Passing with the Stars: Learning from coworkers in collaborative jobs

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Motivation

Research question: how and how much do we learn from peers at work?

- Earlier: more evidence for peer pressure than learning (Mas and Moretti, 2009; Cornelissen et al., 2017)
  - Peer quality: no effect in knowledge-intensive industries on *levels* of wages
- Several other factors:
  - Social pressure (Mas and Moretti, 2009), education spillover (Nix, 2020)
  - Top peers might even be detrimental due to confidence (Bilen and Matros, 2021), and their injuries provide the opportunity to shine (Hoey, 2023)
- **Key benchmark**: Jarosch et al. (2021): more highly-paid coworkers → more future wage *growth*
  - 12% in 3 years, 21% in 10 years

⟹ Ultimate issue: wages are imperfect measurements of human capital!

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$\Longrightarrow$ **Ultimate issue: wages are imperfect measurements of human capital!**

Football and human capital

Madrid Zone ✓
@theMadridZone

Zlatan Ibrahimovic: ""When Zidane stepped onto the pitch, the 10 other guys just got suddenly better. It is that simple. It was magic. He was a unique player. He was more than good, he came from another planet. His team-mates became like him when he was on the pitch."

4:54 PM · Sep 12, 2020

Note: https://twitter.com/theMadridZone/status/1304795531340906498?lang=en

What we do in this paper

Novel evidence on how the quality of coworkers affects human capital

1. We investigate a high-skilled collaborative environment: **football**
   - Sports data allows for more precise measurement of human capital, with less unobserved heterogeneity than usual
   - Homogenous workplace size, occupation
2. Construct a dataset tracking players' market values, skills, and collaboration
   - Go beyond estimating peer effects from shared observed presence in a workplace (firm + occupation)
3. Relate their human capital growth to peer quality and interactions
   - Human capital as skills not wage
   - Additional focus on star impact
4. Examine the mechanisms and heterogeneity
5. Provide evidence on *getting better* vs. *looking better*

Highlights

1. Those with higher human capital peers tend to experience higher growth in their own human capital
2. Those playing with star players tend to experience even more growth in human capital
3. More exposure and team involvement are associated with higher growth
4. Learning happens via interactions: more passing (and shared minutes for juniors) with top teammates correlates with higher human capital growth
5. Learning manifests in skill improvement: better in-game passing experience is associated with higher future passing skills

Dataset

For seasons 2012/2013 – 2019/2020, top 5 European football leagues (England, Spain, Italy, Germany, France):

1. Player careers: player and team characteristics in every half-season
2. Market values: valuation for a player in every half-season
3. Team composition: information on team lineups for each team in each match
4. Events: minutes spent together and passing in each match
5. Skill attributes: FIFA game ratings for each season

- 1-4: `transfermarkt.com` and `whoscored.com`, scraped and cleaned for Békés and Ottaviano (2022)
- 5: `fifaindex.com` via `https://github.com/lbenz730/fifa_model`

Regressions

We run the following types of regression:

- Dependent variable: market value 1-6 half-seasons forward
- Key explanatory variable: team value and composition
- Key control: present market value

- Pooled cross-section OLS regressions
- Clustered standard errors: league $\times$ half-season $\times$ position

$$\mathbb{E}[HC_{t+h}|.] = \alpha HC_t + \beta \text{HC-Team}_t + \gamma X_t$$

Then we elaborate on the human capital of the team, exposure, and the mechanism:

- Team composition
- Exposure and involvement with the team
- Direct interaction with the top players (minutes and passing)

Establishing evidence on learning: Jarosch et al. (2021)

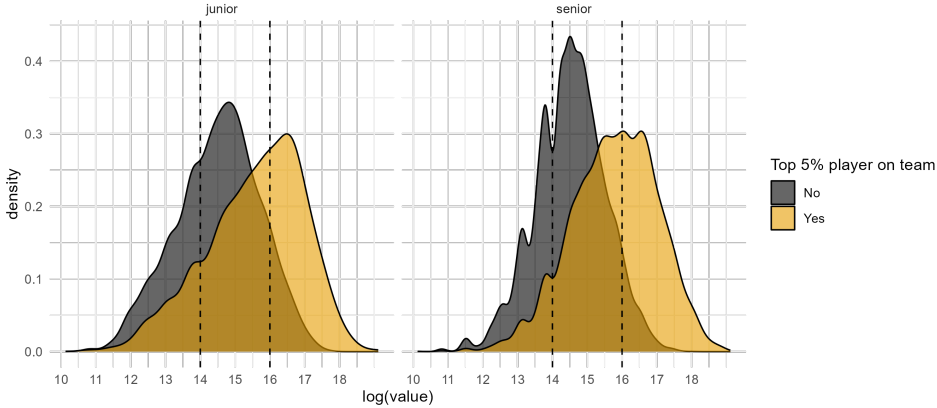
Dependent Variables:	h=1	h=2	h=3	h=4	h=5	h=6
			$\log(\text{value}_{t+h})$			
Model:	(1)	(2)	(3)	(4)	(5)	(6)
Variables						
log(value)	0.916***	0.898***	0.857***	0.839***	0.810***	0.801***
	(0.006)	(0.006)	(0.007)	(0.008)	(0.009)	(0.009)
log(teammates' total value)	0.049***	0.061***	0.099***	0.106***	0.136***	0.129***
	(0.006)	(0.007)	(0.010)	(0.011)	(0.012)	(0.013)
Fixed-effects						
position	Yes	Yes	Yes	Yes	Yes	Yes
player age	Yes	Yes	Yes	Yes	Yes	Yes
league X half-season	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics						
Observations	32,965	32,763	32,488	30,097	27,698	25,299
R^2	0.917	0.867	0.813	0.769	0.729	0.697
Within R^2	0.885	0.814	0.736	0.671	0.612	0.564

Note: All players, all teams. Standard errors clustered at position × league × half-season level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Establishing evidence on learning

1. We replicate the baseline results for Jarosch et al. (2021)
2. Conditional on own value, position, player age, league X time
3. We find that doubling the total market value of peers is associated with 6-11-13% higher market value for a player over the next 1-2-3 years
4. Very similar to Jarosch et al. (2021) results (7-9-12%)
5. Supports an external validity argument that football itself is not outlandish to other professions

Sample restriction: common support cutoffs



Note: Market value densities by types of teams in the sample.

Team heterogeneity: Playing with the Stars

Dependent Variable:	log(value$_{t+6}$)					
	Mid-value sample			Junior		
Model:	(1)	(2)	(3)	(4)	(5)	(6)
Variables						
log(value)	0.899***	0.897***	0.898***	0.931***	0.931***	0.916***
	(0.015)	(0.015)	(0.015)	(0.038)	(0.038)	(0.039)
Teammates' value (Z)	0.060***	0.053***		0.151***	0.151***	
	(0.018)	(0.018)		(0.034)	(0.035)	
Team HHI		1.50**			0.161	
		(0.616)			(1.80)	
Top 5% share			0.206***			0.543***
			(0.075)			(0.137)
Top 25% share			0.064			0.363***
			(0.058)			(0.138)
Observations	14,423	14,423	14,423	2,924	2,924	2,924
R^2	0.492	0.492	0.492	0.274	0.274	0.275

Note: Columns (1) to (3), all medium market value range players, Columns (4) to (6) only young players. Teammates' values are measured as the Z-score. HHI is the team level Hirschman–Herfindahl Index. Standard errors clustered at position × league × half-season level. FE: position, player age, league × half-season. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

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Team heterogeneity: Playing with the Stars

- We switch to the mid-value sample, and measurements in standardized scores or Z-scores, and 3-year forward horizon
- We focus on heterogeneity within teams in terms of value
- Mid-value sample:
  1. Conditional on the previous fixed effects and team value, a 10% higher HHI for the team is assoc. with a 15% higher market value in 3 years
  2. Changing to the share of top players as measure, it can be seen that this correlation is driven by the top 5% share. 10 ppts higher share of the top 5% in market value is assoc. with an around 2% higher market value
- Junior mid-value sample:
  1. Conditional on the previous fixed effects and team value, a 10% higher HHI for the team is assoc. with an insignificant 1.6% higher market value in 3 years
  2. Changing to the share of top players as measure, it can be seen that this correlation is driven by the top 5% and top 25% share. Conditional on each other as well, 10 ppts higher shares are assoc. with 5% and 4% higher market value for a player in 3 years.

Mechanism: Playing time exposure

Dependent Variable:	log(value$_{t+6}$)					
	Mid-value sample			Junior		
Model:	(1)	(2)	(3)	(4)	(5)	(6)
log(value)	0.899***	0.708***	0.709***	0.931***	0.692***	0.682***
	(0.015)	(0.017)	(0.017)	(0.038)	(0.040)	(0.040)
Teammates' value (Z)	0.060***	0.224***	0.219***	0.151***	0.331***	0.420***
	(0.018)	(0.019)	(0.020)	(0.034)	(0.041)	(0.049)
Minutes (Z)		0.144***	0.141***		0.160***	0.188***
		(0.014)	(0.014)		(0.041)	(0.043)
Pass centrality (Z)		0.154***	0.152***		0.237***	0.250***
		(0.012)	(0.013)		(0.038)	(0.038)
Teammates' value (Z) × Minutes (Z)			-0.012			0.108**
			(0.013)			(0.043)
Observations	14,423	14,169	14,169	2,924	2,861	2,861
R^2	0.492	0.534	0.534	0.274	0.343	0.345

Note: Players in the medium market value range, all teams. Standard errors clustered at position × league × half-season level. FE: position, player age, league × half-season. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Mechanism: Playing time exposure

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Mechanism: Playing time exposure

- We focus on exposure in terms of playing time and importance within the team, Z-scores
- Eigenvector centrality for passes captures transitive influence in passes
- Mid-value sample:
  1. 1 SD of minutes assoc. with 14% higher value, 1SD of pass centrality with around 15% higher value, conditional on each other, own and teammates' value
  2. Teammates value remains significant and large conditional on the other two as well
  3. Interaction of teammate value and minutes is insignificant and small: no higher added value in minutes if played with better teammates
- Junior mid-value sample:
  1. 1 SD of minutes assoc. with 16% higher value, 1SD of pass centrality with around 24% higher value (greater than mid-value), conditional on each other, own and teammates' value
  2. Teammates value remains significant and large conditional on the other two as well, greater estimate even
  3. Interaction of teammate value and minutes here is significant and large: if teammates' value is 1SD unit higher, the marginal assoc. with minutes jumps from $18\% \rightarrow 30\% \implies$ For younger players it matters who they play with on the pitch!

Mechanism: Passing with the Stars

Dependent Variable:	log(value$_{t+6}$)			
Model:	(1)	(2)	(3)	(4)
Teammates' total value (Z)	0.153***	0.179***	0.168***	0.189***
	(0.023)	(0.023)	(0.022)	(0.023)
Passes top 5%: in 25-75 percentile	0.126***	0.086**		
	(0.034)	(0.033)		
Passes top 5%: in 75+ percentile	0.282***	0.166***		
	(0.044)	(0.044)		
Passes top 25%: in 25-75 percentile	0.190***	0.088**		
	(0.040)	(0.043)		
Passes top 25%: in 75+ percentile	0.485***	0.257***		
	(0.054)	(0.063)		
Total minutes (Z)		0.160***		0.135***
		(0.019)		(0.016)
Passes top 5% teammates (Z)			0.091***	0.064***
			(0.016)	(0.015)
Passes top 25% teammates (Z)			0.218***	0.145***
			(0.019)	(0.019)
Minutes share top 5% (Z)				
Minutes share top 25% (Z)				
Observations	5,366	5,366	5,366	5,366
R^2	0.558	0.564	0.564	0.569

Note: Players in the medium market value range, all teams. Standard errors clustered at position × league × half-season level. FE: position, player age, league × half-season, additional controls of log-value and the no-minutes category for passes. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

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Dependent Variable:	log(value$_{t+6}$)					
Model:	(1)	(2)	(3)	(4)	(5)	(6)
Teammates' total value (Z)	0.153***	0.179***	0.168***	0.189***	0.095**	0.186***
	(0.023)	(0.023)	(0.022)	(0.023)	(0.038)	(0.040)
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	(0.040)	(0.043)				
Passes top 25%: in 75+ percentile	0.485***	0.257***				
	(0.054)	(0.063)				
Total minutes (Z)		0.160***		0.135***		0.256***
		(0.019)		(0.016)		(0.014)
Passes top 5% teammates (Z)			0.091***	0.064***		
			(0.016)	(0.015)		
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			(0.019)	(0.019)		
Minutes share top 5% (Z)					-0.012	0.009
					(0.039)	(0.039)
Minutes share top 25% (Z)					0.016	0.037
					(0.028)	(0.026)
Observations	5,366	5,366	5,366	5,366	5,273	5,273
R^2	0.558	0.564	0.564	0.569	0.533	0.563

Note: Players in the medium market value range, all teams. Standard errors clustered at position × league × half-season level. FE: position, player age, league × half-season, additional controls of log-value and the no-minutes category for passes. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

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Note: Players in the medium market value range, all teams. Standard errors clustered at position × league × half-season level. FE: position, player age, league × half-season, additional controls of log-value and the no-minutes category for passes. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Mechanism: Passing with the Stars

- We show results here only for the mid-value players, in 3 years forward time.
- How many passes they make with top players relative to the overall pass distribution between players in the league X time.
- Baseline: 0-25 percentile, omitted controls: FE, no shared minutes, and own value
- The team's value being 1SD higher is assoc. with 15-19% higher own value, conditional on the passing. Additionally:
- Conditional on minutes (without the minutes it is around 50% higher):
  1. Compared to the lowest quartile, those whose passes with the top 5% fall within the 25-75 percentile has around 9% higher value, the top quartile around 17%
  2. With the top 25-5% players it is 9% and 26%
  3. Measures in units of SD shows the same: 1 SD more passing to top-5% is assoc. with 6%, top 25% around 15% market value
  4. Minutes shared does not seem to matter, with or without conditioning on total own minutes
  5. Evidence for not only the shared minutes impact, but that interaction itself plays an important role

Stardust vs. learning

- We have documented the association between interacting with skilled peers and improvement in market value
- Two competing stories:
  1. Stardust: the perception of a player improves, *just looking better*
  2. Learning: skill improvement leading to higher market value, *getting better*
- We augment the analysis with ratings from FIFA games
  - Matched using the player name, team name, and season ($\sim$90% matching rate)
- Do relevant skill attributes respond to interaction with high-quality peers
  - Based on correlation structure, we focus on *short passes*, and also consider: finishing, reactions, interceptions, ball control, and speed
  - Measured in units of standard deviation

Skill attributes and teammates for mid-value players

Dependent Variables:	Short pass$_{t+6}$	Ball control$_{t+6}$	Reactions$_{t+6}$	Interceptions$_{t+6}$	Finishing$_{t+6}$	Speed$_{t+6}$
Model:	(1)	(2)	(3)	(4)	(5)	(6)
Own skill$_t$	0.697***	0.776***	0.505***	0.780***	0.776***	0.899***
	(0.017)	(0.016)	(0.018)	(0.017)	(0.014)	(0.013)
Team avg. skill$_t$	0.021***	0.013**	0.085***	0.0002	0.0003	-0.0007
	(0.006)	(0.005)	(0.019)	(0.004)	(0.005)	(0.009)
Fixed-effects						
position	Yes	Yes	Yes	Yes	Yes	Yes
player age	Yes	Yes	Yes	Yes	Yes	Yes
league X half-season	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics						
Observations	9,162	9,162	9,162	9,162	9,162	9,162
R^2	0.881	0.924	0.278	0.914	0.907	0.787
Within R^2	0.492	0.576	0.227	0.631	0.646	0.641

Note: Mid-value players. Standard errors clustered at position × league × half-season level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Skill attributes and teammates for mid-value players

- With 1 unit higher team avg. skill, the 3-year forward value of the own skill is
  1. Short-pass: 0.02 unit higher
  2. Ball control: 0.01 unit higher
  3. Reaction (speed of deciding for an action): 0.08 unit higher
  4. Interceptions, finishing, sprinting speed are all unaffected
  5. We find evidence that for skills that are associated the team's group-level play, the initial avg. skill level is assoc. with higher future skill for a player
- But not for all skills: interceptions, finishing or sprinting speed, the latter being obviously more innate, so we would not expect anything

Short pass skills and passing with the Stars

Dependent Variable:	Short pass$_{t+6}$			
Model:	(1)	(2)	(3)	(4)
Teammates' avg. short pass	0.033***	0.033***	0.032***	0.032***
	(0.009)	(0.009)	(0.009)	(0.009)
Pass count with top 5%: in 25-75 percentile	0.010	0.009		
	(0.019)	(0.019)		
Pass count with top 5%: in 75+ percentile	0.020	0.020		
	(0.020)	(0.021)		
Pass count with top 25%: in 25-75 percentile	0.037**	0.036*		
	(0.017)	(0.019)		
Pass count with top 25%: in 75+ percentile	0.093***	0.091***		
	(0.023)	(0.028)		
Total minutes		0.0008		0.008
		(0.008)		(0.007)
Pass count with top 5% teammates			0.012	0.010
			(0.007)	(0.008)
Pass count with top 25% teammates			0.028***	0.023***
			(0.008)	(0.009)
Minutes shared with top 5% out of total				
Minutes shared with top 25% out of total				
Observations	3,509	3,509	3,509	3,509
R^2	0.893	0.893	0.892	0.893

Note: Players in the medium market value range, all teams. Standard errors clustered at position × league × half-season level. FE: position, player age, league × half-season, additional controls of short pass skill and the no-minutes category for passes. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

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Pass count with top 5%: in 25-75 percentile	0.010	0.009				
	(0.019)	(0.019)				
Pass count with top 5%: in 75+ percentile	0.020	0.020				
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Pass count with top 25%: in 25-75 percentile	0.037**	0.036*				
	(0.017)	(0.019)				
Pass count with top 25%: in 75+ percentile	0.093***	0.091***				
	(0.023)	(0.028)				
Total minutes		0.0008		0.008		0.031***
		(0.008)		(0.007)		(0.006)
Pass count with top 5% teammates			0.012	0.010		
			(0.007)	(0.008)		
Pass count with top 25% teammates			0.028***	0.023***		
			(0.008)	(0.009)		
Minutes shared with top 5% out of total					0.041***	0.047***
					(0.012)	(0.012)
Minutes shared with top 25% out of total					0.011	0.010
					(0.011)	(0.011)
Observations	3,509	3,509	3,509	3,509	3,456	3,456
R^2	0.893	0.893	0.892	0.893	0.892	0.892

Note: Players in the medium market value range, all teams. Standard errors clustered at position × league × half-season level. FE: position, player age, league × half-season, additional controls of short pass skill and the no-minutes category for passes. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Short pass skills and passing with the Stars

Dependent Variable:	Short pass$_{t+6}$					
Model:	(1)	(2)	(3)	(4)	(5)	(6)
Teammates' avg. short pass	0.033***	0.033***	0.032***	0.032***	0.012	0.013
	(0.009)	(0.009)	(0.009)	(0.009)	(0.010)	(0.010)
Pass count with top 5%: in 25-75 percentile	0.010	0.009				
	(0.019)	(0.019)				
Pass count with top 5%: in 75+ percentile	0.020	0.020				
	(0.020)	(0.021)				
Pass count with top 25%: in 25-75 percentile	0.037**	0.036*				
	(0.017)	(0.019)				
Pass count with top 25%: in 75+ percentile	0.093***	0.091***				
	(0.023)	(0.028)				
Total minutes		0.0008		0.008		0.031***
		(0.008)		(0.007)		(0.006)
Pass count with top 5% teammates			0.012	0.010		
			(0.007)	(0.008)		
Pass count with top 25% teammates			0.028***	0.023***		
			(0.008)	(0.009)		
Minutes shared with top 5% out of total					0.041***	0.047***
					(0.012)	(0.012)
Minutes shared with top 25% out of total					0.011	0.010
					(0.011)	(0.011)
Observations	3,509	3,509	3,509	3,509	3,456	3,456
R^2	0.893	0.893	0.892	0.893	0.892	0.892

Note: Players in the medium market value range, all teams. Standard errors clustered at position × league × half-season level. FE: position, player age, league × half-season, additional controls of short pass skill and the no-minutes category for passes. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Short pass skills and passing with the Stars

- Focus on short passes, the most direct variable to pass counts
  1. Conditional on own skill, team skill, FE, 1 SD-unit higher team avg. is assoc. with around 0.03 unit higher own skill in 3 years. In addition:
  2. Passing with the top 25% players being in the top quartile is assoc. with 0.09 SD-unit higher skill level, and being in the 25-50 percentiles with around 0.04 SD-unit
  3. Passing measured in units of standard deviation as well, 1 SD-unit higher passing is assoc. with around 0.02 SD-unit higher short-pass-skill
  4. But: sharing minutes with the top5% rather is assoc. with higher short-pass skill in the future. We do not know, one possible reason: being exposed to high-level moments, or more exposure to people who evaluate players and overrate them?

Challenges and ideas

1. Player's unobserved growth potential and team quality
2. Selection into and out of sample: extend the sample to more football leagues
3. Dynamic treatment problem: learning from future good teams captured as the effect of the initial team
4. Senior mentoring: role of stars past their prime
5. Tails of the value distribution: what happens at the low and high ends?
6. Coaching and institutional culture

Conclusion

- We investigate the effect of peer quality on human capital growth
- We use sports data that finely measure human capital and collaboration between colleagues when they work
- Beyond having high-quality coworkers, the intensity and nature of the interaction are also key factors
- Strong evidence pointing towards the additional impact of having high-flying colleagues
- Evidence found not only for market value but also for improvement in relevant skill attributes

Thank you for your attention!

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Descriptives

Table: Descriptives of the key numeric variables

	N	mean	sd	p1	p5	p50	p95	p99
Value (in mn EUR)	33148	7.88	13.02	0.20	0.40	3.25	30.00	65.00
log(value)	33148	15.06	1.30	12.21	12.90	14.99	17.22	17.99
Teammates' value (in mn EUR)	33148	173.14	189.00	21.34	30.43	96.78	585.00	919.74
Teammates' value (Z-score)	33148	0.00	1.00	-0.80	-0.76	-0.40	2.18	3.95
log(Teammates' value)	33148	18.53	0.90	16.88	17.23	18.39	20.19	20.64
HHI of team	33148	0.07	0.01	0.05	0.05	0.07	0.10	0.12
Share of top 5% players in team	33148	0.11	0.19	0.00	0.00	0.00	0.59	0.74
Share of top 25% players in team	33148	0.36	0.20	0.00	0.04	0.35	0.68	0.77
Total minutes	33148	913.20	579.47	11.00	62.00	897.00	1840.00	2175.53
Total minutes (Z-score)	33148	0.00	1.00	-1.66	-1.48	-0.01	1.58	2.17
Pass eigenvector centrality (Z-score)	32396	0.00	1.00	-1.43	-1.37	-0.12	1.89	1.95
Pass count top 5% (Z-score)	14907	0.00	1.00	-0.95	-0.95	-0.29	1.96	3.63
Pass count top 25% (Z-score)	32512	0.00	1.00	-1.04	-1.02	-0.27	1.96	3.40
Minutes shared with top 5% (Z-score)	32528	0.00	1.00	-0.60	-0.60	-0.60	2.46	2.95
Minutes shared with top 25% (Z-score)	32528	0.00	1.00	-1.78	-1.56	0.03	1.56	1.94

Note: All players, all teams.

Back

Empirical details

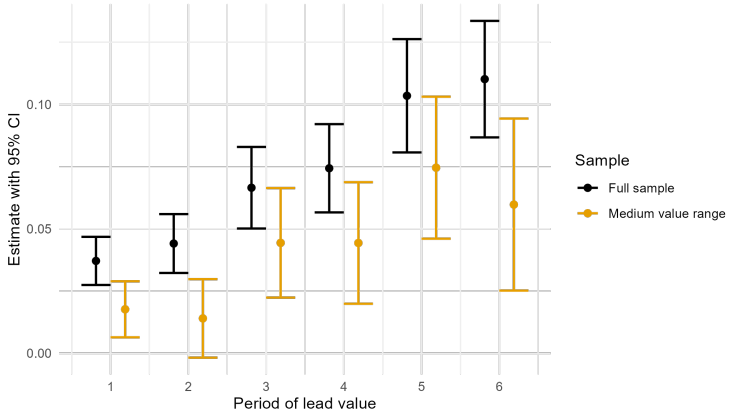
- *Basic setup*: compare future value of human capital with the same amount of human capital, but varying peers
  - Market value should capture all relevant information
- *Position*: market value reflects value for teams, but positions differ in value
- *Player age*: unknown injury potential should be captured by age dummies
- *Leagues and time*: player valuations depend on leagues and time (inflation) $\Longrightarrow$ we include league $\times$ half-season dummies
- *Contracting*: unresolved, but a lot of it should be captured by the fixed effects, and the market value
- *Common support*: key issue, we resolve it later on

Key variables

- **Market value**: market value of the player in the half-season, targets *expected value of a player in a free market*
- **Star/highflyer player**: in the top 5% / 25% of the market values in position
- **Seniors vs. juniors**: players are split by age at 23 years of age
- **Team quality**:
  - Teammates' total market value
  - Team HHI
  - Share of top 5% and 25% players on team
- **Passing**:
  - Passes between a couple (undirected): in counts, categories, or normalized
  - Pass eigenvector centrality (directed): importance in the team's pass network
- **Minutes**:
  - Minutes shared: in shares of total minutes, or normalized
  - Total minutes

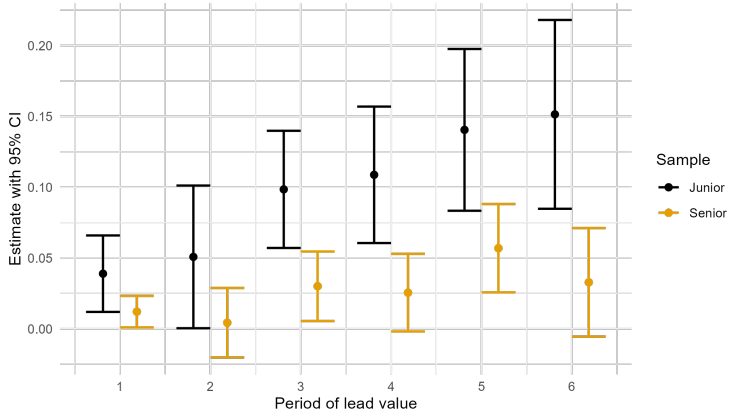
Descriptives

Human capital gain over time: full sample vs. medium value players



Note: Association of market values with the team's total value evolving over the career, in the entire sample and the medium value range.

Heterogeneity: junior vs. senior workers



Note: Association of market values with the team's total value evolving over the career, in the medium value range seniors vs. juniors.

Mechanism: Young players passing with the Stars

Dependent Variable:	log(value$_{t+6}$)			
Model:	(1)	(2)	(3)	(4)
Teammates' total value (Z)	0.270***	0.306***	0.276***	0.301***
	(0.046)	(0.047)	(0.046)	(0.046)
Passes top 5%: in 25-75 percentile	0.125	0.052		
	(0.084)	(0.083)		
Passes top 5%: in 75+ percentile	0.326**	0.147		
	(0.131)	(0.133)		
Passes top 25%: in 25-75 percentile	0.298***	0.175*		
	(0.092)	(0.100)		
Passes top 25%: in 75+ percentile	0.831***	0.513***		
	(0.146)	(0.172)		
Total minutes (Z)		0.234***		0.165***
		(0.060)		(0.054)
Passes top 5% teammates (Z)			0.151**	0.103*
			(0.058)	(0.057)
Passes top 25% teammates (Z)			0.354***	0.261***
			(0.048)	(0.052)
Minutes share top 5% (Z)				
Minutes share top 25% (Z)				
Observations	1,156	1,156	1,156	1,156
R^2	0.391	0.401	0.403	0.408

Note: Junior players in the medium market value range, all teams. Standard errors clustered at position × league × half-season level. FE: position, player age, league × half-season, additional controls of log-value and the no-minutes category for passes. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Mechanism: Young players passing with the Stars

Dependent Variable:	log(value$_{t+6}$)					
Model:	(1)	(2)	(3)	(4)	(5)	(6)
Teammates' total value (Z)	0.270***	0.306***	0.276***	0.301***	0.267***	0.376***
	(0.046)	(0.047)	(0.046)	(0.046)	(0.088)	(0.087)
Passes top 5%: in 25-75 percentile	0.125	0.052				
	(0.084)	(0.083)				
Passes top 5%: in 75+ percentile	0.326**	0.147				
	(0.131)	(0.133)				
Passes top 25%: in 25-75 percentile	0.298***	0.175*				
	(0.092)	(0.100)				
Passes top 25%: in 75+ percentile	0.831***	0.513***				
	(0.146)	(0.172)				
Total minutes (Z)		0.234***		0.165***		0.395***
		(0.060)		(0.054)		(0.045)
Passes top 5% teammates (Z)			0.151**	0.103*		
			(0.058)	(0.057)		
Passes top 25% teammates (Z)			0.354***	0.261***		
			(0.048)	(0.052)		
Minutes share top 5% (Z)					-0.019	0.015
					(0.094)	(0.088)
Minutes share top 25% (Z)					0.143**	0.171***
					(0.065)	(0.062)
Observations	1,156	1,156	1,156	1,156	1,131	1,131
R^2	0.391	0.401	0.403	0.408	0.334	0.396

Note: Junior players in the medium market value range, all teams. Standard errors clustered at position × league × half-season level. FE: position, player age, league × half-season, additional controls of log-value and the no-minutes category for passes. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Mechanism: Young players passing with the Stars

Dependent Variable:	log(value$_{t+6}$)					
Model:	(1)	(2)	(3)	(4)	(5)	(6)
Teammates' total value (Z)	0.270***	0.306***	0.276***	0.301***	0.267***	0.376***
	(0.046)	(0.047)	(0.046)	(0.046)	(0.088)	(0.087)
Passes top 5%: in 25-75 percentile	0.125	0.052				
	(0.084)	(0.083)				
Passes top 5%: in 75+ percentile	0.326**	0.147				
	(0.131)	(0.133)				
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	(0.092)	(0.100)				
Passes top 25%: in 75+ percentile	0.831***	0.513***				
	(0.146)	(0.172)				
Total minutes (Z)		0.234***		0.165***		0.395***
		(0.060)		(0.054)		(0.045)
Passes top 5% teammates (Z)			0.151**	0.103*		
			(0.058)	(0.057)		
Passes top 25% teammates (Z)			0.354***	0.261***		
			(0.048)	(0.052)		
Minutes share top 5% (Z)					-0.019	0.015
					(0.094)	(0.088)
Minutes share top 25% (Z)					0.143**	0.171***
					(0.065)	(0.062)
Observations	1,156	1,156	1,156	1,156	1,131	1,131
R^2	0.391	0.401	0.403	0.408	0.334	0.396

Note: Junior players in the medium market value range, all teams. Standard errors clustered at position × league × half-season level. FE: position, player age, league × half-season, additional controls of log-value and the no-minutes category for passes. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Mechanism: Young players passing with the Stars

- We show results here only for the mid-value young players
- How many passes they make with top players relative to the overall pass distribution between players in the league X time.
- Baseline: 0-25 percentile, omitted controls: FE, no shared minutes, and own value
- Conditional on minutes (without the minutes it is around 50% higher):
  1. Compared to the lowest quartile, top 5% is not significant, larger noisy estimate
  2. With the top 25-5% players, passing in the 25-75 percentiles is assoc. with 17% higher, in the top quartile with 50% higher market value
  3. Measures in units of SD reveal: 1 SD more passing to top-5% is assoc. with 10%, top 25% around 26% market value
  4. Minutes shared: an extra 1SD-unit with top 25% is assoc with around 17% higher value, cond. on total minutes

Skill attributes and teammates for all players

Dependent Variables:	Short pass$_{t+6}$	Ball control$_{t+6}$	Reactions$_{t+6}$	Interceptions$_{t+6}$	Finishing$_{t+6}$	Speed$_{t+6}$
Model:	(1)	(2)	(3)	(4)	(5)	(6)
Own skill$_t$	0.754***	0.808***	0.649***	0.780***	0.790***	0.895***
	(0.012)	(0.011)	(0.013)	(0.013)	(0.012)	(0.011)
Team avg. skill$_t$	0.034***	0.021***	0.126***	0.0004	0.006	-0.001
	(0.004)	(0.004)	(0.012)	(0.004)	(0.004)	(0.007)
Fixed-effects						
position	Yes	Yes	Yes	Yes	Yes	Yes
player age	Yes	Yes	Yes	Yes	Yes	Yes
league X half-season	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics						
Observations	15,046	15,046	15,046	15,046	15,046	15,046
R^2	0.897	0.933	0.475	0.917	0.916	0.802
Within R^2	0.595	0.661	0.433	0.647	0.683	0.657

Note: All players. Standard errors clustered at position × league × half-season level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Skill attributes and teammates for all players

- With 1 unit higher team avg. skill, the 3-year forward value of the own skill is
  1. Short-pass: 0.03 unit higher
  2. Ball control: 0.02 unit higher
  3. Reaction (speed of deciding for an action): 0.13 unit higher
  4. Interceptions, finishing, sprinting speed are all unaffected
  5. We find evidence that for skills that are associated the team's group-level play, the initial avg. skill level is assoc. with higher future skill for a player
- Skills that can be learnt seem to react to peers
- Skills that cannot really be learnt do not: interceptions, finishing or sprinting speed, the latter being obviously the most innate

Evolution of short pass skills

	Short pass (All players)			Short pass (Mid-value players)		
Dependent Variables:	h=2	h=4	h=6	h=2	h=4	h=6
Model:	(1)	(2)	(3)	(1)	(2)	(3)
Short pass	0.899***	0.819***	0.754***	0.872***	0.774***	0.697***
	(0.007)	(0.010)	(0.012)	(0.009)	(0.013)	(0.017)
Teammates' avg. short pass	0.021***	0.028***	0.034***	0.018***	0.018***	0.021***
	(0.003)	(0.003)	(0.004)	(0.004)	(0.005)	(0.006)
Fixed-effects						
position	Yes	Yes	Yes	Yes	Yes	Yes
player age	Yes	Yes	Yes	Yes	Yes	Yes
league X half-season	Yes	Yes	Yes	Yes	Yes	Yes
Observations	25,108	20,051	15,046	14,294	11,871	9,162
R^2	0.957	0.923	0.897	0.948	0.909	0.881
Within R^2	0.828	0.693	0.595	0.774	0.607	0.492

Note: Standard errors clustered at position × league × half-season level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Evolution of short pass skills

- With 1 SD-unit higher team avg. skill, the 1-2-3-year forward value
  1. For all players: 0.02-0.03-0.03
  2. For mid-players: 0.02-0.02-0.02
  3. Improvement is immediate in terms of years, a little bit accumulative only

Skill attributes and teammates, young mid-value players

Dependent Variables:	Short pass$_{t+6}$	Ball control$_{t+6}$	Reactions$_{t+6}$	Interceptions$_{t+6}$	Finishing$_{t+6}$	Speed$_{t+6}$
Model:	(1)	(2)	(3)	(4)	(5)	(6)
Variables						
Own skill$_t$	0.641***	0.695***	0.468***	0.792***	0.762***	0.786***
	(0.028)	(0.025)	(0.032)	(0.032)	(0.027)	(0.024)
Team avg. skill$_t$	0.021	0.013	0.094***	-0.0007	0.002	-0.003
	(0.015)	(0.012)	(0.028)	(0.012)	(0.014)	(0.016)
Fixed-effects						
position	Yes	Yes	Yes	Yes	Yes	Yes
player age	Yes	Yes	Yes	Yes	Yes	Yes
league X half-season	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics						
Observations	1,961	1,961	1,961	1,961	1,961	1,961
R^2	0.811	0.880	0.230	0.899	0.856	0.721
Within R^2	0.426	0.481	0.191	0.617	0.558	0.564

Clustered (league X half-season X position) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Note: Mid-value young players. Standard errors clustered at position × league × half-season level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Skill attributes and teammates, young mid-value players

The young players sample

- Qualitatively similar estimates to mid-players, only significance is lost
- Again: skills that are harder to learn or cannot be learned, are not learned

Short pass skills and passing with the Stars: Young players

Dependent Variable:	Short pass$_{t+6}$			
Model:	(1)	(2)	(3)	(4)
Teammates' avg. short pass	0.045*	0.044*	0.047*	0.047*
	(0.023)	(0.024)	(0.024)	(0.024)
Pass count with top 5%: in 25-75 percentile	0.026	0.030		
	(0.036)	(0.034)		
Pass count with top 5%: in 75+ percentile	0.059	0.068		
	(0.052)	(0.052)		
Pass count with top 25%: in 25-75 percentile	0.020	0.029		
	(0.039)	(0.046)		
Pass count with top 25%: in 75+ percentile	0.181***	0.202***		
	(0.055)	(0.071)		
Total minutes		-0.013		-0.004
		(0.023)		(0.021)
Pass count with top 5% teammates			0.025	0.027
			(0.019)	(0.020)
Pass count with top 25% teammates			0.060***	0.062***
			(0.017)	(0.021)
Minutes shared with top 5% out of total				
Minutes shared with top 25% out of total				
Observations	773	773	773	773
R^2	0.794	0.794	0.791	0.791

Note: Junior players in the medium market value range, all teams. Standard errors clustered at position × league × half-season level. FE: position, player age, league × half-season, additional controls of short pass skill and the no-minutes category for passes. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Short pass skills and passing with the Stars: Young players

Dependent Variable:	Short pass$_{t+6}$					
Model:	(1)	(2)	(3)	(4)	(5)	(6)
Teammates' avg. short pass	0.045*	0.044*	0.047*	0.047*	0.017	0.021
	(0.023)	(0.024)	(0.024)	(0.024)	(0.027)	(0.026)
Pass count with top 5%: in 25-75 percentile	0.026	0.030				
	(0.036)	(0.034)				
Pass count with top 5%: in 75+ percentile	0.059	0.068				
	(0.052)	(0.052)				
Pass count with top 25%: in 25-75 percentile	0.020	0.029				
	(0.039)	(0.046)				
Pass count with top 25%: in 75+ percentile	0.181***	0.202***				
	(0.055)	(0.071)				
Total minutes		-0.013		-0.004		0.056***
		(0.023)		(0.021)		(0.016)
Pass count with top 5% teammates			0.025	0.027		
			(0.019)	(0.020)		
Pass count with top 25% teammates			0.060***	0.062***		
			(0.017)	(0.021)		
Minutes shared with top 5% out of total					0.053*	0.064**
					(0.030)	(0.031)
Minutes shared with top 25% out of total					0.045	0.046
					(0.033)	(0.032)
Observations	773	773	773	773	759	759
R^2	0.794	0.794	0.791	0.791	0.781	0.786

Note: Junior players in the medium market value range, all teams. Standard errors clustered at position × league × half-season level. FE: position, player age, league × half-season, additional controls of short pass skill and the no-minutes category for passes. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Short pass skills and passing with the Stars: Young players

Dependent Variable:	Short pass$_{t+6}$					
Model:	(1)	(2)	(3)	(4)	(5)	(6)
Teammates' avg. short pass	0.045*	0.044*	0.047*	0.047*	0.017	0.021
	(0.023)	(0.024)	(0.024)	(0.024)	(0.027)	(0.026)
Pass count with top 5%: in 25-75 percentile	0.026	0.030				
	(0.036)	(0.034)				
Pass count with top 5%: in 75+ percentile	0.059	0.068				
	(0.052)	(0.052)				
Pass count with top 25%: in 25-75 percentile	0.020	0.029				
	(0.039)	(0.046)				
Pass count with top 25%: in 75+ percentile	0.181***	0.202***				
	(0.055)	(0.071)				
Total minutes		-0.013		-0.004		0.056***
		(0.023)		(0.021)		(0.016)
Pass count with top 5% teammates			0.025	0.027		
			(0.019)	(0.020)		
Pass count with top 25% teammates			0.060***	0.062***		
			(0.017)	(0.021)		
Minutes shared with top 5% out of total					0.053*	0.064**
					(0.030)	(0.031)
Minutes shared with top 25% out of total					0.045	0.046
					(0.033)	(0.032)
Observations	773	773	773	773	759	759
R^2	0.794	0.794	0.791	0.791	0.781	0.786

Note: Junior players in the medium market value range, all teams. Standard errors clustered at position × league × half-season level. FE: position, player age, league × half-season, additional controls of short pass skill and the no-minutes category for passes. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Short pass skills and passing with the Stars: Young players

- Focus on short passes, the most direct variable to pass counts
  1. Conditional on own skill, team skill, FE
  2. Passing with the top 25% players being in the top quartile is assoc. with 0.20 SD-unit higher skill level (twice the size of the mid-value only)
  3. Passing measured in units of standard deviation as well, 1 SD-unit higher passing with top-25% is assoc. with around 0.06 SD-unit higher short-pass-skill (0.03 SD-unit higher but not significant for the top-5%)
  4. But: sharing minutes with the top5% rather is assoc. with higher short-pass skill in the future. We do not know, one possible reason: being exposed to high-level moments, or more exposure to people who evaluate players and overrate them?

Placebo regressions for skills

Dependent Variables:	Short pass$_{t+6}$	Finishing$_{t+6}$	Interceptions$_{t+6}$	Ball control$_{t+6}$	Reactions$_{t+6}$	Speed$_{t+6}$
Model:	(1)	(2)	(3)	(4)	(5)	(6)
Short pass	0.705***	0.069***	0.045***	0.030	0.136***	-0.008
	(0.021)	(0.018)	(0.017)	(0.020)	(0.036)	(0.026)
Teammates' avg. short pass	0.032***	0.013*	0.008	0.016**	0.089***	0.026
	(0.009)	(0.008)	(0.008)	(0.006)	(0.028)	(0.015)
Pass count with top 5%	0.010	0.001	0.002	0.011	0.033**	-0.030***
	(0.008)	(0.007)	(0.006)	(0.007)	(0.016)	(0.011)
Pass count with top 25%	0.023***	0.010	0.007	0.012*	0.028	0.032**
	(0.009)	(0.009)	(0.006)	(0.006)	(0.021)	(0.013)
Total minutes	0.008	0.002	0.014**	0.004	0.110***	0.013
	(0.007)	(0.007)	(0.007)	(0.006)	(0.020)	(0.013)
Finishing		0.763***				
		(0.016)				
Interceptions			0.798***			
			(0.024)			
Ball control				0.751***		
				(0.025)		
Reactions					0.460***	
					(0.033)	
Sprint speed						0.884***
						(0.018)
Observations	3,509	3,509	3,509	3,509	3,509	3,509
R^2	0.893	0.911	0.919	0.928	0.336	0.791

Note: Players in the medium market value range, all teams. Standard errors clustered at position × league × half-season level. FE: position, player age, league × half-season, additional controls of short pass skill and the no-minutes category for passes. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Placebo regressions for skills

- Do the right skills react to more passing interactions?
  1. Conditional on own skill, team skill, FE, measured in units of SD
  2. Passing measured in units of standard deviation as well, 1 SD-unit higher passing with top-25% is assoc. with around 0.02 SD-unit higher short-pass-skill (0.03 SD-unit higher but not significant for the top-5%), the team skill avg also seems to matter still
  3. Passing does not relate to the others, except for reactions which makes sense (top5% with around 0.03 units), and weirdly speed ($\pm$ 0.03)