Human Capital Development in Professional Golf: Web.com Tour as Pathway to the PGA Tour

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Within the economics of sport literature, economists have begun to apply Gary Becker's human capital formation theory as a method to examine the value of developmental (or minor) league level performance on an athlete's success at the highest (or major) league level of professional sports.

This research applies Becker's theory to a model of a professional golfer's human capital development as they progress from the minor league (Web.com Tour) level to the major league (PGA Tour) level. Several empirical model specifications are developed.

Empirical results show that of the shot-makings skills, long-game skills (i.e., driving power and driving accuracy) can best be developed through minor league play; while short-game skills (e.g., approach shots, scrambling, and putting) are better developed at the PGA Tour level.

INTRODUCTION

Unlike many other professional sports leagues, such as Major League Baseball, the path from developmental leagues to the major leagues has been far less clear-cut in professional golf. However, one thing is certain and best expressed by John Feinstein in his 1995 book "A Good Walk Spoiled," an ode to the trials and tribulations of the touring professional. Feinstein notes that "no one turns pro dreaming about playing anyplace *but* the big tour. That is the major leagues. Everything else is Triple-A. Or worse" (1995, xiv).

To clarify the process for "minor" league golfers to be promoted to the "majors", the PGA Tour announced in 2013 that the "path to the PGA Tour" would be directly through the Web.com Tour, the highest of all "minor" league golf tours. Specifically, each season 50 spots become available on the PGA Tour. Which Web.com Tour golfers receive these spots will be decided by how well these players perform during the previous Web.com Tour season (Web.com Tour, 2017). Therefore, each Web.com Tour player has a vested interest in understanding the key shot-making skill factors that will allow them to succeed at golf's highest level. As such, the issue of human capital development as it relates to a golfer's shot-making skills is an appropriate avenue to investigate.

The sports economics literature has a robust history of studying the link between player skills and their on-field performance, as the availability of data and transparency of performance evaluation via statistical measures make professional sport labor markets enticing for researchers. The majority of this literature as it relates to professional golf seeks to apply a single-equation model that relates specific shot-making metrics to a player's tournament performance, most often measured by scoring average or tournament winnings. This research has been done predominantly on PGA Tour data and is often focused on measuring the relative importance of a particular shot-making skill against another in determining the impact on a player's ultimate PGA Tour tournament success.

This study seeks to establish the importance of human capital formation at developmental levels of professional golf on the performance of PGA Tour players. Put another way, this research hopes to provide evidence of a link between a player's performance at the "minor league" level (i.e. Web.com Tour) over multiple seasons and his subsequent scoring average on golf's biggest stage (i.e. PGA Tour). As opposed to analyzing specific shot-making skill metrics for players on the Web.com Tour or PGA Tour for just one season, the inclusion of multiple years of developmental data yields information about the importance of dynamic human capital formation in aspiring PGA Tour players. By applying a methodology previously used by Longley and Wong (2011) to study Major League Baseball (MLB) pitchers, this research evaluates the information value of specific shot-making skill metrics from the Web.com Tour in predicting players' PGA Tour scoring. The importance of dynamic human capital formation in specific shot-making skill areas is demonstrated by the relative explanatory power of Web.com Tour performance on PGA Tour success in each specific shot-making skill area.

Though in golf there are no general managers concerned about drafting the most capable players, both fans and players alike have an interest in understanding not only what skills are most important to success on the PGA Tour, but more importantly, which skills must be developed on the Web.com Tour for success at the highest level of professional golf. By demonstrating competency in specific shot-making skills at the developmental level, players are able to score low and earn enough money to move to the next level in professional golf. However, once on the PGA Tour, a new host of shot-making skills separate top performers from journeymen, as many players find themselves bouncing back and forth between the PGA Tour and the Web.com Tour over the course of their career. Further, the PGA Tour as an entity has an interest in promoting players from the Web.com Tour to the PGA Tour who have the greatest chance to be successful, providing fans with the most entertaining product. Empirical analysis on dynamic human capital formation in specific shot-making skill areas relevant to PGA Tour scoring may help players to more efficiently allocate practice time and ultimately provide a higher level of competition on the PGA Tour.

The following section discusses key trends within the base of previous research related to this topic area. Next, a PGA Tour scoring human capital production function is developed theoretically and examined empirically. Finally, concluding remarks are offered based on the key findings of this research.

LITERATURE REVIEW

As an economic theory, the study of investment in human beings to develop tangible skills that increase productivity began largely in the 1960s with foundational studies conducted by Schultz (1961) and Becker (1962). Previously, the consensus among economists was that differences in productivity could be explained exclusively by the amount of physical capital available to workers. Schultz (1961), however, shows that in Western societies the acquisition of useful skills and knowledge predominantly accounts for the productive superiority of most advanced countries. Becker (1962) builds upon the ideas set forth by Schultz, applying human capital formation theory to explain differences in individual earnings over time. As he notes, observed earnings are affected by both investments made in human capital and the expected rate of return of these investments (higher marginal benefits lead to additional investment). These studies were considered novel among economists who had long found it difficult to consider human beings as a source of capital in the same sense as a machine or other types of inanimate property. More importantly, however, they helped to develop the theory of human capital formation, which provides the broader economic and labor market framework that underpins this application of the dynamic human capital formation theory to professional golf.

Economists have frequently utilized professional sports as a way to understand how labor markets reward the accumulation of specific, job-relevant skills. Kahn (2000) writes explicitly about the value of the sports business as a "labor market laboratory," (p.75) as few other industries provide widely available data about the compensation and performance of each production worker over time. Examples of team sport-related production function literature include the work of Scully (1974), Rosen (1981), and Sommers and Quinton (1982) in professional baseball, Scott, Long, and Somppi (1985) in professional basketball, Jones and Walsh (1988) and Idson and Kahane (2000) in professional hockey, and Sloane (1971) and Lucifora and Simmons (2003) in European professional soccer. Each of these studies tests labor market theories and considers the role of human capital in the salary determination of professional athletes. While this is not nearly an extensive list of human capital theory related research in professional sport labor markets, this does provide evidence that the theory has previously been applied to consider the link between human capital development and performance of professional athletes. Though economists have not studied individual sports, such as golf and tennis, as extensively as other professional sports, there is a growing base of literature concerning the role of human capital as it relates to statistical determinants of tournament performance for individual sport athletes.

The majority of professional golf related research takes the form of single-equation production function model relating specific inputs (shot-making skills) to an output variable measuring individual golfer performance, namely scoring average or tournament earnings. Research employing this methodology includes: Davidson and Templin (1986); Shmanske (1992, 2000); Belkin, *et al* (1994); Moy and Liaw (1998); Nero (2001); Rishe (2001); Scully (2002); Kahane (2010); and Sharma and Reilly (2013). The reduced-form production function generated by these studies can be generalized as:

$$\mathrm{OUTPUT}_i = f(\mathrm{SKILL}_i, \mathrm{EXPER}_i), \tag{1}$$

Where OUTPUT_i is the ith player's performance, SKILL_i represents a vector of specific shot-making skills for the ith player, and EXPER_i represents a vector of factors that capture the ith player's experience level. Output, or tournament performance, is most often measured as a seasonal aggregate of average tournament scores or season-ending tournament earnings.[1] Inputs, or specific shot-making skills, vary slightly by researcher, though nearly all prior studies utilize some measure of driving distance, driving accuracy, iron play, short game, and putting. These foundational studies do find a general consensus that driving distance, putting proficiency, and accuracy with approach shots are nearly always statistically significant in predicting either tournament score or earnings. In terms of relative importance, the results suggest that putting performance and short-game accuracy skills are more important to PGA Tour tournament success than is driving distance. This lends support to the old adage, "Drive for show, putt for dough."[2]

Shmanske (1992) is the first and only existing study to our knowledge to explicitly examine the path of human capital formation on a professional golfer's tournament performance. He finds that for putting and driving distance, skill is related to the amount of hours that a player practices that specific skill, with putting acting as the more significant relationship. Further, he estimates the economic value to a professional golfer of an additional hour of putting practice to be worth approximately \$300-\$400, a direct link between the development of human capital and tournament earnings. However, like most researchers who developed production functions relating shot-making skill inputs to an output variable, Shmanske (1992) only utilizes one year of PGA Tour data (1986 season). As a result, the human capital formation in his study remains static. By incorporating up to six years of developmental level data and one year of PGA Tour level data for the players in this study it is hoped that a better pathway of human capital development can be uncovered. Furthermore, the small number of observations (only eleven golfers) in Shmanske's (1992) research is also improved upon by examining 157 PGA golfers in this study.

The use of a larger dataset is critical to the examination of the path between human capital development and PGA Tour performance. Perhaps the best example of a methodological approach that studies the importance of human capital formation in a sports setting is that of Longley and Wong (2011). In their study of human capital development among Major League Baseball (MLB) pitchers, Longley and Wong

(2011) use performance in specific minor league pitching skill areas (hits, strikeouts, walks) as the pathway to predict specific major league pitching skill performance (Earned Run Average). This is a direct application of human capital formation theory to a competitive labor market in which general managers hope to be able to identify promising personnel quickly and accurately to build a competitive roster. Longley and Wong's (2011) research also studies the pathway of human capital formation over a number of years of participation in minor league baseball, a key differentiator from numerous other studies of human capital formation in professional sport labor markets. This methodological approach, which analyzes human capital formation over several years of developmental data, has not been applied to the sport of golf and thus this study of will be a novel contribution to the existing literature surrounding shot-making skill development for PGA Tour golfers.

THEORETICAL MODEL: PGA TOUR SCORING AVERAGE PRODUCTION FUNCTION AND HUMAN CAPITAL DEVELOPMENT

This study seeks to build upon the base of literature in professional golf that applies a single-equation approach to measuring the relative importance of shot-making skills on PGA Tour performance. Then, by applying Longley and Wong's (2011) methodology to measure the pathway of human capital formation among Web.com Tour players, an estimation of which specific shot-making skills are developed on the Web.com Tour and how this skill development produces success on the PGA tour can be investigated.

In order to estimate the importance of human capital formation in specific shot-making skill areas for PGA Tour professionals, a direct relationship between a player's vector of shot-making skills and his tournament performance is assumed. A player's ability to competently execute specific shots that he may encounter on the golf course determines how few shots the player requires to complete a full round of golf. Experience factors, first recognized by Shmankse (1992) as important to a player's tournament success, are also included in the models produced by this research, exploring the possibility that factors outside of a player's explicit shot-making skills may contribute to his tournament success. By first using actual PGA Tour level specific shot-making skill data to predict PGA Tour tournament success, and then substituting observed Web.com Tour level shot-making skill data and residuals, an estimation of the pathway of human capital development at the Web.com Tour level can be produced.

The first step in this sequence of theoretical model specifications is to identify a production function that relates the vector of shot-making PGA skill inputs ($\mathrm{SKILL}_{ij}^{\mathrm{PGA}}$) and experience factors (EXPER_i) to PGA Tour scoring average ($\mathrm{SCORE}_i^{\mathrm{PGA}}$). The vector of specific shot-making skill inputs was chosen to replicate similar studies in the existing literature. Thus, an underlying structural model is developed for each player's production of his scoring average on the PGA Tour, which is a modification of (1):

$$\mathrm{SCORE}_i^{\mathrm{PGA}} = (\ \mathrm{SKILL}_{ij}^{\mathrm{PGA}},\ \mathrm{EXPER}_i) \tag{2}$$

Theoretically, the more proficient the i[th] player is with the j[th] skill $\mathrm{SKILL}_{ij}^{\mathrm{PGA}}$, the lower his tournament scores, everything else held constant. Furthermore, the more experience the i[th] golfer has, holding all shot-making skills constant, the lower his tournament scores. To apply the Longley and Wong (2011) theoretical approach to professional golf, we must determine to what degree specific shot-making skills at the PGA Tour level ($\mathrm{SKILL}_{ij}^{\mathrm{PGA}}$), or the input variables in (2), may be attributable to these skills at the Web.com Tour level ($\mathrm{SKILL}_{ij}^{\mathrm{Web.Com}}$). For example, a player who drives the ball a long distance off the tee on the Web.com Tour should be expected to exhibit a similar acumen on the PGA Tour. This produces the following shot-making skill-specific production function model:

$$\mathrm{SKILL}_{ij}^{PGA} = f(\mathrm{SKILL}_{ij}^{Web.Com}) \tag{3}$$

Specifically, (3) can be represented by a linear regression model illustrating the theory behind Longley and Wong's (2011) hypothesis of human capital development. In general, this regression model is as follows:

$$SKILL_{ij}^{PGA}=\beta_0+\beta_1 SKILL_{ij}^{Web.Com}+\varepsilon_{ij} \quad (4)$$

where β_0 and β_1 are least square parameter estimates and ε_{ij} is a well-behaved random error term.

Theoretically, for each shot-making skill, the above model is hypothesized to capture shot-making skill development on the Web.com Tour, which linearly influences shot-making skill level on the PGA Tour. This specification provides a way to analyze the variability in each PGA Tour shot-making skill that may be predicted by Web.com Tour performance, demonstrating the importance of human capital formation on the Web.com Tour within specific shot-making skill inputs. Further, (4) allows for the computation of a residual value for each specific shot-making skill (ε_{ij}), which may be interpreted as the portion of a player's PGA Tour performance (with regard to a specific shot-making skill input) that was not predictable from his performance on the Web.com Tour. As demonstrated by Longley and Wong (2011), the estimates from (4) can be used to replace $SKILL_{ij}^{PGA}$ variables in (2).[3] This substitution (into the player's $SCORE_i^{PGA}$ function) yields the following:

$$SCORE_i^{PGA}=f(SKILL_{ij}^{Web.Com}, SKILL_{ij}^{RPGA}, EXPER_i) \quad (5)$$

where $SKILL_{ij}^{Web.Com}$ is player i's actual Web.com Tour performance for a given j shot-making skill metric (e.g. actual driving distance) and $SKILL_{ij}^{RPGA}$ is the residual value generated from the regression (4) for player i's given skill j.[4]

The relative magnitude of the parameter estimates provided by (5) help to demonstrate the value of human capital development within specific shot-making skill areas. A large coefficient value on the shot-making skill residual term would indicate that shot-making skill ability does not translate effectively from the Web.com Tour to the PGA Tour, as PGA Tour performance would largely be a result of factors other than observed Web.com Tour performance. On the other hand, a relatively large parameter estimate on the $SKILL_{ij}^{Web.Com}$ term would indicate a high level of importance for human capital development in that particular shot-making skill area in terms of producing a lower PGA Tour scoring average.

DATA

To empirically estimate the human capital development pathway of PGA Tour golfers, a dataset has been collected which consists of 157 players who competed in five or more events during the 2016 PGA TOUR season. Most important to the research is that all of these players played at least one event on the Web.com Tour between 2010 – 2015 seasons. All data collected on these players was retrieved from the online PGA Tour database.

Summary statistics for these players and variable descriptions relevant to this study may be found in Table 1. Based on these descriptive statistics, the average player in the dataset has been a professional for 11 years (YEARS) and achieved a 2016 PGA Tour scoring average of 71.38 strokes per round (SCORE).

TABLE 1
BASIC SUMMARY STATISTICS

Variable	Mean	Standard Deviation	Minimum	Maximum
SCORE	71.380	0.797	69.956	74.754
YEARS	11.331	6.363	2.000	28.000
EVENTS	22.854	6.742	6.000	34.000
PGADD	289.297	8.766	264.900	312.200
PGADA	60.235	5.266	43.020	73.360
PGAGIR	65.211	3.064	54.230	71.630
PGASCR	57.852	3.433	46.430	65.990
PGAPUTT	1.780	0.027	1.723	1.905
WEBDD	298.284	9.462	276.400	328.900
WEBDA	62.303	5.205	41.070	78.573
WEBGIR	68.619	3.200	57.290	77.780
WEBSCR	59.411	4.828	44.830	74.470
WEBPUTT	1.771	0.035	1.605	1.892

EMPIRICAL SPECIFICATIONS AND ESTIMATION RESULTS

Following the theoretical production function model (2) outlined in Section 3, (6) below develops an empirical specification of a production function which models each player's PGA Tour scoring average as a function of his specific shot-making skills and his level of professional experience.

$$\begin{aligned} SCORE_i = {} & \beta_0 + \beta_1 YEARS_i + B_2 YEARS^2_i + \beta_3 EVENTS_i + \beta_4 PGADD_i + \beta_5 PGADA_i + \beta_6 PGAGIR_i + \\ & \beta_7 PGASCR_i + \beta_8 PGAPUTT_i + \varepsilon_i \end{aligned} \tag{6}$$

where all variable definitions follow those previously defined and ε_i is the disturbance term for this model.

Regression estimates for the parameters in (6) are presented in Table 2.[5] Recall that this equation assumes that PGA Tour scoring average is a function of PGA Tour level shot-making skills and experience (measured by YEARS and EVENTS).[6]

This model most closely follows the single equation production function literature. Overall, a player's shot-making skills and experience explain 76.91% of the variation in his PGA Tour scoring average.

As hypothesized, all shot-making coefficients in Table 2 have the expected sign and are statistically significant at the 10% level or better. More specifically, increases in a player's driving distance, driving accuracy percentage, greens in regulation percentage, and scrambling percentage reduce his score, while a reduction in his putting average also helps to improve his scoring average. These parameter estimates may also be interpreted more precisely to evaluate the impact of improvements in each respective shot-making skill included in the regression. For example, a one percentage point increase in the average number of greens that a player hits in regulation decreases his average score by 0.11 strokes per round. Further, a one stoke decrease in average putts per green in regulation would decrease a player's score by 9.765 strokes.

TABLE 2
CONVENTIONAL PGA SCORING AVERAGE PRODUCTION FUNCTION

Variable	Coefficient	Robust Standard Error
Intercept	73.590	4.423[a]
YEARS	0.018	0.019
YEARS2	-0.001	0.001
EVENTS	-0.026	0.007[a]
PGADD	-0.020	0.008[a]
PGADA	-0.019	0.012[c]
PGAGIR	-0.114	0.023[a]
PGASCR	-0.079	0.012[a]
PGAPUTT	9.765	2.209[a]

Notes: $R^2 = 0.7691$, Breusch-Pagan Test for heteroscedasticity $\chi^2 = 17.73^a$
a denotes significant at 1%, and c denotes significant at 10%

This large decrease is expected given that this skill metric is measured on a per hole basis, however, both the absolute and relative importance of putting on a player's average score has been identified by numerous economists, including Sharma and Reilly (2013), Callan and Thomas (2007), Nero (2001), Moy and Liaw (1998), Shmanske (1992) and others.

Among the experience measures, EVENTS is found to be significant at the 1% level, while YEARS and YEARS^2 are not statistically significant.[7] It is possible that the number of events played is a more accurate gauge of a player's experience level than a simple aggregate measure of his years since becoming a professional. The number of events played controls for players acclimating themselves to the pressure of a PGA Tour event and the courses on which these events are being played, whereas some of the years that a player was a professional may not have been spent playing on the PGA Tour. As later results will demonstrate, the additional events played may also help a player to become comfortable with typical green complexities and speeds on the PGA Tour, allowing him to develop scrambling and putting skills which do not translate as well as other skills from the Web.com Tour to the PGA Tour.

Following the hypothesis set forth in (3), a professional golfer's minor league shot-making skill assists in the development of his major league shot-making skill. To investigate the impact of this human capital development, the analysis must estimate separate linear regressions for each PGA Tour shot-making skills as a function of similar Web.com Tour shot-making skills.[8] Therefore, according to the specification developed in (4), and as discussed by Longley and Wong (2011) in their application to Major League Baseball pitchers, the following relationship holds true (for each specific j^{th} shot-making skill):

$$\text{SKILL}_{ij}^{\text{PGA}} = \text{SKILL}_{ij}^{\text{PGAP}} + \text{SKILL}_{ij}^{\text{RPGA}} \tag{7}$$

where $\text{SKILL}_{ij}^{\text{PGA}}$ is player i's actual PGA Tour shot-making skill j; $\text{SKILL}_{ij}^{\text{PGAP}}$ is player i's predicted shot-making skill j based on his Web.com Tour shot-making skill j, and $\text{SKILL}_{ij}^{\text{RPGA}}$ is player i's shot-making skill j error from the regression in (4).

Following Longley and Wong (2011), the predicted variables ($\text{SKILL}_{ij}^{\text{PGAP}}$) for each of the five shot-making skill inputs are linearly transformed in order to produce inputs that are in units of Web.com Tour performance, as opposed to PGA Tour performance. Through this transformation, $\text{SKILL}_{ij}^{\text{PGAP}}$, for example, can be rewritten as:

$$\text{SKILL}_{ij}^{\text{PGAP}} = \beta_0 + \beta_1 \text{SKILL}_{ij}^{\text{Web.Com}} \tag{8}$$

Where β_0 is a constant and β_1 measures the influence of $SKILL_{ij}^{Web.Com}$ on the player's PGA shot-making skill ($SKILL_{ij}^{PGA}$). Therefore, (7) may now be rewritten as:

$$SKILL_{ij}^{PGA} = \beta_0 + \beta_1 SKILL_{ij}^{Web.Com} + SKILL_{ij}^{RPGA} \quad (9)$$

A regression following the empirical model established by (9) is estimated for each individual shot-making skill factor included in this study. This generates residual values for each of the five shot-making skill factors ($SKILL_{ij}^{RPGA}$). As discussed by Longley and Wong (2011), $SKILL_{ij}^{Web.Com}$ is simply a linear transformation of $SKILL_{ij}^{PGAP}$. Thus, the use of $SKILL_{ij}^{Web.Com}$ in subsequent regressions provides a clearer interpretation of the impact of Web.com Tour developed skills on overall PGA score production.

The parameter estimates and explanatory power of (9) for each specific j^{th} shot-making skill variable is presented in Table 3. All parameter estimates have the expected sign, suggesting that as a player develops his shot-making skill on the Web.com Tour, this improvement in human capital leads to improved shot-making skills on the PGA Tour. With the exception of scrambling (which is statistically significant at the 5% level), the estimates for all other shot-making skill coefficients are statistically significant at the 1% level.

TABLE 3
HUMAN CAPITAL SHOT-MAKING SKILL DEVELOPMENT
PRODUCTION FUNCTION ESTIMATES

	Dependent Variable = PGA Shot-Making Skill				
Web.Com Shot-Making Skill	PGAADD	PGADA	PGAGIR	PGASCR	PGAPUTT
WEBDD	0.682				
	(13.52)[a]				
WEBDA		0.596			
		(9.06) a			
WEBGIR			0.208		
			(2.77) a		
WEBSCR				0.095	
				(1.68) b	
WEBPUTT					0.252
					(4.16) a
Intercept	86.000	23.140	50.920	52.220	1.330
	(5.72)[a]	(5.65)[a]	(9.88)[a]	(15.48)[a]	(12.43)[a]

Notes: t statistic in parentheses, a denotes significant at 1% and b denotes significant at 5%

In the context of driving distance, the shot-making skill coefficient may be interpreted as follows: Each additional yard of average driving distance that a player produces (i.e. develops) on the Web.com Tour is expected to increase driving distance on the PGA Tour by 0.68 yards. The parameter estimate for driving accuracy is also of note, as a one percentage point increase in average driving accuracy percentage on the Web.com Tour increases PGA Tour driving accuracy percentage by 0.60 percentage points. On the other end of the spectrum, the parameter estimate for scrambling indicates that a one percentage point increase in Web.com Tour scrambling percentage (WEBSCR) increases PGA Tour scrambling percentage by just 0.09 percentage points.

The explanatory power of the Web.com Tour shot-making skill varies significantly by PGA Tour level skill. While Web.com Tour driving distance explains 54.12% of the variation in PGA Tour driving distance, Web.com Tour scrambling percentage explains just 1.78% of the variation in PGA Tour scrambling percentage. Driving distance and driving accuracy at the Web.com Tour level had the greatest explanatory power (54.12% and 34.64% respectively) on these respective skills at the PGA Tour level, while the explanatory power of greens in regulation percentage, scrambling percentage and putting average at the Web.com Tour level was low. As such, residuals for driving distance and driving accuracy are low compared to residuals for greens in regulation percentage, scrambling percentage, and putting average, implying that PGA Tour performance in short-game related skill areas is more attributable to other PGA Tour-related factors than to the development of Web.com Tour performance. This may indicate that a baseline level of skills must be developed at the Web.com Tour level to demonstrate proficiency in a player's overall game such that he may be able to reach the PGA Tour. The factors related to hitting the golf ball (i.e. distance and accuracy off the tee) help to separate those who are prepared to strike the ball at a competent level relative to PGA Tour standards. Thus, developing a stock of human capital is critical for prospective PGA Tour players as it relates to driving distance and driving accuracy, as a fair portion of PGA Tour performance in these skill areas can be explained by Web.com Tour performance.

There is a marked difference in the importance of human capital formation, however, as it relates to a player's iron play and short game skills. While the relative importance of putting skills on PGA Tour has been noted by the literature, Web.com Tour performance in these skill areas is less able to explain PGA Tour performance.[9] Web.com Tour scrambling percentage, greens in regulation percentage, and putting average explain just 1.78%, 4.73%, and 10.06% of PGA Tour performance in each of these respective shot-making skill areas.

The contention here is that short game performance on the PGA Tour is much more a factor of a player's familiarity with courses on which tournaments are played than it is upon a player's stock of Web.com Tour performance. While a player may develop competent putting and chipping techniques through years of practice on the Web.com Tour, it is only once he reaches the PGA Tour that he begins to learn the intricacies of reading the greens at popular PGA Tour venues. Many players rely upon extraordinarily detailed notebooks that chart the varying degrees of slopes and other details of green complexes when reading greens, and often these books take years of input to develop completely. Further, green speeds at the PGA Tour level are, on average, slightly higher than at the Web.com Tour level, increasing the difficulty of pitching and putting to challenging hole locations during tournament play (GCSAA, 2016). Thus, it is not necessarily surprising that a PGA Tour player's scrambling percentage and putting average is explained far more by his years of play on the PGA Tour (i.e. the PGA-level residuals from the shot-making skill regressions) and his familiarity with particular golf courses, than his prowess in these specific shot-making skill areas demonstrated on the Web.com Tour.

It should also be noted that these skills are related in important ways. A player may be a more or less effective scrambler based on his putting ability, as the holing of a longer putt on the green can compensate for a poor chip. The ability to chip effectively from the bunker also complicates the scrambling skill metric, as players often find themselves in the sand when they miss the green in regulation. As a result of the wide number of factors that contribute to a player's shot-game skill metrics in this study, PGA Tour performance in these shot-making skill areas is found to be relatively independent of Web.com Tour performance. With that being said, the estimates presented in table 3 do indicate that the stock of Web.com Tour human capital development influences a PGA Tour players' shot-making skill performance and is most important for driving related skills.

Employing the residual values ($SKILL_{ij}^{RPGA}$) generated by (4) and the actual values of Web.com Tour shot-making skills ($SKILL_{ij}^{Web.Com}$), a regression is run which follows the theoretical framework established by (5), predicting PGA Tour scoring average as a function of Web.com Tour shot-making skills, PGA shot-making skill residuals, and the vector of experience factors. This equation may be written as:

$$\begin{aligned}\mathrm{SCORE}_i = {} & \beta_0 + \beta_1\mathrm{YEARS}_i + \beta_2\mathrm{YEARS}^2_i + \beta_3\mathrm{EVENTS}_i + \beta_4\mathrm{WEBDD}_i + \beta_5\mathrm{DD}_i{}^{R}{}_{PGA} + \\ & \beta_6\mathrm{WEBDA}_i + \beta_7\mathrm{DA}_i{}^{R}{}_{PGA} + \beta_8\mathrm{WEBGIR}_i + \beta_9\mathrm{GIR}_i{}^{R}{}_{PGA} + \beta_{10}\mathrm{WEBSCR}_i + \\ & \beta_{11}\mathrm{SCR}_i{}^{R}{}_{PGA} + \beta_{12}\mathrm{WEBPUTT}_i + \beta_{13}\mathrm{PUTT}_i{}^{R}{}_{PGA} + \varepsilon_i \qquad (10)\end{aligned}$$

where all skill variable definitions follow those offered in Table 1, β_0 is a constant, β_1 - β_3 capture the impact of various experience factors, and β_4 - β_{13} measure the impact of Web.com Tour skill performance and associated skill residuals on player *i*'s PGA Tour scoring average, and ε_i is the random disturbance term for this model.

The parameter estimates for all shot-making skill factors and their associated residuals are presented in Table 4. All parameter estimates have the expected sign and, with the exception of the driving accuracy variable (WEBDA), these estimates are found to be statistically significant.

Within the vector of experience factors, EVENTS is again found to be statistically significant at the 1% level, while YEARS and YEARS^2 are not, despite having the correct quadratic signs. Overall, the combination of Web.com Tour shot-making skill performance and skill specific residual values explains 78.04% of PGA Tour scoring average.[10]

TABLE 4
HUMAN CAPITAL ADJUSTED PGA SCORING AVERAGE PRODUCTION FUNCTION

	Coefficient	Robust Standard Error
Intercept	75.9689	3.953[a]
YEARS	0.022	0.019
YEARS2	-0.001	0.001
EVENTS	-0.027	0.007[a]
WEBDD	-0.019	0.006[a]
DDRPGA	-0.016	0.009[b]
WEBDA	-0.007	0.008
DARPGA	-0.023	0.013[b]
WEBGIR	-0.027	0.011[a]
GIRRPGA	-0.112	0.024[a]
WEBSCR	-0.022	0.010[b]
SCRRPGA	-0.076	0.013[a]
WEBPUTT	2.837	1.325[b]
PUTTRPGA	9.372	2.320[a]

Notes: $R^2 = 0.7804$ Breusch-Pagan Test for heteroscedasticity $\chi^2 = 22.605^a$. Where a denotes significant at 1% and b denotes significant at 5%.

Analyzing each specific shot-making skill individually produces the most useful interpretations of the parameter estimates recorded in Table 4. Consider, for example, driving distance. Because the coefficients of both observed Web.com Tour performance (WEBDD) and the PGA Tour driving distance residual value (DD^{RPGA}) are statistically significant, differences across golfers in terms of Web.com Tour driving distance are found to have an impact on future PGA Tour scoring average. However, we might also note, that because the DD^{RPGA} coefficient is significant, there are also differences across golfers in terms of driving distance at the PGA Tour level that are *not* explained by prior Web.com Tour performance. These differences are also significant in explaining a professional golfer's PGA Tour scoring average.

The magnitude of the coefficients presented in Table 4 also provide a way to analyze the relative effect of each variable on PGA Tour scoring average. The coefficient value on a player's driving distance residual term is less than that of the coefficient on the player's actual Web.com Tour driving distance variable. This can also be interpreted as showing that 54.33% of the total impact of driving distance on PGA Tour scoring average is attributable to the development of driving distance on the Web.com Tour. Compare this finding to the relative importance of GIR development. The parameter estimate for WEBGIR is -0.027, while the coefficient on GIR^{RPGA} is approximately four times larger at -0.1119 (on an absolute value basis). This indicates that a player's greens in regulation percentage skill development at the PGA Tour level is approximately four times as valuable when trying to explaining a player's PGA Tour scoring average than is his greens in regulation percentage skill development at the Web.com Tour level. Similar differences in terms of the magnitude of coefficients on the Web.com Tour performance variables versus the residual values are seen for scrambling percentage and putting average. The coefficient on a player's scrambling residual value is approximately 3.5 times as large as the corresponding coefficient on the Web.com Tour scrambling percentage performance variable and the coefficient on a player's putting average residual value is approximately 3.3 times as large as the corresponding coefficient on the player's Web.com Tour putting average performance variable. We may conclude that for greens in regulation, scrambling, and putting skills, approximately 20% of the impact of the particular skill on PGA Tour performance is attributable to the development of a player's shot-making skill performance on the Web.com Tour, while the remaining impact is explained by the direct development of the skill on the PGA Tour.

Given the high explanatory power of Web.com Tour driving distance on PGA Tour driving distance, and the driving distance estimates reported in table 4, we can draw some considerable implications. Driving distance is the skill that most clearly translates from Web.com Tour performance into performance (and ultimately scoring average) on the PGA Tour. The fact the distance a player hits the ball is largely a factor of fairly stable characteristics, such as height, weight, and strength, helps to explain why driving distance more so than other shot-making skill factors translates effectively between these levels of professional golf.[11] Thus, there is considerable similarity in the findings that while PGA Tour driving distance can be accounted for by development of a player's shot-making skill performance on the Web.com Tour, shot-making skill factors that are determined more predominately by skill and course familiarity, such as greens in regulation, putting, and scrambling, cannot be accounted for as effectively by development of shot-making skill on the Web.com Tour. Ultimately, this means that the value of human capital development on the Web.com Tour is important with regard to driving related shot-making skills, but less important with regard to short-game related specific shot-making skills.[12]

CONCLUSIONS

The primary contribution of this research is to estimate the importance of human capital development in a variety of shot-making skills to the production of PGA Tour golfer's on course success. As such, we employ the methodology proposed by Longley and Wong (2011) and extend the literature first investigated by Shmanske(1992).

We use six years of Web.com Tour level specific shot-making skill data to develop a stock variable for each shot-making skill. Next, we investigate the influence that each shot-making skill has on a golfer's PGA Tour level shot-making skill performance. Thus, the importance of human capital development with regard to each specific shot-making skill area becomes clearer. The findings relating specific shot-making skill inputs to PGA Tour scoring average are largely in accordance with the old adage, "Drive for Show, Putt for Dough," as the coefficients for putting average and greens in regulation percentage are larger relative to other shot-making skill inputs. Given that we are not examining a golfer's earnings, perhaps a better interpretation of our estimates is "Drive to Play, Putt to Stay." Thus, we do contribute a novel finding suggesting that a significant amount of the impact of driving skills on PGA Tour scoring average may be explained by the stock of human capital development in these shot-making skill areas developed on the Web.com Tour. Unfortunately, the pathway of human capital development of short-game shot-making skills on the Web.com Tour to PGA Tour performance is less convincing. PGA Tour short-game shot-making performance, which may be described as a finesse element of golf, is explained predominantly by factors other than developmental level performance, reducing the value of Web.com Tour human capital development in these skill areas. One hypothesis is that course familiarity may be playing a more critical role in determining PGA Tour players' short-game skill metrics than their past Web.com Tour performance, though this demands additional research.

Future research may also seek to address several of the limitations of the dataset employed in this study. A larger dataset with more players could help to strengthen the value of the conclusions drawn from this analysis. Further, a more accurate estimation of the value of human capital development in professional golfers may be drawn by restricting player inclusion into the dataset to those who played a greater number of events on the Web.com Tour. Finally, because some young star players on the PGA Tour do not spend any developmental time on the Web.com Tour, so it may also be valuable to study human capital development at the collegiate level, as shot-making skill translation between the college level and the PGA Tour may be different than that that between the Web.com Tour and the PGA Tour.

Despite these limitations, this research provides statistical evidence of a pathway of human capital development originating from the minor league level of professional golf. Aspiring PGA Tour professionals ought to focus their practice hours while on the Web.com Tour towards developing driving skills, which translate effectively to PGA Tour performance, though these practice hours should shift towards developing short-game shot-making skills once at the PGA Tour level, given the relative returns to short-game skills shown by both the existing literature and this study.

ENDNOTES

1. Shmanske (1992) and more recently, Alexander and Kern (2005) have used tournament level data to investigate the production function for a professional golfer.
2. This consensus has been challenged by research that highlights the relative importance of driving skills on PGA Tour earnings, including Engelhart (1995) and Baugher, Day, and Burford Jr. (2014).
3. The use of actual Web.com Tour shot-making skill metrics as opposed to predicted PGA Tour shot-making skill metrics allows for a measure of variability across players in the dataset in units of minor league (Web.com Tour) performance (as opposed to in units of predicted PGA Tour level performance), as discussed by Longley and Wong (2011).
4. Within the golf production function literature, the employment of a regression residual has been used before. For example, Alexander and Kern (2005) use this approach to obtain estimates of iron play and putting ability. The major difference between their approach and the one employed here is that they examined PGA skill level and we are looking at Web.com Tour skill development and its influence on PGA Tour skills.
5. Equation 6 and all subsequent empirical models have been estimated using an ordinary least squares regression model in *Stata*. Each model is tested for heteroskedasticity using the Breusch-Pagan/Cook-Weisberg test and, where necessary, reported results have been corrected for heteroskedastic tendencies.
6. Following convention, the experience level (YEARS) is assumed to follow a quadratic relationship.
7. While YEARS and $YEARS^2$ have the correct quadratic signs, unfortunately, neither parameter estimate is statistically significant.
8. The methodology employed here follows that presented by Longley and Wong (2011).
9. Researchers noting the importance of PGA Tour putting skills on tournament performance include: Shmanske (1992), Alexander and Kern (2005), Rinehart (2009), Sharma and Reilly (2013), Baugher, Day, and Burford Jr. (2014).
10. The model is tested for heteroscedasticity using the Breusch-Pagan/Cook-Weisberg test and reported estimated in table 4 have been corrected using robust standard errors. In addition, Ramsey's (RESET) test for omitted variables is conducted and the hypothesis of an omitted variable in rejected. Lastly, a series of joint F-tests is performed to test if the $SKILL_{ij}^{Web.Com}$ or $SKILL_{ij}^{RPGA}$ as a group is insignificant. Test results indicate that each null hypothesis regarding no group effects can be rejected at the 1% significance level.
11. Longley and Wong (2011) suggest a similar link in major league professional pitchers' abilities to strikeout batters at the minor league and major league levels. While the ability to strike batters out may depend largely upon natural physical ability, they suggest that the number of hits and walks given up depend more on "finesse and experience" (p. 200).
12. Shmanske (1992) reaches a similar conclusion regarding a golfer's stock of driving versus short-game skills.

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