Comparative Study of the Impacts of Conventional and Online Retailing on the Environment: A Last Mile Perspective

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ABSTRACT
Online shopping has an increasing impact on the environment in terms of the related 'last mile' processes, which lies in the CO2 emissions. Thus, this study compares transport-related CO2 emissions of online and conventional shopping in terms of supply, home delivery and travel data from consumers to a physical store branches in the capital of Jordan "Amman". Real data were collected from consumers and analyzed to highlight the different factors that affect CO2 emissions, such store supply, consumer trip distance to physical store, first-attempt failed delivery, returns. The results show that online shopping play an important role in minimizing CO2 emissions including all the related processes to such shopping mode. However, conventional hopping can be more environmentally friendly shopping mode in case the store distance to travel is short. In addition, the use of public transport mode for traditional shopping and the shopping behavior of the consumers are considered as advantages for such shopping mode.

Keywords
Online shopping, Conventional shopping, CO2 emissions, Emission factors, Amman

1. INTRODUCTION
Today's rapid developments of technologies are having a significant effect on the modern society shopping behavior which affects the environment. Theses technological effects are

significant in reducing CO2 emissions through convincing people to adopt online shopping as a new shopping mode instead of conventional shopping. Online shopping is one of the most significant Internet business models that increased in the demand of home delivery service [25]. In addition, online shopping is one of the most attractive facilities for internet users where consumers place an online orders and the retailer is responsible for fulfilling their orders [18]. Xia, Huang and Zhu (2010), identified the process of order fulfilling as the process of planning, organizing and dispatching consumers' orders and preparing them to be delivered to their doorstep or any other location.

However, little research has paid attention in the area of reducing CO2 gas emission through developing new systems and services where last mile or home delivery service play an important role in preserving the environment [28]. The role of home delivery service lies in reducing consumers trips into physical shops for shopping or collecting their items [10] [11]. Moreover, advances in positioning technologies such as GIS and GPS have a significant role in preserving the environment by reducing traffic and energy consumption [21]. The future developments of last mile service will have a significant impact on the potential and the effects of online shopping. The body of knowledge of the environmental effects of online shopping toward greener environment is expanding rapidly. General studies on the environmental effects of online shopping including Cairns (1998, 1999) and Siikavirta, Hanne, et al. (2002) studied the environmental effects of home delivery service [28].

The purpose of the present study was to (1) review the literature on the environmental effects of online shopping and (2) to translate the environmental effects of carbon emissions associated with delivering products bought online to the consumer's doorstep, compared with consumers making trips to the physical shops for shopping.

The rest of the paper is structured as follows: first, review of the existing literature of effects of online and conventional shopping on the environment. This is followed by the study methodology and CO2 emissions factors are discussed. Thereafter, the results of the collected and analyzed data are presented. Finally, the study results are presented and discussed.

2. EFFECTS OF ONLINE AND CONVENTIONAL SHOPPING ON THE ENVIRONMENT
Online and conventional shopping modes are common amongst societies in developed and developing countries. However, online shopping is the most disseminated shopping mode amongst developed countries societies due to the technological advances in such countries and vice versa. The big difference between both shopping modes is the fulfilment process, which identified as of planning, organizing, and dispatching consumers' orders [36]. In addition, the delivery of online purchased goods will be on the responsibility of the seller which encourage people to shop online and then reducing the number of shopping trips to physical shopping stores. The delivery of online purchases can be done by the seller's delivery fleet or third-party logistics (3PL) (such as DHL, ARAMEX, TNT, etc.) within specific time windows to meet their customers' expectations [11]. Whilst in traditional shopping, the consumers have to visit physical shopping stores to buy their needs and they might make several shopping trips to get their purchases from several shopping stores. Nevertheless, e-retailers claim that online shopping affects the environment positively because it presents beneficial services to the customers, which encourage them to buy online rather than physical shopping stores [29]. Consumers have a wide-experience in both shopping modes and realize that online shopping, mainly its related delivery

service is beneficial to the environment due to the huge reduction in the shopping trips made by consumers to the physical shopping stores [16] [27]. Also, from the perspective of researchers, online consumers will find many e-retailers offer thousands of products in one place which make the shopping process easy and effortless. Thus, online shopping reduced the delivery of consumers' orders in one trip to multiple consumers rather than individual trip to each consumer which increased the efficiency of the delivery process [26]. So, online shopping mode is considered as the alternative of conventional shopping mode, which reduces the environmental affects by reducing or eliminating the overall travel trips for shopping and lead to greener environment [31].

Many previous research studies have been conducted to compare online with conventional shopping whereas most of them were concentrating on grocery sector [1] [6] [3] [4] [13] [23] [14]. A study by Weltevreden & Reitbergen (2007), is conducted on online shopping and showed that shopping trips varies between shoppers depending on their lifestyle and the technological advances in the country they live in. For example, shoppers might visit physical shopping store on their way from work to home or vice versa [34]. In addition, the technological advances such as the availability of advanced delivery systems will play an important role in convincing shoppers to shop online which could change their lifestyle. However, people's modern lifestyle might lead to delivery failure because of customer's absence at the delivery time due to the long working hours during the day. This results in the failure of delivery first-attempt, causing lower customer satisfaction and higher costs for retailers or delivery companies [22]. Therefore, retailers and delivery companies must improve the delivery service in order to be cost-effective by adapting delivery scenario that could lower the delivery costs and gain customer satisfaction to encourage them to shop online. These scenarios are. First, using the existing physical stores, nearest petrol station, or nearest post office as pickup and delivery points for goods ordered online where customers can pick up their orders from the nearest pick up point at any time. Second, direct home delivery from distribution depot within specific delivery time window or by offering early night delivery slots which can be beneficial for delivery success and lead to avoid traffic peak time [5]. Finally, the use of reception boxes that can be placed in the nearest gas station or post office for depositing consumers' deliveries, while consumers are not-at-home which reduces 50% of the delivery distance [17]. Previous studies found that 12% to 78% of online shoppers are making fewer shopping trips that sometimes could reach 0% [10]. This variation could be attributed to the used methodology and the available positioning technologies that been used at that time. Positioning technologies are extensively used these days for delivering consumers' orders and help in making the delivery service more reliable and efficient. Cairns et al. (2005) conducted a study in the UK for calculating the millage of delivery vans that deliver consumers' orders and found that 70% of car-millage can be saved when replacing trips to supermarket. In addition, weber et al., (2008), compared CO2 emission for both shopping modes and found that approximately 65% of CO2 emissions are caused by consumers' trips to the physical shopping stores.

The previously conducted studies shows the difference between online and conventional shopping in terms of CO2 emission and their effects on the environment by considering the last mile operations as the bottleneck for the success of online shopping. Thus, the concentration of this paper on this stage of the supply chain is due to its importance for online shopping success and energy saving by reducing shopping trips which lead to greener environment.

3. RESEARCH METHODOLOGY

This study compares the results of CO2 emissions generated from both last mile deliveries of online bought goods and conventional shopping trips. The products that been considered in this research are non-food products, such as small home appliances, electronic devices, books, and clothes. However, these products have been found to be the most frequently online bought items respectively. In addition, these items might have more characteristics than other items, such as clothes which causing higher CO2 emissions [9] [35]. The study contributes to the body of knowledge by collecting and analyzing real data used from shoppers' survey that been conducted at two branches of a retailers' store that run both shopping modes. The first branch is located close to the center of the capital of Jordan, Amman; the distance from the shop to the supply warehouse is 120 km. The second branch is located on the border of the capital around 13.5 km distance, close to the retailers' warehouse; the distance from the shop to the warehouse is 35 km. Also, online orders information from the same store and last mile delivery information were provided.

However, previous studies such as Edwards, Mckinnon& Culinnane (2010) were depending on average values for examining CO2 emissions caused from delivering consumer's products at the 'last mile' stage in the supply chain. These values were published by the UK government statistics organizations and home delivery companies to model the emitted CO2 from online and conventional shopping modes. Therefore, these studies are not considered as realistic studies and not reflecting consumers' shopping behavior that influence their shopping mode. However, this study aims to compare the amounts of CO2 emissions caused by both shopping modes under the influencing factors of the consumers' shopping behavior.

CO2 emission effects were analyzed based on the collected data from a retailers' store depending on both shopping modes for selling his products in the capital of Jordan, Amman. The delivery service of online orders is provided by a foreign delivery courier such as ARAMEX. Online orders delivery starts form the retailer's central warehouse which used for supplying of products to the physical store as well.

4. CO2 EMISSION FACTORS

4.1 Conventional shopping

To calculate CO2 emissions of goods transport from the central warehouse to store branches and consumers' trips to the stores; the following assumptions have been considered. First, the warehouse supplies are imported by the retailer's fleet using a Volvo truck with payload of 26 tons. The Volvo truck runs on diesel emits 2.6 kg/ton-km of CO2 and the combustion of fuel is approximately 0.275 litre/km (according to the producer, see www.volvo.com), when fully- loaded with warehouse supplies. This percentage is taken depending on the diesel type (standard diesel) used during the transportation, and the road (motorway). CO2 emissions caused by transporting goods to the store branches are computed by multiplying the fuel consumption value with the CO2 emission factor of the fuel per payload of the vehicle depending on the following equation:

0.275 L/km*2.6 kg/L per 26 tons ≈ 0.0275 kg/ton-km of CO2

Second, a study has been conducted by using a sample size of 319 questionnaires at both branches to understand the

shopping behaviour of the consumers, such as transport mode used to get into the shop, products that been bought, trip distance to store and how they collect products information such as offers, availability, etc. To calculate CO2 emission amounts caused by shopping trips depending on the transport mode used (e.g. Cars and buses) for conventional shopping; the distance between the customer home and the store was multiplied by the CO2 emissions of the transport mode used for shopping. Also, the study took the CO2 emissions per passenger-km travelled using the different transport modes from Wiese, Toporowski and Zielke (2012) study, which showed that the amount of CO2 emissions for cars is 144 gCO2 and 73.5 gCO2 for buses.

Conventional shopping dedicated trips

High street shopping or conventional shopping is the typical way for many shoppers considering it as the way of spending time and have fun. This mode of shopping requires the shoppers to use a transport mode (e.g. cars and buses) for getting to the shops [10]. Commonly, 72% of shopping trips for high-street shops made by cars and buses; this is due to the convenience and other benefits of using such modes of transport [11]. Using such transport modes for shopping causes CO2 emissions; where shopping-trip is defined as "a one-way journey with a single main purpose, with outward and return halves of a return trip treated as two separate movements" [11]. Thus, shopping trip distance would be doubled.

To calculate CO2 emissions caused by consumers' trips to the shops using these transport modes, the trips that been made for the purpose of shopping-only were taken into account. Otherwise, no other trips were considered in the calculations (i.e. shopping is not the main purpose for the trip). In addition, cycling and walking were excluded from the calculations because they considered as an environmental transport modes that do not require energy consumption [11].

4.2 Online shopping

To calculate CO2 emissions caused by 'last mile' processes of online shopping; the retailer has provided information about 15000 orders and their destinations in a period of 5 weeks. In addition, information about the delivery information such as distances, delivery vehicles used and the vehicles payload were provided. The retailer uses 3PL Company for delivering consumers' orders. This delivery company uses Mercedes sprinter vans that run on diesel for delivering consumer's orders. The payload is up to 3.5 tons with fuel combustion of 8.1 L/100 km and CO2 emission factor of 214 gCO2 (for more information, see www.mercedes-benz.com). The delivery process starts by delivering consumer's orders from the central warehouse to the distribution centre and then to its final destination (consumers' home). The distance between the central warehouse and the distribution centre is 15 km and the average number of deliveries is 100 parcel/day. Thus, the average distance per parcel delivery is 1.5 km. This value is calculated by the overall distance of the delivery trip (150 km) divided by the average number of delivered parcels. This section uses the same approach used for the store supply in the conventional shopping to calculate CO2 emissions caused by last mile process.

5. RESULTS

This section presents the comparisons of both shopping modes from the perspective of the last mile process in terms of CO2 emissions. It presents also the other factors affecting CO2 emissions through using both shopping modes.

5.1 Conventional shopping mode

CO2 emissions caused by conventional shopping mode are analysed depending on the process of store supply and the transport mode used by consumers to get into the shop. First, regarding to store branches supply, branch 1 requires driving of 120 km and branch 2 requires 13.5 km of driving due to its proximity to the supply warehouse. Second, regarding to consumer trip for each branch, branch 1 requires a trip distance of 10.9 km and 27.5 km for branch 2. These shopping trips would be doubled in terms of the distance. Nevertheless, most of consumers in Jordan are using their own cars for shopping due to inconvenient public transport. Therefore, 85% of consumers used their cars for shopping from both branches and 15% used public transport for shopping. An assumption has been made to calculate the payload of truck that supplies the store branches and the number of bought items at each branch per trip. Regarding the supply process, the average payload of the supply truck per trip is 70% of the total payload for both branches. Whilst, the average number of bought items from each branch per trip is 15 items weighting up to 10 kg.

Table 1: CO2 emissions of conventional shopping

	Partial CO2 emissions			Total of CO2 emissions for each transport mode	
	CO2 emissions of branch supply	CO2 emissions of customer trip			
		Car	Bus	Car	Bus
Branch 1	0.7	2.6	0.74	3.3	1.44
Branch 2	0.2	1.0	0.29	1.2	0.49

Table 1 shows the total CO2 emissions of conventional shopping (in kilogram) for both store branches supply and consumer trips using both transport modes. The CO2 emissions computed depending on the truck payload, distance and fuel combustion factor. CO2 emissions of consumers' trips computed depending on the distance to store branch and the CO2 emission factor; whilst public transport CO2 emissions computed depending on distance to store branches, average CO2 emission factor (110 gCO2/passenger-km) [15].

5.2 Online shopping mode

CO2 emissions caused by home delivery known as 'last mile' of bought items online depending on the used vans for delivering consumers' orders. As mentioned earlier, the delivery company uses Mercedes-Benz sprinter vans that run on diesel with fuel combustion of 8.1 L/100 km and emits 214 gCO2. The retailer uses the second branch as a distribution center for online bought items due to its proximity from the warehouse. The total of CO2 emissions of using such shopping mode are presented in Table 2.

Table 2: CO2 emissions of 'last mile' processes

Last mile process		Total CO2 emissions per parcel
Distribution center	Consumers' house	
0.049	0.115	0.164

Table 2 shows the total CO2 emissions of 'last mile' process caused by online shopping (in kilogram). The results in the table show that the last mile delivery process to the consumer's house causes the most CO2 emissions, which is consistent with the results [11] [32].

A comparison has been made between conventional and online shopping in terms of CO2 emissions. The comparison reveals that the total CO2 emissions of conventional shopping (as shown in table 1) when using cars is 3.3 kg of CO2 for branch1 and 1.2 kg of CO2 for branch2, while CO2 emissions for using public transport was 1.44 kg of CO2 for branch 1 and 0.49 kg of CO2 for branch 2. These results are consistent with the results [7] [8]. According to CO2 emissions caused by online shopping 'last mile' process (as shown in table 2), the final destination delivery process to consumer house which generates 115 g of CO2 with a total CO2 emissions of 164 g of CO2 per parcel causing huge reduction in CO2 emissions in comparison of using both transport modes in convention shopping.

5.3 Other factors of CO2 emissions

Delivery methods

As mentioned previously in this study, goods delivery causes physical movement of delivery fleet for delivering consumer's items to their home addresses. These deliveries could be delivered using the retailer's delivery fleet or by third-party logistics (3PL) (such as DHL, ARAMEX, TNT, etc.) from the warehouse of the retailer or from local parcel depot using delivery vans to the consumers' home. Retailers or 3PL Companies are responsible for providing the delivery service of online purchases to the consumers [36]. Otherwise, consumers have to pick up their purchases from the nearest store or pickup and delivery point. Also, some retailers are employing delivery couriers who are using their own private cars for delivering consumers' orders [11]. Those delivery couriers have different characteristics in terms of vehicles and the delivery process than the official delivery couriers. This could lead to lower CO2 emission due to the use of cars for deliveries instead of vans. Thus, the amounts of induced CO2 will be lower due to the shorter delivery routes than the typical routes of delivery vans. In addition, the work behavior of the delivery logistics is achieving high-density drop per delivery route, which increases the amount of CO2 emissions [11]. Therefore, they have been excluded from the analysis.

Delivery first-attempt failure

Today's life-style of many people has increased the incidence of first-attempt delivery failure due to inexistence of people at their homes during the daytime where most deliveries are made. As a result, delivery companies must cope with the increasing problem of not-at-home during the delivery time. Therefore, home delivery is classified into "attended and unattended home delivery". Attended home delivery stipulates the consumer to be present at home at the delivery time to receive the delivery. However, some delivery companies adopt the strategy of determining delivery time slots for delivering consumer's orders to avoid delivery failure [5]. At the same time, delivery companies use unattended delivery as an alternative solution for the problem of not-at-home at the delivery time [22]. This way of delivery lies in leaving consumers' items in alternative location, such as neighbors, back garden shed, which considered as an insecure places on the long run. Thus, delivery companies started adapting alternative secure locations for leaving consumers' items and avoiding first-attempt delivery failure. These locations are the nearest pick-up or collection points (e.g. nearest petrol station or post office), home reception boxes, and communal reception boxes [19] [24]. However, the use of such delivery alternative would minimize the amount of CO2 emissions by minimizing the consumers' trips. In addition, consumers might pick up their items from the delivery alternative locations by walking rather than cars, which primarily reduces CO2 emissions.

To compute CO2 emissions of first-attempt delivery failure, this study assumes three delivery failure rates. First, failure rate of 15% of deliveries; second, a 30% failure rate; third 50% failure rate, and finally a 100% successful first-attempt delivery achieved by delivery companies use alternative locations for leaving consumers' items as shown in Table 3.

Table 3: CO2 emissions of first-attempt delivery failure rate

Delivery failure rate	15% failure rate	30% failure rate	50% failure rate	100% successful delivery
Van deliveries	188 gCO2	213 gCO2	246 gCO2	164 gCO2

Table 3 shows the average emissions of CO2 per item depending on different first-attempt delivery failure rates. CO2 emissions amount increases with the increase of the first-attempt delivery failure rate from 15% to 50% with 100% successful delivery. The common work behavior of most delivery companies is repeating first-attempt failed deliveries in the next working day, and in case the second-attempt failure happened, they leave a card for the consumer to pick it up from the nearest collection point [11].

Returns of unwanted goods

Returns of unwanted goods are considered as a type of consumers' trips to a physical place (i.e. nearest post office, shop, and collection point) for returning these items. The other types of consumers' trips that increase the emissions of CO2 are: trips physical shops in the conventional shopping, click & collect trips, trips for picking up items after a failed delivery [30].

However, the attributes of goods play an important role in the return rate of unwanted goods. For instance, the percentage of return of small non-food items is 25% and 40% for clothing [11]. These returns of unwanted goods and picking up failed deliveries from pickup points such as nearest post office or petrol station raises consumers' trips, which consequently increase CO2 emissions. Return methods of unwanted goods play an important role in minimizing CO2 emissions. These methods are: first, making arrangement with the delivery company for picking up unwanted goods and returning them to the central warehouse which considered as the most efficient way of products return; and second, returning

unwanted goods directly to the physical shop by the consumer. The first method needs doubling the amount of emitted CO2 due to its similarity of product delivery from the central warehouse. As shown in the first-attempt delivery failure section, the failed delivery results in 164 gCO2 per item, assuming 30% return rate of unwanted goods from online shopping with a distance of 10 km. also, the return rate of unwanted goods from the conventional shopping is assumed as 10 to 20%. Table 4 shows a comparison of unwanted goods bought online return through delivery company courier van and conventional shopping in terms of CO2 emissions (in kilogram).

Table 4: CO2 emissions of goods return from both shopping modes

Branch 1		CO2 emissions of conventional shopping returns by car		CO2 emissions of online shopping returns by van	
Distance (km)	Number of items	Return rate of 6%	Return rate of 10%	Return rate of 30%	Return rate of 100%
<10	30	1.118	1.198	.295	.001
<15	50	1.32	2.20	.328	1.093
<25	80	1.26	2.11	.314	1.049
<40	130	1.28	2.14	.319	1.066

Shopping behavior

Shopping behavior of consumers play an important role in minimizing CO2 emissions. This lies in the availability of products information online such as price, availability, offers, etc. where the consumers browse the products online on the retailers' website and buy them offline from the store. This shopping-behavior would reduce CO2 emissions due to the specified shopping trips to the physical store [9]. Conversely, collecting products' information physically from the stores and buying online would increase CO2 emissions [12]. Also, trip chaining is widely used by consumers to combine shopping with other activities, while some consumers make dedicated trips for shopping only [11]. These shopping behaviors also would affect the environment depending on the transport mode used where the most friendly transport mode for such behavior is the use of public transport mode. In addition to uncertainty which lies in examining the products before buying them where many consumers make trips to the store for this purpose and buy the products online.

6. DISCUSSION

The study shed the lights on the results of a comparative study of CO2 emissions for the delivery process of online purchases and conventional shopping trips. Previous studies on the environmental effects of online shopping has discarded consumer shopping behavior effects that play an important role in minimizing CO2 emissions. For instance, transport mode used, first-attempt delivery failure, return of unwanted goods and trip chaining. The results of this study were depending on real data that been collected from a multi-channel retailer store for the purpose of comparisons. In addition, previous research literature or industry practice, and statistics were applied to different scenarios of consumer trips and delivery.

Many factors of home delivery process affect CO2 emissions. They include: distance, truck payload, delivery road, number of drops per delivery route, type of delivery van and/or truck, and the work-behavior of the delivery company about how to deal with returns and failed deliveries. Also, there are other factors that affect the CO2 amount emitted per item purchased either online or from physical stores. These factors also include: the purpose of the trip should be only for shopping (no other activities was undertaken during the shopping trip), online purchases were successfully delivered, low return rate of online purchased goods, and product information availability.

The results of this study yield several managerial implications. Online retailers should increase the performance of online shopping by tread over the cultural barriers such as product uncertainty. In addition, increase the trust factor between both consumer and retailer, which lies in the provided services to the consumers such as customer service and quality of service (QoS) [20] [2] [35]. Also, delivery companies should adopt the most recent positioning technologies, which help in making the delivery process more efficient and consequently minimizing CO2 emissions. In addition, they should increase the awareness level of consumers about the environmental benefits of the delivery service over the conventional shopping trips to the physical stores. However, physical store retailers who have a large network of stores can increase the awareness level of their consumers. This can be by motivating them to buy from the nearest store due to the lower emissions of shopping trips that can be considered as an alternative for online shopping.

Furthermore, the environmental implications of consumer shopping behavior should be emphasized by retailers about their role in avoiding environmental pollutions generated from shopping behavior. This lies in selecting the most environmental friendly transport mode to the physical store. As noted from the results, public transport mode emits less CO2 than private car journey over the same distance per item purchased. Consequently, public transport mode should be improved more and more to attract consumers to adopt it for their shopping trips instead of private cars. Moreover, maximizing the number of items in one shopping trip rather than buying one or two items per trip. This would allow spreading the emissions to a larger number of items per shopping trip. In addition, physical store retailers should motivate consumers to use greener transport modes such as bikes by making special parking spaces for them and extending their store network to attract consumers to walk to them.

For multi-channel retailers, they should explain the advantages of the each shopping mode to the consumers. This can be by providing full product information, which mainly play an important role in the shopping behavior of the consumers. Moreover, they should adopt the concept "quality of service" or QoS, which include goods quality, delivery service and the technologies, used for processing consumers' orders [20] [2]. Additionally, improving the customer service, which lies in answering consumers' questions and enquiries, after sale service, providing detailed information of products

return and payment policies [2] [37]. This would minimize the return rate of products, which minimize shopping trips and consequently CO2 emissions.

Unwanted goods return play important role in the reduction of CO2 emissions. For instance, delivery courier collecting unwanted goods by van method is considered as the most environment friendly way of good return. On contrary, consumers' trip to store for returning unwanted goods or private couriers using private cars for collecting returns from consumers' home, generates the great amounts of CO2. In addition, using the nearest post office or petrol station as collection and delivery points (CDPs) reduces CO2 emissions further.

For delivery companies, they should develop strategies to avoid first-attempt delivery failure by selecting more appropriate times for deliveries. These strategies lie in early night deliveries, which reduce the chance of the consumer not to be at home at the delivery time. In addition, reducing the time taken to deliver consumers' orders by skipping the peak time, which consequently minimizes CO2 emissions as well.

Finally, delivery companies should use low emission vehicles, e.g. hybrid or electric vehicles. Also, installing reception boxes at consumers' homes or placing communal reception boxes at the nearest post office or petrol station would eliminate delivery failure. In addition, using positioning technologies would help in reducing required mileage for deliveries and skipping peak-time traffic.

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