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Effects of non-aeronautical service on airports: A selected review and research agenda

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Abstract: In the traditional analysis of airports, non-aeronautical service is not the main focus. Given its growing importance, recent airport literature has investigated the impact of non-aeronautical service comprehensively. The main purpose of this article is, by referring to recent literature, to summarize economic effects of non-aeronautical service on airport management (pricing, investment, and self-financing), regulation, airport city and benefit spillover. The studies overviewed look at airports´ aeronautical and non-aeronautical services (and their interactions with other parts of the economy) based on a general two-good model. Finally, we discuss several avenues for further research.
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1. Introduction

What is the essential feature of an airport? A direct answer to this question is that an airport is a place where passengers get on/off airplanes. However, this answer may not fit well with many contemporary airports, in which "non-aeronautical revenue" has become more important than the traditional aeronautical revenue that is directly associated with passengers and airplanes (runways, aircraft parking, and terminals). Non-aeronautical revenue, which is also often referred to as "concession revenue" or "commercial revenue" in the literature, is the revenue from an airport's non-aeronautical service that includes airport retailing, advertising, car rentals, car parking, and land rentals. At many airports around the world, more than half of their revenues come from non-aeronautical services. According to Airports Council International (ACI, 2020), the percentages of non-aeronautical revenue in fiscal year 2019 (the last pre-pandemic, "normal" year) are, for example, 65.7% at Incheon airport (South Korea), 54.9% Sydney airport (Australia), 62.9% Copenhagen airport (Denmark), 63.1% Dublin airport (Ireland), 67.8% Orlando (the US), 68.2% Atlanta (the US), and 62.8% Vancouver airport (Canada). In effect, ATRS (2020) found that non-aeronautical revenue at major airports reached over 60% of their total revenue. Figure 1 shows, overall, airport revenues by distributional share over the period of 2005-2017 (prior to the COVID-19 pandemic). From the financial perspective, therefore, airports may not be best described just as a place for passengers' getting on/off planes, because they significantly rely on non-aeronautical revenue.

Non-aeronautical service is not the main focus of the traditional theoretical studies on airports. This treatment is understandable given it had historically been small and supplementary to aeronautical service, which is an airport's "core business." However, as indicated above, the revenue from non-aeronautical service (the "side business") has grown rapidly over the last three decades to the extent that they become the main revenue source. Furthermore, non-aeronautical service tends to be more profitable than aeronautical service, especially at large airports. As a result, in-depth theoretical analyses on non-aeronautical service, and on the role it plays in airport management, regulation and other aspects, have been growing in the literature. The purpose of this article is to summarize economic effects of non-aeronautical service on airports. We shall focus on reviewing a strand of recent literature that examine theoretically the impact on airport pricing, investment and self-financing), airport regulation, airport city and benefit spillover. We will further discuss an agenda for future research on these issues.

Perhaps the most distinct feature of this article is that we comprehensively treat various economic effects of non-aeronautical service: not only on the traditional problems of airport pricing, self-financing and regulation, but also on the emerging problems of airport city and benefit spillover, which have not been covered by other surveys. To discuss these issues in a consistent manner, we examine airports' aeronautical and non-aeronautical services (and their interactions with other parts of the economy) based on a simple (yet quite general) two-good model. This two-good modeling approach

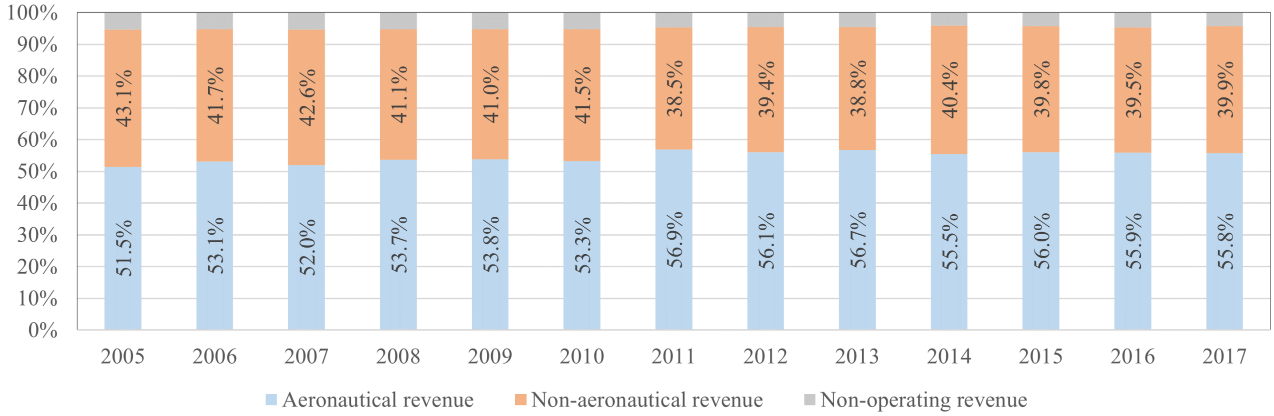

Figure 1: *Evolution of airport revenues by distributional share (2005-2017) (Source: Lucas (2019)).*

has been adopted in a series of studies conducted by the authors of the present article over the past several years; as a consequence, these studies will be the main focus of this review. In addition, we have the obvious opportunity to include more recent material than is discussed in earlier survey articles (e.g., Basso and Zhang, 2007; Zhang and Czerny, 2012), leading to a more complete guide to the literature.

We summarize the main results of our review, which clarify the effects of non-aeronautical services on airport pricing, investment, self-financing, regulation, the size of airport city, and the spillover of airport's benefit. First, after replicating a well-known result that the presence of airports' non-aeronautical service works to lower airport charges, we make explicit the conditions for the result. Second, we point out the possibility that profitable non-aeronautical services result in lower investment by an airport, because the regulator imposes a tighter regulation, taking into account the positive profits from non-aeronautical service. Third, self-financing - i.e., the airport revenue cover costs - can hold with positive profits from non-aeronautical service, even if we take into account its effect to lower airport charges. Fourth, we analyze the effects of non-aeronautical services on social welfare under single-till and dual-till regulations, where single-till regulation means that the total airport profits are regulated while dual-till regulation means that only the aeronautical profits are regulated (i.e., non-aeronautical profits are unregulated). We demonstrate that whether single-till regulation or dual-till regulation yields higher social welfare with positive profits from non-aeronautical service depends on the regulatory profit under unconstrained social welfare maximization. We further show the relationship with the regulator's preference for the utility of consumers or airports' profits. Fifth, we analyze the issue of "airport city," where more and more non-aeronautical services agglomerate like a city. Our result shows that the varieties at an airport shopping mall are oversupplied, i.e., the size of airport city is too big, when an airport maximizes its profit, as long as the downtown shops earn a positive profit. Finally, profits from an airport's non-aeronautical services may work as the device to countervail the spillover of airport benefits to other areas.

The paper is organized as follows. In Section 2, we briefly review related literature. In Section 3, after describing a general two-good model, we examine the effect of non-aeronautical service on optimal airport charges. Section 4 considers airport investment, and Section 5 focuses on self-financing. In Section 6, we consider the effects of non-aeronautical services on single-till and dual-till regulations. Section 7 examines airport city, and Section 8 considers the spillover of airport benefits. Finally, Section 9 discusses avenues for further research.

2. Literature Review

Non-aeronautical activities and revenues have been discussed and measured in a number of studies (e.g., Zhang and Zhang, 1997, 2003; Humphreys and Francis, 2002; Forsyth, 2004; Thompson, 2007; Odoni, 2009; Morrison, 2009; Czerny et al., 2016a; Moulds and Lohmann, 2016; Battal and Bakir, 2017; D'Alfonso et al., 2017). The financial performance of non-aeronautical activities has also been examined in, among others, Jones et al. (1993), Starkie (2001), Francis et al. (2004), Graham (2009), and Fasone and Maggiore (2012). For instance, Jones et al. (1993) have shown that, in 1990-1991, approximately 60% of the revenues of Heathrow, Gatwick, and Stansted – the three airports formerly controlled by British Airport Authority around London – resulted from concession activities. The operating margin for aeronautical activities was -7% for the three airports as a group, while the operating margin for concession activities was 64%. For a useful overview of these issues, see Graham (2018).

A number of studies have attempted to identify factors that are associated with non-aeronautical performance (e.g., Nadezda, 2009; Yokomi et al., 2017; Choi et al., 2020; see Chen et al. (2020) for a review of contemporary airport retail literature). Unlike these studies, this article focuses on the effects of non-aeronautical service. As such, the present article is related to studies exploring implications of non-aeronautical revenue including the implications for: i) the need for airport regulation (e.g., Beesley, 1999; Starkie, 2001; Oum et al., 2004; Kratzsch and Sieg, 2011; Phang, 2016); ii) the forms of regulation (e.g., Crew and Kleindorfer, 2000; Czerny, 2006; Yang and Zhang, 2011; Czerny et al., 2016a); iii) airport pricing and capacity investment (e.g., Zhang and Zhang, 1997, 2003; D'Alfonso et al., 2013; Wan et al., 2015; Karanki et al., 2020); iv) airport efficiency (e.g., Tovar and Martin-Cejas, 2009); and v) airport privatization (e.g., Bilotkach et al., 2012; Czerny, 2013; Gillen and Mantin, 2014). Most of this literature are empirical studies. In contrast, this article surveys a set of theoretical studies. These studies look at airports' aeronautical and non-aeronautical services (and their interactions with other parts of the economy) based mainly on a simple two-good model, which is distinct from the analytical structures adopted in other analytical papers (e.g., those discussed in Czerny, 2021). As mentioned earlier, the two-good modeling approach underlies a series of studies conducted by the authors of the present article over the past several years which will be the main body of literature reviewed below. Furthermore, the unifying framework allows us to examine issues that have not been covered by other surveys, such as airport city and benefit spillover. For example, Czerny (2021) explains the effects of concession services on airport pricing and regulation, but the issues of airport city and benefit spillover are out of his review scope.

Finally, a distinct characteristic of recent airport research is its explicit recognition of airline markets being oligopoly or other forms of imperfect competition (e.g., Daniel, 1995; Brueckner, 2002; Pels and Verhoef, 2004; Zhang and Zhang, 2006; and Basso, 2008). Unlike these studies, all the papers discussed in our survey abstract away airline market power by considering perfectly competitive airlines. This modeling abstraction will, we believe, allow the illustration of the most fundamental insights about economic effects of non-aeronautical service as clear as possible (while minimizing distraction from potentially less relevant practicality). We also note that other relevant papers will be mentioned and discussed in the text below.

3. Non-aeronautical Service and Airport Charges

We consider a simple (yet quite general) two-good model, which consists of the aeronautical service of an airport and the non-aeronautical service the airport offers, such as airport parking or a shopping mall. We develop consumers' utility, monopoly airport's profits, and social welfare in the following, although, for readability, we delegate most of mathematical details to Appendixes. We formulate the utility-maximization problem of the representative consumer as:

(1) Max $U = z + u(x_1, x_2)$, subject to $z + p_1x_1 + p_2x_2 = I$, where z, x_1, x_2, p_1, p_2, and I respectively are the quantity of the numeraire good (and its price is normalized at unity), the demand for the aeronautical service, the demand for the non-aeronautical service, the price of the aeronautical service, the price of the non-aeronautical service, and the income. From the utility-maximization by the representative consumer, which is shown in Appendix A, we have demand functions of $x_1(p_1, p_2)$ and $x_2(p_1, p_2)$.[1] The monopoly airport provides the aeronautical service and the non-aeronautical service to the consumers, and its profit is:

(2) $\Pi^{Airport} = p_1x_1(p_1,p_2) + p_2x_2(p_1,p_2) - c_1x_1(p_1,p_2) - c_2x_2(p_1,p_2)$, where c_1 and c_2 respectively are the unit production costs of the aeronautical and non-aeronautical services.

We abstract away airline market power by considering perfectly competitive airlines, although we acknowledge that a distinct characteristic of recent airport research is its explicit recognition of airline markets being oligopoly or other forms of imperfect competition (e.g., Daniel, 1995; Brueckner, 2002; Pels and Verhoef, 2004; Zhang and Zhang, 2006; and Basso, 2008). This modeling abstraction allows the illustration of the most fundamental insights about economic effects of non-aeronautical service as clear as possible (while minimizing distraction from potentially less relevant practicality). From (1) and (2), we define social welfare as:

(3)
$$\begin{aligned} SW &= U + \Pi^{Airport} \\ &= I - p_1x_1(p_1,p_2) - p_2x_2(p_1,p_2) + u(x_1(p_1,p_2), x_2(p_1,p_2)) \\ &\quad + p_1x_1(p_1,p_2) + p_2x_2(p_1,p_2) - c_1x_1(p_1,p_2) - c_2x_2(p_1,p_2) \\ &= I + u(x_1(p_1,p_2), x_2(p_1,p_2)) - c_1x_1(p_1,p_2) - c_2x_2(p_1,p_2) \end{aligned}$$

The airport literature has repeatedly pointed out that the presence of airports' non-aeronautical service would lead to lower airport charges (e.g., Starkie, 2001; Zhang and Zhang, 2003).[2] To replicate this result in our two-good model, we need: i) the aeronautical and non-aeronautical services are complementary; ii) the profits of non-aeronautical service are positive; and iii) airports take the price of non-aeronautical service as exogenously given. Maximizing social welfare (3) regarding p_1, taking $p_2 = \bar{p}_2$ as given, yields:

(4) $p_1 = c_1 - (\bar{p}_2 - c_2)\left(\frac{\partial x_2}{\partial p_1} / \frac{\partial x_1}{\partial p_1}\right)$.

We naturally assume that the own-price effect is negative, i.e., $\frac{\partial x_1}{\partial p_1} < 0$ (downward-sloping demand), throughout this

[1]Here the demand for aeronautical service depends on airport charges (and on non-aeronautical price); the airline market is not formally modeled. This is a direct consequence of our setting of perfectly competitive airlines indicated in the introduction. In the "vertical structure" approach however, airports provide an input for an airline oligopoly and it is the equilibrium of this downstream market which determines the airports' demand. Basso and Zhang (2008) show, for example, that the present approach is valid if air carriers have no market power. When carriers have market power, this approach may result in a surplus measure (see (3) below) that falls short of giving a true measure of social surplus, and a traffic level that is, for given capacity, smaller than the socially optimal level. We discuss the issue further in Section 9.

[2]In this paper, we use "airport change" and "aeronautical charge" interchangeably.

paper. If the aeronautical and non-aeronautical services are complementary, we have $\frac{\partial x_2}{\partial p_1} < 0$, which yields $\frac{\partial x_2}{\partial p_1} / \frac{\partial x_1}{\partial p_1} > 0$. When the profit of non-aeronautical service is positive, $\bar{p}_2 > c_2$. Then $\frac{\partial x_2}{\partial p_1} / \frac{\partial x_1}{\partial p_1} > 0$ and $\bar{p}_2 > c_2$ lead to $p_1 < c_1$, that is, a profitable non-aeronautical service makes airport charge lower than the marginal cost. Note that, when airports can influence the price of non-aeronautical service, the result does not hold, since not only the airport charge but also the non-aeronautical price are optimized. Maximizing welfare (3) regarding p_1 and p_2 yields the result that the price of non-aeronautical service equals its marginal cost.

When an airport maximizes its profit, however, the non-aeronautical price equals the profit-maximizing price (Kidokoro and Zhang, 2018). In this case too, profitable non-aeronautical services work to lower airport charges, as long as i) the aeronautical and non-aeronautical services are complementary; ii) the profits of non-aeronautical service are positive; and iii) airports take the price of non-aeronautical service as exogenously given. We see this result by maximizing the airport's profit, (2), regarding p_1, taking $p_2 = \bar{p}_2$ as given. We then have:

(5) $p_1 = c_1 - \left(x_1 / \frac{\partial x_1}{\partial p_1}\right) - (\bar{p}_2 - c_2)\left(\frac{\partial x_2}{\partial p_1} / \frac{\partial x_1}{\partial p_1}\right)$. The difference from (4) is that we additionally have the term of monopoly profit, $-\left(x_1 / \frac{\partial x_1}{\partial p_1}\right) > 0$. We still have the effect of $-(\bar{p}_2 - c_2)\left(\frac{\partial x_2}{\partial p_1} / \frac{\partial x_1}{\partial p_1}\right) < 0$, which works to lower airport charges.

If the relationship that profitable non-aeronautical services work to lower airport charges is strong, it may happen that the optimal airport charge could be zero or even negative. In such a situation, we may even consider that non-aeronautical services are core businesses whilst aeronautical services are side businesses. In fact, a numerical simulation in the appendix, K, of Kidokoro and Zhang (2023a) suggests that an airport's total profits can be positive with highly profitable non-aeronautical services, even if zero airport charge makes the aeronautical profit negative. In practice, airport business models appear to be moving towards this direction: i.e., more non-aeronautical profits are targeted, as we note in Introduction. In this trend of focusing more on non-aeronautical profits, what is the difference between airport retails and shopping malls in downtown, where parking is set free so as to increase the number of customers and then, each shop's profit? This point is worthy further investigation in future research. We can derive the same relationship even if we take congestion into account. (The analysis is shown in Appendix A.) Positive non-aeronautical profits still work to lower airport charge. Thus, in large airports with high non-aeronautical profits, the optimal airport charge may be small, even if we include the congestion cost. In an extreme case, a negative airport charge is justified with sufficiently large non-aeronautical profits. This result may seem strange at a first glance, but the story is completely parallel with second-best pricing for road congestion (e.g., Kidokoro, 2010).

4. Airport Investment

We now discuss results regarding the effects of positive non-aeronautical profits on airport investment. Kidokoro et al. (2016) show that the existence of non-aeronautical services would not affect the marginal condition for optimal airport investment, i.e., the marginal benefit of investment equals the marginal investment cost. (We replicate this result in Appendix B.) However, this condition does not tell us whether an airport's actual investment increases or decreases with profitable non-aeronautical services.

If an airport gains a huge profit from non-aeronautical services, it may invest more on airport capacity. However, most airports are economically regulated in aeronautical service because aeronautical service is considered monopoly at least locally. If we take airport regulation into account, we might not say that more non-aeronautical profits result in more investment. This point has been analyzed in Kanemoto and Kiyono (1995) regarding urban railways in Japan. Urban railways, especially in Tokyo, Japan, can be very crowded. This means that the capacity of urban railways is in shortage, compared to the demand. Then, why is the capacity of urban railways so small? Kanemoto and Kiyono argue that urban railway companies have engaged in extensive side businesses, and the regulation by government, which takes the profit from side businesses into account, has hindered the investment. Historically, Japanese urban railways had been regulated by "rate of return" regulation. For rate-of-return regulation, we know the famous Averch-Johnson (AJ) effect (Averch and Johnson, 1962). The AJ effect results in overinvestment, because the regulator needs to make the allowed rate of return for capital no smaller than the capital cost to ensure the regulated firm's stand-alone operation. The argument based on the AJ effect is inconsistent with urban railways in Japan. Kanemoto and Kiyono (1995) then focus on the fact that railway companies have engaged in extensive side businesses, such as housing development and department stores at stations, making large profits. Kanemoto and Kiyono assert that the Japanese government has implicitly considered these profits from side businesses, and set the allowed rate of return lower than the capital cost. If this story holds, the AJ effect reverses, causing underinvestment, which fits the real situation in Japan.[3] The logic that profitable side businesses yield underinvestment is not limited to rate-of-return regulation. Kidokoro (2006) considers the situation in which the government can make the "price cap" lower

[3] Kidokoro (1998) considers another mechanism. Rate-of-return regulation in Japan has been based on the book value of land, which is much lower than the market value. If the government values the land based on the market value, the rate base significantly increases, and this makes allowed profits greater. He shows that the valuation based on the book value makes the allowed profits lower and reduces investment. If an airport is regulated by rate-of-return regulation, the same logic applies.

if railway companies gain more profits. His simulation demonstrates that a tighter price cap, coupled with higher profits from side businesses, lead to lower investment.

Applying the argument of Kanemoto and Kiyono (1995) and Kidokoro (2006) to airports, the regulator can make airport charges lower, considering high non-aeronautical profits. (In fact, single-till regulation, which is to be discussed in Section 5 below, is based on the similar idea.) This lower airport charge could lead to lower investment. Here, more detailed empirical research on the effect of non-aeronautical services on airport investment is needed.

5. Self-financing

What is the effect of non-aeronautical services on an airport's self-financing? Here, self-financing means that a firm's revenue exceeds its cost and so the firm can operate on a stand-alone basis. We use the word of "exact self-financing" to describe the situation in which a firm's revenue just equals its cost, i.e., the firm's profit is zero. Exact self-financing holds under social welfare maximization regarding the prices of the aeronautical and non-aeronautical services, as shown in Kidokoro and Zhang (2018). If the price of non-aeronautical service is exogenously given, self-financing may hold when the profit from non-aeronautical service is positive and the own-price elasticity of aeronautical service is larger than the cross-price elasticity of non-aeronautical service, even if we take into account the effect to lower airport charges. (These results are shown in Appendix C.)

In summary, in the first-best situation, in which an airport can control the prices of both aeronautical and non-aeronautical services, the exact self-financing holds. In the second-best situation, in which an airport cannot control the price of non-aeronautical service, self-financing can hold with positive profits from non-aeronautical service. Thus, we need to make it clear whether we are talking about the first-best or second-best situation in considering an airport's self-financing problem.

6. Implications for Regulation: Single-till vs. Dual-till

It has been a major policy concern whether economic regulation for an airport should include non-aeronautical service. Under single-till regulation, the total airport profits are regulated, including the profits from non-aeronautical service. On the contrary, under dual-till regulation, only the profits from aeronautical service are regulated. Kidokoro and Zhang (2022b) investigate the question of which regulation, single-till or dual-till, attains higher social welfare. We here replicate their results, applying the model described in Section 2.

As a useful analytical tool we introduce the following regulatory profit function:

(6) $Reg(p_1, p_2) \equiv p_1x_1(p_1, p_2) - c_1(x_1(p_1, p_2)) + \beta\left(p_2x_2(p_1, p_2) - c_2(x_2(p_1, p_2))\right)$, where β may represent the degree of single-till regulation (relative to dual-till regulation). $Reg(p_1, p_2)$ is reduced to the combined profits when $\beta = 1$, i.e., single-till regulation; whilst it is reduced to the profits of aeronautical service when $\beta = 0$, i.e., dual-till regulation. In order to analyze the welfare effect of switching from dual-till to single-till regulation, we shall treat β as a continuous variable between 0 and 1. Because we consider social welfare maximization under regulation, the maximized welfare depends on β. We assume that $\frac{dSW}{d\beta}$ has the same sign in the range $0 \le \beta \le 1$. Using (6), we denote the value of regulatory profit under social welfare maximization without regulation by $Reg(p_1{}^*, p_2{}^*)$, where the superscript $*$ denotes the values in the case of social welfare maximization.

Following Kidokoro and Zhang (2022b), we have the two cases to analyze. (The details are shown in Appendix D.) First, consider the case of $Reg(p_1{}^*, p_2{}^*) > 0$. Because the regulatory profit under welfare maximization is positive, the relevant regulatory purpose is to limit the regulatory profit to no larger than zero. In this case, we have:

(7) $\frac{dSW(p_{1Reg_1}, p_{2Reg_1})}{d\beta} < 0$ when $p_{2Reg_1}x_2(p_{1Reg_1}, p_{2Reg_1}) - c_2(x_2(p_{1Reg_1}, p_{2Reg_1})) > 0$. Relationship (7) implies that larger β results in lower social welfare, i.e., dual-till regulation is better for social welfare, assuming that $\frac{dSW(p_{1Reg_1}, p_{2Reg_1})}{d\beta}$ has the same sign in the range $0 \le \beta \le 1$.

Second, consider the case of $Reg(p_1{}^*, p_2{}^*) < 0$. Because the regulatory profit under welfare maximization is negative, the relevant regulatory purpose is to increase the regulatory profit to no smaller than zero, i.e., to attain self-financing at least. In this case, we obtain:

(8) $\frac{dSW(p_{1Reg_2}, p_{2Reg_2})}{d\beta} > 0$ when $p_{2Reg_2}x_2(p_{1Reg_2}, p_{2Reg_2}) - c_2(x_2(p_{1Reg_2}, p_{2Reg_2})) > 0$. Relationship (8) implies that a larger β results in higher social welfare, i.e., single-till regulation is better for social welfare, assuming that $\frac{dSW(p_{1Reg_2}, p_{2Reg_2})}{d\beta}$ has the same sign in the range $0 \le \beta \le 1$.

The intuitive explanation for this result is as follows. If the solution under unconstrained welfare maximization yields a positive regulatory profit, the regulator needs to decrease the airport's profits so as to satisfy the regulation. When the profits from non-aeronautical service are positive, including the positive non-aeronautical profit makes it more difficult to meet the regulation. This implies that the social cost for regulation is smaller under dual-till regulation (recall the non-aeronautical profit is not included under dual-till regulation). On the contrary, if the solution under unconstrained welfare maximization yields a negative regulatory profit, the regulator needs to increase the airport's profit in order to satisfy the regulation. When the profits from non-aeronautical service are positive, including the positive non-aeronautical profit makes it easier to meet the regulation. Thus, the social cost for regulation is smaller under single-till regulation.

The above analysis shows that the result depends on whether the solutions under social welfare maximization yield positive or negative regulatory profits when the profits from non-aeronautical services are positive. Unfortunately, this condition is difficult to apply in practice, because the regulator needs to know hypothetical regulatory profits under unconstrained welfare maximization, which is not directly observable. Kidokoro and Zhang (2023a) demonstrate that the regulator does not need to investigate this condition in certain specific cases.

First, when a regulator maximizes the utility of consumers (e.g., air passengers), single-till regulation is desirable when non-aeronautical services yield positive profits. In this case, under unconstrained welfare maximization (i.e., maximization of consumers' utility), the optimal prices of aeronautical and non-aeronautical services are zero, because lowering prices makes consumers' utility higher. Zero prices make the regulatory profits to become negative. Thus, we can determine that the solutions under social welfare maximization yield negative regulatory profits, and consequently, single-till regulation is better from (8). Second, when the regulator maximizes the profit of airlines, single-till regulation is also desirable under positive profits from non-aeronautical service.[4] In this case, under unconstrained welfare maximization (maximization of the airlines' profit), the optimal prices of aeronautical and non-aeronautical services are zero. This is because: i) lowering the price of aeronautical service makes the profit of airlines higher; and ii) lowering the price of non-aeronautical service makes the demand for air travel, and then aeronautical service, higher, which in turn will, under the assumption that the aeronautical and non-aeronautical services are complementary, increase the profit of airlines. Zero prices make the regulatory profits negative. Thus, again, we can determine that the solutions under welfare maximization yield negative regulatory profits, and consequently, single-till regulation is better from (8). Third, as a natural consequence of the above two results, single-till regulation is preferred under a positive non-aeronautical profit, when the regulator maximizes the weighted sum of consumers' utility and the airlines' profit. Fourth, when the regulator maximizes the profit of an airport, dual-till regulation is preferred if the profits from non-aeronautical service are positive. This is because the airport's profit is greater when the positive profits from non-aeronautical service are unregulated.

In summary, if the profits from non-aeronautical service are positive, consumers and airlines prefer single-till regulation while the airport prefers dual-till regulation. Furthermore, Kidokoro and Zhang (2023a) point out the possibility of "regulatory capture" when the regulator implements dual-till regulation for an airport with positive non-aeronautical profits.[5] This is because the regulator could have attained a higher consumers' utility by adopting single-till regulation.

7. Airport City

Over the last two and half decades, the concept of "airport city" has attracted considerable attention from researchers and planners as well as policy makers. Airport city contains an airport and its surrounding area, where a variety of non-aeronautical services, such as hotels, conference and exhibition facilities, and shopping malls, agglomerate like a city (e.g., Kasarda, 2008; D'Alfonso et al., 2017; Goetz, 2019). From the viewpoint of airport management, airport city appears a fascinating idea, with which an airport can increase its profit. However, is airport city welfare-improving for the society as a whole? To answer this question, Kidokoro and Zhang (2022a) model the development of airport city as an increase in varieties offered at an airport, and investigate the optimal size of an airport city. They show that the airport city would be too big if it is developed by a privatized airport that maximizes its profit.

To investigate this problem, we extend our two-good model to an M -good model, following Kidokoro and Zhang (2022a). The analysis is shown in Appendix E. In social optimum, the marginal development cost of variety at an airport mall equals the marginal social benefit of variety at an airport mall. However, in the airport's profit maximization, the marginal development cost of variety at an airport mall is larger than the marginal social benefit of variety at an airport mall, i.e., the varieties at an airport shopping mall are oversupplied, as long as the downtown shops have positive profits.

The reason for this result is that an airport does not take into account a decrease in profits outside an airport when it decides on the airport-city size. If an airport increases the supply of non-aeronautical services in order to maximize its profit, the demand for substitute services outside the airport decreases. To illustrate, consider car rental at an airport. Car rental at an airport is typically priced higher than car rental outside the airport (by, for example, the airport facility fee). A user of car rental chooses a higher price at an airport in exchange for convenience: while paying a lower price outside an airport, the user needs to go to a car rental place by bus or public transport, thereby encountering inconvenience. The same story applies to a shopping activity at an airport. The price of a bottle of water is typically higher in an airport than in supermarkets in the surrounding areas. An airport user can again choose the purchase of a bottle of water at an airport, or outside the airport with inconvenience (going to supermarkets outside of the airport and bringing it back to the airport). In short, non-aeronautical services at an airport can more or less be substitutable with the substitute services outside the airport, as our model implies.

The same effect emerges if we consider a local government that maximizes the local welfare that consists of consumers' utility and the profits in its local area but does not consider the profits in other areas. Kidokoro and Zhang (2022a) also show

[4]For this analysis, we need a model in which airlines obtain profits. Kidokoro and Zhang (2023a) enable this analysis by modeling airlines that engage in Cournot competition.

[5]Regulatory capture theory asserts that "regulation is acquired by the industry and is designed and operated primarily for its benefit" (Stigler, 1971, p.3). We consider that the regulator is captured by airports when it maximizes their profit.

that the social optimal can be recovered by Pigouvian taxes and subsidies, which make the airport, or the local government, to take the profits of other areas into account.

Another interesting point suggested in Kidokoro and Zhang (2022a) is that an airport may prefer not to locate near downtown, if it can choose its "location." It might be unrealistic to consider that an airport can choose its location, but an airport can choose its "location" with various means. For example, if an affordable high-speed rail connection exists between an airport and downtown, we may consider that the airport locates near downtown. In this context, the airport can choose its location in the sense that it pays, fully or partly, the investment costs for improving airport access. Furthermore, "location" is not just limited to distance, but also is related to the varieties of non-aeronautical services offered at an airport. If an airport sells the same products as those sold in downtown, we may consider that airport location is near downtown. On the contrary, if an airport sells more differentiated varieties, we may consider that airport location is more distant from downtown. If an airport locates near downtown, competition between non-aeronautical services and substitute services in downtown is more intense, and consequently, the profits from non-aeronautical services at the airport decrease. That is, an airport can earn higher profits with less competition if it locates at more distant place from downtown. For instance, if an airport is far from downtown, an ice-cold bottle of water purchased at downtown becomes warm when the air traveler arrives at the airport. In this case, most airport users will buy a bottle of water at the airport even with a bit higher price. This makes the airport's profit higher. If an airport sells the differentiated products exclusively at the airport, the substitutability with the goods sold outside the airport is weakened. The airport has inelastic demands for those goods, contributing to an increase in its profit.

In summary, the regulator needs to consider a change in demand for substitute goods outside an airport, if it pursues the maximization of social welfare. However, if an airport maximizes its profit, it does not consider a decrease in the profit outside the airport, and consequently, the number of varieties offered at the airport is too large. That is, an oversized airport city is created. This result stems from the fact that an airport does not take the profits outside the airport into account. Disregarding this point would lead to a poor policy recommendation, by overlooking at the situation in which the airport gains but the overall society loses.

8. Spillover of Airport Benefit

Non-aeronautical services work to mitigate the spillover of airport benefit. We explain this mechanism based on a modified two-good model. Now we consider two types of consumers: City 1's consumers and City 2's consumers. Both cities are connected by competitive airlines. For the moment, we consider the aeronautical service only. (The analytical details are shown in Appendix F.) When the regulator maximize the social welfare, the optimal price of aeronautical service equals the marginal cost, as we naturally expect. On the contrary, when the regulator maximize the local social welfare in City 1, in which the utility of consumers in City 2 is excluded, the price of the aeronautical service is larger than the marginal cost. This is because City 1's local government behaves like a monopoly for the residents in City 2, by disregarding their utilities in its decision making.

Non marginal-cost pricing by City 1's local government is a natural reaction to the spillover problem of airport's benefit.[6] As Kidokoro and Zhang (2023b) demonstrate, a solution for this problem is to apply the two-part tariff and collect the lump-sum fees, which reflect the spillover benefits of airport users in City 2. However, Kidokoro and Zhang (2023b) also suggest that in the context of an airport, the positive profits from non-aeronautical services or travelers' expenses can work similarly. As we show in Appendix F, if travelers from City 2 yield an additional profit to City 1, the marginal cost pricing can be recovered. This argument reminds us Starkie (2001), who asserts that airport regulation is unnecessary. His logic is as follows. If an airport charges high airport charges, the number of airport users are reduced, and consequently, the profits from non-aeronautical services are also reduced, assuming that the aeronautical and non-aeronautical services are complementary. Thus, an airport will not charge high airport charges even without any regulation. This argument focuses on the two types of profits of aeronautical and non-aeronautical services, and considers that the non-aeronautical profit works to attain the optimal airport charges. Our logic is similar in that the non-aeronautical profit works to mitigate the monopoly price of aeronautical service, although we consider a benefit transfer between the two cities (departure city and arrival city) by modeling a simple airline network.

9. Agenda for Further Research

We have reviewed recent research on economic effects of non-aeronautical service in terms of airport management (pricing, investment, and self-financing), regulation, airport city and benefit spillover. The main results of our review were summarized in the introduction. In concluding this article, we note several avenues for future research.

First, more empirical work on the impact of non-aeronautical service (e.g., Shin and Roh, 2021) and on the interactions between the two services (Ivaldi et al., 2015; Czerny et al., 2016b) is helpful. Second, there is an active stream of research on airport slot policy (and on the slots vs. pricing) but the research has largely ignored non-aeronautical service and its

[6] Cohen and Morrison Paul (2003) found, using US data, that in addition to the substantive impacts of airport infrastructure on the own-state manufacturing industry's cost savings and productivity increases, the airport expansion had a comparable effect in "connected states" with hub airports and an even greater impact in other states.

impacts. Third, the relationship between non-aeronautical services and informational asymmetry needs to be clarified. Martimort et al. (2022) analyze the optimal regulation for an airport, using a model that includes informational asymmetry in the tradition of Laffont and Tirole (1993). The effects of non-aeronautical service on the regulation under asymmetric information are not yet fully investigated; further research is warranted.

Fourth, we need a unified approach towards the effects of consumers' foresight on aeronautical and non-aeronautical services. The present article analyzes airports' aeronautical and non-aeronautical services, by largely applying a simple two-good model, as in Kidokoro and Zhang (2016, 2018, 2022a, 2022b, 2023a). As a result, the price of aeronautical service affects the demands for both the aeronautical and non-aeronautical services; and similarly, the price of non-aeronautical service affects the demands for both services. That is, in their models, consumers have perfect foresight and the aeronautical and non-aeronautical services are complementary with each other. In contrast, D'Alfonso et al. (2017) consider one-sided complementarity and Flores-Fillol et al. (2018) analyze consumer myopia, applying the notion of one-sided complementarity. One-sided complementarity in D'Alfonso et al. means that the demand of aeronautical service does not depend on the price of non-aeronautical service. Flores-Fillol et al. define the situation in which consumers only consider the utility of core service (air ticket) when they buy core-service as fully-myopic, while the situation in which they at least partly consider the utility of non-core service (non-aeronautical service in the airport context) as foresighted.[7] Czerny et al. (2016b) show that the price of car rental affects the demand of air trips; and given the result, consumers are foresighted at least to some extent.[8] More empirical studies are needed to answer the question of to what extent the demand for aeronautical service depends on the price of non-aeronautical services. Related to the issue in question, Kidokoro and Zhang (2016, 2018, 2022a, 2022b, 2023a) do not restrict the degree of complementarity between the aeronautical and non-aeronautical services. This implies that their model can include the case in which the demand for aeronautical service is independent of the price of non-aeronautical service as an extreme case. Thus, their model may shed light on the theoretical relationship between non-aeronautical service and consumers' myopia.

Fifth, as pointed out by Czerny et al. (2016b) and Czerny and H. Zhang (2020), aeronautical regulation can (indirectly) affect non-aeronautical price, yet the literature has not fully investigated the effects of direct regulation on non-aeronautical services. Under single-till regulation, the total profit is regulated, while under dual-till regulation, only aeronautical profit is regulated. Do non-aeronautical services need any distinct regulation? If so, what type of regulation is appropriate? From the empirical finding of Czerny et al. (2016b) that the prices of non-aeronautical services are related with the aeronautical demand, it might be argued, given the complementarity between aeronautical and non-aeronautical services, that non-aeronautical services should be regulated in addition to aeronautical services, or that the regulation for non-aeronautical services can be a substitute for the regulation on aeronautical services. In effect, Kidokoro and Zhang (2023d) suggest that price-cap regulation for non-aeronautical services may enhance social welfare. Nevertheless, we need more research on the necessity of the regulation for non-aeronautical services as well as on its distributional effect.

Sixth, we need to clarify the nature of profits from non-aeronautical services. Forsyth (2004) classifies the profits of airports into "locational rent" and "monopoly rent". He argues that while monopoly rents are related to economic efficiency, locational rents are not; but that it is sometimes difficult to differentiate each other. His argument suggests that the locational and monopoly rents have different characteristics. Thus, whether the profits of non-aeronautical services reflect locational or monopoly rents will significantly influence analysis and policy. In fact, Kidokoro and Zhang (2016, 2022a) have attempted to model locational rents, but their models do not include monopoly rents. The effect by the difference between locational and monopoly rents is still unclear. More recently, Kidokoro and Zhang (2023c) formulated a model to include both the locational and monopoly rents in a consistent fashion, and takes a first step in modeling the problem. More studies on the difference between the two rents and their distinct effects are needed, however.

Seventh, it is important to incorporate airport networks into the analysis. In practice, airlines connect many airports, and accordingly, non-aeronautical services at an airport may affect the aeronautical and non-aeronautical services at other airports. Although airport networks have been extensively studied in literature, the relationship between airport networks and non-aeronautical services has not yet been fully investigated. We point out that the profits of non-aeronautical service may alleviate the spillover of airports' benefits to other areas, because passengers from other areas demand non-aeronautical services and thus contribute to an airport's profit, following Kidokoro and Zhang (2023b). The issues, including the countervailing effect of non-aeronautical profits for the benefit spillover, warrant further analyses in well-developed airport network models.

Eighth, as indicated in the introduction, the literature surveyed in this article has abstracted away airline market power. Incorporating airline market structure into the analyses may yield further important and relevant insights. Finally, the

[7]D'Amico (2022) further studies the effect of consumer-foresight intensity on non-aeronautical pricing. The author finds that when consumers are myopic, they undervalue the surplus they derive from consuming non-aeronautical service, thus airports optimally set low aeronautical charges and allow for a concentrated non-aeronautical (e.g., airport retail) market. When consumers are foresighted, on the other hand, they "overvalue" the presence of sellers in non-aeronautical service, thus airports set high aeronautical charges and allow for a perfectly competitive non-aeronautical market. Moreover, these results appear insensitive to changes in the market structure as they hold under both monopoly and duopoly. D'Amico's analysis could have a policy implication in that the consumer-foresight intensity may impact on the competitive environment of non-aeronautical service.

[8]A related notion in the literature is the airport being a two-sided market (Ivaldi et al., 2015; Wan and Zou, 2020; Starkie, 2021). In either case, it is possible that the price of non-aeronautical (aeronautical, respectively) service can affect the passenger travel demand (the non-aeronautical demand, respectively).

COVID-19 pandemic significantly reduced flights and passengers which, together with social distance regulations and shop closures, have imposed huge pressures on airport non-aeronautical activities (Sun et al., 2022). The pandemic-related issues deserve further research.

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Appendix A. Analysis in Section 3

For the sake of analytical simplicity, we assume that the second-order conditions are always satisfied throughout the paper. Consumers simultaneously choose x_1 and x_2, being fully aware of the own and cross-price effects. Solving the unity maximization problem of (1), we have:

(A1) $p_1 = \frac{\partial u(x_1,x_2)}{\partial x_1}$,

(A2) $p_2 = \frac{\partial u(x_1,x_2)}{\partial x_2}$.

Solving (A1) and (A2) immediately yields the demand functions of $x_1(p_1, p_2)$ and $x_2(p_1, p_2)$.

When we consider congestion, what we need to do is to change c_1x_1 and c_2x_2 in (2) and (3) to $c_1(x_1)$ and $c_2(x_2)$, where $\frac{dc_1}{dx_1} > 0$ and $\frac{dc_2}{dx_2} > 0$. When the regulator maximizes welfare social welfare, (3), regarding p_1, taking $p_2 = \bar{p}_2$ as given, we have:

(A3) $p_1 = \frac{dc_1}{dx_1} - \left(\bar{p}_2 - \frac{dc_2}{dx_2}\right)\left(\frac{\partial x_2}{\partial p_1}/\frac{\partial x_1}{\partial p_1}\right)$.

The only difference from (4) is that the marginal costs of c_1 and c_2 are changed to $\frac{dc_1}{dx_1}$ and $\frac{dc_2}{dx_2}$ including the congestion cost.

Appendix B. Analysis in Section 4

Suppose that the cost of aeronautical service is now $c_1(K)x_1 + F(K)$ in (2) and (3) where $\frac{dc_1(K)}{dK} < 0$ and $\frac{dF(K)}{dK} > 0$, i.e., airport investment lowers the marginal cost of aeronautical service but increases the fixed cost. Maximizing social welfare, (3), regarding K, yields:

(B1) $-\frac{dc_1(K)}{dK}x_1(p_1, p_2) = \frac{dF(K)}{dK}$,

where the left-hand side (LHS) shows the marginal benefit of investment while the right-hand side (RHS) shows the marginal investment cost. Eq. (B1) implies that the equilibrium value of K depends on p_1 and p_2, and consequently, it does not tell us whether an airport's actual investment increases or decreases with profitable non-aeronautical services.

Appendix C. Analysis in Section 5

Suppose first that an airport can control the prices of both aeronautical and non-aeronautical services. Maximizing social welfare, (3), regarding p_1 and p_2, yields

(C1) $p_1 = c_1$,

(C2) $p_2 = c_2$,

which lead to:

(C3) $p_1x_1 + p_2x_2 = c_1x_1 + c_2x_2$,

i.e., exact self-financing holds under social welfare maximization.

Suppose next that the price of non-aeronautical service is exogenously given. From (4), we obtain:

(C4) $p_1x_1 + \bar{p}_2x_2 = c_1x_1 + c_2x_2 + (\bar{p}_2 - c_2)x_2\left(\frac{\varepsilon_{x_1,p_1} - \varepsilon_{x_2,p_1}}{\varepsilon_{x_1,p_1}}\right)$,

where ε_{x_1,p_1} and ε_{x_2,p_1} are respectively the own-price elasticity of aeronautical service and the cross-price elasticity of non-aeronautical service, with $\varepsilon_{x_1,p_1} = -\frac{\partial x_1}{\partial p_1}\frac{p_1}{x_1} > 0$ and $\varepsilon_{x_2,p_1} = -\frac{\partial x_2}{\partial p_1}\frac{p_1}{x_2} > 0$ if the aeronautical and non-aeronautical services are complementary. If we assume that i) non-aeronautical service yields positive profits, i.e., $\bar{p}_2 > c_2$, and ii) the own-price elasticity of aeronautical service is larger than the cross-price elasticity of non-aeronautical service, we have $(\bar{p}_2 - c_2)x_2\left(\frac{\varepsilon_{x_1,p_1} - \varepsilon_{x_2,p_1}}{\varepsilon_{x_1,p_1}}\right) > 0$, which leads to:

(C5) $p_1x_1 + \bar{p}_2x_2 > c_1x_1 + c_2x_2$.

That is, self-financing holds with positive profits from non-aeronautical service.

Appendix D. Analysis in Section 6

First, consider the case of $Reg(p_1{}^*, p_2{}^*) > 0$. Because the regulatory profit under welfare maximization is positive, the relevant regulatory purpose is to limit the regulatory profit to no larger than zero. Thus, the maximization problem to be solved is:

(D1) Max SW, subject to $Reg(p_1, p_2) \leq \mu_1$,

where $\mu_1 \geq 0$ is a "regulatory waste" following Braeutigam and Panzar (1989), including the possibility that the monopoly might employ wasteful resources due to regulation. (Kidokoro and Zhang (2023a) additionally consider the participation constraint of $\Pi^{Airport} \geq 0$. Including the participation constraint does not change our results, as long as the profits of non-aeronautical service are positive.) Taking the abuse of resources into account is natural, given that cost-based regulations may cause inefficiencies, as pointed out in Averch and Johnson (1962) and Train (1991). This rather technical setup helps us to determine the upper boundary of the Lagrangian multiplier for the regulatory constraint, although $\mu_1 = 0$ finally holds, as Kidokoro and Zhang (2022b) show. The Lagrangian can be formed as:

(D2) $\Lambda_1 = SW + \lambda_1(\mu_1 - Reg(p_1, p_2)) + \eta_1\mu_1$
$= I + u(x_1(p_1, p_2), x_2(p_1, p_2)) - c_1(x_1(p_1, p_2)) - c_2(x_2(p_1, p_2)) - \mu_1$
$+\lambda_1(\mu_1 - p_1x_1(p_1, p_2) + c_1(x_1(p_1, p_2)) - \beta(p_2x_2(p_1, p_2) - c_2(x_2(p_1, p_2)))) + \eta_1\mu_1$

where $\lambda_1 \geq 0$ and $\eta_1 \geq 0$ respectively are the Lagrangian multipliers for the regulatory constraint and the regulatory waste. Kidokoro and Zhang (2022b) prove that $0 \leq \lambda_1 < 1$. We then compare single-till and dual-till regulations in terms of social welfare. From (D3), applying the envelope theorem we derive:

(D3) $\frac{dSW(p_{1Reg_1}, p_{2Reg_1})}{d\beta} = \frac{\partial \Lambda_1}{\partial \beta} = -\lambda_1\left(p_{2Reg_1}x_2(p_{1Reg_1}, p_{2Reg_1}) - c_2(x_2(p_{1Reg_1}, p_{2Reg_1}))\right)$,

where the subscript Reg_1 denotes the solution under the maximization problem of (D2). From (D3), we obtain (7).

Second, consider the case of $Reg(p_1{}^*, p_2{}^*) < 0$. Because the regulatory profit under welfare maximization is negative, the relevant regulatory purpose is to increase the regulatory profit to no smaller than zero, i.e., to attain self-financing at least. Thus, the maximization problem to be solved is:

(D4) Max SW, subject to $Reg(p_1, p_2) \geq \mu_2$,

where $\mu_2 \geq 0$ is a regulatory waste, as in (D2). Kidokoro and Zhang (2022b) show that $\mu_2 = 0$ finally holds. In the same way as (D2), we form the Lagrangian as follows:

(D5) $\Lambda_2 = SW + \lambda_2(Reg(p_1, p_2) - \mu_2) + \eta_2\mu_2$
$= I + u(x_1(p_1, p_2), x_2(p_1, p_2)) - c_1(x_1(p_1, p_2)) - c_2(x_2(p_1, p_2)) - \mu_2$
$+\lambda_2(p_1x_1(p_1, p_2) - c_1(x_1(p_1, p_2)) + \beta(p_2x_2(p_1, p_2) - c_2(x_2(p_1, p_2))) - \mu_2) + \eta_2\mu_2$

where $\lambda_2 \geq 0$ and $\eta_2 \geq 0$. We again compare single-till and dual-till regulations in terms of social welfare. From (D5), applying the envelope theorem we derive:

(D6) $\frac{dSW(p_{1Reg_2}, p_{2Reg_2})}{d\beta} = \frac{\partial \Lambda_2}{\partial \beta} = \lambda_2\left(p_{2Reg_2}x_2(p_{1Reg_2}, p_{2Reg_2}) - c_2(x_2(p_{1Reg_2}, p_{2Reg_2}))\right)$,

where subscript Reg_2 denotes the solution under the maximization problem of (D5). From (D6), we obtain (8).

Appendix E. Analysis in Section 7

We extend our two-good model to M -good model. Kidokoro and Zhang (2022a) classify consumers as visitors, local residents, and downtown residents. For simplicity, we here consider just one-type of consumers. This simplification does not affect the theoretical result materially. We formulate the utility-maximization problem of the representative consumer as:

(E1) Max $U = z + u(x_1, x_2, ..., x_M)$, subject to $z + p_1x_1 + \sum_{j=2}^{M}(p_j + \phi)x_j = I$,

where $x_2, ..., x_M$ and $p_2, ..., p_M$, respectively, are the total demands for services (or goods) $2, ..., M$ and their exogenous prices. The number of services (or goods) varieties offered at an airport is endogenously determined with m. We denote the demands for the non-aeronautical services at an airport as $x_2^{Airport}, ..., x_m^{Airport}$. We assume that airport shops compete with downtown shops, and set the price at $p_2 + \phi, ..., p_M + \phi$, taking into account the transport cost between the airport and downtown, denoted as ϕ.

The utility-maximization by the representative consumer yields:

(E2) $p_1 = \frac{\partial u(x_1, x_2, ..., x_M)}{\partial x_1}$,

(E3) $p_j + \phi = \frac{\partial u(x_1, x_2, ..., x_M)}{\partial x_j}$ $(j = 2, ..., M)$,

from which we obtain $x_1(p_1, p_2 + \phi, ..., p_M + \phi)$ and $x_j(p_1, p_2 + \phi, ..., p_M + \phi)$.

The monopoly airport's profits are:

(E4) $\Pi^{Airport} = p_1x_1 + \sum_{k=2}^{m}(p_k + \phi)x_k^{Airport} - c_1x_1 - \sum_{k=2}^{m}c_kx_k^{Airport} - c(m)$,

where c_k is the unit production cost of non-aeronautical service k, and $c(m)$ is the airport's development cost of shopping space, assuming that more varieties of airport shops need more space and thus increase the development cost, i.e., $\frac{dc(m)}{dm} > 0$. We need to make assumptions about the determination rule for $x_2^{Airport}, ..., x_m^{Airport}$. Kidokoro and Zhang (2022a) considers that they depends on the demand for air trips and the varieties offered at airport shops. Other determination rule is also consistent with our analysis, as long as the marginal social benefit of variety at the airport mall, which will be explained below, is positive.

The profits of downtown shops, $\Pi^{Downtown}$, play an important role in this section and can be written as:

(E5) $\Pi^{Downtown} = \sum_{k=2}^{m}(p_k - c_k)(x_k - x_k^{Airport}) + \sum_{k'=m}^{M}(p_{k'} - c_{k'})x_{k'}$,

which implies that the downtown demands are the residual for non-aeronautical services offered at an airport. Note that the downtown demands are the total demands for services (or goods) not offered at an airport.

From (E1), (E4) and (E5), we define social welfare as:

(E6) $SW = U + \Pi^{Airport} + \Pi^{Downtown}$
$= I - c_1x_1 - \sum_{k=2}^{M}(p_k + \phi)x_k + u(x_1, x_2, ..., x_M) + \sum_{k=2}^{m}\phi x_k^{Airport} - c(m) + \sum_{j=2}^{M}(p_j - c_j)x_j$

Maximizing (E6) regarding m yields:

(E7) $\frac{dc(m)}{dm} = \frac{\partial\left(\sum_{k=2}^{m}\phi x_k^{Airport}\right)}{\partial m}$,

where the LHS of equation (E7) is the marginal development cost of shopping space, which is always positive. The RHS of (E7) represents the marginal social benefit of variety at the airport mall. For an interior solution, we need an assumption that this marginal social benefit of variety at the airport mall is positive, because the LHS is always positive.

On the contrary, maximizing the airport's profit, (E4), yields:

(E8) $\frac{dc(m)}{m} = \frac{\partial\left(\sum_{k=2}^{m}(p_k+\phi-c_k)x_k^{Airport}\right)}{\partial m} > \frac{\partial\left(\sum_{k=2}^{m}\phi x_k^{Airport}\right)}{\partial m}$ when $p_k - c_k > 0$.

This shows that the marginal development cost of shopping space is higher than the marginal social benefit of variety at the airport mall, i.e., the varieties at an airport shopping mall are oversupplied, as long as the downtown shops have positive profits.

Appendix F. Analysis in Section 8

We formulate the utility-maximization problem of the representative consumer in Cities 1 and 2 as:

(F1) Max $U^1 = z^1 + u^1(x_1^1)$, subject to $z^1 + p_1 x_1^1 = I^1$,

(F2) Max $U^2 = z^2 + u^2(x_1^2)$, subject to $z^2 + p_1 x_1^2 = I^2$,

where the superscripts represent the two cities. For the moment, we consider the aeronautical service only. Solving (F1) and (F2) immediately yields the demand functions of $x_1^1(p_1)$ and $x_1^2(p_1)$.

The monopoly airport's profits in City 1 are:

(F3) $\Pi^{Airport} = p_1\left(x_1^1(p_1) + x_1^2(p_1)\right) - c_1\left(x_1^1(p_1) + x_1^2(p_1)\right)$.

To focus on the airport in City 1, the airport in City 2 is assumed to be operated under the marginal cost pricing.

From (F1), (F2), and (F3), social welfare is:

(F4) $SW = U^1 + U^2 + \Pi^{Airport}$

$= I^1 + u^1(x_1^1(p_1)) + I^2 + u^2(x_1^2(p_1)) - c_1(x_1^1(p_1) + x_1^2(p_1))$

Maximizing (F4) regarding p_1 yields:

(F5) $p_1 = c_1$,

which says that the optimal price of aeronautical service equals the marginal cost, as we naturally expect.

Let us then assume that City 1's airport is controlled by a local government that maximizes the local welfare:

(F6) $SW^{Local} = U^1 + \Pi^{Airport}$

$= I^1 + u^1(x_1^1(p_1)) + p_1 x_1^2(p_1) - c_1(x_1^1(p_1) + x_1^2(p_1))$

where the utility of the representative consumer in City 2 is excluded. Maximizing local welfare (F6) regarding p_1 yields:

(F7) $p_1 = c_1 - \frac{x_1^2}{\frac{\partial x_1^1}{\partial p_1} + \frac{\partial x_1^2}{\partial p_1}} > c_1$,

which demonstrates that the price of the aeronautical service is larger than the marginal cost. This is because City 1's local government behaves like a monopoly for the residents in City 2, by disregarding their utilities in its decision making.

Suppose that travelers from City 2 yield an additional profit of φ to City 1 per visit. For the sake of simplicity, we assume that this φ arises as an increase in the profits of the airport in City 1. (The argument does not change if we consider that City 1 receives φ in other ways, such as an increase in local tax or an increase in the profits in the downtown shops in City 1.) The utility-maximization problem of the representative consumer in City 2 is now:

(F8) Max $U^2 = z^2 + u^2(x_1^2)$, subject to $z^2 + p_1 x_1^2 + \varphi x_1^2 = I^2$,

which changes the demand functions in City 2 to $x_1^2(p_1 + \varphi)$.

The monopoly airport's profit is:

(F9) $\Pi^{Airport} = p_1\left(x_1^1(p_1) + x_1^2(p_1 + \varphi)\right) - c_1\left(x_1^1(p_1) + x_1^2(p_1 + \varphi)\right) + \varphi x_1^2$,

including the additional profits from City 2's residents. City 1's local welfare is changed to:

(F10) $SW^{Local} = U^1 + \Pi^{Airport}$

$= I^1 + u^1(x_1^1(p_1)) + p_1 x_1^2(p_1) - c_1(x_1^1(p_1) + x_1^2(p_1)) + \varphi x_1^2$

Maximizing local welfare, (F10), regarding p_1 yields:

(F11) $p_1 = c_1 + \frac{x_1^2 + \varphi\frac{\partial x_1^2}{\partial p_1}}{-\left(\frac{\partial x_1^1}{\partial p_1} + \frac{\partial x_1^2}{\partial p_1}\right)} >$

$=$

$<$

c_1, if $\varphi <$

$=$

$>$

$\frac{p_1}{\varepsilon_{x_1^2,p_1}}$,

where $\varepsilon_{x_1^2,p_1}$ is the own-price elasticity of City 2's demand for aeronautical service. If the aeronautical and non-aeronautical services are complementary, we have $\frac{\partial x_1^2}{\partial p_1} < 0$, which yields $-\left(\frac{\partial x_1^1}{\partial p_1} + \frac{\partial x_1^2}{\partial p_1}\right) > 0$, from the assumption that the own-price effect is negative, i.e., $\frac{\partial x_1^1}{\partial p_1} < 0$. From (F11), we know that a positive value of φ counteracts City 1's monopoly pricing. The marginal cost pricing is recovered when $\varphi = \frac{p_1}{\varepsilon_{x_1^2,p_1}}$. When φ is larger, the price can even be lower than the marginal cost.