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Abstract

Destination cards have been recognized as effective tools for promoting tourism destinations. However, their role as mechanisms for coordination among tourism service providers remains under-explored. We address this gap by developing an enriched version of the Hotelling price competition model to investigate the welfare effects of destination cards. We consider a destination with two price-setting attractions and one complementary good (transportation), and a card offering discounts on attractions and free access to local transportation. By partially internalizing the externalities resulting from service complementarity, we find that the destination card enhances social welfare but may alter the pricing behavior of attractions, potentially reducing tourists' welfare.

Keywords: Destination Card; Tourist Card; Tourism Destination; Coordination; Welfare Effects; Hotelling Model.

JEL Codes: Z3 (Tourism Economics); L83 (Sports • Gambling • Restaurants • Recreation • Tourism); L13 (Oligopoly and Other Imperfect Markets)

1. Introduction

Tourism destinations are markets where the spatial concentration of service providers (Yang and Fik, 2014) (e.g., amusement parks, hotels, restaurants, transport), organizations (e.g., Destination Management Organizations, or DMOs), natural attractions, landscape, heritage, and infrastructure yields the supply of an integrated tourism product (Zach and Hill, 2017). This product results from the combined efforts of all the (independent) economic agents co-located within the destination, where agents' activities are complementary and mutually relevant. For instance, introducing an effective transport system might trigger tourists to visit distant attractions; similarly, tourists' utility from visiting a museum may be enhanced when restaurants offering good food open nearby. As a result, the tourism

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product exhibits characteristics of an anticommon good (Heller, 1998, 1999; Michelman, 1982; Candela et al., 2008), where ownership and production are fragmented among multiple providers, each contributing a single complementary component to the whole product. In this context, tourists visiting a destination need a (kind of) "permission to access" that must be granted by each individual provider of complementary services. If one provider does not deliver or delivers a low-quality component, it creates a negative externality that impacts all the other complementary components, causing the overall tourism experience to worsen and profits to shrink. This specificity of tourism suggests that the resulting inefficiencies are not solved through vertical integration, as is common in other economic sectors; instead, they are mainly addressed through coordination efforts by independent providers (Novelli et al., 2006; Stienmetz and Fesenmaier, 2018). Business practice shows there are two different ways to internalize the anticommon externality: (i) inter-firm coordination agreements, often facilitated by DMOs (Angeloni, 2016); (ii) integration of various tourism services into package tours (e.g., all-inclusive holidays) sold by tour operators and travel agencies (Figini, 2022).

In this paper, we focus on an increasingly popular form of inter-firm coordination agreement—the Destination Card (DC)—and develop a microeconomic model to explore the welfare effects arising from the presence of DCs in tourism destinations. The DC, also called "tourist card", "city card", "city pass", "guest card", "visitor card", or "welcome card", provides tourists with access to attractions, transportation services, and other amenities at discounted rates or for free (Leung, 2020; Zoltan and Masiero, 2012; Le-Klähn et al., 2015). The practical aims of DCs are to encourage greater utilization of available tourism facilities (Zoltan and Masiero, 2012) and enhance the quality of the tourism experience by providing cost- and time-saving functionalities (Leung, 2020; Thirumaran and Eijdenberg, 2021). In Table 1, we examine the top five cities ranked by Popova (2023) and the top five European alpine regions ranked by Landesinstitut für Statistik (ASTAT) (2023) and stress that each destination offers a DC.[1] We then list the main features of these DCs: all provide either free public transit, or discounted access to attractions, or both; some cards are offered free of charge, while others are available for purchase.

The relevance of coordination for tourism destinations is well-documented (for a recent review see Messori and Volo, 2024). From an economic theory perspective, DCs are a specific form of coordination, functioning as *price* coordination agreements among providers of substitute services (i.e., attractions) and complementary services (i.e., transportation). In the tourism economics literature, price coordination has been first analyzed by Wachsman (2006) and then extended by Andergassen et al. (2013, 2017). The authors consider a stylized destination with two suppliers of complementary tourism services (e.g., an airline and a hotel) and show that both consumer surplus and producer surplus improve when the two firms coordinate their pricing to maximize their *joint* profits, an outcome referred to as "coordination theorem"; this is because tourists benefit from lower prices, while firms gain from increased sales. We

[1]More precisely, the Dubai DMO does not offer DCs; however, its website links to cards offered by tour operators. The table provides an example of one such card.

Name	Price	Website	City/Region	Free Public Transport	Attractions
Paris Passlib'	positive	parisjetaime.com	Paris	yes after supplement [a]	free
Dubai Unlimited Pass	positive	dubaipass.visitdubai.com	Dubai	no	free
Madrid City Card	positive	citycard.esmadrid.com	Madrid	yes	discount
Tokyo Pass	positive	mytokyopass.com	Tokyo	yes after supplement [b]	free
I Amsterdam City Card	positive	iamsterdam.com	Amsterdam	yes	some free, some with a discount
TirolWest Card Basic	zero	tirolwest.at	Tyrol	yes	free
Alto Adige Guest Pass	zero	suedtirol.info	South Tyrol	yes	free
Salzburg Card	positive	salzburg.info	Salzburg	yes	free
Zugspitz Arena Bayern Tirol Card	zero	gapa-tourismus.de	Bavaria	yes	free guided hikes, discounts on attractions
Trentino Guest Card	zero	trento.info	Trentino	yes	some free, some with a discount

Table 1: Destination cards in selected destinations

[a]The Paris Passlib' does not include transportation, but the Navigo Day Pass or Forfait Paris Visite can be purchased separately at a flat rate for unlimited transport.

[b]The Tokyo Pass offers the option to add unlimited subway travel within the specified time frame for a one-time additional cost.

contribute to this body of literature by providing a less stylized representation of tourism destinations. In particular, we acknowledge that (i) multiple firms managing similar tourism attractions (e.g., museums and galleries; churches and castles; theme and amusement parks) co-exist within a destination and may compete to attract time-constrained visitors; (ii) tourists may rely on local transportation services to reach attractions, provided the destination has an effective transport system; (iii) tourists typically seek to visit multiple attractions, i.e., they exhibit a preference for variety (Andergassen et al., 2013), though they may be unable to visit all desired attractions due to constraints such as distance or high transportation costs.

To take the above features onboard, we consider the Hotelling price competition model and adopt its original spatial interpretation. More precisely, we build on the approach presented in the tourism economics literature by Àlvarez-Albelo and Martínez-González (2022) and extend it, introducing a three-firm framework where two attractions compete over prices and a third firm offers a complementary service, i.e., public transportation, at a regulated price. The inclusion of the transportation company crucially differentiates our analysis from Àlvarez-Albelo and Martínez-González (2022): the model would overlook the consequences of having complementary goods in the tourism bundle if the transportation firm were absent. The advantage of using the Hotelling framework to study DCs is twofold. First, it conceptualizes a linear city (or region) that reflects the physical nature of a destination, with the two firms located at the opposite endpoints and tourists enjoying accommodation services distributed along the city. Second, it incorporates the transportation costs incurred by tourists to reach attractions. More specifically, these costs, typically used to measure horizontal differentiation in Hotelling, are herein interpreted as the actual time *and* monetary costs that tourists bear when traveling from their hotel to the attractions.

A key assumption of the standard Hotelling model is that consumers purchase at most one unit of the good from either firm, which fails to capture their love for variety (Andergassen et al., 2013). Therefore, we extend the standard framework to allow tourists to buy from both firms and refer to it as the non-unit demand Hotelling model (for similar specifications, see Kim and Serfes, 2006; Jeitschko et al., 2017; Àlvarez-Albelo and Martínez-González, 2022; Anderson et al., 2010). An important novelty of our approach is that we let the transportation costs take *any* positive value relative to the tourists' gross utility from visiting the attractions. This marks a departure from all previous studies employing the non-unit Hotelling framework, as well as from most papers utilizing the standard framework (for a recent exception, see Bacchiega et al., 2023).

With such a model set-up, we solve the following price competition game: first, the two attractions simultaneously choose prices to maximize profits; second, tourists make their purchasing decisions. At equilibrium, two main scenarios arise. When transportation costs are relatively high, tourists located near either attraction opt to visit only that attraction to minimize transportation expenses, while the others visit both. When transportation costs are lower—this is the novel scenario we emphasize—all tourists visit both attractions.

We then introduce a DMO that provides tourists with a DC, offering free public transport and a percentage discount on the price of the two attractions. We show that the DC modifies tourists' purchasing decisions and alters the outcome of the price competition game. In particular, we derive the conditions under which, due to lower transportation costs that reduce demand elasticity, all tourists choose to visit both attractions only when the DC is available. Anticipating this, attractions respond by increasing their prices, ultimately causing tourists to pay *more* despite the discount.

The final step of our analysis consists of studying how the presence of the DC affects the three firms' equilibrium profits, tourist surplus, and the sum of these four values, i.e., total surplus. Our findings are as follows. Both the total surplus and the two attractions' equilibrium profits improve with the DC's presence, thanks to the demand boost. By contrast, when transportation costs are such that all tourists opt to visit both attractions only if endowed with the DC, the tourist surplus decreases due to the price increase described earlier. This is a novel result that deviates partially from the coordination theorem and arises from solving the Hotelling game without parametric restrictions: this approach allows firms to adjust their pricing strategies in response to the presence of the DC and the resulting change in tourists' purchasing behavior. Note in conclusion that the increase in total surplus due to the DC has the following implications: the losses incurred by tourists and the transport company, which no longer collects revenue from travel ticket sales, can be compensated, making a Pareto improvement achievable.

To the best of our knowledge, this is the first study to provide an economic theory analysis of price coordination mechanisms involving providers of complementary and substitute services. Our paper is related to three streams of literature: (i) the economics literature on complementarities and coordination, (ii) the tourism management literature on DCs, and (iii) the industrial organization literature on pricing strategies in the presence of externalities. In Section 2, we describe these strands in detail. In Section 3, we present the non-unit Hotelling model applied to tourism destinations. In Sections 4 and 5, we study the market equilibrium without the DC and with the DC, respectively. Section 6 investigates the welfare effects of the DC. Section 7 introduces some extensions of the model to check the robustness of our results, while the two final sections summarize the main findings, discuss their practical implications from a tourism policy perspective, and describe their limitations.

2. Literature Review

2.1. Complementarities and coordination

Although the implications of treating complementary goods have been well known since the work of Cournot (1838) on complementary duopoly, the anticommon problem has received scant attention in microeconomics. When this problem is present in a market, the double marginalization analysis of Spengler (1950) needs to be extended to a more general situation where firms do not necessarily constitute a succession of production stages.[2] As Baumol (2001) and Ruffin (2008) note, when firms produce components of the final product (which may or may not represent different stages of production), the negative externality resulting from complementarity drives the sum of individual prices to exceed the profit-maximizing price of the final product (Economides and Salop, 1992). Baumol (2001), in his analysis of R&D policies, notes that R&D generates positive externalities for all firms within the same geographical area. Consequently, he argues that the management of R&D should be coordinated at the local level, with approval from antitrust authorities. Parisi and Depoorter (2003) apply the same reasoning to intellectual property rights, while Teller et al. (2016) and Vitorino (2012) to the retail market.

In the tourism economics literature, Wachsman (2006) introduces a simple coordination model among local complementary stakeholders. As mentioned, Andergassen et al. (2013, 2017) later extend and strengthen this approach in what they call the "coordination theorem": "Given the anticommon property of the tourism product, coordination among firms in the destination, which can either be provided by the destination management or by a tour operator, increases profits from tourism"(Andergassen et al., 2013, p. 93). Accordingly, the rise in profits is attributed to a coordinated strategy aimed at reducing prices relative to the non-coordination benchmark. Tourists also benefit from this price reduction by experiencing an increase in consumer surplus due to lower prices, which improves overall market welfare. Coordination can be limited to only some components of the tourism product or extended to all through the organization of an all-inclusive package (Andergassen et al., 2017). Coordination can occur in various forms (Figini, 2022): quantity, to prevent bottlenecks in tourism supply; quality, to meet tourists' expectations; or price between producers of complementary (and substitute) goods. Our analysis focuses on price coordination, employing DCs to

[2] When instead firms operate at different production stages, it is well-known that vertical integration is the efficient solution.

model coordination dynamics. DCs are particularly suitable for this purpose as they enable the exogenous introduction of coordination within a destination. Moreover, the established use of DCs in business practice underscores their relevance and validity for this study.

2.2. Destination cards

Previous research on DCs covers various topics, including their function and impact. Primarily, these studies examine the potential marketing use of tourists' behavioral patterns, exploiting data on tourists' use of destination cards when accessing attractions or public transport, integrated with their socio-demographic characteristics (Scuderi and Nogare, 2018; Zoltan and McKercher, 2015). Few studies explore how the presence of a DC in a destination can foster inter-firm coordination. For instance, Schnitzer et al. (2018) explore suppliers' motives in joining a DC alliance, while d'Angella and Go (2009) emphasize the need for coordination to achieve individual success within a destination. To the best of our knowledge, Àlvarez-Albelo and Martínez-González (2022) is the only (other) microeconomic analysis of DCs. However, their definition of DCs appears to align more closely with a bundle pricing agreement involving providers of substitute services than with the conventional definition of DCs in business practice. Thus, their conclusion that DCs increase firm profits while reducing consumer surplus would be better framed within the industrial organization literature on bundling rather than on coordination.[3] Finally, Àlvarez-Albelo and Martínez-González (2023) expand their previous analysis to explore the coordination between a DMO and a foreign tour operator.

From a methodological perspective, these papers rely upon different approaches, primarily within the field of management and, to a lesser extent, economics. Most studies adopt qualitative methodologies, collecting data through interviews, surveys, or focus groups (Angeloni, 2016; Leung, 2020). Others employ conceptual modeling to develop frameworks (Thirumaran and Eijdenberg, 2021) or apply cluster analysis and pattern recognition (Zoltan and McKercher, 2015; Scuderi and Nogare, 2018). On the quantitative side, Zoltan and Masiero (2012) perform an ordered logistic regression to identify the benefits that tourists may find important in a DC. While these studies address relevant gaps, their predominant reliance on qualitative and, to a lesser extent, quantitative methods highlights the need for more theoretical investigations to advance the understanding of DCs. In this sense, the limited available research in economic theory focuses primarily on substitute goods (Àlvarez-Albelo and Martínez-González, 2022), while the analysis of coordination in destinations should include complements. We fill this gap by providing an in-depth analysis of the equilibrium welfare effects of DCs, using a three-firm framework to simultaneously capture the complementarity and substitutability of the tourism product.

[3] More precisely, Àlvarez-Albelo and Martínez-González (2022) find that consumer surplus can increase when a relatively large proportion of tourists travel to a two-attraction destination but are bounded to visit no attractions.

2.3. *Pricing strategies in the presence of externalities*

Understanding the effect of tourism firms' coordination on pricing strategies is integral to the configuration of the tourism product. Indeed, prior literature (Armstrong, 2013; Jeitschko et al., 2017; Àlvarez-Albelo and Martínez-González, 2022) examines substitute products that might be converted into complements (jointly purchased) through a bundle discount and finds a reduction in consumer welfare. According to Armstrong (2013), when firms offer a bundle discount, they (i) mitigate the substitutability of their products, converting "products which intrinsically are substitutes into complements" (Armstrong, 2013, p. 454), and (ii) relax competitive pressures, which induce firms to raise prices, thereby increasing their profits but shrinking consumer surplus. This outcome relates to the wider industrial organization literature on bundling strategies in duopolies (Anderson and Leruth, 1993; Chen, 1997; Matutes and Regibeau, 1992), showing how such strategies enable competitors to increase product differentiation and loosen competition at the expense of social welfare. Bloch (1995), using a coalitions approach, and Goyal and Moraga-González (2001), using a bilateral link formation approach, show that excessive horizontal coordination among substitutes can lead to asymmetric and inefficient equilibria, while an intermediate level of coordination maximizes both aggregate profits and social welfare, thereby intensifying the debate on the desirability of coordination.

Differently, the tourism literature highlights that coordination is welfare-enhancing if there are at least two complementary products that are always demanded together. The coordination theorem results in an unambiguous increase in the total surplus; however, Mantovani and Ruiz-Aliseda (2016) show that when markets reach saturation, coordination among firms selling complementary products may not allow firms to capture greater value. Such contrasting results stem from a misalignment in the interpretation of coordination and bundling: see Bojamic and Calantone (1990) for a framework integrating the economic and marketing approaches to tourism price bundling. In this sense, price coordination—and the DCs—can be considered a specific form of bundling, but not all bundling strategies involve coordination between complementary goods, as bundling can also apply when there are only substitutes. While not addressed explicitly, this distinction has been indirectly acknowledged by Llanes et al. (2019), who examine a market featuring both complements and substitutes. In their model, two producers offer complements to a monopolistic product. The authors compare bundling and coordination strategies based on sharing the complementary benefits with the incumbent. They find that coordination becomes advantageous as network strength rises and the degree of complementarity decreases. Conversely, bundling with a specific complement proves more effective with weaker networks and higher complementarity.

We enter this debate by showing that the tourism sector provides an interesting example of the implications of coordination with complementary goods. This is why our model, which integrates several strands of literature, has a hybrid nature. We draw from tourism economics the emphasis on complements and the anticommon nature of the tourism product. We draw from microeconomics the theoretical approach—the Hotelling model—to better represent the specific features of the tourism destination. We adapt the Hotelling approach to model the effects of a DC offering discounted transport and access to attractions. Finally, we provide a thorough analysis of the Hotelling model without imposing any parametric restriction; in doing so, we contribute to this niche topic in the Hotelling literature (Mérel and Sexton, 2010; Bacchiega et al., 2023).

3. The model

A tourism destination is (i) a physical space in which (ii) tourists visit attractions (iii) using infrastructures, such as roads and public transport, and (iv) enjoy accommodation services to stay a limited amount of time (at least one night) (dos Santos Estevão et al., 2015). To capture these four aspects in a parsimonious mathematical framework, we rely on an enriched version of the Hotelling model, taking it in its original spatial interpretation.

This model is characterized by a unit-length linear city (or region); this incorporates feature (i). There are two tourism attractions, denoted $i = 1, 2$, and each managed by a profit-maximizing firm, located at the endpoints of the city/region, firm 1 at 0 and firm 2 at 1; this captures feature (ii). There is a third company providing transport services in the area: this incorporates feature (iii). A unit mass of tourists, referred to as consumers, enjoy accommodation services that are uniformly distributed along the city/region; this captures feature (iv). The location of a consumer's accommodation within the city/region is denoted by $x \in [0, 1]$ and is exogenously determined by the distribution and availability of accommodations. In Figure 1, we visually represent such a tourism destination within the Hotelling model.

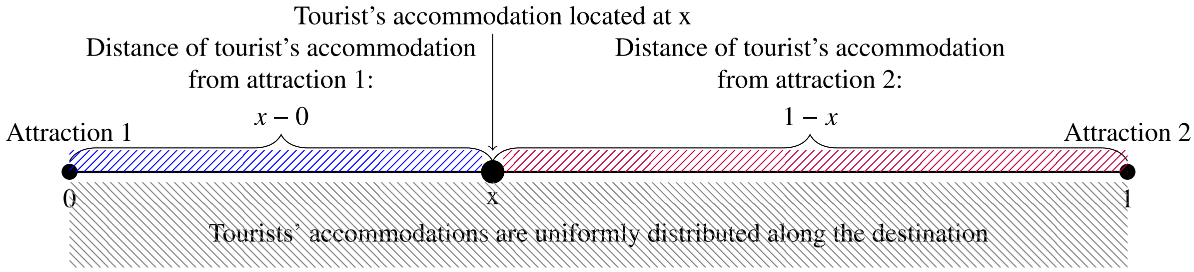

Figure 1: The tourism destination in the Hotelling framework

When a consumer located at x visits firm i, she bears a transportation cost $Td_i(x)$, where $d_i(x) \equiv \{x, 1 - x\}$ is the Euclidean distance between the consumer's location and that of firm i, and $T \equiv (t + m)$ is the marginal transportation cost. More precisely,

1. t is the per-unit-of-distance time disutility; one can think of t as the per-unit-of-distance travel time—affected

by, e.g., traffic congestion or quality of the public transport infrastructure—and/or the per-unit-of-distance travel disutility—affected by, e.g., the consumers' length of stay; we refer to t as the *marginal time cost* of transportation;

2. m is the per-unit-of-distance *regulated* fare of the travel ticket; $md_i(x)$ is then, e.g., the metro, or bus, or train fare to get to firm i and cashed by the transport company (TC, henceforth); we refer to m as the *marginal monetary cost* of transportation.

The choice to rely on two distinct parameters to model the transportation costs stems from the recognition that the time and the monetary components, capturing inherently different aspects, are not perfectly correlated: for instance, more congested cities do not necessarily have more expensive public transport.[4]

In our non-unit demand Hotelling model, consumers can visit only one firm, both firms, or no firm. When a consumer located at $x \in [0, 1]$ visits only firm i at price p_i, her utility function is

$$U_i \equiv v - Td_i(x) - p_i, \tag{1}$$

where v is the gross utility from visiting firm i, $Td_i(x)$ is the transportation cost to get to firm i, and p_i is the price charged by firm i; we refer to consumers visiting only one firm as *single purchasers*. Instead, when a consumer located at $x \in [0, 1]$ visits both firms, her utility is

$$U_{1+2} \equiv 2v - T - (p_1 + p_2), \tag{2}$$

where $2v(= v + v)$ is the gross utility from visiting firm 1 and firm 2, $T(= T(x + 1 - x))$ is the transportation cost borne by the consumer to get to both firms, and $p_1 + p_2$ is the sum of prices of the two attractions. We define these consumers as *joint purchasers*. Finally, when consumers do not visit any firm, their utility is zero.[5]

We now derive the demand structures of firms 1 and 2 and proceed in three steps.

1. First, we calculate the location of the consumer indifferent between visiting firm 1 or visiting both firms. This amounts to solve equation $U_1 = U_{1+2}$ for x. We get

$$x_1 = D_1 \equiv \frac{T - v + p_2}{T}; \tag{3}$$

[4]For a similar specification, see de Palma et al. (2018), who study competition between transport facilities in a Hotelling framework and assume that travelers bear two different types of transportation costs: an actual monetary cost to get to the facility and a time disutility cost.

[5]The assumption that both attractions provide consumers with the same gross utility v is made for simplicity. Alternatively, one could consider two different parameters, $v_1 \neq v_2$, but this would complicate the analysis without offering additional qualitative insights. At the same time, our simplifying hypothesis does not imply that consumers perceive the attractions as identical. On the contrary, it accommodates the idea of two similar but distinct sites (e.g., a monument and a museum) that are equally valued by consumers, for instance, due to their popularity within the destination.

the demand of single purchasers of firm 1 is made by the consumers located in interval $[0, x_1]$. Intuitively, those located close to firm 1 may prefer visiting only the nearby firm to save on transportation costs.

2. Second, we solve equation $U_2 = U_{1+2}$ for $1 - x$,

$$1 - x_2 = D_2 \equiv \frac{T - v + p_1}{T}, \tag{4}$$

to get the demand of single purchasers of firm 2: this amounts to the consumers located in interval $[x_2, 1]$, hence close to firm 2.

3. Finally, we derive the demand of joint purchasers, which is simply given by the proportion of consumers between the one located at x_1 and the one located at x_2,

$$x_2 - x_1 = D_{1+2} \equiv \frac{2v - T - (p_1 + p_2)}{T}. \tag{5}$$

Consumers in (x_1, x_2) are pretty far from both firms, so they have less incentive to visit only one attraction and save on transportation costs.

We are interested in solving the following price competition game: first, the two firms managing the attraction simultaneously choose prices p_i to maximize profits; then, consumers make their purchasing decisions. Without loss of generality, we let the firms' and TC's production costs be zero. Most importantly, we analyze this game by letting the marginal transportation disutility T take any positive real value for any given $v > 0$. Doing so, three alternative equilibrium configurations will arise.

1. Some consumers purchase from both firms, while all the others visit only one firm. This is the *mixed-purchase scenario*, in which all consumers buy at least from one firm, hence the market is fully covered: see Figure 2 for a graphical representation; the blue and red sloping lines indicate the utility of single purchasers of firm 1 and 2, respectively, as a function of their location x, while the green horizontal line denotes the utility of joint purchasers. Intuitively, this configuration occurs when the marginal transportation cost T is neither negligible relative to v, otherwise all consumers would visit both firms, nor it is relatively sizable, otherwise no consumers would buy from both firms; graphically, the blue and red lines are not too flat, nor too steep.
2. Every consumer visits both firms. This is the full-coverage *joint-purchase scenario* that arises when T is low relative to v, hence consumers can easily move around the city/region: see Figure 4, where the green horizontal line indicating the utility of joint purchasers extends over the entire city/region.
3. No consumer buys from both firms, and some consumers do not buy at all, i.e., the market is partially covered. This is the *single-purchase scenario* that occurs when T is relatively high: see Figure 5, where the green

horizontal line indicating the utility of joint purchasers disappears because the consumers located relatively far from the endpoints do not visit any firm.[6]

4. Equilibrium

We solve for the Nash equilibrium of the price competition game played by the profit-maximizing firms. We first consider the mixed-purchase scenario and then move to the other two configurations.

4.1. Mixed-purchase Scenario

Each firm sets its own price to maximize profits. In the mixed-purchase scenario, the profit function of firm i is $\Pi_i = p_i(D_i + D_{1+2})$, where D_i is the mass of single purchasers and D_{1+2} that of joint purchasers. Graphically, the demand of firm 1 is given by the blue and green lines in Figure 2, while that of firm 2 by the red and green lines. Using (3), (4), and (5), firm i profit function can be rewritten as

$$\Pi_i(p_i) = p_i\left(\frac{v - p_i}{T}\right). \tag{6}$$

Remarkably, the demand function of firm $i = 1, 2$ is not affected by the price p_j charged by competitor $j = 2, 1$; in other words, there is no strategic interaction between firms, though the market is fully covered. This is because the last consumer purchasing from firm i is the one indifferent between joint-purchasing and single-purchasing from firm j: see Figure 2. In turn, this consumer's location is affected only by price p_i. The reason can be explained as follows. When firm 1, say, reduces p_1, consumers in $[x_2(p_M), x_2'(p_M)]$ shift from patronizing only firm 2 to joint-purchasing: see Figure 3. Accordingly, the decrease in D_2 is fully compensated by the increase in D_{1+2} and the overall demand function of firm 2, $D_2 + D_{1+2}$, is unaffected. This is a pivotal aspect of the non-unit demand Hotelling model: firms are not competing in business stealing because an aggressive pricing strategy by firm j does not decrease the demand of firm i.[7]

The Nash equilibrium prices turn out to be symmetric,

$$p_1^* = p_2^* \equiv p_M \equiv \frac{v}{2},$$

where the subscript M is a mnemonic for the mixed-purchase scenario: see Appendix A.1 for all the proofs and calculations related to this subsection. For future reference, we remark that the last consumer buying from firm i

[6]The single-purchase scenario captures a possibly implausible situation where some tourists travel to the destination, buy accommodation services, but decide to visit no attractions. We include it to have a thorough analysis of the price competition game; however, in Section 7, we exclude it and verify that our welfare analysis is completely unaffected.

[7]For further details, see Kim and Serfes (2006), who refer to this result as the "aggregate demand creation effect" (p. 575).

would derive zero utility if she bought solely from firm i - see points $x_1(p_M)$ and $x_2(p_M)$ in Figure 2; if the price of firm i were higher, this consumer would get negative utility from visiting attraction i and, therefore, would prefer buying only from firm j.

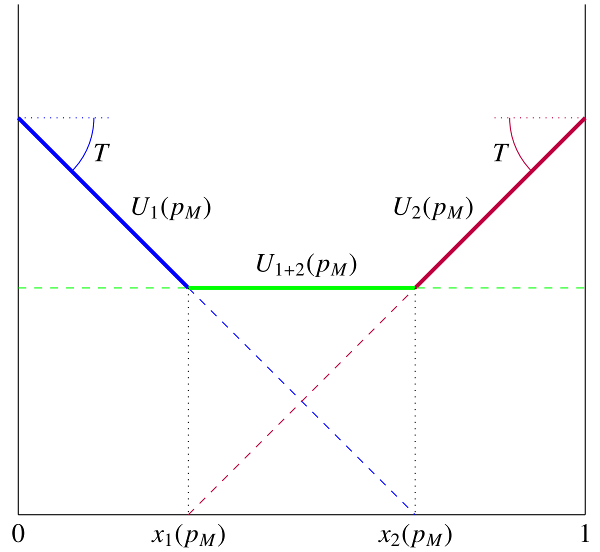

Figure 2: Consumers' equilibrium utility functions in the mixed-purchase scenario

To derive the parametric interval under which the mixed-purchase equilibrium arises, we substitute p_M into (3) and (4), and get the (symmetric) equilibrium demands of single purchasers, $D_1(p_M) = D_2(p_M) \equiv 1 - \frac{v}{2T}$, which are positive when $T > \frac{v}{2}$ and always lower than 1. Similarly, we plug p_M into (2) and verify that the joint purchasers, whose equilibrium demand is $D_{1+2}(p_M) \equiv \frac{v}{T} - 1$, get nonnegative utility when $T \leq v$. Overall, the parametric condition for the mixed-purchase equilibrium is

$$\frac{v}{2} < T \leq v. \tag{7}$$

As anticipated, transportation costs have to be neither small, otherwise all consumers would visit both firms ($D_1 = D_2 = 0$ and $D_{1+2} = 1$), nor big, otherwise no consumers would buy from both firms (i.e., $D_{1+2} = 0$).

As T rises within interval (7), joint purchasers located close to $x_1(p_M)$ and $x_2(p_M)$ shift to single-purchasing to save on increasingly expensive transportation costs. More precisely, when T tends to $\frac{v}{2}$, almost all consumers are joint purchasers (i.e., $D_{1+2}(p_M) \to 1$) because transportation costs are relatively mild. In the opposite case where $T = v$, all consumers become single purchasers, (i.e., $D_{1+2}(p_M) = 0$).

We conclude this subsection by providing a welfare analysis. In particular, we compute (i) the producer surplus PS, defined as the sum of the two attractions' equilibrium profits, $\Pi_1(p_M) + \Pi_2(p_M)$, (ii) the TC's equilibrium profits Π_{TC}, stemming from the sales of travel tickets to consumers, and (iii) the consumer surplus CS, given by the aggregate

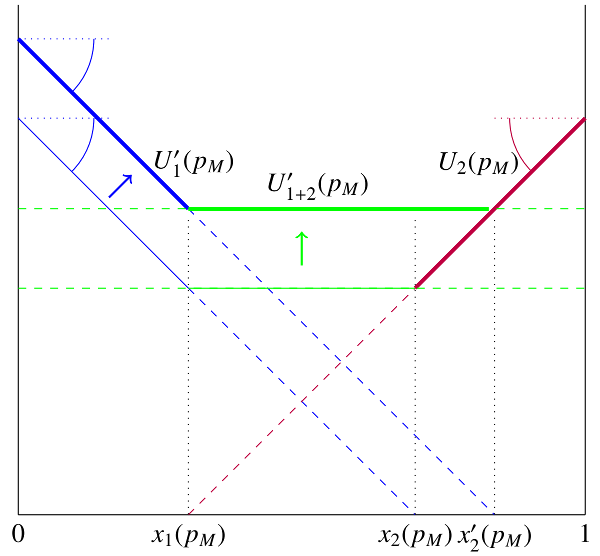

Figure 3: Absence of business stealing in the mixed-purchase scenario

consumer utility computed over all single and joint purchasers. We get

$$PS_M \equiv \frac{v^2}{2T},$$
$$\Pi_{TC,M} \equiv \frac{mv^2}{4T^2},$$
$$CS_M \equiv \frac{v^2}{4T}.$$

We also compute the value of total surplus, defined as the sum of PS_M, $\Pi_{TC,M}$, and CS_M. We obtain $TS_M \equiv \frac{(4m+3t)v^2}{4T^2}$.

As a final remark, note that the welfare values are negatively affected by T. Indeed, as T grows, (i) firms are worse off because their demands shrink; (ii) the TC is worse off because fewer consumers choose to joint-purchase and, accordingly, they travel less; (iii) consumers are worse off because they bear higher transportation costs.

4.2. Joint-purchase Scenario

When the transportation costs are relatively low, $T \leq \frac{v}{2}$, and the attractions' price is p_M, the analysis in Subsection 4.1 shows that *all* consumers prefer to visit *both* firms, i.e., $D_{1+2}(p_M) = 1$. As a result, the profit function of firms is not as in (6) anymore and the firms play a different price competition game. In Appendix A.2, we show that the Nash equilibrium prices turn out to be symmetric and equal to

$$p_1^* = p_2^* \equiv p_J \equiv v - T, \tag{8}$$

where J is a mnemonic for the joint-purchase scenario.

Here, transportation costs are relatively low, so both firms can cover the entire market. At equilibrium, each firm actually serves the entire market, i.e., their demand is $D_{1+2}(p_J) = 1$, at the highest possible price. Intuitively, this price is such that the consumer located at 0 (1) would get zero utility if she purchased only from firm 1 (0) (see points $x_1(p_J)$ and $x_2(p_J)$ in Figure 4): if the price were higher, the consumers at the endpoints would obtain negative utility from visiting the attraction at the opposite end, hence firms could not serve all consumers.

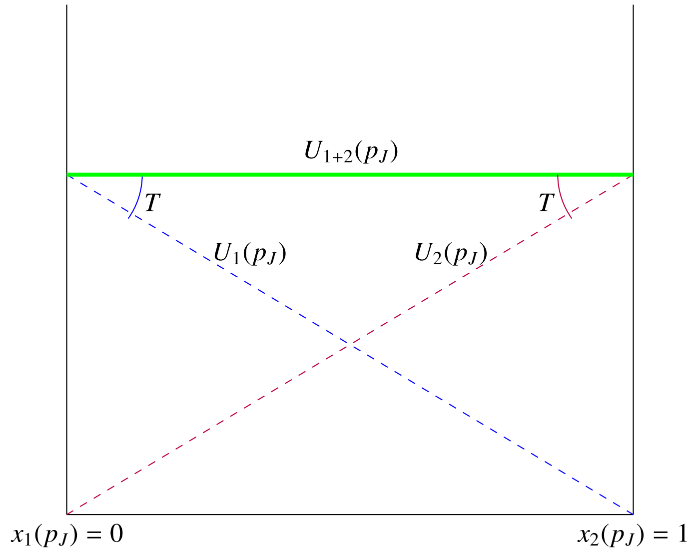

Figure 4: Consumers' equilibrium utility functions in the joint-purchase scenario

We can now calculate the welfare values: the producer surplus is $PS_J \equiv 2(v - T)$, the TC's equilibrium profits are $\Pi_{TC,J} \equiv m$, and the consumer surplus is $CS_J \equiv T$. The total surplus is, accordingly, $TS_J \equiv 2v - t$. Note that PS_J decreases with T, while CS_J increases with it: this is because a higher T forces firms to reduce the equilibrium prices if they want to serve the entire market. By contrast, $\Pi_{TC,J}$ is fixed at m because every single consumer travels the entire city/region.

4.3. Single-purchase scenario

The remaining parametric interval to be considered to complete the analysis of the price competition game is $T > v$. Here, transportation costs are relatively high, and the analysis in Subsection 4.1 shows that no consumers engage in joint-purchase behavior when the price is p_M because their utility would be negative. As a consequence, the last consumer willing to buy from firm i is not anymore the one indifferent between buying from both firms and buying from firm j, as it occurs under the mixed-purchase scenario. Rather, it is the consumer indifferent between buying from firm i and not buying at all: see points $x_1(p_S)$ and $x_2(p_S)$ in Figure 5. Solving equations $U_1 = 0$ for x and $U_2 = 0$ for $1 - x$, we hence get the demand for attraction 1, $D_1 = \frac{v-p_1}{T}$, and for attraction 2, $D_2 = \frac{v-p_2}{T}$, and we easily derive the symmetric Nash equilibrium prices, $p_S \equiv \frac{v}{2}$, where S is a mnemonic for the single-purchase scenario.

Note that $p_S = p_M$ because firm i's demand and profit functions are as in (6). This, in turn, is due to the fact that the last consumer gets zero utility when patronizing only firm i, under both the single-purchase and the mixed-purchase scenarios. However, a crucial difference arises. Here, the last consumer $x_i(p_S)$ is actually patronizing firm i only, with the effect that consumers in interval $(x_1(p_S), x_2(p_S))$ do not visit any firm, and the market is partially covered. By contrast, the last consumer $x_j(p_M)$ patronizes firm j too under the mixed-purchase scenario, and full coverage occurs.

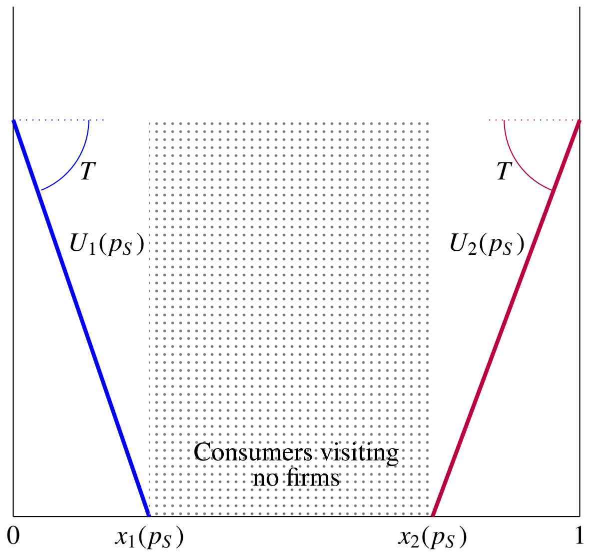

Figure 5: Consumers' equilibrium utility functions in the single-purchase scenario

Given $p_S = p_M$, the welfare analysis under the joint-purchase scenario is straightforward in that all values take the same functional forms as under the mixed-purchase one, $PS_S \equiv \frac{v^2}{2T}$, $\Pi_{TC,S} \equiv \frac{mv^2}{4T^2}$, $CS_S \equiv \frac{v^2}{4T}$, and $TS_S \equiv \frac{(4m+3t)v^2}{4T^2}$: see Appendix A.3 for details. Notably, same functional forms do not mean same values because, for any given v, T is higher here.

We summarize the results of Subsections 4.1 to 4.3 in the following

Lemma 1. *Three alternative equilibrium configurations of the price competition game arise, depending on the value of T relative to v.*

(i) If $T \leq \frac{v}{2}$, joint-purchase equilibrium with symmetric prices $p_J \equiv v - T$, producer surplus $PS_J \equiv 2(v-T)$, TC's equilibrium profits $\Pi_{TC,J} \equiv m$, consumers surplus $CS_J \equiv T$, and total surplus $TS_J \equiv 2v - t$.

(ii) If $\frac{v}{2} < T \leq v$, mixed-purchase equilibrium with symmetric prices $p_M \equiv \frac{v}{2}$, producer surplus $PS_M \equiv \frac{v^2}{2T}$, TC's equilibrium profits $\Pi_{TC,M} \equiv \frac{mv^2}{4T^2}$, consumers surplus $CS_M \equiv \frac{v^2}{4T}$, and total surplus $TS_M \equiv \frac{(4m+3t)v^2}{4T^2}$.

(iii) If $T > v$, single-purchase equilibrium with symmetric prices $p_S \equiv \frac{v}{2}$, producer surplus $PS_S \equiv \frac{v^2}{2T}$, TC's equilibrium profits $\Pi_{TC,S} \equiv \frac{mv^2}{4T^2}$, consumers surplus $CS_S \equiv \frac{v^2}{4T}$, and total surplus $TS_S \equiv \frac{(4m+3t)v^2}{4T^2}$.

5. Destination Card

We now introduce a DMO that provides tourists with a DC in the city/region. The DC offers two benefits. (i) Free public transport (e.g., the metro, bus, or train fare is waived), so that consumers do not bear the marginal monetary transportation cost m anymore; put differently, the overall marginal transportation cost borne by consumers falls from $T \equiv m + t$ to t and the TC's equilibrium profits drop to zero. (ii) Percentage discount on the attractions' prices: if the price of attraction i is p_i, consumers pay αp_i, with $\alpha \in (0, 1]$. As shown in Table 1, the DC can be offered to tourists either for free or for a fee. Here, we consider a free DC; in Section 7, we discuss the robustness of our findings when a fee is required, and we also investigate the case of a 100% discount on attraction prices, i.e., $\alpha = 0$.

To get the utility of a joint purchaser using the DC, we substitute $m = 0$ into (2) and consider the discount α:

$$U_{1+2}^{DC} \equiv 2v - t - \alpha(p_1 + p_2), \tag{9}$$

where the superscript *DC* is a mnemonic for destination card. Similarly, the utility of a single purchaser using the DC and located at $x \in [0, 1]$ becomes

$$U_i^{DC} \equiv v - td_i(x) - \alpha p_i. \tag{10}$$

Finally, when consumers do not visit any firm, their utility is 0.

The new timing of the game is as follows: first, consumers decide whether to use the DC; second, firms simultaneously choose prices to maximize profits; finally, consumers make their purchasing decisions. From this three-stage game, which is solved in Appendix B, we derive the following

Lemma 2. *When a DC is present, all consumers decide to use it, and three alternative equilibrium configurations of the price competition game arise, depending on the value of t relative to v.*

(i) If $t \leq \frac{v}{2}$, joint-purchase equilibrium with symmetric prices $p_J^{DC} \equiv \frac{v-t}{\alpha}$, producer surplus $PS_J^{DC} \equiv 2(v - t)$, PTC's equilibrium profits $\Pi_{PTC,J}^{DC} \equiv 0$, consumers surplus $CS_J^{DC} \equiv t$, and total surplus $TS_J^{DC} \equiv 2v - t$.

(ii) If $\frac{v}{2} < t \leq v$, mixed-purchase equilibrium with symmetric prices $p_M^{DC} \equiv \frac{v}{2\alpha}$, producer surplus $PS_M^{DC} \equiv \frac{v^2}{2t}$, PTC's equilibrium profits $\Pi_{PTC,M}^{DC} \equiv 0$, consumers surplus $CS_M^{DC} \equiv \frac{v^2}{4t}$, and total surplus $TS_M^{DC} \equiv \frac{3v^2}{4t}$.

(iii) If $t > v$, single-purchase equilibrium with symmetric prices $p_S^{DC} \equiv \frac{v}{2\alpha}$, producer surplus $PS_S^{DC} \equiv \frac{v^2}{2t}$, PTC's equilibrium profits $\Pi_{PTC,S}^{DC} \equiv 0$, consumers surplus $CS_S^{DC} \equiv \frac{v^2}{4t}$, and total surplus $TS_S^{DC} \equiv \frac{3v^2}{4t}$.

We discuss Lemma 2, restricting our attention to the firms' pricing reaction to the DC; in the next section, we turn the focus to the welfare values and compare them to those in Lemma 1. Under the mixed- and single-purchase scenarios, two results are worth remarking. First, firms increase the price with the presence of the DC, $p_M^{DC} \geq p_M$ and $p_S^{DC} \geq p_S$, because they anticipate that consumers will enjoy a discount. Second, consumers end up paying the same actual price as without the DC because the price rise is such that the discount is neutralized, $\alpha p_M^{DC} = p_M \equiv \frac{v}{2}$ and $\alpha p_S^{DC} = p_S \equiv \frac{v}{2}$.

Under the joint-purchase scenario, firms increase the prices not only as a consequence of the price discount but also because the public transport is now free. At this equilibrium, indeed, the price is such that the consumers at the endpoints would get zero utility when visiting only the firm at the opposite end. When their cost to travel the entire city/region decreases by the amount m thanks to the DC, firms can raise the equilibrium price by the same amount. This triggers the counterintuitive outcome that consumers end up paying more when the DC is available, $\alpha p_J^{DC} = v - t > p_J \equiv v - (t + m)$.

6. Welfare Effects of the DC

In this section, we evaluate the welfare effects of the DC by proceeding in two steps. First, we compare the parametric intervals involving t, m, and v that give rise to the three equilibrium configurations without the DC, on the one hand, and with the DC, on the other hand. Second, for each interval, we compare the welfare values without the DC and with the DC.

To complete the first step, we recall that $T \equiv t + m$ and express the intervals in Lemma 1 as follows: (i) $t \leq \frac{v}{2} - m$; (ii) $\frac{v}{2} - m < t \leq v - m$; (iii) $t > v - m$. Doing so, we make them directly comparable to the intervals in Lemma 2: Figure 6 provides a graphical visualization.[8]

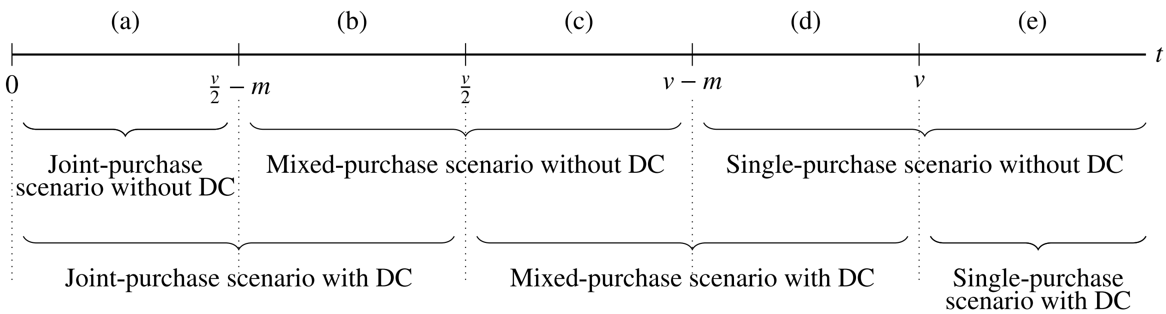

Figure 6: Equilibrium configurations without the DC and with the DC

[8]The existence of interval $t \leq \frac{v}{2} - m$ implies that $m < \frac{v}{2}$ and $\frac{v}{2} < v - m$.

The figure shows that the presence of a DC may trigger a change in the equilibrium configuration. More precisely,

(a) if $t \leq \frac{v}{2} - m$, all consumers are joint purchasers both without the DC and with the DC.

(b) If $\frac{v}{2} - m < t \leq \frac{v}{2}$, some consumers are single purchasers, and some others are joint purchasers without the DC, but all turn into joint purchasers with the DC.

(c) If $\frac{v}{2} < t \leq v - m$, some consumers are single purchasers and some others are joint purchasers both without the DC and with the DC. However, the proportion of joint purchasers grows, thanks to the DC.

(d) If $v - m < t \leq v$, no consumer is a joint purchaser without the DC, but some turn joint purchasers with the DC.

(e) If $t > v$, all consumers are single purchasers both without the DC and with the DC. However, the proportion of consumers that visit no firm shrinks, thanks to the DC.

Note that the DC boosts the demand for attractions in all of the above intervals, except interval (a), where demand is already maximized without the DC. The interesting question is whether such a demand-enhancing effect is also accompanied by higher welfare. To answer this question, we move to the second step of the welfare analysis, comparing welfare without the DC and with the DC in each of the above intervals. We derive the following

Proposition 1. *The welfare effects of the destination card depend on the value of t relative to v and m. In particular:*

(i) if $t \leq \frac{v}{2} - m$, producer surplus increases, consumer surplus decreases, TC's equilibrium profits decrease, and total surplus stays the same;

(ii-a) if $\frac{v}{2} - m < t < \frac{\sqrt{m^2+v^2}-m}{2}$, producer surplus increases, consumer surplus decreases, TC's equilibrium profits decrease, and total surplus increases;

(ii-b) if $\frac{\sqrt{m^2+v^2}-m}{2} < t \leq \frac{v}{2}$, producer surplus increases, consumer surplus increases, TC's equilibrium profits decrease, and total surplus increases;

(iii) if $t > \frac{v}{2}$, producer surplus increases, consumer surplus increases, TC's equilibrium profits decrease, and total surplus increases.

Proof. See Appendix C. □

When $t \leq \frac{v}{2} - m$, the time cost of transportation is so low that all consumers visit both firms even without DC. As discussed in the last paragraph of Section 5, the DC induces firms to raise the equilibrium price to the extent that consumers pay more despite the price discount; since the demand of both firms is already at its maximum, producer surplus grows at the expense of consumer surplus. Total surplus is unaffected because the DC does not increase the overall demand; as a result, the gain enjoyed by the attractions is equivalent to the sum of losses suffered by the TC and the tourists. One might argue that this interval is of limited interest from a policy perspective: it is indeed unlikely that a DMO would introduce a DC in a destination where all tourists are already visiting all attractions. Our result confirms this, as the DC proves to be ineffective.

We now shift our attention to interval $t > \frac{v}{2}$, which subsumes regions (c)-(d)-(e) in Figure 6 and involves the mixed- and the single-purchase scenarios. As discussed right after Lemma 2, consumers are charged the same price as without the DC, despite the discount; however, free public transport enhances the demand, either because some single purchasers decide to visit the other firm too - regions (c) and (d) -, or because some inactive consumers decide to visit at least one firm - regions (d) and (e). As a result, producer and consumer surpluses grow. Total surplus improves too, thanks to the increase in the overall demand, which makes the gains enjoyed by firms and consumers outdo the profit loss suffered by the TC. This is true also in region (e) of Figure 6, where the time component of the travel cost is so significant that even a reduction in the monetary component does not convince any tourist to become joint purchaser. These results are consistent with the coordination theorem, while offering a further contribution. Existing studies (Cools et al., 2016 and, for the specific case of tourists, Leung, 2020, and Le-Klähn et al., 2015) have stressed the importance of transportation costs in driving consumer purchasing decisions and affecting their surplus. We show that the benefits due to lower transportation costs extend beyond individual travelers, generating broader collective benefits.

Our analysis provides a novel result in intervals (ii-a) and (ii-b). Here, the DC turns out to be particularly effective as the reduction in transportation costs induces all consumers to purchase from both firms. On this basis, a DMO aiming at maximizing the demand would be keen on introducing the DC. Indeed, both producer and total surpluses are enhanced with the DC, thanks to the boost in sales. However, in interval (ii-a), t consumers are worse off even though they buy more. The explanation for this counterintuitive outcome is as follows. The DC triggers a change in the equilibrium configuration, moving from a mixed-purchase equilibrium to a joint-purchase one. This, in turn, induces firms to modify the equilibrium price: each one charges $p_M \equiv \frac{v}{2}$ without the DC, while the price paid by consumers is $\alpha p_J^{DC} \equiv v - t \geq p_M$ with the DC. In interval (ii-a), t is relatively low, hence the price difference $(\alpha p_J^{DC} - p_M)$ is pronounced. This negative effect on consumer surplus prevails over the positive one due to higher demand, with the effect that consumers are worse-off.

In conclusion, we observe that the total surplus improves in (the relevant) intervals (ii-a), (ii-b), and (iii). As a result, there is room to compensate the TC and, in interval (ii-a), the consumers for the losses incurred with the presence of the DC, so achieving a Pareto improvement.

7. Extensions

In this section, we provide natural extensions and alternative interpretations of the main analysis, to check the robustness of Proposition 1.

Other means of transportation. Our analysis relies on the implicit assumption that all consumers use public transport to travel across the city/region. This is not necessarily the case as tourists may, e.g., (i) use private transport or (ii) simply walk to get to attractions. Here, we discuss why our model can easily accommodate these alternative transportation options. In case (i), it is sufficient to interpret m, or any other positive parameter, the marginal monetary cost of transportation, as the expenditure for private transport. In case (ii), one can suppose that T, or any other parameter larger than t, indicates the increased marginal time cost of transportation, due to the fact that travel time is generally longer when walking. Suppose both categories of tourists shift to public transport when endowed with the DC, either because they save on the monetary component of transportation - case (i) - or on the time component - case (ii). This is likely to be the case because (saving) money and time are generally indicated as the two most influencing factors in driving tourists' transport choice (e.g., Le-Klähn et al., 2015). As a result, the whole analysis, including Proposition 1, turns out to be robust to this extension.

No single-purchase scenario. To provide a thorough analysis of the price competition game, no restrictions were made on the value of parameter t relative to v and m. However, we anticipated in Footnote 6 that the single-purchase equilibrium, though interesting from a theoretical perspective, may have no relevance from an applied point of view. Here, we assume away this scenario by letting t be non-higher than $v - m$; this indeed excludes regions (d) and (e) in Figure 6, where the single-purchase equilibrium arises without (and in region (e) even with) the DC. One can easily check that Proposition 1 is robust to this sensible parametric restriction in that the three intervals describing all possible DC's welfare effects remain.

Priced DC. We now assume that the DC does not come for free but is priced by the DMO, so we modify the game's timing accordingly. First, the DMO sets a price k for the DC; second, consumers decide whether to buy the DC; third, firms simultaneously choose prices to maximize profits; finally, consumers make their purchasing decisions. In Appendix D, we show that the results of Proposition 1 are robust to this extension: total surplus stays the same in the interval (i) of Proposition 1 and increases for higher values of t; producer surplus always increases; consumer surplus is instead less likely to increase, which comes as no surprise because consumers are worse off when buying the DC compared to the case of free DC. More precisely: in interval (ii) of Proposition 1, condition $\frac{\sqrt{m^2+v^2}-m}{2} < t \leq \frac{v}{2}$ is not anymore sufficient for consumer surplus to increase with the DC; in interval (iii), consumer surplus decreases if the DC price is sufficiently high.

100% Price Discount. When $\alpha = 0$, the DC eliminates not only the monetary transportation cost m, but also the prices p_1 and p_2 to visit the attractions. Our model then collapses because the firms cannot set prices anymore. To circumvent the problem, we assume that only a share $\mu \in (0, 1)$ of consumers have access to the DC. In Appendix D, we show that, unlike the case $\alpha \in (0, 1]$, the firms' equilibrium prices are not affected by the presence of the DC. This is because firms profit only from the consumers without the DC, who enjoy neither free public transport nor price discounts.

Most importantly, we verify that the results of Proposition 1 are robust to this extension in that the DC increases the total surplus. Differently from the main analysis, producer surplus shrinks because a proportion μ of consumers no longer pay for the attractions. Consumer surplus instead increases for two reasons: on the one hand, consumers without the DC pay the same price as they would without it; on the other hand, consumers with the DC have free access to the two attractions and public transport.

8. Discussion

DCs are increasingly recognized in the tourism economics literature as one of the most relevant coordination tools implemented in business practice. They are agreements that typically include discounts (up to free availability in the extreme case) on a mix of substitute and complementary services. From the economic theory perspective, they are double-edged. On the one hand, they allow for internalizing the externality generated by the complementarity of several services included in the tourism product, bringing advantages for the industry and the destination alike, as stressed by the tourism literature (Andergassen et al., 2013; Figini, 2022). On the other hand, they might raise concerns of collusion and should be targeted and limited by anti-trust regulators as they might redistribute welfare from consumers to producers (Armstrong, 2013; Jeitschko et al., 2017; Àlvarez-Albelo and Martínez-González, 2022). Such contrasting views stem from the fact that the industrial organization literature tends to identify price coordination with bundle pricing, while the tourism economics literature insists that price coordination involves goods and services that must be consumed together, such as transportation and attractions.

We contribute to this debate by showing that tourism services offer a compelling example of the implications of dealing with an anticommon product. (Heller, 1998, 1999; Michelman, 1982; Candela et al., 2008). We do so by modeling the market equilibrium in the local tourism sector first without, and then with a coordination tool, the DC. We rely on the Hotelling framework and extend it to explicitly consider the existence of complementarity services. This way, we depart from Àlvarez-Albelo and Martínez-González (2022), who examine substitute products that might be jointly purchased (and hence somehow converted into complements). On the contrary, we highlight that coordination applies if and only if there are at least two products always jointly demanded by the consumer: transportation and (at least one) attraction, in our case. In this sense, the DC can be considered a type of bundling, but not all bundling agreements involve coordination between complementary goods. To allow for this crucial feature, we extend Àlvarez-Albelo and Martínez-González (2022) to a 3-firm structure with two substitute goods (attractions) that, under certain conditions, can be jointly purchased (i.e., tourists decide to visit both), and a complementary good (transport) which is always part of the bundle. Compared to Andergassen et al. (2013), this spatial approach based on an enriched version of Hotelling has the advantage of capturing all the fundamental aspects at play when dealing with tourism: it represents (i) a physical space (a linear city/region), where (ii) tourists located in the position of the accommodation services within the city/region (iii) visit attractions (spatially differentiated, as they are located at the opposite extremes of the region) using (iv) infrastructures (such as roads and public transport) which enter the model through the time and monetary cost to cover the distance between accommodation and attraction.

Our model results allow us to discuss the welfare implications of the presence of a DC offering free local transport and price discounts on attractions. In Table 2, we summarize the findings of Proposition 1 and Figure 6. The welfare effects depend on the parameters t and m, and v, which roughly represent the relative importance of the two complementary goods for the tourists' budget: t captures the time component of transportation cost, m the monetary component—that is waived by the DC—and v denotes the gross utility tourists enjoy when visiting an attraction.

The first important result of our analysis shows that the act of coordinating the prices of transportation and attractions increases total surplus (except in Scenario 1, where it does not change) and producer surplus: this is in line with the coordination theorem and partially differs from Àlvarez-Albelo and Martínez-González (2022). The overall increase in welfare ensures that any losses incurred by the transport company can be offset through cross-subsidization, using local taxes levied on attractions and, when consumer surplus rises, on tourists as well. Such general conclusion can be enriched with interesting policy implications once we dig deeper into the five scenarios.

In Scenario 1, for any given m, the time component of the transportation cost t is so low relative to the appeal of the attractions, v, that the anticommon problem is not severe, and all tourists visit both attractions even without the DC. In this case, the DC does not enhance total surplus because the overall demand for attractions remains unchanged. However, this scenario has limited policy relevance since a DC is unlikely to be implemented in a destination where tourists already purchase all services.

In Scenarios 3, 4, and 5, t is relatively high: the DC enhances the demand for attractions but is not able to induce all tourists to visit both attractions. Here, findings align with the tourism economic literature since reducing the monetary transportation cost results in collective benefits: firms experience higher demand, hence producer surplus increases, and tourists enjoy lower transportation costs, hence their surplus increases too. These scenarios extend the results of

Scenario	Parameters	Description	Producer surplus	Transport Company surplus	Consumer surplus	Total surplus
1	$t \leq \frac{v}{2} - m$	All tourists visit both attractions even without the DC	+	−	−	=
2-a	$\frac{v}{2} - m < t < \frac{\sqrt{m^2+v^2}-m}{2}$	All tourists visit both attractions only with the DC	+	−	−	+
2-b	$\frac{\sqrt{m^2+v^2}-m}{2} < t \leq \frac{v}{2}$	All tourists visit both attractions only with the DC	+	−	+	+
3	$\frac{v}{2} < t \leq v - m$	Thanks to the DC, more tourists visit both attractions and less visit only one	+	−	+	+
4	$v - m < t \leq v$	Without the DC, all tourists visit one attraction; with the DC, some visit both	+	−	+	+
5	$t > v$	Thanks to the DC, more tourists visit one attraction and less do not visit any	+	−	+	+

Table 2: Welfare effects of a DC offering free local transport and discounts on the attractions

the coordination theorem to a three-firm framework, including both substitute and complementary tourism services.

The last words are reserved for Scenarios 2-a and 2-b, the most interesting ones. Here, transportation costs are such that all tourists decide to visit both attractions only when they have access to the DC. The DC is, therefore, highly effective in stimulating the demand for attractions. At the same time, however, it reduces demand elasticity and encourages attractions to set prices as high as possible. In scenario 2-a, the price increase is particularly pronounced, with the effect that tourists are worse-off despite the increase in demand. This result provides an economic theory rationale for the observation made by Messori and Volo (2024), who noted that while most tourism studies highlight the positive benefits of coordination, they often overlook its potential negative impacts.

9. Conclusions

This paper contributes to the tourism economics literature by offering a comprehensive perspective on the coordination challenges faced by tourism destinations in the presence of both complementary and substitute products. We highlight the benefits—as well as the potential drawbacks—of internalizing the anticommon externalities that characterize the tourism product. Moreover, our analysis contributes to the industrial organization literature by showing that complementary externalities are relevant for the organization of important markets, such as tourism, and deserve proper investigation. It also argues that a spatial economics model like Hotelling provides a more accurate representation of the tourism market structure, given its geographic dimension, than other competition models, such as Cournot or Bertrand. Finally, our study points to the importance of solving the Hotelling game without parametric restrictions, as this approach can unveil important and counterintuitive insights, such as a decline in tourist welfare despite an increase in their demand for attractions following the availability of a DC.

Our findings show that the presence of the DC never decreases total welfare and always increases total profits. Additionally, we demonstrate that this increase in welfare efficiency may, under specific parametric conditions, coexist with a reduction in consumer surplus. From a practical perspective, this study could serve as a valuable tool for policymakers, DMOs, and tourism firms in assessing whether a DC can be welfare-improving, depending on the destination's characteristics and tourists' preferences.The DC has been shown to be particularly effective in boosting the demand for attractions in Scenarios 2-a and 2-b (Table 2), when the time component of transportation cost, t, is not high relative to the appeal of the attractions, v. This, in turn, is likely to occur in destinations where traffic flows smoothly and public transport infrastructure is of high quality—so tourists' travel time is low—or where the tourists' average length of stay is long, reducing their travel disutility. Tourism organizations should therefore work toward fulfilling these conditions: collaborating with local authorities to ensure that private and public transportation services are effective and strengthening the factors that encourage tourists to plan longer stays. At the same time, the DC has been shown to enhance total and producer surplus but harm tourists in Scenario 2-a. Consequently, there is both room and a need to levy local taxes on attractions to offset the losses incurred by tourists and the transport company.

A second practically relevant aspect of our analysis is to show that an effective price coordination mechanism in tourism must involve goods and services consumed together, such as transportation and attractions. Suppose instead the DC offers only price discounts on attractions, as in the Dubai case (see Table 1). Our model predicts that the DC would fail to influence tourists' purchasing decisions and, accordingly, would have no impact on total welfare. In fact, we verified that attractions would raise their prices to the extent that tourists end up paying the same actual price as they would without the discount.

This work is not without limitations, which also suggest avenues for further research on the topic. First, there are reasons beyond price coordination that justify the existence of DCs. One important reason, particularly in natural areas such as coastal zones, mountains, and lakes, is to encourage tourists to shift from private to public transportation, thereby reducing congestion and pollution.[9] Although mentioned in the model's extensions, this aspect could be

[9]In this respect, DCs might not be successful in natural areas where tourists associate public transport with higher disutility compared to private

explicitly addressed by incorporating the local population an the environment into the model and the subsequent welfare analysis. Second, the model assumes that tourists' locations are exogenously determined by the availability of accommodations. When the two attractions are equally valued ($v_1 = v_2 = v$), it is reasonable to assume that tourists are indifferent in their choice of location. However, if one attraction is more appealing, tourists will likely seek to stay closer to it, making the location choice endogenous.

Nevertheless, since the use of Hotelling in the analysis of tourism coordination is still in its infancy and this is the first study to develop a three-firm representation of tourism destinations, we believe that our analysis in its current form is sufficient to draw attention to the topic and provide insight into its primary dynamics and welfare implications. If this approach proves valuable, more comprehensive models will follow.

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vehicles. Consider a shuttle service at a mountain resort transporting guests from their hotel to the ski slopes. Since tourists must carry skis, ski boots, and other equipment, private cars might be perceived as a more attractive option.

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Appendices

Appendix A. Equilibrium

Appendix A.1. Mixed-purchase Scenario

Equilibrium prices. The symmetric equilibrium price p_M readily stems from the first-order condition, $\frac{\partial\left[p_i\left(1-\frac{v-p_i}{T}\right)\right]}{\partial p_i} = 0$. One can check that the second order condition is fulfilled.

Interval $\frac{v}{2} < T \leq v$. Plugging p_M into (3) and (4) yields $D_1(p_M) \equiv \frac{T-\frac{v}{2}}{T} \equiv D_2(p_M)$. Solving $\frac{T-\frac{v}{2}}{T} \in (0,1)$ for T yields $T > \frac{v}{2}$. Plugging p_M into (5) yields $D_{1+2}(p_M) \equiv \frac{v}{T} - 1$. Plugging p_M into (2) yields $2v - T - (\frac{v}{2} + \frac{v}{2}) = v - T$, which is nonnegative when $T \leq v$.

Welfare analysis. The producer surplus is given by

$$2 \times p_M \left(\frac{v - p_M}{T} \right) = 2 \frac{v}{2} \left(\frac{v - \frac{v}{2}}{T} \right) = \frac{v^2}{2T}.$$

The TC's equilibrium profits are

$$\int_0^{x_1(p_M)} (mx)\, dx + \int_{x_1(p_M)}^{x_2(p_M)} m dx + \int_{x_2(p_M)}^{1} [m(1-x)]\, dx$$
$$= \int_0^{\frac{T-\frac{v}{2}}{T}} (mx)\, dx + \int_{\frac{T-\frac{v}{2}}{T}}^{\frac{v}{2T}} m dx + \int_{\frac{v}{2T}}^{1} [m(1-x)] dx = \frac{mv^2}{4T^2}.$$

The consumer surplus is given by

$$\int_0^{x_1(p_M)} (v - p_M - Tx)\, dx + \int_{x_1(p_M)}^{x_2(p_M)} (2v - 2p_M - T)\, dx + \int_{x_2(p_M)}^{1} [v - p_M - T(1-x)]\, dx$$
$$= \int_0^{\frac{T-\frac{v}{2}}{T}} \left(\frac{v}{2} - Tx \right) dx + \int_{\frac{T-\frac{v}{2}}{T}}^{\frac{v}{2T}} (v - T)\, dx + \int_{\frac{v}{2T}}^{1} \left[\frac{v}{2} - T(1-x) \right] dx = \frac{v^2}{4T}.$$

Appendix A.2. Joint-purchase Scenario

Equilibrium prices. When the price charged by both firms is p_M, the location of the last consumer buying from firm 1 (respectively, 2) is $x_1(p_M) = \frac{v}{2T}$ (respectively, $x_2(p_M) = 1 - \frac{v}{2T}$). Note that $x_1(p_M) \geq 1$ and $x_2(p_M) \leq 0$ if $T \leq \frac{v}{2}$, meaning that the last consumer buying from firm 1 (2) is actually located at the endpoint 1 (0) and, most importantly, she enjoys weakly positive utility when buying only from firm 1 (2): $v - T - \frac{v}{2} = \frac{v}{2} - T \geq 0$. The profit-maximizing price chosen by firms must therefore be weakly higher than p_M; in particular, it must be such that the consumer located at the endpoint 0 (1) is left with zero utility from the consumption of the service 1 (0); in symbols, $v - T - p_i = 0$. Solving this equation for p_i gives (8).

Though intuitive, the reasoning above does not rely on first-order conditions. Accordingly, we check that no unilateral profitable deviations from (8) exist to show that (8) is indeed an equilibrium. At this candidate equilibrium, the firms' profit is $(v - T) \times 1$. Suppose $p_i^* = v - T$ and analyze the two possible deviations available to firm j. First, if firm j sets $p_j < v - T$, one can easily check that firm j serves the entire market; however, its deviation profits are $p_j \times 1 < (v - T) \times 1$, so this downward deviation is not profitable. Second, if firm j sets $p_j > v - T$, one can easily check that firm j's demand is less than 1; in particular, it is equal to $D_j = \frac{v - p_j}{T}$. The resulting deviation profit function, $p_j \left(\frac{v - p_j}{T} \right)$, is maximized at $p_j = \frac{v}{2}$ according to the proof in Appendix A.1. However, $\frac{v}{2} \leq v - T$ in interval $T \leq \frac{v}{2}$, so this upward deviation is not feasible. We conclude that (8) is an equilibrium of the price competition game.

Welfare analysis. The producer surplus is given by $2\times p_J \times 1 = 2(v-T)$. The TC's equilibrium profits are $\int_0^1 m dx = m$. The consumer surplus is given by

$$\int_0^1 (2v - T - p_J)\, dx = \int_0^1 [2v - T - 2(v - T)]\, dx = T.$$

Appendix A.3. Single-purchase Scenario

Welfare analysis. The producer surplus is given by

$$2 \times p_S \left(\frac{v - p_S}{T}\right) = 2\frac{v}{2}\left(\frac{v - \frac{v}{2}}{T}\right) = \frac{v^2}{2T}.$$

The TC's equilibrium profits are

$$\int_0^{x_1(p_S)} mxdx + \int_{x_1(p_S)}^{x_2(p_S)} 0dx + \int_{x_2(p_S)}^{1} m(1-x)\,dx$$
$$= \int_0^{\frac{v}{2T}} mxdx + \int_{1-\frac{v}{2T}}^{1} m(1-x)\,dx = \frac{mv^2}{4T^2}.$$

The consumer surplus is given by

$$\int_0^{x_1(p_S)} (v - p_S - Tx)\,dx + \int_{x_1(p_S)}^{x_2(p_S)} 0dx + \int_{x_2(p_S)}^{1} \left[v - \frac{v}{2} - T(1-x)\right] dx$$
$$\int_0^{\frac{v}{2T}} \left(v - \frac{v}{2} - Tx\right) dx + \int_{1-\frac{v}{2T}}^{1} \left[v - \frac{v}{2} - (t+m)(1-x)\right] dx = \frac{v^2}{4T}.$$

Appendix B. Destination card

We solve backwards the three-stage game described in the text. Before proceeding, we anticipate that all consumers decide to use the DC in the first stage: we then verify this is true at equilibrium.

Third stage. In the third stage, the utility of any joint purchaser and any single purchaser is given by (9) and (10), respectively, because all consumers use the DC. Solving equations $U_1^{DC} = U_{1+2}^{DC}$ for x and $U_2^{DC} = U_{1+2}^{DC}$ for $1-x$ yields the demand of single purchasers of service i, $D_i^{DC} \equiv \frac{t-v+\alpha p_j}{t}$. The demand of joint purchasers is therefore $D_{1+2}^{DC} \equiv \frac{2v-t-\alpha(p_1+p_2)}{t}$.

Second stage. In the second stage, firms compete over prices. We consider the three subgame equilibrium scenarios separately. (a) Under the mixed-purchase scenario, firm i's profit function is

$$\Pi_i^{DC} = \alpha p_i (D_i^{DC} + D_{1+2}^{DC}) = \alpha p_i \frac{v - \alpha p_i}{t}$$

and the FOC yields the symmetric equilibrium price $\frac{v}{2\alpha}$. (b) Joint-purchase scenario: following the reasoning developed in Appendix A.2, the profit-maximizing price is such that the consumers located at the endpoints enjoy zero utility from the consumption of the service at the opposite end: $v - t - \alpha p_i = 0$; solving this equation for p_i gives $\frac{v-t}{\alpha}$. (c) Single-purchase scenario: solving equations $U_1^{DC} = 0$ for x and $U_2^{DC} = 0$ for $1 - x$, we get the demand for service 1, $\frac{v-\alpha p_1}{t}$, and for service 2, $\frac{v-\alpha p_2}{t}$. Therefore, the symmetric Nash equilibrium price is $\frac{v}{2\alpha}$.

First stage. In the first stage, any single consumer decides whether to use the DC or not. To show that using the DC is a dominant strategy for any single consumer, both joint purchasers and single purchasers, under any second-stage equilibrium scenario, we proceed as follows. Plugging the second-stage equilibrium prices into (9) and (10) yields the utility of any joint purchaser and any single purchaser, respectively, using the DC. Plugging the same prices into (2) and (1) gives instead the utility of any joint purchaser and any single purchaser, respectively, not using the DC. One can easily check that any consumer is better off when using the DC because she enjoys free public transport and price discounts. In conclusion, we remark that inactive consumers get zero utility both when using and not using the DC, so these two options are equally liked.

Parametric intervals and welfare analysis. Replicating the analysis of Appendix A.1, one can easily check that the parametric interval under which the mixed-purchase equilibrium arises is $\frac{v}{2} < t \leq v$ and that the producer and consumer surplus are $\frac{v^2}{2t}$ and $\frac{v^2}{4t}$, respectively. Under the joint-purchase scenario, the producer and consumer surplus are as PS_J and CS_J with t rather than T. Finally, the single-purchase-scenario producer and consumer surplus are $\frac{v^2}{2t}$ and $\frac{v^2}{4t}$, respectively.

Appendix C. Proposition 1

Interval (i). One can easily check that: (i) $PS_J^{DC} \equiv 2(v-t) > PS_J \equiv 2(v-T)$; (ii) $\Pi_{TC,J}^{DC} \equiv 0 < \Pi_{TC,J} \equiv m$; (iii) $CS_J^{DC} \equiv t < CS_J \equiv T$; (iv) $TS_J^{DC} \equiv 2(v-t) + 0 + t = TS_J \equiv 2(v-T) + m + T$.

Interval (ii). Solving $PS_J^{DC} \equiv 2(v-t) > PS_M \equiv \frac{v^2}{2(t+m)}$ for t yields $\frac{v-m-\sqrt{m^2+2vm}}{2} < t < \frac{v-m+\sqrt{m^2+2vm}}{2}$. One can check that $\frac{v}{2} - m < \frac{v-m-\sqrt{m^2+2vm}}{2} < \frac{v-m+\sqrt{m^2+2vm}}{2} < \frac{v}{2}$, so inequality $PS_J^{DC} > PS_M$ is fulfilled in interval (ii).

Solving $CS_J^{DC} \equiv t < CS_M \equiv \frac{v^2}{4(t+m)}$ for t yields $t < \frac{\sqrt{m^2+v^2}-m}{2}$. One can check that $\frac{v}{2} - m < \frac{\sqrt{m^2+v^2}-m}{2} < \frac{v}{2}$, so inequality $CS_J^{DC} < CS_M$ is fulfilled in interval (ii) if and only if $\frac{v}{2} - m < t < \frac{\sqrt{m^2+v^2}-m}{2}$.

Finally, solving $TS_J^{DC} \equiv 2v-t = TS_M \equiv \frac{(4m+3t)v^2}{4(m+t)^2}$ for t yields $t_1 \equiv \frac{3v-2m-\sqrt{(2m+v)(2m+9v)}}{4}$, $\frac{v}{2}-m$, $t_3 \equiv \frac{3v-2m+\sqrt{(2m+v)(2m+9v)}}{4}$. One can check that $t_1 < \frac{v}{2} - m < \frac{v}{2} < t_3$. It follows that $TS_J^{DC} \neq TS_M$ in interval (ii). To determine whether TS_J^{DC} is larger or smaller, we compute $\frac{\partial(TS_J^{DC}-TS_M)}{\partial t}$, evaluate it at $t = \frac{v}{2} - m$, and get $\frac{4m+2v}{v}$. Since this value is positive and the difference $\left(TS_J^{DC} - TS_M\right)$ is continuous in t, we conclude that $TS_J^{DC} = TS_M$ at $t = \frac{v}{2} - m$ and $TS_J^{DC} > TS_M$ in interval (ii).

Interval (iii). First consider $\frac{v}{2} < t \leq v - m$. One can easily check that: (i) $PS_M^{DC} \equiv \frac{v^2}{2t} > PS_M \equiv \frac{v^2}{2T}$; (ii) $CS_M^{DC} \equiv \frac{v^2}{4t} > CS_M \equiv \frac{v^2}{4T}$. Rearranging $TS_M^{DC} \equiv \frac{3v^2}{4t} > TS_M \equiv \frac{(4m+3t)v^2}{4(m+t)^2}$ yields $m(3m + 2t) > 0$, which is true. These findings extend to intervals $v - m < t \leq v$ and $t > v$ because the welfare values under the single-purchase scenario take the same functional forms as under the mixed-purchase scenario.

Appendix D. Robustness Checks

Priced DC. We solve backwards the four-stage game described in the text. Before proceeding, we assume that all consumers buy the DC in the second stage: we then verify under which conditions this is true at equilibrium. Note that if this is the case, consumers decide to visit at least one firm in the fourth stage: visiting no firms would indeed yield utility $-k$, in which case consumers would be better off by not buying the DC. As a result, we can restrict our attention to the joint- and the mixed-purchase scenario only.

In the fourth stage, the utility of a joint purchaser and a single purchaser when buying the DC is as in (9) and (10), respectively, minus the price k of the DC. This implies that the demands of joint and single purchasers are as in Appendix B.

In the third stage, firms choose prices. (a) The mixed-purchase equilibrium price is still $\frac{v}{2\alpha}$, but the parametric interval shrinks to $\frac{v}{2} < t \leq v - k$ because of the DC price paid by consumers. (b) Under the joint-purchase scenario, arising in the usual interval $t \leq \frac{v}{2}$, the equilibrium price is still $\frac{v-t}{\alpha}$ and the resulting consumer equilibrium utility is $t - k$. However, when this value is negative (i.e., $t < k$), firms reduce the symmetric equilibrium price to $\frac{2v-t-k}{2\alpha}$ so that consumers get zero utility and the market is still covered.

In the second stage, consumer utility when buying the DC is: (a) $v - t - k$ for joint purchasers and $\frac{v}{2} - td_i(x) - k$ for single purchasers, under the mixed-purchase scenario; (b) $\max\{t - k, 0\}$ under the joint-purchase scenario. Consumer utility when not buying the DC is: (a) $v(\frac{2\alpha-1}{\alpha}) - T$ for joint purchasers and $v(\frac{2\alpha-1}{2\alpha}) - Td_i(x)$ for single purchasers, under the mixed-purchase scenario; (b) $2v - T - 2(\frac{v-t}{\alpha})$, under the joint-purchase scenario.

In the first stage, we verify all consumers are better off when buying the DC, provided that the DMO sets $k \leq \min\{m, v(\frac{1-\alpha}{2\alpha})\} \cap \alpha \leq \frac{2}{3}$. Intuitively, the DC price must be relatively low and, at the same time, the discount on attractions relatively high for all consumers to be willing to buy the DC.

On the above basis, we can compare the welfare values with the priced DC to those without the DC. Before proceeding, two aspects must be highlighted. First, total surplus contains also the profits accruing to the DMO from the sale of the DC; since the market is fully covered, this profit is given by the price k times the mass 1 of consumers. Second, this amount is transferred from consumers to the DMO, so it factors out in the calculation of total surplus.

1. When $t \leq \frac{v}{2} - m$, the welfare comparison gives the same results as those in interval (i), Appendix C.
2. When $\frac{v}{2} - m < t \leq \frac{v}{2}$, two parametric constellations must be considered separately. (a) If $k < \frac{v}{2} - m$ or if $k > \frac{v}{2} - m \cap k \leq t \leq \frac{v}{2}$, the welfare comparison is as in interval (ii), Appendix C, except for the consumer surplus CS_J^{DC}, which is now given by $t - k$. (b) If $k > \frac{v}{2} - m \cap \frac{v}{2} - m < t < k$, CS_J^{DC} becomes zero and, accordingly, lower than CS_M; PS_J^{DC} becomes $2v - t - k$, which turns out to be higher than PS_M.
3. When $\frac{v}{2} < t \leq v - k$, the welfare comparison is as in interval (iii), Appendix C, except the consumer surplus CS_M^{DC}, which is now given by $\frac{v^2}{4t} - k$. One can check that CS_M^{DC} becomes lower than CS_M when k is sufficiently high.

100% Price Discount. We focus on full market coverage because we showed that the single-purchase scenario does not add to the welfare comparison in Proposition 1. When $\alpha = 0$, firm i's profit function is as in Section 4, but multiplied by the share $(1 - \mu)$ of consumers that still pay p_i for attraction i. As a result, one can easily check that the equilibrium prices are as in Section 4: $\frac{v}{2}$ in the mixed-purchase scenario, which arises in interval $\frac{v}{2} - m < t \leq v - m$, and $v - T$ in the joint-purchase one, which arises when $t \leq \frac{v}{2} - m$. The scenarios are defined by the purchasing decisions of consumers without the DC because firms obtain profits only from them. As for the share $(1 - \mu)$ of consumers endowed with the DC, one can check that the proportion of joint purchasers is given $\frac{2v-t}{t}$ and that this value is larger than 1 in our interval of interest, $t \leq v - m$. As a result, all consumers receiving the DC decide to joint-purchase.

On the above basis, we can compute the welfare values and compare them to those without the DC.

1. When $t \leq \frac{v}{2} - m$, we obtain: $PS_J^{DC} \equiv 2(1 - \mu)(2v - T) < PS_J$; $\Pi_{PTC,J}^{DC} \equiv (1 - \mu)m < \Pi_{PTC,J}$; $CS_J^{DC} \equiv (1 - \mu)T + \mu(2v - t) > CS_J$; and $TS_J^{DC} \equiv 2v(2 - \mu) - t > TS_J$.
2. When $\frac{v}{2} - m < t \leq v - m$, we get: $PS_M^{DC} \equiv (1 - \mu)\frac{v^2}{2T} < PS_M$; $\Pi_{PTC,M}^{DC} \equiv (1 - \mu)\frac{mv^2}{4T^2} < \Pi_{PTC,M}$; $CS_M^{DC} \equiv (1 - \mu)\frac{v^2}{4T} + \mu(2v - t) > CS_M$; and $TS_M^{DC} \equiv \frac{(4m+3t)v^2 + \mu(8T^2 v - 4T^2 t - 3Tv^2 - mv^2)}{4T^2} > TS_M$.