmicker 2011; Mulholland and Jensen 2014; Weir and Wu 2014). In these studies, NFL productivity is typically measured by number of games played, number of games started and position specific statistics such as passing yards, net points (see Berri, Schmidt, and Brook 2006) or approximate value.

Some studies show that players from Bowl Championship Series (BCS) universities and schools ranked in the final Associated Press Top 25 poll tend to be selected earlier in the NFL draft, relative to otherwise comparable prospects.[2] In a study by Kitchens (2015), this finding is reported as evidence of statistical discrimination in hiring in the NFL labour market. Hendricks, DeBrock and Koenker (2003) find additional evidence of statistical discrimination. Their research reveals that players entering the draft from Football Bowl Subdivision (FBS) schools are selected earlier than players from Football Championship Series (FCS) schools.[3] Yet, players from FCS schools actually have longer careers than players from FBS schools, other things equal.

Another strand of literature, in the Exercise Science discipline, focuses more closely on the NFL combine. These studies typically seek to determine whether there are statistically significant correlations between NFL productivity and the variables measured at the combine. For example, Kuzmits and Adams (2008) do not find any consistent evidence of a statistically significant relationship between the combine variables and their NFL performance measures, except in the case of sprint drills for running backs, in which faster times are correlated with being selected earlier in the NFL draft.

Additionally, there is a strand of literature that gives specific attention to the impact of a player's Wonderlic score on his draft position and expected NFL productivity; these studies are of particular interest to the current research. There is disagreement between these studies as to the importance of Wonderlic scores in determining draft order. Berri and Simmons (2011), Gill and Brajer (2012) and Welter (2013) all find that a player's Wonderlic test score has a significant impact on when he is selected in the NFL draft. Alternatively, Mirabile (2005) and Lyons, Hoffman and Michel (2009) find no evidence of a significant relationship between Wonderlic scores and draft order. Gill and Brajer (2012) do not examine the relationship between Wonderlic scores and NFL productivity for quarterbacks. However, Lyons, Hoffman and Michel (2009), Mirabile (2005), Welter (2013) and Berri and Simmons (2011) find no significant relationship between Wonderlic scores and NFL productivity.

As explanatory variables in regression models, a few studies include pre-draft player rankings constructed by media outlets (Treme and Allen 2009;

[1]For example, see the following: (1) http://bleacherreport.com/articles/1130900-nfl-draft-2012-how-important-is-a-wonderlic-score-to-on-field-success, (2) http://www.sportingnews.com/nfl/news/wonderlic-test-nfl-combine-results-past-scores-does-it-predict-success/2y203zun9z7g1kpu2nuasywkj, (3) https://en.wikipedia.org/wiki/Wonderlic_test#Predictor_of_success_in_the_NFL, (4) https://www.theguardian.com/sport/blog/2015/feb/17/testing-the-nfls-wonderlic-do-athletes-really-need-to-be-smart-to-succeed and (5) http://profootballtalk.nbcsports.com/2013/04/18/were-officially-out-of-the-wonderlic-business/. Last Accessed 2 March 2017.

[2]BCS universities include schools belonging to the Atlantic Coast, Big East, Big 12, Big Ten, Pacific-12 and Southeastern conferences as well as Notre Dame.

[3]FBS universities include schools from the aforementioned BCS conferences as well as those belonging to the Mid-American, Conference USA, Mountain West, Sun Belt and Western Athletic conferences. FCS universities include those schools playing a tier below FBS schools in the NCAA system.

Gill and Brajer 2012; Kitchens 2015). However, it would seem that these pre-draft player rankings may obscure the relevance of other explanatory variables in models predicting draft outcomes. For example, these pre-draft rankings may make it difficult to determine the relationship between productivity in college or performance at the NFL combine and draft order if players who are highly productive in college or excel at the NFL combine are the same players who receive better pre-draft rankings.

The current study also differs from the existing literature in other important ways. For example, the study by Lyons, Hoffman and Michel (2009) essentially only includes dummy variables identifying position along with Wonderlic scores and fails to account for anything else that might be correlated with NFL productivity. Also, in several of their regressions, the authors employ several interaction terms between Wonderlic scores and position dummies, which could lead to high SEs for their Wonderlic variable. Mirabile (2005) only examines quarterbacks drafted between 1989 and 2004; thus, there is little overlap between our samples. Furthermore, we consider very different measures of NFL productivity in our study. The primary NFL outcomes measured by Mirabile (2005) are quarterback salaries and quarterback ratings during players' rookie seasons. Similarly, Welter (2013) considers different NFL productivity measures than those employed in our study. The primary NFL outcomes measured by Welter (2013) are number of plays per season and quarterback rating. Berri and Simmons (2011) only examine the NFL productivity of quarterbacks who played in at least 100 games at some point during their first 4 years in the NFL, while the current study considers the NFL productivity of all quarterbacks drafted between 2002 and 2012. Lastly, Berri and Simmons (2011) and Welter (2013) do not employ average productivity per season as the dependent variable in their models. Rather, both studies appear to treat individual NFL seasons for quarterbacks as separate observations, and they use different estimation methods to correct for the interdependence of errors associated with such a sampling procedure. For these reasons, a new and more comprehensive study using updated data should improve researchers' understanding on the role of Wonderlic scores as a predictor of NFL success.

III. Data and empirical methods

The data for this study are collected from multiple sources, which are listed at the bottom of Table 1. All quarterbacks selected in the NFL draft between 2002 and 2012 who completed the Wonderlic test are included in the sample.[4] This time period is chosen for sample inclusion due to

Table 1. Definitions of variables.

Variable	Definition
BCS[b]	Equals 1 if quarterback played for a BCS university; 0 otherwise
Win%[b]	Winning percentage of quarterback's university in his final collegiate season
NFL coach[ab]	Equals 1 if quarterback's head coach in his final collegiate season was previously an NFL head coach; 0 otherwise
QB drafted[a]	Number of quarterbacks from a player's university selected in the NFL draft in the five years preceding the player's selection in the NFL draft
Early exit[b]	Equals 1 if quarterback enters the NFL draft before his collegiate eligibility is exhausted; 0 otherwise
BMI[b]	Quarterback's BMI calculated as (weight × 703)/height^2
Height[b]	Quarterback's height measured in inches
Forty[cd]	Quarterback's time in the 40-yard dash measured in seconds
Pass yards/att[b]	Quarterback's passing yards per attempt in his final collegiate season
Comp%[b]	Quarterback's completion percentage in his final collegiate season
INT%[b]	Quarterback's interception percentage in his final collegiate season
Heisman finalist[b]	Equals 1 if quarterback was ever a Heisman Trophy Finalist during his collegiate career; 0 otherwise
Wonderlic[d]	Quarterback's score on the Wonderlic test
Media[f]	Number of news entries focused on quarterback in the month preceding the NFL draft
PICK[e]	Quarterback's draft position in the NFL draft
NFL outcomes	
Games started[a]	Number of games started per season during quarterback's NFL career
Approximate value[a]	Quarterback's approximate value per season during his NFL career
NFL wins[a]	Number of wins per season during quarterback's NFL career
NFL pass yards[a]	Quarterback's passing yards per season during his NFL career

[a]Pro-Football-Reference.com, [b]sports-reference.com/cfb, [c]nfldraftscout.com, [d]nflcombineresults.com, [e]NFL.com, [f]Lexis Nexis Academic. NFL: National Football League; BCS: Bowl Championship Series; BMI: body mass index.

[4]Only 16 of the 137 quarterbacks drafted between 2002 and 2012 did not complete the Wonderlic test. Furthermore, only 3 of these 16 quarterbacks were selected earlier than the sixth round – Andrew Walter (third round), Isaiah Stanback (fourth round) and Jonathan Crompton (fifth round), which suggests elite prospects are not skipping the Wonderlic test. Also, only 8 of these 16 quarterbacks actually attended the NFL combine. Thus, very few quarterback prospects appear to have self-selected out of taking the Wonderlic test. At any rate, to check the robustness of our results, a Heckman selection model was estimated by both maximum likelihood and the two-step method. The results are nearly identical to those presented in Table 4. Thus, to save space, we do not report these results in the article, but they are available upon request.

the addition of the Houston Texans in 2002; thus, 32 teams are participating in the NFL draft over the entire time period examined. Also, except in the case of players with careers shorter than 4 years, this allows for at least 4 years of data collection to calculate average NFL productivity measures for each player. Definitions of each variable used in the empirical analysis are reported in Table 1. In Table 2, descriptive statistics are reported for the non-binary variables and frequency distributions are provided for the binary dummy variables.

In order to examine the relationship between individual and school characteristics of a quarterback and the spot he is selected in the NFL draft, the following OLS regression is estimated:

$$PICK_i = x_i'\beta + y_i'\gamma + \varepsilon_i \quad (1)$$

where $PICK_i$ is the draft position of quarterback i, x_i' is a set of school characteristics, y_i' is a set of individual player characteristics, β and γ are parameters to be estimated and ε_i is a random error term.

School characteristics include a dummy variable indicating whether or not the quarterback attended a BCS university (*BCS*) and a dummy variable indicating whether or not the quarterback's head coach during his final collegiate season had any previous experience as an NFL head coach (*NFL coach*). Also, the winning percentage (*Win%*) of each quarterback's university is collected for the player's final collegiate season. Lastly, attending universities well known for producing NFL quarterbacks may have an impact on a player's draft position given that teams have imperfect information about players. To account for this potential relationship, we construct the variable, *QB drafted*, which accounts for the number of quarterbacks from a player's university, over the previous 5 years, who were selected in the NFL draft.

Because highly coveted prospects may choose to leave college early, we include the variable, *early exit*, which is simply a dummy variable indicating whether a quarterback had any college eligibility remaining when he entered the NFL draft. We also include a dummy variable indicating whether a quarterback was a Heisman trophy finalist (*Heisman finalist*) in addition to a quarterback's height (*height*), *BMI* and 40-yard dash time (*forty*).[5] Lastly, we account for a quarterback's score on the Wonderlic test (*Wonderlic*), his passing yards per attempt in his final collegiate season (*Pass yards/att*), his completion percentage in his final collegiate season (*Comp%*) and his interception percentage in his final collegiate season (*INT%*).

In order to examine the relationship between individual and school characteristics of a quarterback and his productivity in the NFL, the following OLS regression is estimated:

$$PROD_i = x_i'\beta + y_i'\gamma + \varepsilon_i \quad (2)$$

Table 2. Descriptive statistics for non-binary variables and frequency distributions for binary variables.

Descriptive statistics	
Variable	Mean and SD
Win%	69.09 (19.57)
QB drafted	0.65 (0.80)
BMI	27.88 (1.31)
Height	75.40 (1.73)
Forty	4.80 (0.17)
Pass yards/att	8.00 (0.98)
Comp%	62.34 (5.25)
INT%	2.48 (0.99)
Heisman finalist	0.27 (0.45)
Wonderlic	27.66 (7.03)
PICK	107.23 (80.31)
Media	37.98 (55.07)
NFL outcomes	
Games started	4.35 (4.94)
Approximate value	3.03 (4.13)
NFL wins	2.04 (2.81)
NFL pass yards	947.64 (1157.11)

Frequency distributions		
Variable	0	1
BCS	40	81
NFL coach	109	12
Early exit	100	21

Total number of observations = 121.
SDs are in parenthesis under the means for non-binary variables.
NFL: National Football League; BCS: Bowl Championship Series; BMI: body mass index.

[5]If a quarterback's 40-yard dash time is unavailable at *nflcombineresults.com*, then the measure is obtained from *nfldraftscout.com*.

where $PROD_i$ represents the NFL productivity of quarterback i, δ reveals the relationship between draft position and NFL productivity and all other variables and parameters are as previously defined. The NFL productivity measures include games started per season (*games started*), approximate value per season (*approximate value*), wins per season (*NFL wins*) and passing yards per season (*NFL pass yards*).[6]

We also estimate a variation of Equation (2) that accounts for a quarterback's draft position. The following equations are estimated via a two-stage least squares (TSLS) regression in order to examine a quarterback's NFL productivity while accounting for his draft position:

$$PICK_i = x_i'\beta + y_i'\gamma + \alpha Media_i + \varepsilon_i \quad (3)$$

$$PROD_i = x_i'\beta + y_i'\gamma + \delta PICK_i + \varepsilon_i \quad (4)$$

where $Media_i$ is the number of news entries focusing on a quarterback in the month preceding the NFL draft according to Lexis Nexis Academic, α is a parameter to be estimated and all other variables and parameters are as previously defined. The media coverage variable is the instrument used to estimate the TSLS regression. Hausman's test of endogeneity developed by Cameron and Trivedi (2005) indicate that TSLS is more appropriate than OLS when including *PICK* as an explanatory variable in Equation (4) for all of the various NFL outcomes measured in this study.

IV. NFL draft results

Table 3 presents the OLS results for the draft position regressions.[7] The second column of results includes fixed effects for the year in which a quarterback was drafted, while the first column does not include these year fixed effects. Results with year fixed effects included are reported to account for changes in demand for quarterbacks across years as well as to account for particularly strong/weak quarterback draft classes.[8] The majority of the findings presented in Table 3 align with findings from previous research. For example, our results show that taller quarterbacks with faster 40-yard dash times tend to be selected earlier in the draft, other things equal. A one SD increase in a quarterback's height is associated with him being selected about 26 spots earlier in the draft, while a 1 SD improvement in a quarterback's 40-yard dash time is related with him being selected about 18 spots earlier in the draft. Similar to Weir and Wu (2014), there is no evidence that a quarterback's draft position is improved by staying in college longer than required, as evidenced by an insignificant coefficient for *early exit*. Similar to Berri and Simmons (2011), we find some evidence that quarterbacks with higher BMIs tend to be selected earlier in the draft, all else equal. Also, similar to Berri and Simmons (2011), we find no evidence that a quarterback's passing yards per attempt in college is correlated with draft position.

There is no clear evidence that a quarterback's interception percentage or winning percentage in his final collegiate season impacts his draft position. Similarly, we do not find any evidence that playing for a head coach with previous NFL head coaching experience impacts the draft position of quarterbacks. Also, similar to Weir and Wu (2014), we find no evidence that quarterbacks from BCS colleges are selected earlier in the draft, other things equal. However, quarterbacks who are Heisman finalists in college do tend to be selected about 61–64 spots earlier in the NFL draft than otherwise similar quarterbacks who were not Heisman finalists. It is likely that this variable captures attributes that are otherwise difficult to measure such as perceived character and leadership ability as these are often, but not always, traits associated with Heisman Trophy candidates. Thus, it makes sense that quarterbacks receiving this recognition in college would tend to be drafted higher in the NFL.

The results also suggest that a one SD increase in a quarterback's completion percentage in his final

[6]Details on the calculation of the approximate value measure created by mathematician Doug Drinen and reported by Pro-Football-Reference.com are available at http://www.pro-football-reference.com/blog/?page_id=8061.

[7]In addition to the OLS regressions reported in Table 3, ordered probit estimates were obtained using the round in which a player was selected as the dependent variable. The results for these models are extremely similar to those reported in Table 3. To save space, they are not reported here but are available upon request.

[8]For example, if there are many strong quarterback prospects in a given draft, a prospect may be selected later in the draft than he would be if the quarterback pool was more typical. Conversely, a prospect in a weak draft year for quarterbacks will probably be drafted earlier if there are few strong prospects.

Table 3. OLS draft position regression.

Variable	Without year fixed effects	With year fixed effects
Constant	1054.23***	1188.71***
	(2.94)	(3.12)
BCS	−12.78	−12.58
	(−0.96)	(−0.85)
Win%	0.64	0.55
	(1.56)	(1.27)
NFL coach	8.20	19.84
	(0.40)	(0.94)
QB drafted	−15.79*	−17.96**
	(−1.86)	(−2.12)
Early exit	−22.25	−17.33
	(−1.21)	(−0.87)
BMI	−9.47**	−7.55
	(−2.03)	(−1.56)
Height	−14.18***	−15.88***
	(−3.08)	(−3.40)
Forty	114.78**	98.45**
	(2.51)	(2.08)
Pass yards/att	3.25	8.69
	(0.43)	(1.05)
Comp%	−2.79*	−3.62*
	(−1.94)	(−1.96)
INT%	4.13	2.40
	(0.60)	(0.31)
Heisman finalist	−61.18***	−63.56***
	(−3.24)	(−3.52)
Wonderlic	−1.21	−0.93
	(−1.25)	(−0.85)
R^2	0.35	0.41
Adjusted R^2	0.28	0.28

Robust *t*-statistics are in parenthesis under the coefficients.
*Significant at the 10% level; **significant at the 5% level; ***significant at the 1% level.
NFL: National Football League; BCS: Bowl Championship Series; BMI: body mass index.

Table 4. OLS NFL productivity regressions not accounting for draft position.

Variable	Games started	Approximate value	NFL wins	NFL pass yards
Constant	−57.01**	−31.22	−29.06*	−10,425.20
	(−2.20)	(−1.34)	(−1.82)	(−1.60)
BCS	1.15	1.00	0.47	237.92
	(1.27)	(1.30)	(0.83)	(1.09)
Win%	−0.002	−0.01	−0.004	−1.14
	(−0.10)	(−0.69)	(−0.30)	(−0.22)
NFL coach	0.38	0.43	0.36	216.12
	(0.22)	(0.32)	(0.39)	(0.49)
QB drafted	−0.10	−0.38	−0.17	−63.62
	(−0.20)	(−0.99)	(−0.65)	(−0.54)
Early exit	0.48	0.33	0.19	259.40
	(0.42)	(0.35)	(0.28)	(0.86)
BMI	0.70**	0.50**	0.36**	108.93
	(2.58)	(2.11)	(2.45)	(1.66)
Height	0.78***	0.44*	0.37*	136.29*
	(2.79)	(1.66)	(1.96)	(1.94)
Forty	−5.50**	−5.03**	−2.77**	−782.42
	(−2.19)	(−2.48)	(−2.05)	(−1.21)
Pass yards/att	0.56	0.68	0.35	119.83
	(1.13)	(1.50)	(1.17)	(1.00)
Comp%	−0.02	0.02	0.002	−6.06
	(−0.29)	(0.34)	(0.05)	(−0.31)
INT%	0.04	0.13	0.06	−14.73
	(0.10)	(0.43)	(0.30)	(−0.16)
Heisman finalist	4.05***	3.59***	2.53***	846.49***
	(3.65)	(3.75)	(3.95)	(3.00)
Wonderlic	0.17***	0.12**	0.09***	33.89**
	(2.95)	(2.60)	(2.95)	(2.33)
R^2	0.35	0.35	0.34	0.27
Adjusted R^2	0.27	0.28	0.26	0.18

Robust *t*-statistics are in parenthesis under the coefficients.
NFL: National Football League; BCS: Bowl Championship Series; BMI: body mass index.
*Significant at the 10% level; **significant at the 5% level; ***significant at the 1% level.

collegiate season is associated with him being selected about 17 spots earlier in the NFL draft. Interestingly, we find that quarterbacks from collegiate programmes with a recent record of producing NFL quarterbacks tend to be selected earlier in the NFL draft. A one SD increase in the number of quarterbacks selected from a quarterback's university in the previous 5 seasons is correlated with him being selected about 14 spots earlier in the draft. It is likely that this finding is related to imperfect information in the draft. If a quarterback is coming from the same collegiate programme that recently produced an NFL quarterback, then coaches and general managers likely view this as a positive attribute for the quarterback.

Lastly, in regards to Wonderlic test scores, our findings align with Mirabile (2005) and Lyons, Hoffman and Michel (2009) and run contrary to Berri and Simmons (2011), Gill and Brajer (2012) and Welter (2013). That is, we do not find statistically significant evidence that a quarterback's Wonderlic score impacts his draft position.

V. NFL productivity results

Table 4 presents the NFL productivity regression results without accounting for a quarterback's draft position. Many of these findings are also in agreement with previous research. For example, the findings suggest that taller, bigger and faster quarterbacks tend to be more productive in the NFL, other things equal. Based on the SDs reported in Table 2 and the OLS results reported in Table 4, a 1 SD increase in a quarterback's height is associated with him starting about 1.35 more games per season, earning about a 0.76 higher approximate value per season, winning about 0.64 more games per season and throwing for about 236 more yards per season. Similarly, a one SD improvement in a quarterback's 40-yard dash time is associated with him starting about one more game per season, earning about a 0.86 higher approximate value per season and winning about 0.47 more games per season. Only Berri and Simmons (2011) find no relationship between a quarterback's 40-yard dash time and his expected NFL productivity.

We also find that quarterbacks who were Heisman Trophy finalists in college tend to be more productive in the NFL. Based on the results reported in Table 4, other things equal, Heisman Trophy finalists tend to start about 4 more games per season, have approximate values per season about 3.59 points higher, win about 2.53 more games per season and pass for about 846 more yards per season than quarterbacks who were not Heisman Trophy finalists. Similar findings are reported in Table 5 for Heisman Trophy finalists. When comparing these findings for Heisman Trophy finalists to the means for the NFL outcomes reported in Table 2, there is much evidence that Heisman Trophy finalists enjoy substantially more productive careers than otherwise similar quarterbacks who were not Heisman Trophy finalists in college. This suggests that Heisman Trophy voters as a whole exhibit at least some level of proficiency in identifying elite talent at the quarterback position.

Table 5. TSLS NFL productivity regressions accounting for draft position.

Variable	Games started	Approximate value	NFL wins	NFL pass yards
Constant	−71.81*	−45.12	−35.05	−13,070.10
	(−1.91)	(−1.43)	(−1.57)	(−1.38)
PICK	0.01	0.01	0.01	2.51
	(0.54)	(0.64)	(0.39)	(0.39)
BCS	1.33	1.17	0.54	270.00
	(1.39)	(1.46)	(0.92)	(1.16)
Win%	−0.01	−0.02	−0.01	−2.75
	(−0.42)	(−0.98)	(−0.48)	(−0.44)
NFL coach	0.27	0.32	0.31	195.54
	(0.15)	(0.24)	(0.34)	(0.45)
QB drafted	0.12	−0.17	−0.08	−24.01
	(0.20)	(−0.36)	(−0.27)	(−0.16)
Early exit	0.79	0.62	0.32	315.23
	(0.61)	(0.58)	(0.43)	(0.93)
BMI	0.84**	0.62*	0.42**	132.68
	(2.20)	(1.98)	(2.01)	(1.42)
Height	0.97**	0.63	0.45	171.85
	(2.08)	(1.57)	(1.59)	(1.45)
Forty	−7.11*	−6.54**	−3.42	−1,070.39
	(−1.74)	(−1.99)	(−1.55)	(−1.03)
Pass yards/att	0.52	0.63	0.33	111.68
	(1.01)	(1.37)	(1.08)	(0.90)
Comp%	0.02	0.06	0.02	0.94
	(0.15)	(0.69)	(0.30)	(0.04)
INT%	−0.02	0.07	0.04	−25.10
	(−0.05)	(0.24)	(0.18)	(−0.26)
Heisman finalist	4.91**	4.40***	2.88**	999.98**
	(2.56)	(2.75)	(2.54)	(2.08)
Wonderlic	0.19***	0.14**	0.09***	36.93**
	(2.81)	(2.57)	(2.73)	(2.13)
R^2	0.35	0.36	0.34	0.27
Adjusted R^2	0.26	0.27	0.26	0.18

Robust *t*-statistics are in parenthesis under the coefficients.
*Significant at the 10% level; **significant at the 5% level; ***significant at the 1% level.
NFL: National Football League; BCS: Bowl Championship Series; BMI: body mass index.

Whether or not a quarterback had a collegiate head coach with previous NFL head coaching experience does not appear to be a good predictor of NFL productivity. Similarly, we find no evidence that a quarterback's winning percentage or interception percentage in his final collegiate season is correlated with his productivity in the NFL. Also, contrary to Weir and Wu (2014), we do not find evidence of a significant relationship between whether or not a quarterback exits college early and his NFL productivity. Lastly, contrary to Mirabile (2005) and Weir and Wu (2014), there is no evidence to suggest that quarterbacks from BCS universities enjoy more productive NFL careers, other things equal. Thus, according to our analysis, teams are correct to give little consideration to these variables on draft day, as shown in Table 3.

Table 5 presents the NFL productivity regression results while accounting for a quarterback's draft position. Our findings for these regressions can be best compared with previous studies by Lyons, Hoffman and Michel (2009) and Berri and Simmons (2011) since each of these studies also include a quarterback's draft position in some of their NFL productivity regressions. Lyons, Hoffman and Michel (2009) find evidence that a quarterback's draft position is correlated with his NFL productivity, after controlling for other factors. However, similar to Berri and Simmons (2011), we do not find any evidence that a quarterback's draft position is correlated with his NFL productivity. According to the TSLS estimates reported in Table 5, a quarterback's draft position is not a statistically significant determinant of any of the NFL outcomes measured in our study. This is somewhat of an indictment on the ability of NFL coaches and general managers to sort quarterbacks by productivity in the draft because we would expect the coefficients on the *PICK* variable to be negative and statistically significant in our regressions if coaches and general managers were adept predictors of a quarterback's expected productivity.

Comparing the results in Tables 4 and 5 to those in Table 3 does offer some suggestions for teams to improve their draft strategies of quarterbacks. The results in Table 3 show that a quarterback's completion percentage in his final collegiate season is significantly correlated with his draft position. However, the variable is not significantly correlated

with a quarterback's NFL productivity in any of the results reported in Tables 4 and 5. Thus, teams appear to be assigning too much weight to a quarterback's collegiate completion percentage on draft day. Similarly, we find no evidence that quarterbacks from college programmes with a recent record of producing NFL quarterbacks have more productive NFL careers, other things equal. However, Table 3 shows that those same quarterbacks do tend to be selected earlier in the draft. Thus, it certainly seems that teams may be relying on this poor predictor of productivity in the face of imperfect information about quarterbacks.

One of the most consistent findings is the significance of Wonderlic scores as a predictor of higher productivity for quarterbacks. This finding is present in both Tables 4 and 5. Thus, not only do we find that NFL teams give little to no consideration to a quarterback's Wonderlic score on draft day, as shown in Table 3, we also find ample evidence that it *should* factor into their draft day decisions regarding quarterbacks. As has been previously mentioned, this finding contradicts all four previous articles that have investigated the relationship between Wonderlic scores and NFL productivity for quarterbacks. Table 2 shows that the average Wonderlic score for our data set is 27.66 with a SD of 7.03. Based on the results presented in Table 5, a one SD increase in a quarterback's Wonderlic score is associated with the quarterback starting about 1.34 additional games each NFL season, earning a 0.98 point higher approximate value per season, winning about 0.63 more games each season and having about 260 more passing yard per season. These relationships may seem small initially, but considering the averages for the NFL productivity variables shown in Table 2, these results are quite meaningful. For example, the average quarterback in our sample only starts about four games per season in the NFL. Thus, an increase of 1.34 expected starts per season is a substantial increase relative to the average. Similarly, the average quarterback in our sample earns an approximate value per season of 3.03. Thus, a 0.98 point increase in approximate value per season is again a substantial increase relative to the average. Similar statements can be made for the other two NFL productivity measures as well. Furthermore, among those variables with significant coefficients in any of the TSLS estimates reported in Table 5 and excluding *Heisman finalist*, a one SD increase in a quarterback's Wonderlic score is correlated with similar or larger increases in expected NFL productivity.

VI. Further discussion on Wonderlic scores and the expected productivity of NFL quarterbacks

We do not mean to overstate the importance of the Wonderlic test as a predictor of NFL productivity for quarterbacks since there are certainly better predictors of a quarterback's NFL productivity; however, scores on the test are shown to have a statistically significant, and rather meaningful, relationship with the number of games started per season, approximate value per season, wins per season and passing yards per season for a quarterback. This finding might be interpreted as evidence of a relationship between intelligence and productivity at the quarterback position; however, there are additional explanations for this relationship. Individuals who score well on the Wonderlic test likely also exhibit other personality traits that are positively correlated with a quarterback's expected NFL productivity. For example, they may exhibit greater attention to detail, better preparation/study habits, better work ethic and more commitment to achieving a goal. Also, since individuals only have 12 min to complete the 50 question Wonderlic test, it may be that quarterbacks who score well on the test simply perform well under pressure or in high stress situations.

Through a thorough meta-analysis of the Psychology literature, Ackerman and Heggestad (1997) show that personality traits such as introversion and stress reaction are negatively correlated with various measures of intelligence, while personality traits such as extroversion are positively correlated with various measures of intelligence. To the extent that a quarterback's Wonderlic score implies his likelihood of possessing these personality traits correlated with intelligence, it makes sense that introverted quarterbacks who respond poorly to stressful situations would experience less productivity in their careers than otherwise similar extroverted quarterbacks whose teammates may view them as more amiable teammates. Thus, there are a number of things that may be correlated with Wonderlic scores, other than just cognitive ability, which may help to explain our findings.

Among academics and many others, Wonderlic scores have garnered a poor reputation as a predictor of NFL performance. However, many coaches, general managers, owners, fans and media pundits often discuss a quarterback's intelligence, work ethic, study/preparation habits, attitude, performance under pressure and other psychological traits likely positively correlated with Wonderlic scores in relation to his ability to comprehend offensive schemes, adjust to various defensive strategies, motivate teammates as well as his ability to understand or read defensive coverages. Thus, it seems that our finding aligns with conventional wisdom.

VII. Discussion on disparate findings

This is the first academic study we are aware of that finds a direct link between a quarterback's Wonderlic score and his productivity in the NFL. As previously mentioned, Mirabile (2005), Lyons, Hoffman and Michel (2009), Berri and Simmons (2011) and Welter (2013) all find no evidence of a relationship between Wonderlic scores and expected NFL productivity for quarterbacks. Our results may differ from those of previous research due to sample selection, differences in measures of NFL productivity or empirical methodology.

It is likely that the difference between our findings and those by Berri and Simmons (2011) is driven by sample selection. Berri and Simmons (2011) include in their sample only quarterbacks who logged at least 100 plays in a given season. Then, rather than examining the career averages of these quarterbacks as we do in our study, they treat individual seasons completed by a quarterback as separate observations. Thus, they are essentially attempting to identify factors correlated with quarterback productivity from a sample heavily weighted towards fairly productive NFL quarterbacks, whereas our sample includes quarterbacks with much less productive careers and is more similar to the sample of quarterbacks available to NFL teams in a draft. Similar to Berri and Simmons (2011), Welter (2013) treats individual seasons by a quarterback as separate observations rather than focusing on the career averages of quarterbacks.

The sample used by Lyons, Hoffman and Michel (2009) does not include only quarterbacks but also players at all NFL positions except offensive linemen, kickers and punters, and they normalize their NFL performance measures in order to estimate regressions including players from different positions. Furthermore, they only examine the 2002–2004 NFL draft classes. While their sample consists of 762 players, only 32 of those players are quarterbacks. Even with the interaction terms included in their empirical models, it may be difficult to distinguish the impact of Wonderlic scores on quarterback productivity from the impact of Wonderlic scores on the expected productivity of other positions given their sampling and estimation procedures.

Mirabile's (2005) measure of a quarterback's NFL performance is his salary and his passer rating in his rookie season. First, a quarterback's salary in his rookie season is a poor measure of his productivity since it is almost exclusively determined by his draft position. Second, only focusing on a quarterback's rookie season for any productivity measure is likely inadvisable since many quarterbacks tend to have relatively unproductive rookie seasons and may not even play at all during their rookie seasons as they adjust to the differences between college and professional football. Furthermore, focusing only a quarterback's rookie season may discount the importance of Wonderlic scores if quarterbacks with higher Wonderlic scores are better able to adjust to the nuances of professional football following their rookie seasons.

In regards to the disparate findings across the literature concerning the relationship between a quarterback's Wonderlic score and his draft position, it seems that this can largely be explained by the time period under consideration. Berri and Simmons (2011), Gill and Brajer (2012) and Welter (2013) all find a significant relationship between a quarterback's Wonderlic score and his draft position. The samples employed by Berri and Simmons (2011) and Welter (2013) consist of quarterbacks drafted between 1999 and 2008, while the sample employed by Gill and Brajer (2012) consists of quarterbacks drafted between 2004 and 2008. On the other hand, Mirabile (2005), Lyons, Hoffman and Michel (2009) and our study all find an insignificant relationship between a quarterback's Wonderlic score and his draft position. Mirabile's (2005) sample consists of quarterbacks drafted between 1989 and 2004. Lyons, Hoffman and Michel (2009) sample consists of quarterbacks

drafted between 2002 and 2004, and our sample consists of quarterbacks drafted between 2002 and 2012. Thus, the ability of Wonderlic scores to predict a quarterback's draft position seems to vary depending on the time period under consideration, which may be reflective of constantly changing opinions among NFL front office personnel regarding the validity of scores as a predictor of a quarterback's productivity.

VIII. Conclusion

While we find evidence that Wonderlic scores correlate with NFL performance among quarterbacks, we do not find clear evidence that Wonderlic scores correlate with draft position. This puzzling result indicates that Wonderlic scores can be used as an indicator of a quarterback's potential value, but NFL teams seem to be either unaware or unwilling to use the information when making their draft selections. Admittedly, more research is probably needed. Among studies on the subject (including the current research) results are evenly split; three studies find that Wonderlic scores correlate with the draft positions of quarterbacks and three additional studies find no correlation. If NFL teams are indeed ignoring or paying too little attention to a quarterback's Wonderlic score, our research suggests that it should be a much more important consideration when deciding which quarterback to select in the NFL draft. Thus, our findings could be valuable to NFL coaches, managers and executives. In other words, our results regarding Wonderlic scores are not just trivially interesting; rather, NFL teams could use this information to improve their selections of quarterbacks in the NFL draft.

Disclosure statement

No potential conflict of interest was reported by the authors.

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