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Environmental Unfamiliarity and Work Performance: Evidence from Chinese Basketball during COVID-19*

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Abstract

This paper examines the causal impact of the working environment on worker performance and explores the underlying mechanisms. Specifically, we use games from the Chinese Basketball Association (CBA) as our research sample and exploit the "neutral-venues policy" induced by COVID-19 to address endogeneity concerns. Sports teams offer an ideal research setting, as each team competes both at home (familiar environment) and away (unfamiliar environment). The "neutral-venues policy", which relocated all games to neutral sites without crowds, provides a quasi-experimental setting. We find that when teams no longer had to compete in their opponents' courts, their performance significantly improved. This improvement is not driven by changes in referee behaviour, but rather by the absence of home crowd pressure and the avoidance of competing in regions with extreme cold temperatures. Furthermore, we show that even strong teams are unable to mitigate the negative impact of environmental disruptions. This paper provides important general implications by offering causal evidence on how environmental conditions affect productivity when workers lack environmental familiarity.

Keywords: Environmental unfamiliarity; Worker performance; Basketball; Home advantage; COVID-19; neutral-venues
JEL Codes: D91, L83, Q54, Z20

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1 Introduction

Workers' performance is often closely linked to the familiarity of their working environment. In practice, many firms strive to create familiar and supportive settings for their employees, even during business travel, to enhance productivity. A recent article by the Financial Times (2025) explores what constitutes a good workplace and how to boost employee performance.[1] It highlights that many top-ranked companies emphasize the importance of providing a positive working environment, promoting employee agency, and allowing flexibility. This emphasis is echoed by firms in practice. For instance, companies like Swanton Welding believe that fostering a family-like atmosphere not only improves employee performance but also benefits employers.[2] Similarly, professional consulting and human resources firms such as McKinsey[3] and Michael Page[4] also recognize the workplace environment as a key factor influencing both employee productivity and well-being. From the academic perspective, some studies attribute this to local supportive factors; for instance, individuals operating businesses near their hometowns often receive more support and preference from local residents (Morey, 2016; Coşar et al., 2018; Chen et al., 2022). Others highlight the role of institutional behaviours, such as tariffs and bureaucratic regulations (Herz and Varela-Irimia, 2020; Liu et al., 2022; Mulabdic and Rotunno, 2022; Turrini and van Ypersele, 2010; Zhao et al., 2022). Moreover, several studies stress the impact of natural environmental factors, including climate and temperature unfamiliarity (Zhang et al., 2023; Somanathan et al., 2021; Lai et al., 2022; Cook and Meyes, 2020; Rao et al., 2021). Despite these insights, the literature has not reached a consensus on the causal impact of the environmental unfamiliarity on one's

[1]https://www.ft.com/content/5b2f678d-953f-4826-bbf5-3651ea490ef8
[2]https://swantonweld.com/the-benefits-of-a-family-like-work-environment/
[3]https://www.mckinsey.com/careers/essential-functions-firm-management
[4]https://www.michaelpage.co.uk/our-expertise/human-resources/importance-adopting-dynamic-working-environment

performance, nor on what is the interplay between these potential contributors.

Building on the existing literature, this paper explores the following questions: (1) What is the causal impact of working in an unfamiliar environment on individual performance, and what are the underlying mechanisms? (2) Are the effects driven solely by supportive behaviours from local residents and authorities, or also influenced by natural factors? (3) Can individuals with stronger abilities overcome the impact of unfamiliarity? Nevertheless, from a causal inference perspective, identifying the impact of environmental unfamiliarity on performance is challenging due to endogeneity issues. There could be self-selection issues: individuals or firms may self-select into familiar environments where they can perform better or receive more support. Moreover, it could also suffer from reverse causality: unproductive individuals may be more difficult to adapt the environment. Besides, omitted variable bias may arise if unobserved confounders (such as psychological resilience or adaptability) influence both environmental choices and work performance. To estimate the causal impact of unfamiliar environments on productivity, and to further explore the moderating role of personal characteristics, it is essential to address these endogeneity concerns.

Sports athletes provide an excellent target group for studying the effects of environmental unfamiliarity on performance, due to the unique structure. Firstly, in many sports, particularly ball games within a competition season, teams are required to play both at their home venues (as home teams) and at opponents' venues (as away teams). The team is still the team itself, but the only difference is its competing environment. Indeed, it is a well-established phenomenon that teams tend to perform worse when playing away from their home court (i.e., away disadvantage or home advantage). Secondly, in most professional leagues of ball games, the match schedule and opponent assignments are arranged by an organising committee. This means that teams typically do not choose their opponents or the locations of their matches.[5] Thus, this minimise the potential selection bias from teams. However, despite this advantage, endogeneity concerns are not entirely eliminated due to some confounding factors (e.g., a superstar player). On the one hand, a superstar player helps to improve the performance of the team; on the other hand, this superstar also attracts a large number of fans which reduce the unfamiliarity of the environment.

The "neutral-venues policy" implemented by the Chinese Basketball Association (CBA) during the COVID-19 pandemic provides an excellent opportunity to address the issues discussed above. In response to the pandemic, the CBA relocated all games to neutral venues with nearly no crowds from June 2020 to January 2023, retaining the nominal home-away system. As a result, teams that would normally have travelled and competed in opponents' courts (i.e., as away teams) no longer faced unfamiliar environments or pressure from home crowds. Given that the COVID-19 outbreak was an exogenous shock, the resulting regulatory intervention in sports can be viewed as a quasi-natural experiment. For each team, we can compare the difference in their performance between home and away games before COVID-19, to the difference in their performance between home and away games after COVID-19. We expect that, when playing as away teams, the teams would perform better under the"neutral-venues policy", as it effectively removed the traditional "away disadvantage" due to environmetal unfamiliarity.

If performance improvements were observed for away teams since the implementation of "neutral-venues policy", one straightforward explanation is the absence of a supportive home crowd due to the strict regulation of COVID-19. However, this raises a further question: is the empty stadium the only factor driving this improvement for away teams? We propose two additional mechanisms. Firstly, we hypothesise that referee decisions may also be affected.

[5]This is in contrast to sports like boxing or mixed martial arts, where fighters can sometimes choose their opponents.

Specifically, under normal conditions, referees may feel social pressure from home fans and make biased calls in favour of the home team (Bryson et al., 2021). In the absence of such crowd pressure, referees may behave more neutrally, thus indirectly benefiting the away team. Secondly, we hypothesise that when away teams do not need to face extreme weather, especially in northern regions during winter, their performance can be improved. While basketball is played indoors, external weather still affects athletes' daily training, travel, and even fan support. In particular, inadequate heating in CBA stadiums is common, as highlighted by previous studies and media reports (Bandao Morning Post, 2011; China Daily, 2012; Daily News Post, 2012; Huashang Morning Post, 2012; Qingdao Evening Post, 2012; Modern Gold Post, 2013; Xinmin Evening News, 2013).[6] China's vast geographic diversity offers a unique setting to examine this effect, allowing us to observe what happens when teams from warmer regions no longer have to compete in extremely cold northern areas.

We manually collected data from the CBA's official website, obtaining 3,879 match records from 2014 to 2024 across 19 teams, allowing us to study how the "neutral-venues policy" affects match outcomes. To account for potential unobserved confounders, such as team quality, that may vary across seasons, we include team-season fixed effects. To further control for the characteristics of competing team pairs, including historical rivalries (which may reflect countering play styles) or the distance between their home courts (which may reflect travel-related fatigue), we incorporate team-pair fixed effects. This approach is inspired by the gravity model literature (Yotov, 2016), enabling our study to contribute methodologically by addressing the above confounders that have often been overlooked in the existing sports literature.

[6]See also the discussion of the insufficient heating supply in CBA stadium from Zhihu (the online knowledge forum in Chinese, which is similar to Quora): https://www.zhihu.com/question/266935315 and https://www.zhihu.com/question/305709427/answer/560348760

Our empirical findings indicate that environmental unfamiliarity negatively affects team performance. During the "neutral-venues policy" period (June 2020 to January 2023), away teams exhibited significant performance improvements, including higher self-productivity in scoring, stronger team cooperation, and fewer mistakes. However, this improvement vanished immediately after the policy was removed in February 2023. Furthermore, we identify referee decisions as a potential contributor to the away disadvantage: prior to the policy, referees called more fouls against away teams and awarded more free throws to home teams. Notably, this bias persisted even during the "neutral-venues" period, suggesting that referee behaviour is not driven by audience pressure. In addition, we find that unfamiliar natural environments also played a key role. Specifically, away teams that would have competed in northern regions during winter showed substantial performance improvement under the "neutral-venues policy". However, when required to compete in an unfamiliar environment, even strong teams are unable to overcome the negative impact of environmental disruptions. The above empirical findings are robust across multiple specifications and placebo tests.

Our findings carry important implications for understanding worker performance. Firstly, using a comprehensive CBA dataset and a rigorous empirical strategy, we show that environmental unfamiliarity has a negative causal impact on performance, including reduced self-productivity, weaker team cooperation, and more mistakes. From a general perspective of human resource management, firm managers and directors should take this into account when assigning employees to unfamiliar work settings. Secondly, we show that the decline in productivity under unfamiliar conditions can stem from multiple sources, including reduced local support, potential unfair treatment from the authorities of an unfamiliar environment, and challenges posed by natural environmental conditions. These factors should be carefully considered and addressed to mitigate adverse effects on performance. Thirdly, from a societal perspective, it is essential to create inclusive and neutral frameworks that promote fair competition and provide support for workers from diverse backgrounds.

The remainder of this paper is organised as follows: Section 2 reviews related literature, highlighting our contributions. Section 3 explains the institutional background and the "neutral-venues" policy of CBA. Section 4 presents data descriptions, introduces variables and details the empirical strategy. Section 5 illustrates the baseline results, mechanisms, and contributing factors. Section 6 focuses on the heterogeneous impact with respect to team strength. Section 7 shows robustness checks. Finally, Section 8 concludes.

2 Literature review

Human behaviours and productivity are significantly shaped by environmental factors, encompassing both natural and social settings (Zivin and Neidell, 2012; He et al., 2019; Albarracín and Dai, 2024). Regarding the natural environment, empirical evidence highlights the importance of temperature. Lai et al. (2022) demonstrate that both extreme hot and cold temperatures exert immediate negative impacts on consumption patterns, though human adaptation can effectively attenuate these effects. Cook and Heyes (2020) demonstrated that exposure to outdoor cold temperatures can significantly impair indoor cognitive performance, even when indoor climate control systems are in operation. In terms of social forces and environmental influences, the existing literature has shown substantial impacts on human behaviour and decision-making (Reade et al., 2020; Becker and Murphy, 2000), as well as on productivity (Bandiera et al., 2008; Bartel et al., 2014; Bah and Fang, 2015). Through experimental analysis, Charness et al. (2007) highlight that the social environment (i.e., an individual's membership within a crowd) significantly influences one's social behaviours.

Among different areas, sports offer diverse settings that reveal how both natural and built environments shape human behaviour and activity patterns (Bryson et al., 2021). Numerous studies have shown that athletes' or sports teams' performances are sensitive to the gaming environments. For instance, teams playing on their home courts are more likely to win, while away teams competing on unfamiliar grounds face a competitive disadvantage (Sanchez et al., 2007). This phenomenon is often explained by the supportive audience, which might boost the performance of home teams while also imposing a relatively negative performance effect on the visiting teams (Ponzo and Scoppa, 2018; Boudreaux et al., 2017; Thrane, 2024).[7] These additional home advantages granted from support of locals are often also observed in other areas. For example, Coughlin and Novy (2013) show that intrastate trade in the U.S. dominates both inter-state trade and international trade with foreign partners. Cosar et al. (2018) demonstrate that consumers exhibit a marked preference for domestic automobile brands, particularly those with local production facilities. Chen et al. (2022) find strong home preference in that patients prefer to consult doctors located in the same prefecture or region when using online medical services.

The underperformance of players or teams in unfamiliar environments is also frequently linked to institutional biases. In professional sports, research has consistently documented home advantage effects stemming from referee bias. The referee tends to make decisions in favor of the home team (Ponzo and Scoppa, 2018), which is likely induced by the pressure from the local crowds (Boudreaux etal., 2017; Dohmen, 2008). Bryson et al. (2021) find that the reduced crowds, driven by COVID-19 regulations, result in fewer cards being awarded to away teams by the referee. This is also supported by Reade et al. (2021) and van Ours (2024), who find that empty stadiums result in away teams receiving fewer yellow cards

[7] However, Harb-Wu and Krumer (2019) identify a "choking under pressure" effect, where biathletes' precision suffered at home.

and cautions. Similar institutional biases manifest in other domains. In international trade, tariffs are one of the most common tools governments use to protect domestic producers by restricting imports (Fajgelbaum et al., 2019). Local governments often adopt protectionist policies that favor local firms, imposing non-tariff barriers and additional costs on outside competitors (Mulabdic and Rotunno, 2022).

Lastly, the natural environment also affects sports teams' performance and productivity. Piccino and van Ours (2024) find that the performances of professional tennis players decrease with the ambient temperature. However, the temperature in the previous game mitigates this effect, indicating an adaptation in the short-run. Recent research shows that external conditions can affect indoor environments, impacting individuals' performance (Cook and Meyes, 2020). A growing body of literature highlights how outdoor environments impact productivity in indoor activities. For instance, optimal temperatures are crucial for indoor sports like basketball, with extreme cold affecting muscle flexibility, cognitive ability, and physical resilience (Rao et al., 2021). Zivin et al. (2020) also demonstrate that high temperatures negatively affect student exam performance. Within this strand, other studies highlight the detrimental effects of air pollution on indoor performance, with evidence from eSports players (Mo et al., 2023) and pear packers (Chang et al., 2016).

3 Background

CBA represents China's premier professional men's basketball league and stands as Asia's most prominent basketball competition. Since the 2014-15 season, the league has maintained a twenty-team structure, with teams distributed across China's major geographic and climatic regions. Before COVID-19, it operated under a home-away system that required away teams to travel to the home venues of their opponents. However, starting in June 2020 of the 2019-2020 season, the CBA implemented the "neutral-venues policy", which relocated all games to neutral venues without crowds. This "neutral-venues policy" was due to the strict COVID-19 restrictions, which was in effect until January 2023 (2022-2023 season).[8] The choice of these neutral venues was primarily based on local COVID-19 control measures.[9] Figure 1 displays the location of the venues during regular times and the neutral sites during COVID-19. Notably, while all games were relocated to neutral venues following this policy implementation, the league maintained the nominal designation of home and away teams. This setup allows us to compare home and away team performance before and after the policy change.

Compared to leagues in other countries, such as Bundesliga, NBA, etc., CBA implemented more stringent COVID-19 restrictions, without audience attendance. Combined with China's significant climatic diversity, this provides an ideal quasi-experiment to examine the effects of environmental unfamiliarity on work performance and explore the mechanisms behind them. Moreover, the duration of the restrictions in China's CBA was much longer than similar policies in other countries (i.e., "neutral-venues policy" was in effect from June 2020 to January 2023, approximately 2.5 years), allowing us to investigate the long-term effects of environmental unfamiliarity and to examine what happened when the policy was lifted.

[8]See CBA (2020, 2022); General Administration of Sport of China (2020a, 2020b, 2023) for details.

[9]For example, the second stage of the 2021-22 season was initially planned in Zhuji, a county-level city in Shaoxing, Zhejiang. However, due to the worsening local epidemic conditions, the CBA moved all games to Changchun, where epidemic control was more effective (CBA, 2021).

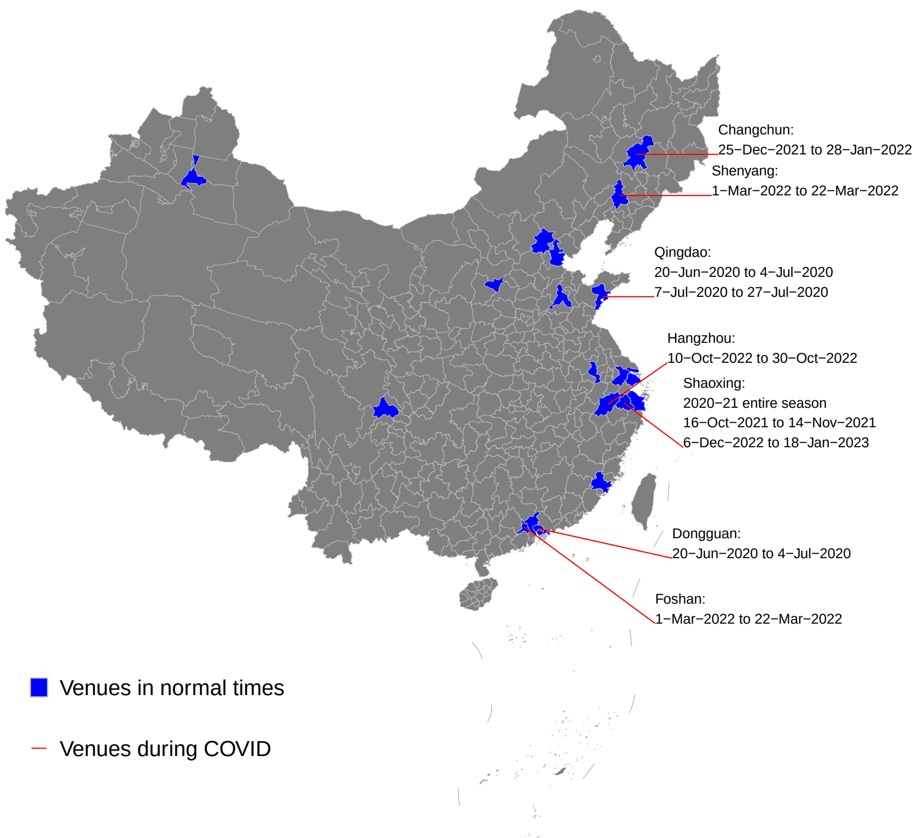


Figure 1: Venues during normal times and during the COVID-19 pandemic

4 Data and method

4.1 Data and variables

From the official CBA website, we manually collect information on 3,879 CBA games played during the 2014-15 to 2023-24 season by 19 teams.[10] The reason for choosing the 2014-15 season as the starting point is that it marks a significant structural change in the CBA. Each observation in our data set contains information on a particular game and the statistics of the participating teams, such as game results, points, fouls, etc. To study the impact of the natural environment, we use the temperature data collected from *China Statistical Yearbook* (NBS, 2015-2023).

Following Clarke and Norman (1995) and most of the literature, our dependent variables Y_{ijt} include (1) $Away\ win_{ijt}$, a dummy representing whether the away team wins this game or not. As noted in Table 2, the average winning rate of away teams is 40.2 percent across these ten seasons, during which their winning rates were 36.8 and 47.2 percent in periods with and without the neutral-venues policy, respectively; (2) $Net\ points_{ijt}$, which indicates the net points between away and home teams (away points minus home points). Therefore, positive net points mean that the away team wins. The average net points are around -3.2 points for the whole sample.

Our key explanatory variable is $Neutral_t$, a dummy equal to one if the game is played in neutral venues (under "neutral-venues policy") and zero when it is played at the home team's venue (without "neutral-venues policy").

Aligning with most of the relevant literature, e.g., Price and Wolfers (2010), we use the information on fouls called and free-throw attempts (FTA) for both away and home

[10]The Ningbo Rockets (formerly the Bayi Rockets) were not included due to a lack of historical data.

teams to measure referees' behaviour. Specifically, a foul refers to a violation of basketball rules, judged by the referee (i.e., a punishment). FTA refers to the number of free throw opportunities obtained due to a specific type or number of fouls made by the opponent (i.e., a reward). These two metrics are tied to referees' subjective decision-making during games.

To examine how individual performances are affected by environmental unfamiliarity, we categorize team performance metrics into three dimensions related to work performance: self-productivity, team cooperation performance, and mistakes. These are presented in Table 1 below.

Table 1. Categories of team performance

Work performance dimensions	Self-productivity	Collaboration	Work errors
Team metrics	Rebounds, Steals, Blocks, Field goals, Three-pointers made, Free-throws	Assists	Turnovers

Rebounds: the possession of the ball obtained by a player after a missed shot.
Steals: players directly intercept the opponent's pass or dribbling, resulting in the transfer of possession of the ball.
Blocks: when a defender legally deflects or stops an offensive player's shot attempt from going into the basket.
Field goals: all successful shot during the game excluding free-throws.
Three-pointers: all successful three-point shot during the game.
Free throws: successful unguarded shots made by a player from the free throw line after being fouled or violated.
Assists: assists are awarded to players who make a direct pass leading to a goal by a teammate.
Turnovers: players lose possession of the ball before attempting a shot, due to a mistake.

Additionally, in order to test the hypothesis that the performance of away teams is affected by the extreme weather of the home team's location, we use $Freeze_i$, which is a binary variable representing home teams from regions classified as part of the severe cold zone. The classification is based on the criteria from NBS. (2015-2023), Yang et al. (2023) and official temperature zone information.[11]

[11] Since we classify teams based on their regional temperature, we also account for changes in team locations across seasons. Some teams experienced changes in their home-court cities. For instance, Beijing Royal Fighters were based in Chongqing during 2014-15 season but later relocated to Beijing, and no team is currently situated in Chongqing.

Furthermore, to explore whether those strong teams can overcome the negative impact of environmental unfamiliarity, we use three measures for team strength: (1) the binary variable $Champion_i$, which indicates whether an away team had won championship during 2014 to 2019; (2) the binary variable $Finalist_i$, which takes the value of one for away teams that had played in the CBA finals between 2014 and 2019 and zero otherwise; (3) the average rank $Rank_i$ of the away team among 2014 to 2019. Table 2 displays the summary of statistics.

Table 2. Summary statistics.

Variable	Obs	Mean	Std. Dev.	Min	Max
Away win	3,879	0.402	0.490	0	1
Net points	3,879	-3.233	16.17	-60	55
Neutral	3,879	0.320	0.467	0	1
Season	3,879	5.733	2.840	1	10
Year	3,879	2,019	2.960	2,014	2,024
Away foul	3,879	23.52	5.020	5	49
Away free throw attempts	3,879	23.71	7.677	4	61
Home foul	3,879	23.17	4.846	2	48
Home free throw attempts	3,879	24.78	8.103	3	65
Freeze	3,879	0.157	0.364	0	1
Champion (2014-2019)	3,879	0.262	0.440	0	1
Finalist (2014-2019)	3,879	0.315	0.465	0	1
Rank (2014-2019)	3,879	10.051	4.488	2.2	17

4.2 Empirical strategy

We start by estimating the following model

$$Y_{ijt} = \alpha_0 + \alpha_1 Neutral_t + \gamma_{is} + \theta_{js} + \sigma_{ij} + \epsilon_{ijt} \tag{1}$$

where i, j, t and s denote the away team, the home team, the match date and the season respectively. Our main variable of interest is the $Neutral_t$, which takes the value of one for games played in neutral venues and zero for games that occurred in the home teams' location. We include several sets of fixed effects to capture the unobserved confounding factors.[12] γ_{is} and θ_{js} control for the season-specific characteristics of the away and home teams, respectively.[13] This approach allows us to control not only for the time-invariant factors, such as the team tradition, fan enthusiasm, geographical factors, etc., but also for the seasonal variation of the team quality, form and fitness levels, ownership and investment, etc. Inspired by the trade literature (e.g., Yotov et al., 2016), we add team-pair fixed effects σ_{ij}, which captures the features of the competing pair, such as the geographical distance the teams have to travel before the match, whether it is a derby game within a province or city, etc. An extra benefit of including the team-pair fixed effect is that it implicitly controls for the relative team quality and relative playing style between two competing teams. Weaker teams often struggle against historically stronger opponents but may compete more effectively against teams of similar strength. We also take into account the directional team-pair fixed effect. For instance, for the same team pair, when the home team is different, the away team's means of transportation may also be different. Similarly, players may react differently to travelling from hot to cold areas compared to travelling from cold to hot areas.

The application of the above-mentioned fixed effects minimises the endogeneity arising from incorporating actual controls for team quality, such as team rank, whether a team has all-star/national team players, game-level statistics, etc., as they might be affected by the outcome variables. Therefore, in baseline regression, we prioritize the use of fixed effects to

[12]To address potential omitted variable bias (e.g., geographical factors and individual heterogeneity), as discussed in Dawson et al. (2023) and Gschwend and Krumer (2021), our study extends prior methodologies (Genakos and Pagliero, 2012, 2015; Krumer and Lechner, 2017) by implementing comprehensive fixed effects to control for confounding factors.

[13]Note that these two-way interactive fixed effects automatically account for individual fixed effects of each of the two dimensions.

capture team quality. For robustness, we also use some control variables like the previous season' ranking instead of fixed effects to proxy for team quality. The results remain robust and are available upon request. We cluster standard errors at the level of the team pair to allow for the auto-correlation of errors within any team pair.

To ensure the robustness of our results, we adopt an alternative difference-in-differences like method, following Ponzo and Scoppa (2018), Fischer and Haucap (2021), and Scoppa (2021). Specifically, rather than treating each game as an observation, we consider each team's record in a game as one observation. In other words, each game record generates two observations: one for the home team and one for the away team. We then include a dummy variable $Away_{k,t}$ (i.e., whether this team k played as an away team in date t), a dummy variable $Neutral_t$, and their interaction term. Considering there could exist a disadvantage for away teams, this empirical strategy allows us to explore if such disadvantage can be moderated by the implementation of "neutral-venues policy". We provide the estimated results for below regression Equation 2 in the Section 7 as a robustness check.

$$Y_{k,t} = \alpha_0 + \alpha_1 Away_{k,t} + \alpha_2 Neutral_t + \alpha_3 Away_{k,t} * Neutral_t + \gamma_{is} + \theta_{js} + \sigma_{ij} + \epsilon_{k,t} \qquad (2)$$

5 Main results

5.1 The overall effect of "neutral-venues policy"

Table 3 presents the results of our baseline regressions with different outcome variables in each panel. In panel A, the dependent variable is a binary indicator of whether the away team won a given match. Column (1) includes season, home team, and away team fixed effects. The coefficient for *Neutral* is 0.157, suggesting that the probability of winning away games increased by 15.7 percentage points when games were played at neutral sites without audiences. In columns (2) through (4), we gradually add more fixed effects to capture additional confounding factors. Column (2) controls for team-by-season fixed effects, and the last two columns take into account the team-pair fixed effects. By column (4), the coefficient for *Neutral* increases to 0.174, indicating a more pronounced positive impact, with winning rates of away teams increasing by 17.4 percentage points under the neutral-venues policy with no crowds.

In Panel B, our dependent variable becomes the net points between away and home teams (i.e., away points minus home points), using the same fixed effects as those in Panel A. As shown in column (8), the net points increased by around five points when playing in neutral venues with no crowds.

To explore dynamic effects over time, we use the 2014-2015 season as our reference period and apply an event-study methodology to analyse the neutral-venues policy's impact. The results are displayed in Figure 2. As shown, neither the away-winning rate nor the away-home point differential during normal seasons—when games are played at home teams' venues—significantly differs from those in the baseline season. However, following the shift to neutral venues without audiences in the 2019-20 season, a significant deviation from the 2014-15 season gradually emerges. Following the return to the home-away system in the third stage of the 2022-23 season, the difference becomes insignificant again.

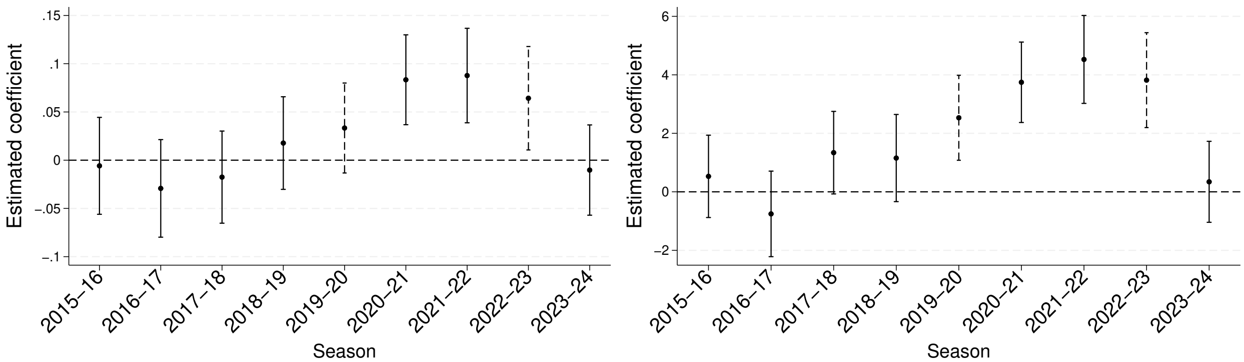
Our findings are consistent with broader sports literature, such as Ponzo and Scoppa (2018) and Thrane (2024), which show that audience presence is an important source of home advantage. Additionally, by leveraging the stricter and more prolonged neutral venue policy employed in the CBA, we validate its persistence and mitigate short-term fluctuations.

Table 3. Effect of playing in neutral venues on home advantages.

Panel A	Away win			
	(1)	(2)	(3)	(4)
Neutral	0.157***	0.176***	0.177***	0.174***
	(0.035)	(0.032)	(0.033)	(0.033)
Observations	3,879	3,879	3,879	3,879
Adjusted R-squared	0.211	0.327	0.324	0.319
Panel B	**Net points**			
	(5)	(6)	(7)	(8)
Neutral	4.876***	5.298***	5.160***	4.966***
	(1.114)	(0.996)	(1.027)	(1.032)
Observations	3,879	3,879	3,879	3,879
Adjusted R-squared	0.275	0.423	0.422	0.417
Fixed effects:				
Season	Y	-	-	-
Home team	Y	-	-	-
Away team	Y	-	-	-
Season-home team	-	Y	Y	Y
Season-away team	-	Y	Y	Y
Non-directional team pair	-	-	Y	-
Directional team pair	-	-	-	Y

Robust standard errors clustered at non-directional pair level are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

(a) Away win (b) Net points



Note: neutral-venues policy started and ended during the season of 2019-20 and 2022-23 respectively, thus games in home-away settings and held in neutral venues are both included in these two seasons. 2014-15 season is the reference group. Home team, away team and directional team pair fixed effects are included. We report 90% confidence intervals. The robust standard errors are clustered at the non-directional team-pair level.

Figure 2: Regression of season dummies

5.2 The effect on different performance dimensions of teams

To examine how environmental unfamiliarity influences distinct behavioural patterns of individuals, we classify away teams' statistics into three dimensions: (1) self-productivity (measured by rebounds, steals, blocks, field goals, three-pointers, free-throws), (2) collaborative performance (measured by assists), (3) and error numbers (measured by turnovers). We then estimate whether these indicators are affected by the introduction of a neutral-venues policy. Our analysis employs net-dependent variables, calculated as away-team performance metrics minus home-team ones, to isolate the relative performance of away teams.

As demonstrated in Table 4, the relative steals, blocks, field goals, and three-pointers of away teams significantly improve under the neutral-venues policy. Meanwhile, the relative number of assists also significantly improves. Conversely, the relative turnovers decrease. In other words, these findings suggest that operating in unfamiliar environments leads to a marked decline in work efficiency and team coordination, coupled with elevated errors.

Table 4. The impact of environmental unfamiliarity on individual performances

Dependent variable	(i) Task execution						(ii) Collaborations	(iii) Errors
	Rebounds	Steals	Blocks	Field goals	Three-pointers	Free-throws	Assists	Turnovers
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Neutral	0.127	0.684**	0.864***	2.093***	0.824**	-0.044	2.767***	-1.516***
	(0.673)	(0.318)	(0.198)	(0.458)	(0.367)	(0.535)	(0.490)	(0.376)
Observations	3,879	3,879	3,879	3,879	3,879	3,879	3,879	3,879
Adjusted R-squared	0.235	0.168	0.137	0.333	0.167	0.121	0.303	0.203

Season-home-team, season-away-team, and directional team-pair fixed effects are included in all specifications. All dependent variables represent net values (away-team minus home-team performance). *** p<0.01, ** p<0.05, * p<0.1.

5.3 Referee's behaviours

Subsequently, we raise several follow-up questions. Whether referee decisions are biased against away teams while playing in home teams' venues? Do referees make more neutral decisions when they are not under pressure from supportive crowds?

To answer these questions, we first compare the referee-related variables from the perspective of descriptive statistics. As shown in the first three columns of Table 5, when games were played in normal settings (i.e., home-team setting), referees called significantly more fouls on away teams than on home teams. Meanwhile, referees awarded significantly fewer free throws to away teams compared to home teams. These differences suggest referees potentially favour home teams when games happen in home-team venues. When moving to "Neutral-venues setting", as shown in column 4 to 6 in Table 5, the referees still place more fouls on away teams and reward more FTAs to home teams, although the the magnitude and significance slightly reduced.

To test it with more reliable empirical strategy, we estimate Equation 3 to see whether these referee-related factors $Referee_{ijt}$ (foul and FTA) have been affected by the neutral-venues policy.

Table 5. Mean value of referee-related variables and corresponding test results with and without neutral-venues policy

	Normal settings			Neutral venues		
	Away (1)	Home (2)	P value (3)	Away (4)	Home (5)	P value (6)
Fouls	23.34	22.97	[0.00]	23.91	23.60	[0.05]
FTA	23.57	24.95	[0.00]	24	24.43	[0.13]

We present the corresponding P value (in brackets) for the t-test with the null hypothesis being *Away−Home =0*.

$$Referee_{ijt} = \beta_0 + \beta_1 Neutral_t + \gamma_{is} + \theta_{js} + \sigma_{ij} + \epsilon_{ijt} \tag{3}$$

As illustrated by Table 6 below, even moving to a neutral venue without a supportive audience for home teams, the behaviour of referees does not change. This indicates that the biased behaviours of referees were not driven by the social pressure from the supportive audience. Our results differ from studies like Bryson et al. (2021) and Thrane (2024), which argue that referee behavior depends on crowd-induced public pressure.

Table 6. The impact of neutral-venues policy on referee-related variables

Dependent variable	Fouls			FTA		
	Away (1)	Home (2)	Away-Home (3)	Away (4)	Home (5)	Away-Home (6)
Neutral	-0.158	-0.103	-0.056	-0.301	-0.487	0.186
	(0.333)	(0.316)	(0.364)	(0.547)	(0.568)	(0.637)
Observations	3,879	3,879	3,879	3,879	3,879	3,879
Adjusted R-squared	0.311	0.299	0.174	0.176	0.176	0.138

Season-home-team, season-away-team, and directional team-pair fixed effects are included in all specifications. The robust standard errors clustered at non-directional pair level are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

5.4 Natural factors

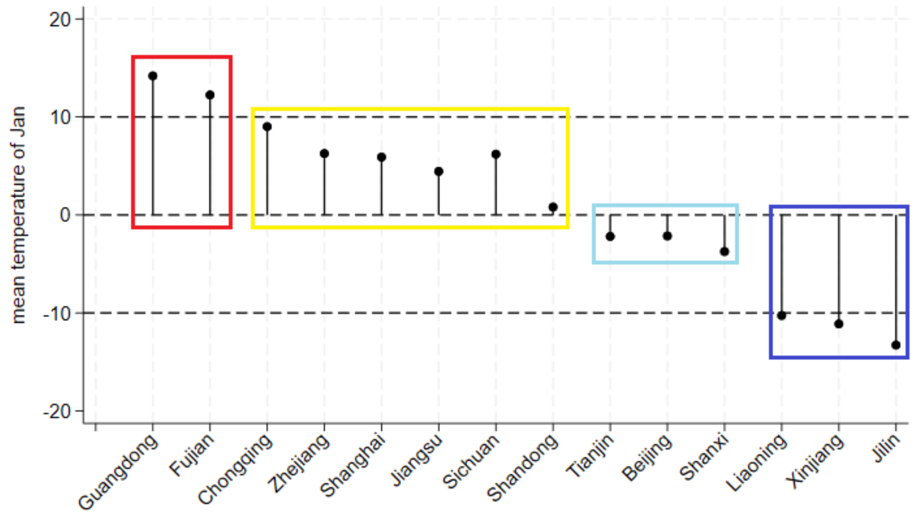
Beyond human factors (audience and referee effects), does the natural environment also play a role? Based on extensive anecdotal evidence from news reports and player accounts, CBA away teams competing in extreme cold regions during winter experience significant physical discomfort and performance challenges, exacerbated by inadequate heating systems in CBA stadiums (China Daily, 2012; Daily News Post, 2012; Xinmin Evening Post, 2013; Dongguan Daily Post, 2020; CBA, 2023). To what extent does low temperature affect away teams' performance?

We focus on low temperatures rather than high temperatures, as the CBA off-season coincides with summer. The 20 CBA teams are dispersed across China, where climates vary significantly. Figure 3 shows the average January temperatures for each province, calculated using data from the *China Statistical Yearbook* (NBS, 2014-2019).[14] Temperatures in Xinjiang, Jilin, and Liaoning are distinctly lower than in other regions, averaging below minus ten degrees Celsius. Additionally, because the monthly average temperature from the *China Statistical Yearbook* is based on daily averages, and the winter games in these three places are usually played after sunset, the perceived temperature is likely to be lower than the recorded averages.

It is also worth mentioning that *The People's Republic of China Yearbook*,[15] classifies these three regions as experiencing extremely cold winters because of their mid-temperate climate, contrasting with the warm-temperate or subtropical climates of other regions. Additionally, the Chinese thermal comfort dataset by Yang et al. (2023) categorizes these regions as part of China's severe cold zone.

[14] We calculate the average monthly temperatures from 2014 to 2019 using temperature data from provincial capital as proxies for each team's regional temperatures.

[15] Editorial Department of the People's Republic of China Yearbook, 2014



Note: we use the temperature of the province capital as proxy for the climate of where the team is located.

Figure 3: January temperature (Celsius)

To analyse this effect, we create a dummy variable $Freeze_j$ which equals one if the opponents of away teams (i.e., the home teams) are located in extremely cold regions, and zero otherwise. We then interact this variable with the $Neutral_t$ dummy and estimate the following equation.

$$Y_{ijt} = \alpha_0 + \alpha_1 Neutral_t + \alpha_2 Neutral_t * Freeze_j + \gamma_{is} + \theta_{js} + \sigma_{ij} + \epsilon_{ijt} \quad (4)$$

The individual term of $Freeze_j$ is absorbed by the fixed effect. We anticipate that away teams would experience a greater improvement in performance when facing cold-region teams during the harsh winter months when playing at neutral venues with no crowds, as indicated by a significantly positive α_2.[16]

[16]Notably, both Jilin and Liaoning are classified as extremely cold regions, but also hosted 185 neutral-venues games during the policy period. To avoid potential contamination, we exclude these games from our analysis.

Table 7 displays the results of estimating Equation 4, incorporating only December to March when the mean temperature is below or near zero degrees Celsius (the coldest months in the three locations throughout the year). As expected, the coefficients of the interaction terms are significantly positive, irrespective of whether the dependent variable is the winning dummy or net points (away points minus home points). This indicates that away teams experienced on average a larger decline in both winning rate (33.1 percent) and net points (14.6 points) when competing with these three cold-region teams during winter after moving to neutral venues in comparison with other teams. Put differently, when a team competes in an unfamiliar environment with an extremely cold climate, it experiences significantly stronger negative impacts on its performance.

Table 7. The impact of unfamiliarity on performance: role of low-temperature

Months: Dec-Mar	Away win (1)	Net points (2)
Neutral	0.170***	4.748**
	(0.058)	(1.926)
Neutral×Freeze	0.331**	14.564**
	(0.154)	(6.169)
Observations	2,420	2,420
Adjusted R-squared	0.309	0.400

Season-home-team, season-away-team, and directional team-pair fixed effects are included for all specifications. Robust standard errors, clustered at non-directional pair level are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

To explore if there is any dynamic impact of temperature, we divide the teams into four categories based on the average temperature of their home court in January. Based on our data, we categorize these teams into four groups, as shown in Figure 3: (1) Cold (lower than -10 degrees Celsius), including teams from Jilin, Liaoning, Xinjiang; (2) Cool (between -10 and 0 degrees Celsius), including teams from Beijing, Shanxi, Tianjin; (3) Warm (between 0 and

10 degrees Celsius), including teams from Chongqing, Jiangsu, Shandong, Shanghai, Sichuan, Zhejiang; (4) Hot (above 10 degrees Celsius), including teams from Fuijan, Guangdong.

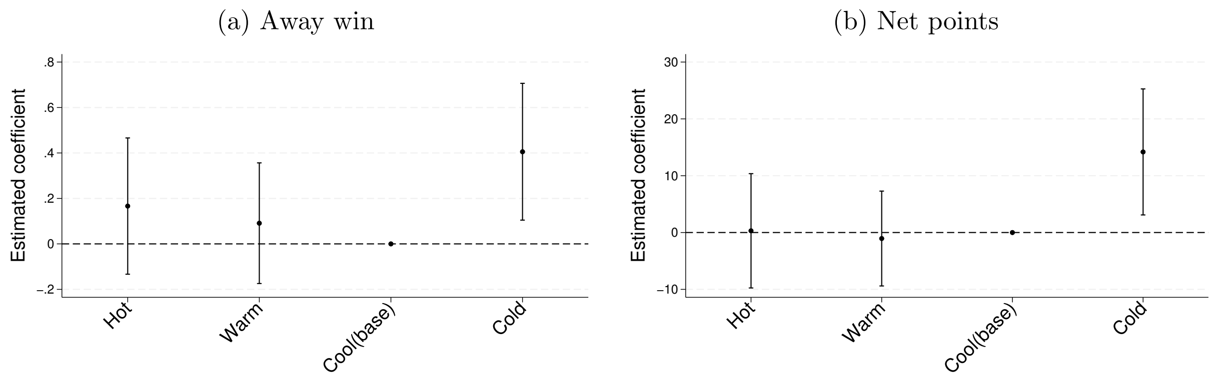
Figure 4 plots the results of heterogeneous changes in away-win rate (panel (a)) and away-home net points (panel (b)) when playing at neutral venues, with the "cool" group serving as the baseline. Notably, the away teams experience a significantly greater positive impact on performance when facing cold-region teams while playing at neutral venues compared to teams in the cool-group. For robustness, we reclassify these teams using two alternative classifications mentioned before: the temperature zone and the thermal comfort zone (instead of average January temperatures), and the results are consistent.[17]

We contribute to the literature on natural sources of home advantage, such as van Damme and Baert (2019), who highlight altitude as a key factor. We demonstrate that extreme cold is an additional natural contributor to the reduced performance due to unfamiliarity. This aligns with studies on extreme temperatures' negative effects on labor productivity (Piccino and van Ours, 2024).

6 Heterogeneous impact by team strength

Can good teams overcome the negative impact of environmental unfamiliarity? To answer this question, we estimate the following Equation 5 focusing on the heterogeneous impacts, where $Team\ ability_i$ incorporate three measures: (1) $Champion_i$, which equals one if the away team had won championship during 2014-2019, and zero otherwise; (2)$Finalist_i$, which indicates if the away team had played in CBA finals during 2014-2019; (3) the average rank $Rank_i$ during 2014-2019 (the lower the rank, the higher the competence).

[17] For a more detailed discussion, please refer to Appendix A.3.



Note: The "cool" group, which includes teams from Beijing, Shanxi, and Tianjin, is the reference group. We report 90% confidence intervals, with robust standard errors clustered at the non-directional team pair level.

Figure 4: Heterogeneous effects of temperature on away win (a) and net points (b) when playing at neutral venues

$$Y_{ijt} = \alpha_0 + \alpha_1 Neutral_t + \alpha_2 Neutral_t * Team\ ability_i + \gamma_{is} + \theta_{js} + \sigma_{ij} + \epsilon_{ijt} \quad (5)$$

Table 8 shows the results.[18] The interaction terms are statistically insignificant across all specifications, regardless of which team-quality metric is employed. These results reject the intuitive hypothesis that greater individual ability buffers against the adverse impact of environmental unfamiliarity. Instead, our results indicate that unfamiliarity with the environment has such a profound negative impact on job performance, even individuals with strong abilities cannot overcome it. To some extent, this also implies that it is difficult for individuals to alleviate this negative impact through the improvement of their own abilities.

[18]Note that we display the interaction effects only, as the individual effects of these team-quality variables are absorbed by the away team fixed effect.

Table 8. The role of team competence in affecting the negative impact of an unfamiliar environment on work performance

Dependent variable	Away win			Net points		
	(1)	(2)	(3)	(4)	(5)	(6)
Neutral	0.166***	0.160***	0.209**	4.892***	4.648***	6.569**
	(0.040)	(0.041)	(0.082)	(1.252)	(1.263)	(2.555)
Neutral*Champion	0.036	-	-	0.308	-	-
	(0.083)			(2.279)		
Neutral*Finalist	-	0.048	-	-	1.077	-
		(0.076)			(2.215)	
Neutral*Rank	-	-	-0.003	-	-	-0.158
			(0.007)			(0.226)
Observations	3,879	3,879	3,879	3,879	3,879	3,879
Adjusted R-squared	0.319	0.319	0.319	0.417	0.417	0.417

Season-home-team, season-away-team, and directional team-pair fixed effects are included in all specifications.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$.

7 Robustness checks

To ensure the robustness of our findings and rule out potential confounding factors, we conduct several robustness checks of the baseline regression results, including employing an alternative empirical strategy (Subsection 7.1), trying different clustering method on standard errors (Subsection 7.2), using logistic regression (Appendix A.1), and controlling for potential within-season variation of team characteristics (Appendix A.2). In addition, we also ensure the robustness of our natural-environmental-factor analysis by doing several checks.

7.1 Baseline results with an alternative method

First, we adopt an alternative method as indicated by regression function 2. It disentangles each game into two separate observations, one from the home and one from the away team's perspective (i.e., a difference-in-differences like setting). This was used in previous studies such as Ponzo and Scoppa (2018), Fischer and Haucap (2021) and Scoppa (2021). Table 9 confirms the robustness of our baseline results. The significantly positive coefficient of the interaction term $Away_{k,t} \times Neutral_t$ indicates there is a significant improvement of the away-team performance under the neutral-venues policy without an audience.

Table 9. Baseline results under an alternative method.

	Win or lose (1)	Net points (2)
Away	-0.268***	-9.119***
	(0.017)	(0.500)
Neutral	-0.112***	-4.182***
	(0.015)	(0.456)
Away×Neutral	0.224***	8.365***
	(0.029)	(0.912)
Observations	7,758	7,758
Adjusted R-squared	0.309	0.412

Season-home-team, season-away-team, and directional team-pair fixed effects are included for all specifications. The robust standard errors clustered at non-directional pair level are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

7.2 Baseline results using different standard errors adjustments

In this section, we estimate several additional specifications of the baseline regressions, adopting different standard errors (SE) adjustments. As shown in Table 10, columns (1) and (4) apply heteroscedasticity-robust standard errors, columns (2) and (5) cluster standard errors at the away-team level, and columns (3) and (6) cluster them at the away team-season level. Our results remain robust across all standard error specifications. We additionally estimate specifications with two-way clustered standard errors (accounting for both home and away teams) and directional team-pair clustering. These robustness checks yield consistent results, with full results available upon request.

Table 10. Baseline results using different standard errors adjustments

Dependent variable	Away win			Net points		
	(1)	(2)	(3)	(4)	(5)	(6)
Neutral	0.174***	0.174***	0.174***	4.966***	4.966***	4.966***
	(0.033)	(0.029)	(0.040)	(1.051)	(0.922)	(1.303)
SE adjustments	Robust	Clustered Away	Clustered Away-season	Robust	Clustered Away	Clustered Away-season
Observations	3,879	3,879	3,879	3,879	3,879	3,879
Adjusted R-squared	0.323	0.317	0.321	0.420	0.415	0.418

Season-home-team, season-away-team, and directional team-pair fixed effects are included in all specifications. *** p<0.01, ** p<0.05, * p<0.1.

7.3 Robustness on the role of low-temperature

First, we use different classifications of climate zones to re-estimate the results displayed in Figure 5. The corresponding results are presented in Appendix A.3 and are in line with our previous findings.

Moreover, we introduce two additional tests for the role of cold temperature. One potential concern is that the observed impact of natural environmental factors on work performance might be driven by characteristics other than low temperature, such as geographical remoteness, altitude, etc. To address this, we first include all months in the regression in Equation 4, rather than limiting the analysis to winter months. The rationale is that if the observed impact is driven by factors like geographical remoteness, which remain constant over time, we would expect to see significant effects across all months. However, as shown in Table 11, the coefficients of the interaction terms become statistically insignificant across the specifications including all months. This approach allows us to rule out the potential influence of time-invariant factors common to extremely cold regions.

Second, we gradually incorporate teams from less cold regions into the $Freeze$ dummy. We find that both the magnitude and the significance are diminishing no matter which outcome variable we use (Figure 5). These results reaffirm that low temperatures exacerbate the negative performance effects of environmental unfamiliarity, demonstrating that the low-temperature impairs individuals lacking adaptation to such environments.

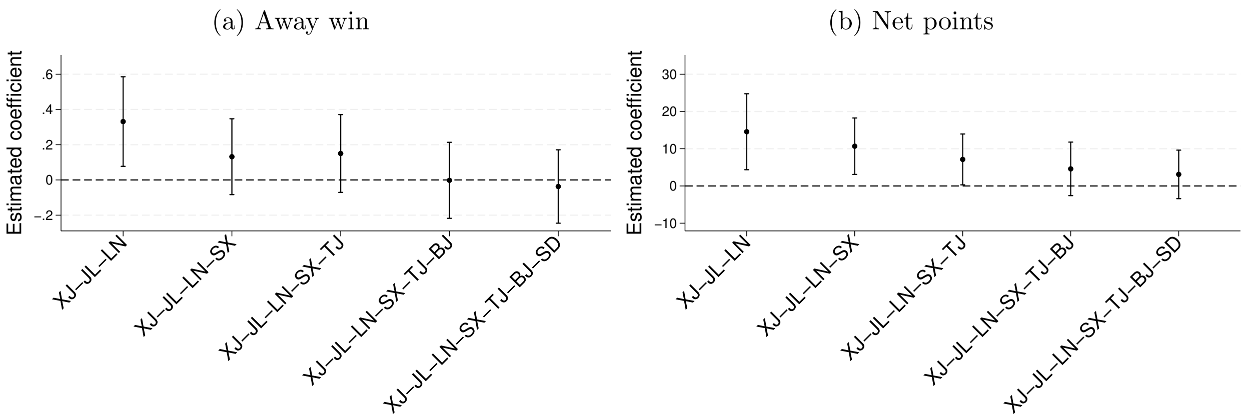
Table 11. Placebo test: using all months instead of limiting to winter

Months: all	Away win (1)	Net points (2)
Neutral	0.162***	4.699***
	(0.036)	(1.119)
Neutral×Freeze	0.084	0.985
	(0.084)	(2.770)
Observations	3,694	3,694
Adjusted R-squared	0.315	0.411

Season-home-team, season-away-team, and directional team-pair fixed effects are included in all specifications. Robust standard errors, clustered at non-directional pair level are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

8 Discussion and conclusion

To conclude, this paper investigates whether basketball teams' performance is affected by environmental unfamiliarity, using Chinese basketball matches as the research sample. We exploit the implementation of the "neutral-venues polic" by the Chinese Basketball Association in June 2020 as an exogenous shock, which relocated all games to neutral venues without audience attendance, providing a quasi-experimental setting. We find that when



Note: XJ, JL, LN, SX, TJ, BJ, SD denote Xinjiang, Jilin, Liaoning, Shanxi, Tianjin, Beijing, and Shandong, respectively. We report 90% confidence intervals, with robust standard errors clustered at the non-directional team-pair level.

Figure 5: Diminishing heterogeneity of temperature effects on home win (a) and net points (b) when gradually adding less cold regions

away teams no longer needed to travel and compete in their opponents' home courts, their performance significantly improved. Specifically, they demonstrated better individual scoring performance, stronger team cooperation, and a lower probability of making errors. This improvement effect immediately disappeared when the neutral-venues policy was removed in February 2023.

We further investigate whether the absence of audiences in empty stadiums altered referees' behaviour. We find that referees consistently imposed more fouls on away teams and awarded more free-throw opportunities to home teams, regardless of the presence of a crowd. This suggests that the potentially biased referee behaviour is not driven by social pressure from the audience, and that the improvement in away team performance during the neutral-venues policy is not explained by changes in referee decisions. Additionally, this paper highlights that extreme cold weather is another important factor contributing to the underperformance of basketball players. Extreme temperatures not only create difficulties on the day of competition but also disrupt travel and daily training, particularly when indoor heating facilities are inadequate. Specifically, we show that when away teams no longer needed to travel to freezing regions for matches during winter, their performance improved more significantly. Finally, we explore whether stronger teams were less affected by environmental unfamiliarity. We do not find evidence supporting this. It indicates that environmental unfamiliarity has a homogeneous negative effect across teams of different strengths, and even strong teams are unable to overcome it.

This research has three limitations. (1) The study lacks precise data on indoor temperatures in basketball stadiums. Although we have carefully justified the potential influence of outdoor temperatures on indoor activities, particularly in the context of Chinese basketball where indoor heating systems are inadequate, we acknowledge that more precise data could further improve the analysis. Specifically, with detailed indoor temperature data, we would be able to explore whether the observed negative impact stems primarily from players' underperformance on the game day, or from disruptions during travel and daily training in freezing regions. (2) The study does not have data on players' biometric indicators or psychological assessments. As a result, we cannot clearly determine whether the effect of environmental unfamiliarity is driven primarily by physical discomfort or psychological stress. It is possible that extreme temperatures negatively affect physical performance by limiting proper warm-up activities, increasing the risk of injury, and reducing physical flexibility. It is also plausible that unfamiliar environments psychologically affect players' mental states, when facing a crowd supporting their opponents or when experiencing potential referee bias. Furthermore, cold temperatures may cause players to adopt a more cautious playing style to avoid injury, which could also contribute to lower performance. (3) Another limitation of this study is its external validity. Basketball athletes are typically individuals with strong physical adaptability and mental resilience (Bonetti et al., 2025) due to their experience competing under pressure. Therefore, the negative impact of environmental unfamiliarity observed in this study could be even more pronounced among the general population, although this remains for further investigation.

There are two interesting directions for future research. Firstly, future research could explore whether the negative impact of environmental unfamiliarity varies between weekdays and weekends. Previous studies suggest that match dynamics and audience composition differ by day of the week. For instance, Krumer and Lechner (2018) show that home teams tend to perform worse in midweek matches compared to weekends, while Ermakov and Krumer (2023) find that weekend events, particularly those on Saturdays, attract larger audiences. Therefore, it would be interesting to investigate whether environmental factors, such as extreme weather, interact with the timing of matches to influence the distribution of home and away audiences, and consequently, the performance of teams. Secondly, it would be valuable to examine the potential existence of strategic behaviour of referees, and the moderating effect of audience presence. It is possible that, overall, referees appear to make balanced decisions in terms of total fouls; however, they may strategically favour home teams at critical moments, such as match points or crutch moments. This subtle bias may not be evident in aggregate statistics but could significantly affect match outcomes, which remains for future research.

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A Appendix: additional results

A.1 Baseline results under logistic regression

In this section, we employ a logistic regression model rather than a linear probability model to estimate our baseline regression for winning. As shown in Table A1, logistic regression reconfirms our results that the performance of the away team improved under "neutral-venues policy".

Table A1. Baseline results: logistic regression with odds ratios

	Away wins	Away wins
Neutral	1.533***	3.634***
	(0.094)	(0.889)
Observations	3,879	3,433
Fixed effects:		
Season-home team	-	Y
Season-away team	-	Y
Directional team pair	-	Y

The robust standard errors clustered at non-directional pair level are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

A.2 Controlling for potential within-season variation of teams

In the main analysis, we consistently control for seasonal variation in team characteristics by including team-season fixed effects. However, potential within-season variation in team remains unaccounted for. Although we could not control for team-month fixed effects due to the multi-collinearity, we conduct a robustness check by incorporating team-half season fixed effects. As presented in Table A2, our results remain robust.

Table A2. Baseline results controlling for within-season variation of teams.

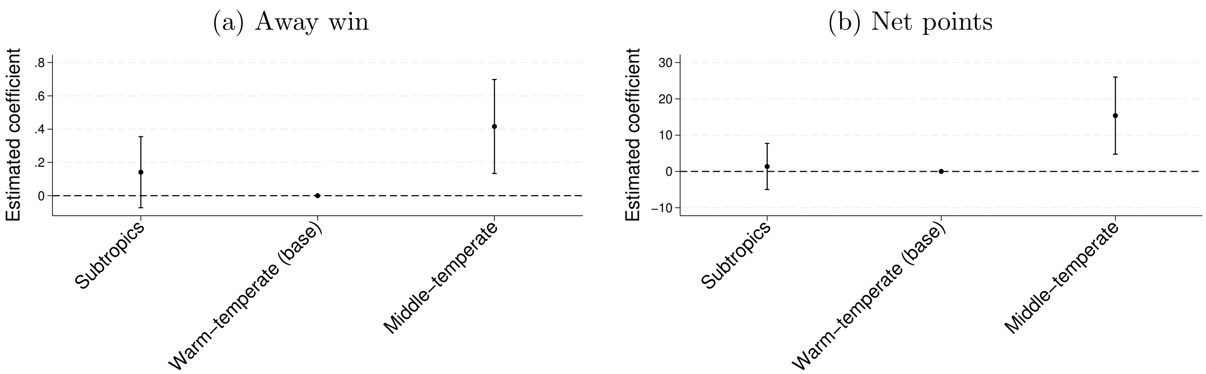
	Win or lose (1)	Net points (2)
Neutral	0.106***	3.947***
	(0.015)	(0.475)
Observations	3,879	3,879
Adjusted R-squared	0.194	0.257

Half season-home team, half season-away team, and directional team-pair fixed effects are included for all specifications. The robust standard errors clustered at non-directional pair level are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

A.3 Other classifications of temperature zones

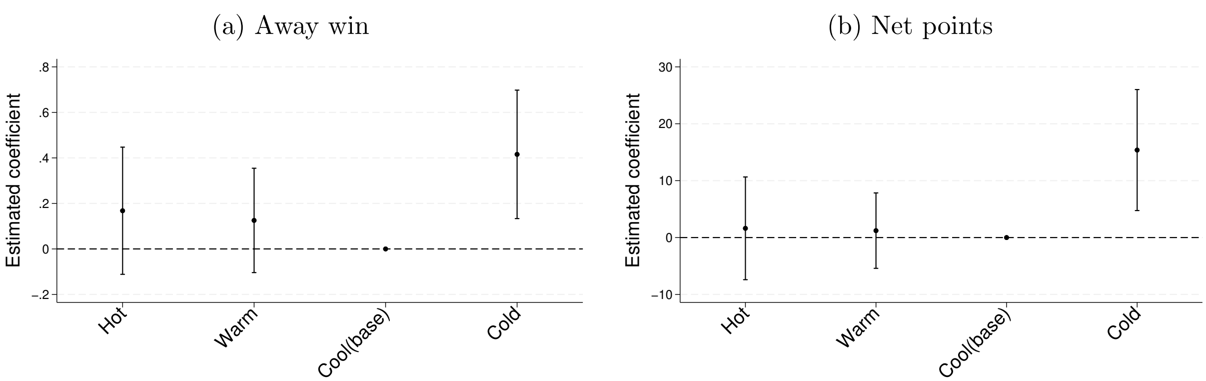
In the main text, we use the average January temperature of teams' locations to group them into different categories. Here, we refer to two other sources to conduct the robustness checks. On the one hand, we refer to *The People's Republic of China Yearbook* (Editorial Department of the People's Republic of China Yearbook, 2014), according to which we can classify these locations into three temperature zones: (1) mid-temperate (Jilin, Liaoning, Xinjiang); (2) warm-temperate (Beijing, Shandong, Shanxi, Tianjin); (3) subtropics (teams from other regions).[19] The results generated upon this source are plotted in Figure A1. On the other hand, we follow *The Chinese thermal comfort dataset* by Yang et al. (2023) and assign these teams into four groups, which closely assembles the classification in the main text except for moving teams from Shandong to the "cool" group. We present the results in Figure A2, which reconfirms our main findings that away teams experienced larger improvement when competing with teams located in frigid areas in winter after moving to neutral venues.

[19] Retrieved from https://www.gov.cn/guoqing/2005-07/27/content_2582628.htm



Note: warm-temperate group, which includes teams from Beijing, Shandong, Shanxi, Tianjin, is the reference group. We report 90% confidence intervals, the robust standard errors are clustered at non-directional team pair level.

Figure A1: Heterogeneous effects of temperature on away win (a) and net points (b) when playing at neutral venues (source 2)



Note: cool group, which includes teams from Beijing, Shandong, Shanxi, Tianjin, is the reference group. We report 90% confidence intervals, the robust standard errors are clustered at non-directional team pair level.

Figure A2: Heterogeneous effects of temperature on away win (a) and net points (b) when playing at neutral venues (source 3)

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