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Using loyalty card data to understand the impact of weather on click & collect behaviours in UK retailing

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ABSTRACT

This study assesses the influence of weather on Click & Collect (C&C) usage in England, examining differences between the day of order and day of collection, and how the weather influences the time taken to collect an order. Using sales and loyalty card data from a national retailer, we employ a series of gradient boosting models to analyse the influence of weather on daily order/collection totals, totals stratified by demographic group, and the time taken to collect an order. Weather is found to be consistently more influential on the day of order than the day of collection, however store location and thetiming of purchase have a higher relative influence than weather overall. The findings also evidence significant differences in influence between male and female customers and those aged above and below 65. Temperature and humidity are typically the most influential weather conditions, demonstrating a wide variation in effect on order totals. Temperature was also found to be significantly more influential than other weather conditions on the time taken to collect an order, with the highest temperatures leading to the longest collection times. Understanding the influences of different weather conditions on online consumption behaviours is of significant value to retailers, policy makers and associated stakeholders. However, it is an area that has been significantly under-researched compared to physical retailing, often due to a lack of reliable data. This study provides key insights into how different types of consumers behave on these platforms.

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KEYWORDS
Click & collect; UK weather; loyalty card; hybrid retailing

Introduction

Over the past decade, there has been a significant shift toward online and convenience retailing as consumer decision making is increasingly influenced by technology, speed and ease of the retail experience (Dolega and Lord, 2020; Duarte, Silva, and Ferreira 2018). In response to these changes in consumer behaviour, retailers have been innovating and experimenting with new sales channels, store formats and marketing techniques to embrace their needs (Grewal, Roggeveen, and Nordfält 2017). Click & collect (C&C) retailing, also referred to as 'Buy online, pick up in store' (BOPS, e.g. Gallino and Moreno 2014), 'Online-to-offline' (O2O, e.g. Wang, Somogyi,

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and Charlebois 2020) and 'Click and drive' (e.g. Colla and Lapoule 2012), is part of that innovation and evolution of sales formats (Vyt et al. 2022) which has been driven by the shift in consumer behaviour. The C&C format, was designed by retailers to respond to 'the last mile' problem, providing a convenient alternative to traditional online deliveries (Gielens, Gijsbrechts, and Geyskens 2021). Essentially, it is a hybrid format, where consumers can order products online, and once available, collect their order from the store or chosen location at their own convenience. C&C first introduced in the UK in 2011, has grown rapidly since and is now considered one of the dominant forms of hybrid retailing in the UK (Dalgleish 2021) as well as globally, with over 80% of leading retailers in the UK offering this as a service (Vyt et al. 2022). Post-pandemic, this trend has accelerated further, making it increasingly important for retailers to include C&C as a key hybrid retailing service. Since C&C is offered at a consumer convenient time slot and often at no extra cost (Gielens, Gijsbrechts, and Geyskens 2021), it makes an attractive choice for time-poor consumers seeking convenience and aiming to maximize value for money. This is especially relevant in difficult economic circumstances, such as the current cost of living crisis in the UK. Therefore, the current and projected trends of hybrid retailing popularity growth have made it more important than ever for retailers to understand the key influences on consumer behaviours with regards to these platforms.

Unlike many long-term drivers that have underpinned the shift we have seen in C&C usage such as abovementioned convenience and value for money, the impact of weather is little understood. This is particularly important in the UK, known for its volatile weather patterns representing a particularly situational factor that can prompt almost immediate changes in consumer decision making. Unseasonal or extreme weather conditions are often anecdotally cited by the media as a causefor short-term changes in sales outcomes, however there is also academic research that have shown weather to have a measurable impact on both in store and online retailing (e.g. Rose and Dolega 2022; Steinker, Hoberg, and Thonemann 2017). In a hybrid model, consumer considerations made when using C&C platforms may span from the decision to order online over shopping in a physical store to the choice of location to collect the order, all of which have the potential to be influenced, directly or indirectly, by prevailing weather conditions. Although there is a growing body of research on various aspects of hybrid retailing, there is a scarcity of empirical evidence concerning how consumption behaviours on these platforms respond to different patterns of weather conditions. A better understanding of how and when these services are being utilised, especially through data-driven insights, can be of high value to retailers in informing their logistics and resource management.

This paper combines historic C&C purchases data (2012–14) with loyalty card records and employs novel machine learning techniques to assess the influence of weather on C&C usage in England during the early stage of hybrid retailing business models. Comprehensive and reliable data are fundamental for quantifying the impact of weather on hybrid retailing behaviours, however such data is often inaccessible for researchers due to inclusion of business sensitive information. We believe that there is also a clear value in exploring the early stages of click & collect retailing using novel techniques as online and hybrid retailing have become more prevalent over time. Notably in the face of a changing global climate, and likelihood of far more variable weather in the UK (Hanlon et al. 2021), such insights are increasingly important when preparing for future change.

Furthermore, the time period that this study examines is the recovery period following a significant period of economic downturn in 2008/9. This coincides with the current recovery from the pandemic and aligns with the strategies required to support the economic recovery for retailers and relevant stakeholders. There are three key aims in this study:

(1) Investigate the level of influence various weather conditions have on C&C usage and the nature of the associations identified.
(2) Explore how consumer behaviours differ across different demographic groups in terms of weather-related influence.
(3) Examine how the weather influences the length of time taken to collect C&C orders and the nature of associations identified.

This paper proceeds by reviewing the existing relevant literature, followed by a detailed overview of the data used and methodology employed. The results pertaining to each aim are presented and subsequently discussed alongside the implications of the study.

Literature review

Rise of hybrid and click & collect retailing

The rapid rise of online retailing is a phenomenon that has been heavily documented over the last 15 years, with the UK one of the global leaders of this trend (Hood et al. 2020; Kirby-Hawkins, Birkin, and Clarke 2018; Vyt et al. 2022; Wrigley and Lambiri 2015). Development in technology and the increased popularity of online sales platforms significantly disrupted traditional retailing and incentivised retailers to experiment with their business models. Multi-channel retailing, also referred to as omni-channel or hybrid retailing, such as C&C, has been a key part of this evolution (Kirby-Hawkins, Birkin, and Clarke 2018; Nguyen et al. 2017). Research shows that predominantly due to its convenience, hybrid retailing, including C&C, positively stimulates demand and enhances consumer satisfaction (Hood et al. 2020; Vyt et al. 2022). C&C retailing involves a two-step process, with consumer first visiting a retail website to browse and purchase selected products, and then collecting them from a chosen store (Vyt et al. 2022). This type of hybrid retailing has been growing rapidly in the UK with C&C channels accounting for 12.9% of online salesin 2023 (GlobalData 2019), driven primarily by male shoppers and clothing & footwear retailing.

Akin to almost every other economic sector, these trends were disrupted by the impact of the recent Covid pandemic and related restrictions, however, there is evidence that implementing C&C facilities helped to lessen the effect of falling sales volumes during this time, particularly in the food retail sector (Dalgleish 2021). The popularity of hybrid and C&C retailing is undoubtedly driven by growing consumer expectations of convenience and technological advances, for example through the prevalence and accessibility of smart phones. Initially, including the period covered by this study, the majority of online or hybrid shopping was undertaken on PCs in the home with m -commerce still a relatively new phenomenon. The rapid rise of m-commerce, has been attributed to convenience and accessibility as well as features of interactivity, personalisation, and

localisation (Ciupac-Ulici et al. 2023; Niranjanamurthy et al. 2013), allowing users immediate access to unlimited retail applications. Within the remit of C&C retail, there is capacity for consumers to purchase an item on their phone and collect it within a matter of minutes from a designated location. This level of accessibility and flexibility feeds into the movement of retail convenience and the modern expectations of consumers in terms of minimising time and effort expenditure (Ameen et al. 2021; Gupta and Sharma 2017). Further, it provides opportunities for price comparison searches as consumers seek value for money (Hall, Towers, and Shaw 2017). M-commerce sales in the UK have experienced significant growth in the past decade, reaching £50bn in 2019, and are expected to double by 2024 (Coppola 2022).

Complexity of consumer interactions with hybrid retailing

The rapid growth of multi-channel and hybrid retailing, including Click & Collect, has resulted in complex interactions between customers and retailers (Hood et al. 2020) with a number of key factors that can be considered as key drivers. There is an inherent seasonality in retail that can occur in cycles of various temporal scale. According to a UK-based e-commerce study, Monday is the most popular day for online retail activity with the lowest levels on online traffic occurring Friday to Sunday, with daily peaks commonly at 1 pm and 8 pm (Heritage 2017). On a monthly scale, Mishra et al. (2010) find that consumer purchasing habits fluctuate depending on the proximity to payday. Perhaps most significant is the annual seasonality of online retailing, with revenue primarily peaking around the Christmas season (Jasek et al. 2018), but also other retail events such as Black Friday (Cherrett et al. 2017).

Research also shows that the propensity of online shopping, encompassing C&C and online retail behaviours, can be attributed to access to the Internet and consumer characteristics. Newing et al. (2022) found that lower order volumes correspond with poorer connectivity, while Alexiou and Singleton (2018)attribute online shopping behaviours to various socio-economic and internet infrastructure characteristics. The level of access that consumers have to these platforms has changed significantly with the expansion and prevalence of internet-enabled devices such as smartphones and tablets, enabling online retailing to become much more versatile (Wagner, Schramm-Klein, and Steinmann 2020). Furthermore, demographic differences in C&C behaviours are a key focus in this investigation. Both gender and age have been identified as characteristics that drive variations in usage of e-retail platforms (e.g. Ren and Kwan 2009; Hood et al. 2020; Ciupac-Ulici et al. 2023.

Spatial and temporal variations in consumer behaviour and their associated characteristics are often captured through geodemographic classifications. This tool proves valuable for retailers and is widely utilised in quantitative research. An example of such bespoke classification – the internet user classification (IUC), developed by Alexiou and Singleton(2018) was employed by a study by in Davies et al. (2019), who found a strong negative association with e-rurality (characterised by poor connectivity) and demand for grocery C&C services. Furthermore, Clarke et al. (2015) find that the most common demographic group for online consumption are men aged 25–44 whilst those aged 65+ were the least likely to be regular users. This is supported by Weltevreden (2007) who finds males to be more likely to be frequent online shoppers than females. When studying

online grocery usage, Mortimer et al. (2016) found male and female customers equally likely to be frequent purchases with the lowest percentage of frequent users aged 18–24 years. Again, focussing on food e-commerce, Wang et al. (2020) find statistically significant relationships indicating female customers have higher consumption for 'business-to-consumer' platforms and that there is a negative association with age and all types of online consumption.

In addition to the consumer characteristics, external economic or social factors can significantly impact consumer behaviour and therefore their engagement with online and hybrid retailing (Vyt et al. 2022). Typically, the periods of financial stability, characterised by an increased consumer confidence and their disposable income, lead to greater consumption expenditure (Liu 2022). Conversely, there is evidence that the periods of economic shocks and instability tend to accelerate the undergoing processes, more rapidly change consumer behaviours and negatively impact retail sales (Wrigley and Dolega 2011). Vyt et al. (2022) claim that the recent Covid pandemic has accelerated the implementation ofClick & Collect facilities as many retailers employed this mechanism to cope with the imposed restrictions while a study by Tartaglione et al. (2019) found that unemployment rates used as a proxy for the consumers' economic circumstances, show a near-linear negative association with sales outcomes.

Finally, weather has been found to be an influential factor on many aspects of physical retailing, including total sales outcomes (e.g. Badorf and Hoberg 2020), sales of specific products (e.g. Rose and Dolega 2022) and retail centre footfall (e.Makkar 2020). However, there has been a distinct lack of research on the impact of weather on online retail behaviours

Weather and consumer engagement with online and hybrid retailing

Many researchers have acknowledged the value in understanding how the weather impacts online consumption behaviours (e.g. Martinez-de-Albeniz and Belkaid 2021; Moon et al. 2018). Despite this, few have designed studies to this effect and contributed to the understanding of this relationship. Steinker et al. (2017), regarded as a seminal study in this area, investigated the impact of weather conditions on the sales of the leading online fashion retailer in Europe. They found a significant relationship with sunshine, temperature, and precipitation and that the inclusion of these variables in the models substantially reduced forecasting errors. A similar study on online apparel in the Czech Republic found a significant relationship between each of the weather variables (including sun hours, precipitation, temperature, air pressure and wind) and the sales outcome, with warm temperatures and wind presenting a positive relationship (Boryskova 2022). Gallino et al. (2019) focussed specifically on online winter clothing sales from a retail chain in the US and found increases in sales on cold and snowy days, up to 8.3% and 5.3%, respectively. Furthermore, when examining seasonal changes, they found the greatest level of influence from overall weather conditions in the winter season and the least in the summer. Using data from a large e-commerce company with a more diverse product offering, Anderson et al. (2019) found that including weather in the models (such as temperature, cloud cover, humidity, wind speed and precipitation) reduced forecast errors by up to 18.5%.

Other studies have approached this area with a different angle, looking at the relationship with weather and searches or site traffic rather than direct sales outcomes. Studying

online price searches for an Italian shopbot, Canova and Nicolini (2019) find an increase in price searches on weekdays, in particular Mondays, and when there are unfavourable weather conditions. The relationship with bad weather was found to be consistent across mobile and desktop devices and is attributed to declines in outdoor activities and changes in the mood of consumers. Additionally, Oh et al. (2021) look at search trends for the phrase 'winter jacket' in New York City and examine how different weather conditions influence outcomes. They find that maximum and minimum temperature are significant predictors of search counts.

Research gaps

As discussed, an understanding of how different factors influence consumer behaviours around online and hybrid retailing, has been identified as holding significant value to retailers, policy makers and other relevant stakeholders. Despite this, and the growing popularity of online and hybrid retailing in the UK, this is an area that is still substantially under-represented in the existing literature. Many studies investigating consumer engagement with online and hybrid retailing have considered individual factors that influence consumer behaviours, but these are rarely compared in terms of their relative impacts. When narrowed down to C&C behaviours, there is a distinct predilection towards the fashion and grocery retail sectors. With regards to the weather, where there have been numerous studies looking at the impact of on physical retail sales, the same level of attention has not been paid to online retailing and the majority of existing research here focuses on the seasonal cycles of apparel goods (e.g. Gallino, Karacaoglu, and Moreno 2019; Steinker, Hoberg, and Thonemann 2017). To the best of our knowledge, there are currently no studies that have investigated the impact of weather on C&C behaviours in the UK. Therefore, understanding these trends in both the current period and historical context is crucial for academia and the practitioners. The historic content may be particularly relevant, as currently, the economy still recovers from the disruption of the COVID-19 pandemic. The availableC&C data was captured in a previous period of economic recovery and as such presents a unique opportunity to contribute to retailers'understanding of these increasingly important platforms in the current retail landscape.

Methodology

Data

Sales data was provided by a major high street retailer in the UK that specialises in health and beauty products, procured through the Consumer Data Research Centre (CDRC), and covers over 2000 stores across England between October 2012 and March 2014. The C&C data consist of individual product orders with order and collection date stamps, the store the collection was made from, and the customer ID number. For the purpose of this study, only orders made through a web channel and with a completed collection status were included. Customer ID numbers could be linked to the loyalty card database, which provides customer-level information on self-reported genders, year of birth and postcode. These details are collected when customers sign up to the retailer's loyalty card scheme. Anonymised records were used for analysis inside a secure research environment

compliant with consent legislation. All outputs were aggregated ensuring no identifiable information was permitted outside the secure environment. As is common for loyalty card schemes (Bridson, Evans, and Hickman 2008), there is a distinct skew towards female customers. Other data provided by the retailer contained store-level information on the location type (e.g. high street, transport hub, out-of-town retail centre) and retailer-defined format of the store, as well as location attributes.

The weather data used for this study is the CHESS dataset from the Centre for Ecology and Hydrology (CEH) (Robinson et al. 2017) and includes 1 km gridded daily averages for humidity, precipitation, temperature, and wind. This data was procured and processed, using a spatial interpolation method, as part of a previous project and details of this can be found in Rose andDolega (2022). Additional variables for the study included the monthly national employment rate, obtained from the Office of National Statistics (ONS), and the IUC groups from the CDRC (Alexiou and Singleton 2018). Weather variables, employment rates and IUC groups at LSOA level were joined to the sales data through the LSOA code of the collection store.

Processing

Each aim of the study required the data to be processed in a unique way. For aim 1, the dataset of all individual C&C records was separated into orders and collections and, respectively, aggregated to orders/collections per store, per day. At this point, store level (store characteristics, IUC group) and temporal level (weather, employment rate) variables were added and an 'average basket size' was calculated. Although similar, in order to examine demographic differences to address aim 2, after first separating into orders and collections, a second split was made into customers who identify as male and female (all ages) and then across the age categories: under 30, 31–64 and over 65 (all genders). These groupings were chosen to separate consumers that are expected to have different considerations and behaviours in terms of their online consumption. Each group was then aggregated to orders/collections per store, per day and subsequent data linkage and variable calculation was kept the same. With regards to the third aim of this study, initially a 'days to collect' variable was calculated for each individual record to measure the time between order date and collection date. Store characteristics and weather data were joined using the store of collection, and two sets of weather variables were added, for both day of order and day of collection.

Methodological approach

This study employs a machine learning methodology using a series of gradient boosting models (GBM) from the *gbm* R package (Greenwell et al. 2022). A tree-based ensemble method, gradient boosting models utilise a process of gradient descent to improve model performance, and decision trees are built iteratively, with each tree built to minimise the error residuals of its predecessor (Wanchoo 2019). GBMs have been consistently found to out-perform other machine learning algorithms such as Random Forests and Elastic Nets (e.g. Antipov and Pokryshevskaya 2020) and offer flexibility in terms of data handling and hyperparameter tuning options (Boehmke 2018).

Table 1. Outcome and explanatory variables included in the model for each respective aim.

	Aim 1 & 2	Aim 3
Outcome variable		
No. orders/collections per day per store	x	
No. days taken to collect order		x
Explanatory variables		
Day of week	x	x*
Day of month	x	
Day of year	x	
Store location type	x	x
Store format	x	x
Weather (x4)	x	x*
Employment rate	x	
IUC group	x	
Average basket size	x	
Items per order		x

*Variable(s) included twice, for day of order and day of collection.

Using a 70:30 split, the training data for the models contained over 335,000 individual C&C orders and the GBM was trained with 10-fold cross validation and 1500 trees. Hyperparameter testing was undertaken to find the optimal range of values: Learning rate 0.1, Interaction depth 3 and Minimum number of observations 5. These values were kept constant for each model run. Two model specifications were utilised as highlighted in Table 1. To tackle aims 1 and 2, a model was trained to predict the number of orders/collections as a function of the nine explanatory variables identified in Table 1. Where demographic variations were being studied, this was duplicated for each gender or age group. For aim 3, a different combination of variables was included in the model with the outcome variable of interest as the number of days taken to collect an order. In the case of temporal and weather variables, these were included in the model twice, for the day of order and the day of collection.

Outputs from these models consisted of variable importance statistics, ranking each variable in terms of their relative influence on the respective outcome variables, and partial dependence plots to determine the nature of the associations between each weather variable and sales outcome.

Results

Day of order vs day of collection

Figure 1 shows the relative influence of each of the variables included in the model to estimate the effects on the total number of online C&C orders and collections taking place each day. Firstly, it can be seen that the type of store the order was collected from and the time of the year the order was made are the top drivers for both orders and collections, alternating first and second. For collections, these two variables make up a significant chunk of the influence on the total number of collections. Consequently, weather conditions are more influential to the day of order than the day of collection, both individually and in combination, making up approximately 1/3 of relative influence combined for the order compared to only 5% for the collection. Temperature is the biggest weather driver of C&C orders, followed closely by humidity. Conversely, wind is the biggest weather

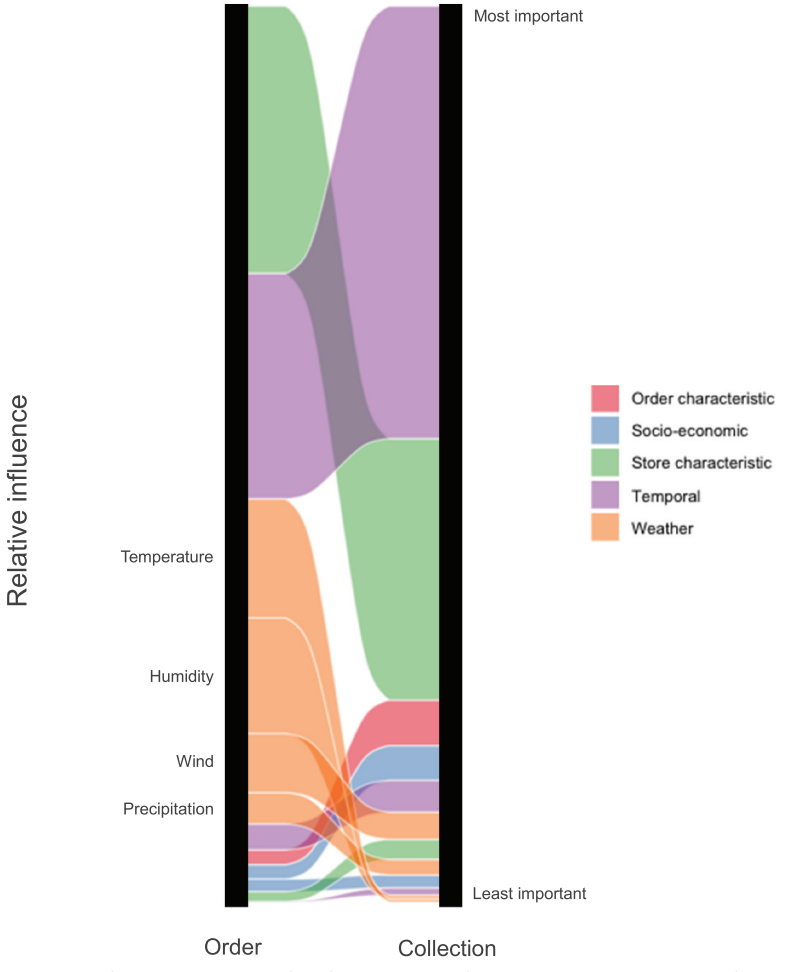

Figure 1. Relative influence rankings of different types of variable on the number of C&C orders and collections.

driver of collections, followed by precipitation. The influence of temperature and humidity appears to become almost negligible when looking at collections.

In addition to quantifying this influence, the nature of relationships between C&C orders/collections and each of the weather conditions can be examined using the partial dependence plots in Figure 2. Each of these plots show the change in the outcome along the y axis and are ordered by their respective ranking in the relative influence statistics. Lower temperatures appear to lead to the greatest number of C&C orders and there is also a general trend of negative associations with humidity. One important thing to note is that precipitation values are highly skewed towards the lowest values, with 90% of data points falling between 0 and 0.0001 kg/m^2/s (equivalent to 8.64 mm/day). In the case of both orders and collections, strong negative associations can be seen with the majority of precipitation data, however these relationships become more complex in the final decile. As the most influential weather condition in this regard, the highest wind speeds appear to coincide with the greatest number of collections.

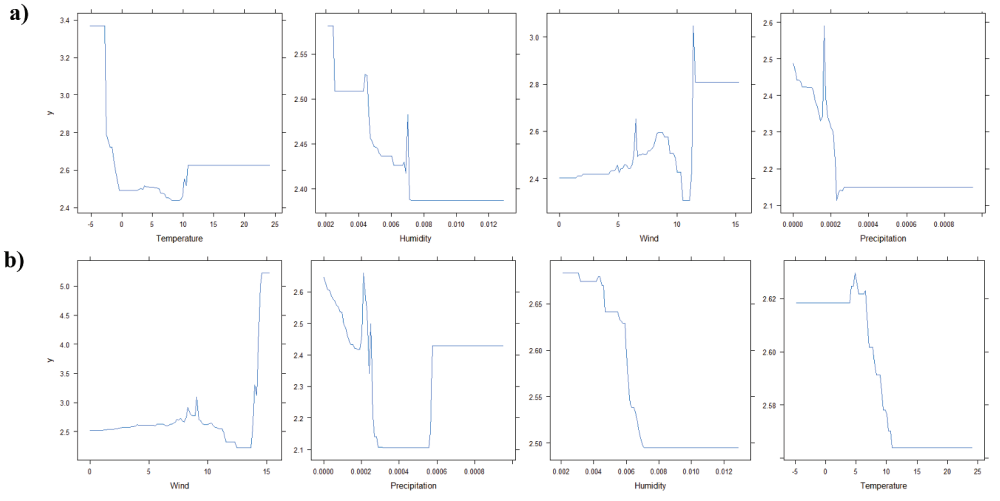

Figure 2. Partial dependence plots for the relationship between a) Orders and b) Collections and each of the four weather variables. Ordered by variable importance ranking.

Demographic variations

This study takes this investigation of weather influence further by exploring variations in these influences between different demographic groups using gender and age data captured by the retailer's loyalty card scheme. When broken down by these demographic groups we can start to see key differences in how weather, amongst other control variables, influences consumer behaviours surrounding C&C ordering. The first bifurcation was made between those who identified as male and female in their loyalty card application. As previously acknowledged, female customers tend to be heavily represented in loyalty card data over their male counterparts and this is somewhat visible in the results in Figure 3 with the female results resembling closely those seen in the case of all customers in Figure 1. However, notably in this instance humidity is found to be a bigger driver of orders than temperature. When comparing these results to male customers, marked differences start to appear. Time of year is consistently the biggest driver of both orders and collections, followed by the socio-economic conditions of the area in the form of internet accessibility and usage profiles. Overall the influence that weather has on orders made by male customers is much lower than those made by female customers but in terms of collections, weather has a marginally greater combined influence on male customers and the difference in influence between orders and collections is lower. Individually, temperature is the biggest weather driver of male orders, followed by wind and humidity in relatively equal value. The influence of precipitation can be seen to be almost inconsequential to the outcome of orders and collections. Wind, again, is the biggest driver of collections and uniquely, the influence that wind has increases between orders and collections. There are more similarities in influence between male and female customers when it comes to collections.

When examining the nature of these relationships in Figure 4, near-opposite trends for temperature and C&C orders can be seen with the lowest temperatures (below 0°C) leading to more orders from female customers but the fewest from male customers.

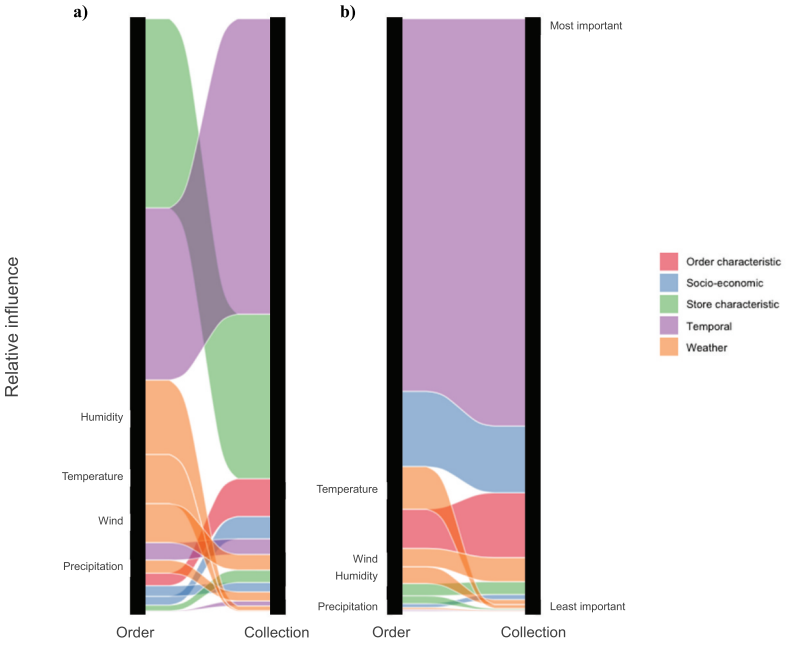

Figure 3. Relative influence rankings of different types of variable on the number of C&C orders and collections for a) Female and b) Male customers.

Furthermore, there are notably different trends for wind as well with higher wind speeds associating with higher female orders whereas in general the opposite is true for male customers. Again, there is more consistency across male and female customers when it comes to collections. In both instances, a spike in collections is seen around the moderate wind speeds of 7-8 m/s and there is a general trend of decreasing collections with increasing humidity.

The second set of variations explored is those between customers of different age groups in Figure 5. Using the groups we have selected (under 30, 31–64 and over 65), it is evident that the customers in the youngest and middle age groups have relatively similar influences. However, this starts to change significantly for the oldest customer group. Time of year is consistently the biggest driver across both orders and collections at various magnitudes across age groups, followed by store characteristics for youngest and middle group and order characteristics for the oldest customers. In terms of the weather influence, temperature, humidity and wind are the biggest drivers for customers under 65, although temperature and humidity alternate primary and secondary influence between the two groups. In both cases, wind is the top weather driver of collections, followed by precipitation. Combined, weather conditions make up about 30% of the influence on C&C orders for the first two groups, each dropping to around 4% for collections. For customers over 65 the influence weather has on both orders and collections is significantly smaller, and almost negligible, making up approximately 1.5% and 0.5% of relative influence, respectively.

From the partial dependence plots in Figure 6 we can see that for customers under 30 there is a positive association between temperature and increased C&C orders being

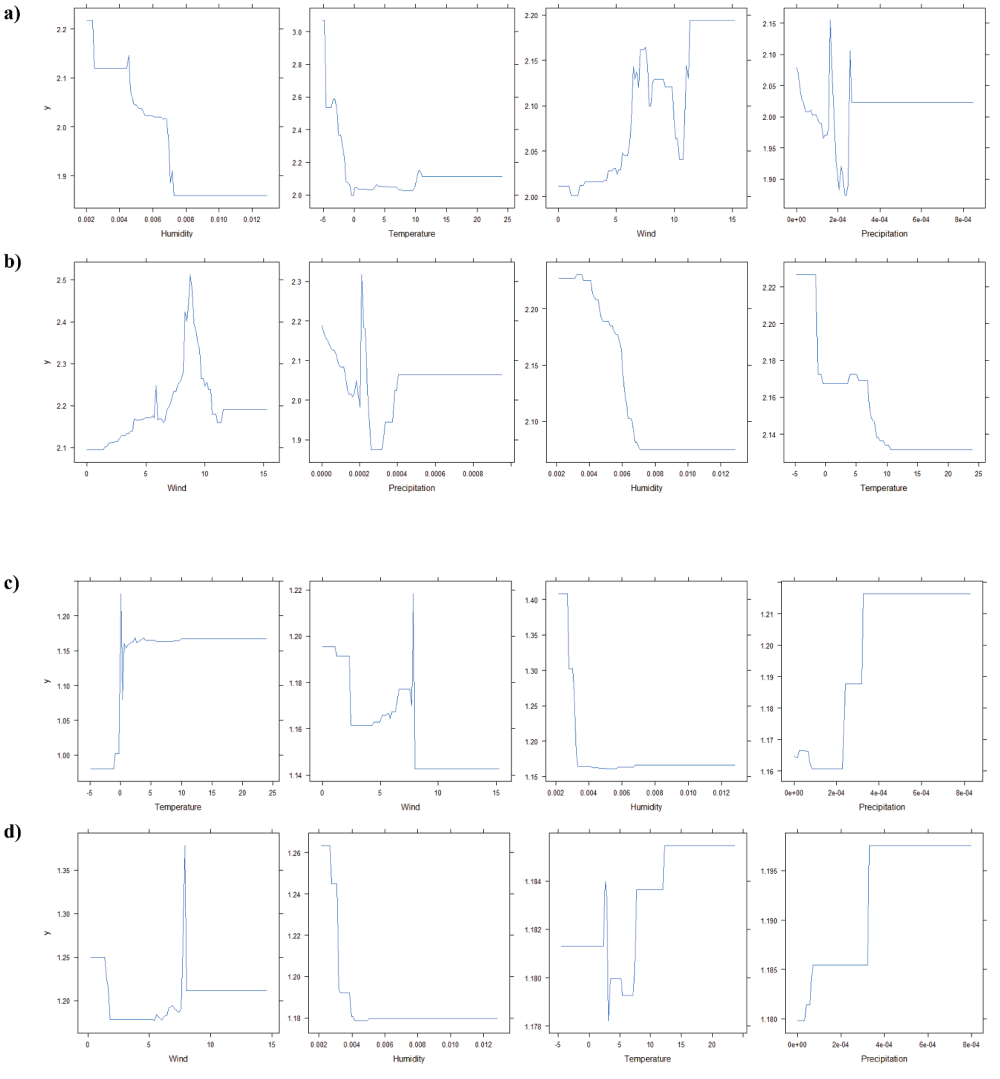

Figure 4. Partial dependence plots for the relationship between a) Female orders, b) Female collections, c) Male orders and d) Male collections and each of the four weather variables. Ordered by variable importance ranking.

made. The opposite, however, is true for humidity with a general trend of negative association. Both higher humidity and higher temperatures appear to lead to a decline in orders for customers in the middle age group. With regards to collections, the plots for wind and precipitation, as the top weather drivers of this outcome in each case, show very similar things for both the youngest and middle age groups. There are overall positive associations with wind and strong negative associations with precipitation when considering that 90% of the data points fall within 0 and 0.0001 kg/m^2/s. As seen previously, the relationship with precipitation becomes more complex in the highest decile of extreme precipitation values. Significant differences can be seen for the over 65 group, but as discussed, the influence of weather on both orders and collections was relatively

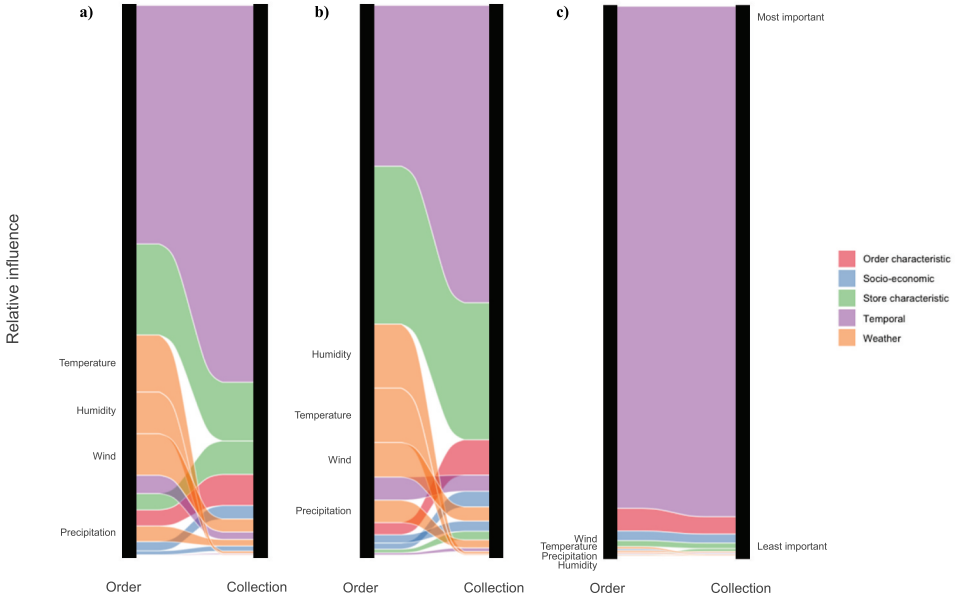

Figure 5. Relative influence rankings of different types of variable on the number of C&C orders and collections for customer aged a) Under 30, b) 31–64 and c) over 65.

negligible. That aside, the highest orders appear to be associated with highest wind speeds and lowest temperatures whilst the highest number of collections coincide with both low temperatures and low wind speeds.

Time taken to collect orders

The third component of this analysis looks at how weather conditions may act to influence the collection time of C&C orders. In this instance, only one model was required and the relative influence statistics for each of the variables included can be seen in Figure 7. In this instance, the weekday on which the order was placed and collected were the most influential variables in the model by a significant margin, followed by all of the weather variables in question. Order characteristics and store characteristics in this case were found to have very little influence overall all. Temperature was found to be the biggest weather driver of collection times, with temperature on the day of collection slightly more influential than on the day of order. The opposite, however, is true for humidity as the second biggest weather driver, where conditions on the day of order were found to have greater relative influence. Precipitation and wind on the day of order were also found to be more influential than their collection day equivalents.

In terms of the nature of these relationships with weather conditions, the plots in Figure 8 have been organised again in order of relative influence ranking but in the interest of interpretability have been separated into conditions for the day of order and conditions for the day of collection. It is further evident that temperature has the greatest influence on collection times, with both temperature figures showing that these conditions may influence collection times by up to 4–6 days. This is greater than for any other

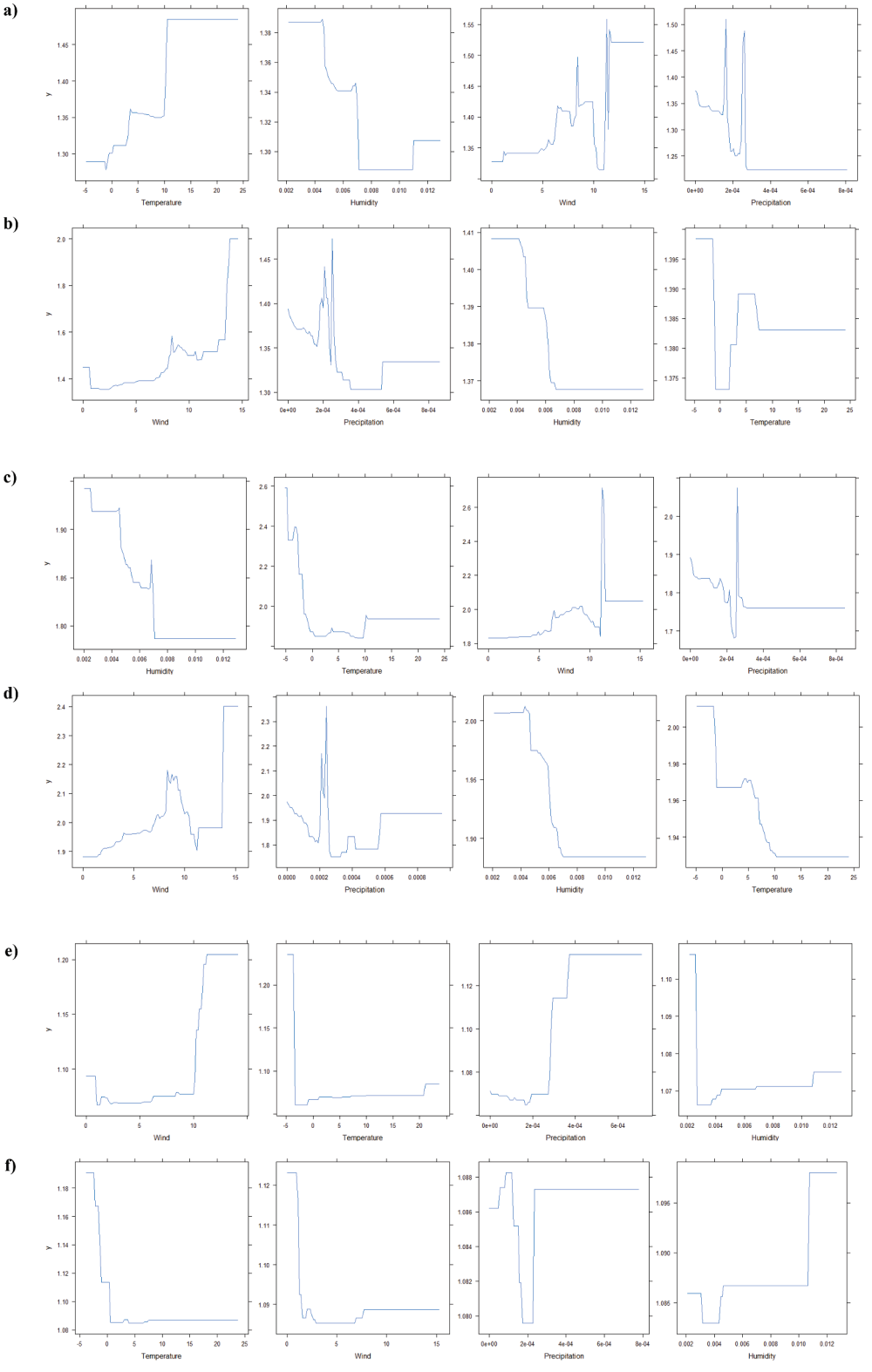

Figure 6. Partial dependence plots for the relationship between a) under 30 orders, b) under 30 collections, c) 31–64 orders, d) 31–64 collections, e) over 65 orders and f) over 65 collections and each of the four weather variables. Ordered by variable importance ranking.

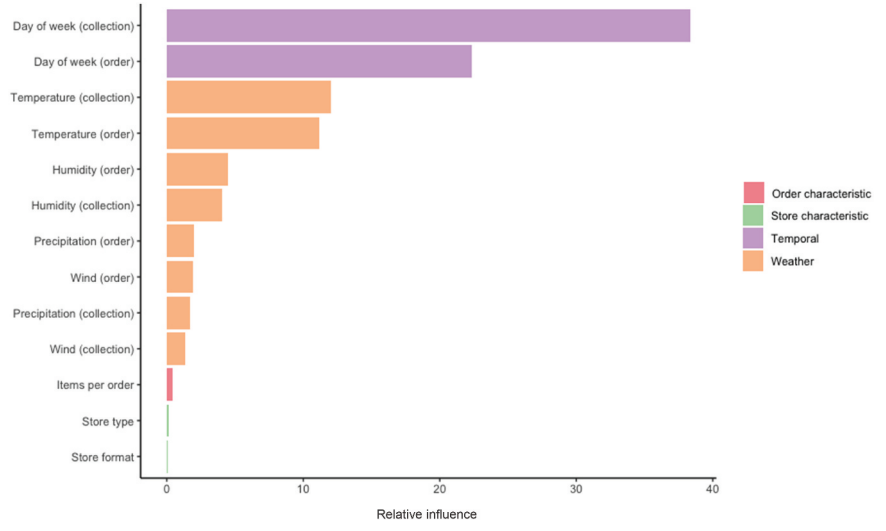

Figure 7. Relative influence rankings of each variable on the time taken to collect an online C&C order.

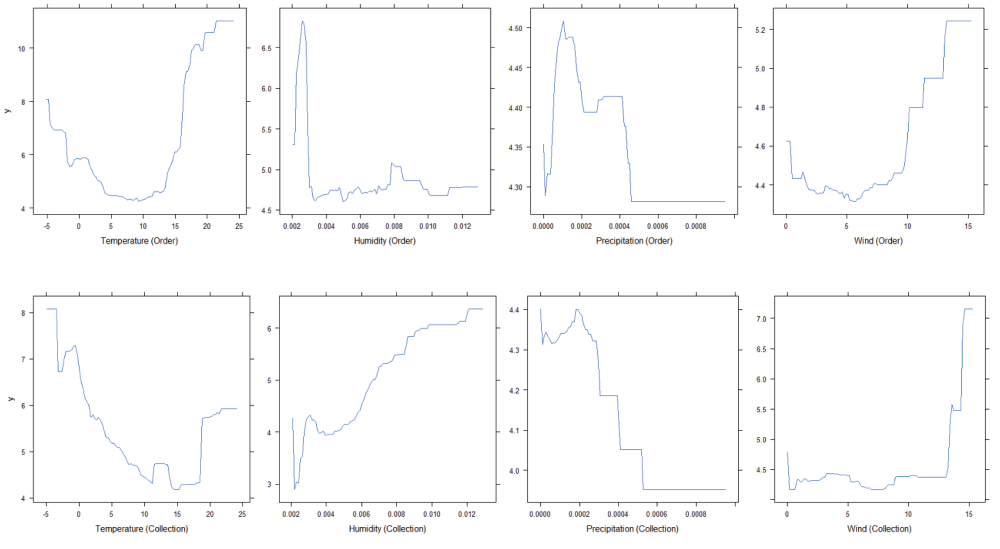

Figure 8. Partial dependence plots for the relationship each of the four weather variables and days taken to collect the order. Ordered by variable importance ranking and split into conditions on the day of order and the day of collection.

weather conditions and in comparison, precipitation makes little-to-no difference in time taken to collect the order, especially when you consider the skew of the data. The shortest collection times are associated with temperatures between approximately 0–15°C on the day of order but between 10°C and 18°C on the day of collection. Low humidity on the day of order appear to lead to longer collection times but for the day of collection there is a relatively strong positive association between humidity and longer collection times. Finally, high wind speeds on both the day of order and collection leads to higher collection times.

Discussion and conclusions

This paper has explored the ways in which weather conditions influence the use of hybrid retailing, in particular C&C facilities by different consumer groups, building on the body of research examining the relationship between weather and physical store sales (e.g. Badorf and Hoberg 2020; Rose and Dolega 2022). Results here have shown weather to have a measurable influence on C&C retailing behaviours, supporting previous studies on the impact of weather on online retail engagement (Anderson et al. 2019; Steinker, Hoberg, and Thonemann 2017). Although present as a factor for both components, weather was consistently found to be collectively more influential on the day of order than the day of collection, with various conditions acting to both increase and decrease the number of events. This could indicate two potential cases: Firstly, that the prevailing conditions provoke the need for certain items that the consumer orders online or secondly, that consumers, already planning to make a purchase, order online in place of a physical store visit. Regarding the former, there is a body of research that has shown sales of certain products to be more influenced by the weather than other factors (e.g. Rose and Dolega 2022) and an increase in e-retail traffic on 'bad' weather days, as found by Canova and Nicolini (2019) would support the latter case. In terms of specific weather conditions, temperature and humidity were consistently found the most influential on the number of orders made, whilst wind and precipitation were commonly the top weather drivers of the number of collections. By comparison, in terms of physical sales for the same retailer, temperature and wind were found to be the most influential drivers (Rose and Dolega 2022). In almost all cases, both the magnitude and nature of the weather influence changes between the day of order and collection, highlighting that, as may be expected, each component of a C&C order requires a unique decision-making process for the consumer.

One of the most interesting and potentially significant findings for retailers was the differences across demographic groups. Differences between male and female customers on the day of order, and those aged above and below 65 are stark. The over 65s are a consumer group that have been identified as the least likely to use C&C services (e.Clarke, Thompson, and Birkin 2015), potentially reflecting limited access or use of digital technology. Weather has a greater influence overall on female customer order numbers, but both groups are comparable with regards to the weather-related influence on collections. Trends of associations between orders and temperature and wind, in particular, were identified as key distinctions in influence, with opposite trends identified for male and female customers. These findings are supported by studies that have identified significant differences in how both male and female consumers use C&C, and the factors that influence their decision-making process (e.Clarke, Thompson, and Birkin 2015; Weltevreden 2007).

Other important findings pertain to the impact of weather on the time taken to collect a C&C order. Notably, the type of weather appears to be more influential than a combination of conditions on either the day of order or the day of collection, with temperature comfortably the biggest weather driver of time taken to collect an order on both days of interest. Warmer temperatures on the day of order lead to longer collection times, whilst the opposite is true for the day of collection. Parsons (2001) describes temperature as one of the most 'tangible' weather conditions,likely allowing it to have the most direct and

immediate influence on consumer purchasing decisions. Arguably, more in-depth explanations as to how the weather drives the time taken to collect an order lies in the sequence of weather conditions between the days of order and collection, however, this is beyond the scope of the investigation.

Despite these findings pertaining to the influence of weather, other factors were found to be more prevalent, such as the characteristics of the store and the time of year the purchase was made. Characteristics such as the location of the store (e.g. high street, out-of-town centre or transport hub) are likely to have a significant influence on C&C services due to the variations in accessibility, such as the availability of parking (Jones and Livingstone 2017) or differing opening hours to fit around work schedules. Equally, it may be influential in terms of a store's proximity to workplaces or on commuting routes, with the same principle applied to parcel lockers (Morganti et al. 2014). With regards the time of purchase, revenues for many different types of products are commonly dominated by Christmas sales (Jasek et al. 2018) or other retail holidays such as Black Friday (Cherrett et al. 2017).

The insights generated from this study come from a time where the UK economy was recovering from a significant period of instability, which mirrors the current circumstances where we are re-stabilising after the economic impacts of the global pandemic. Our findings can help feed into recovery plans for retailers, policy makers and other relevant stakeholders, particularly as hybrid retailing platforms are playing an increasing role in the share of online retail growth (GlobalData 2019). Many of the factors considered in our study, and their respective levels of influence, will be timeless. For example, with regards to seasonality, how different weather or economic conditions influence consumer decision making, or how the level of influence vary across genders. Others, such as store location or variation across age demographics, may look decidedly different. The convenience and flexibility afforded through the rise of m-commerce may diversify options for preferred collection location for consumers, potentially altering of weakening the influence of this characteristic on the outcomes examined here. Further, increased familiarity over time coupled with necessity during the pandemic has led to an increase in older consumers using online retail platforms (Pantano et al. 2020) and perhaps altered the driving forces behind the online retail behaviours of this demographic group.

Study limitations and contributions

Key limitations to this study are acknowledged. Due to the aggregation of daily C&C order counts per store, it was only possible to include socio-economic variables for the location of the store rather than the consumer, which restricts the level of information we can accurately draw from these variables. Assuming the consumers are situated close to the chosen collection store, it is hoped that there is some degree of similarity between areas that are close together (Tobler's First Law of Geography; Tobler (1970). And perhaps most significantly, the use of 'historic' data to study C&C trends that have evolved overthe past ten years, given the rapid increase of online retailing as a whole and accessibility of e-retailing through the prevalence of internet-enabled personal devices.

Despite this, the key contributions of this research stem from increased understanding of how consumers use of C&C models are influenced by the weather and other key factors. The growing importance of hybrid retail models in the current landscape of e-retail and the demand for maximum convenience cannot be understated, however, there has been a lack

of research around C&C outside of the grocery, and occasionally apparel, sectors. Furthermore, there is a lack of research on the impact of weather on all online retailing. This is also an area of increasing importance when considering changing global weather patterns and the escalating variability in British weather forecasts. The results found here bridge this gap and contribute to the understanding of how C&C behaviours have been influenced by the weather in the past, that can be mapped onto current levels and trends of C&C usage. A greater understanding of what influences consumer behaviours can benefit operational management and the potential expansion of these hybrid channels in a way that allows retailers to sustainably balance their resources and maximise outputs. The insights provided by this study can serve as a foundation for constructing a theoretical framework on the influence of weather on various hybrid retail operations and business models. We argue that understanding historic trends are useful from managerial perspective as they provide a benchmark against which most recent trends could be evaluated. Both, the novelty and shortcomings of this investigation leave huge amounts of scope for further research, particularly focussed around how weather influences different e-retailing channels, varying product types and the geographical variations in influence.

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Ethics approval

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