Critical Update of the Post-Security Retail Space Design in Passenger Departure Terminals

This paper deconstructs all the major determinants affecting retail revenue in airport terminal design. Moses Buendia and Alexandre G. de Barros provide two main determinants to improve retail revenues: the penetration factor, and dwell time. Both of these variables depend on the processing rate at security checks upstream and on the boarding rate downstream. The airport terminal configuration and ratio of retail space over the entire retail and departure lounge area can also affect the penetration factor. Maintaining an optimal proportion between space for waiting lounge and retail space can maximize sales and minimize the initial capital investment for airports. With the introduction of a new definition of the penetration factor in this paper, businesses can evaluate the number of shoppers and the size of the potential retail market.

by: Moses Buendia and Alexandre G. de Barros

As retail income has recently emerged to be one of the most important growth drivers for airport revenue, airport planners and operators have focused increasingly on the lucrative airport retail market, and in particular, the post-security retail business.

Recent Air Transportation Landscape

Globalization and commercialization of the airport and airline industries, the reinforced security measures after the 9/11 terrorist attacks, the introduction of Airbus' new large aircraft (NLA) A380 and Boeing's extra-wide-body jets, and the heightened competition between airports have all changed the air transportation landscape in the 21st century, and have presented risks but also opportunities to airport operators, airlines, and end users. It is important that these risks and opportunities are addressed and are managed by both airport designers and airport operators. One of the major risks and/or opportunities is the development of retail space in passenger departure terminals in the post-security area.

Traditionally, commercial space in the design of airports has been regarded as risky, primarily due to the concern about the inability of the retail space to yield the expected revenue projected by the airport (De Neufville and Odoni, 2002). However, since higher security standards in passenger screening have been imposed after the 9/11 terrorist attacks, passengers tend to arrive at airport terminals earlier in advance because they anticipate the waiting time at security checks. The increased time that travelers spend at the airport also includes a longer time spent in the post-security departure area. This represents an enormous business opportunity for retail, duty-free shopping, services, and concession stands in the passenger terminals. As a matter of fact, the emergence of shopping and leisure facilities integrated with airport terminal can add significant value to an airport, and they can enhance the level of service (LOS) provided to the passengers (Janic, 2000). Furthermore, there have been many success stories, such as the See Buy Fly duty-free shopping at Amsterdam Airport Schiphol, and SkyMart (and the new Sky Plaza) at Hong Kong airport Chek Lap Kok, that have shown how airport retail complexes have transformed the travel experience for passengers, and how they have increased revenues and quality of service for the airports. Recently, increased competition between airports has forced airport operators and designers to reconsider retail sizing to capitalize on this emerging opportunity.

Among other revenues, concession space rental – including post-security retail and services – has accounted for one of the main streams of revenues for many major airports in the world. Oum et al (2002) have shown that in medium-sized to large US airports, concession operations have contributed between 75-80 per cent of total airport revenues. The Air Transport Research Society (ATRS, 2004) also reported that non-aviation revenues (most of these are concession revenues for Asian and European airports) accounted for 40 per cent to 80 per cent of total revenues of 50 major airports around the world in 1999. The share of profits would be even more significant, as concession operations tend to be more profitable than aviation operations.

Research Background

The success of post-security retail space depends on a multitude of factors, ranging from airport management to terminal design and airport market position, as shown in table 1.

Airport Operation and Management	Airport Terminal Design	Airport Market Position
Lease terms and contract flexibility (fixed base profit vs. percentage of sales)	Size of concession space	Passenger flow
Diversity of goods (international variety vs. local products on display)	Size of departure lounge	Passenger mix (international vs. domestic)
Ancillary facilities (food/beverage, duty-free, museums, cinemas, spa, etc.)	Terminal configuration (flow of passenger and use of space)	Trip purpose (business vs. leisure)
Architecture, retail layout, and location (space deliberately designed to attract customers)	Concession location (proximity to departure gate)	Service offered to the market (hub transfer vs. origin/destination)
Retail sales operation and management (Staff, System, Standard, Stock, Space)		

Table 1: *Concession Revenue Determinants*

Believing that the success of airport post-security retail begins from the design of terminal space, location and configuration, this research primarily focuses on the relation between airport terminal design and airport retail revenues. Using data collected from 50 major airports with the highest retail concession and food/beverage revenues in United States, this research offers a comparison between different design concepts of concession and waiting area in passenger terminals, including comparisons of the four main concourse terminal configurations: linear, pier, satellite, and transporter. Finally, conclusions are drawn with regard to the optimal design for commercial space in terminals, based on these investigations and studies.

Data Analysis

The data from the 50 selected airports has been analyzed to investigate the relationships between the following:

- Retail revenues (per 1,000 passengers) and the volume of departure passengers;
- Percentage of retail revenues in the total retail and concession stand revenues, and the average revenue per departing passenger;
- Total annual retail and concession revenues, and annual total flow of departing passengers for the four main types of terminal configurations.

The data has been collected from the database of the Federal Aviation Association (FAA) and of the Bureau of Transportation Statistics of the United States. The dataset used for analysis is the available 2004-2005 figures collected from the 50 American airports with the highest total retail and concession revenues (the sum of the retail revenues, RR, and F&B concession revenues, RF&B) in 2004. A graph has been generated to visualize potential patterns between revenues and passenger flow in the 50 American airports that have been the most successful at creating retail and concession revenues, as shown in figure 1.

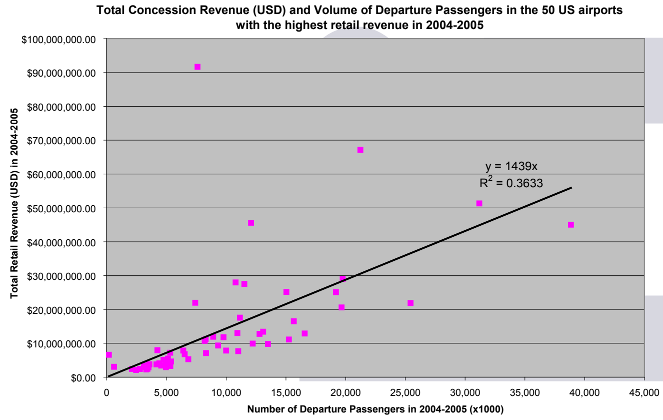


Figure 1: *Total Concession Revenues (USD) and Volume of Departing Passengers in the 50 US airports with the highest retail revenues in 2004-2005*

Findings

Table 2 shows the top 10 performing airports based on the retail revenue per departing passenger. As illustrated in figure 1, a departing passenger generates on average approximately USD 1.44 retail and concession revenue in 2005.

In figure 2, the relations between the percentage of retail revenue from the total retail and concession revenues (RT = RR + RF&B) and the average revenue per passenger is shown. There is also a tendency that higher revenue will be generated out of each departing passenger if a higher percentage of the total retail and concession revenues is originated from retail. Most of the airports with high revenues per departing passenger are those with at least 65 per cent of retail concession revenues from retail stores.

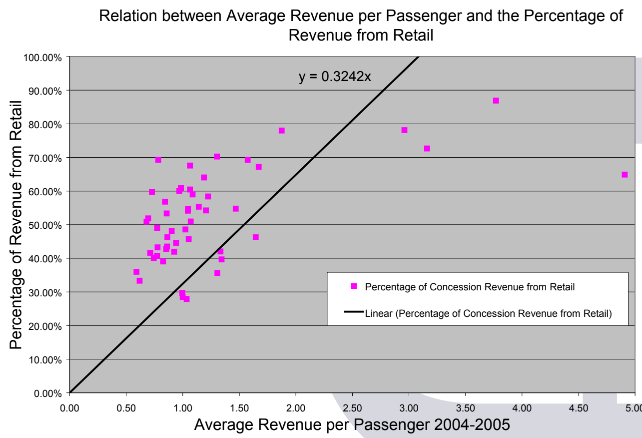


Figure 2: *Relation between Average Revenue per Passenger and the Percentage of Revenue from Retail*

Table 2: *Top Retail Performers (Based on Average Retail Revenue per Passenger in the Dataset)*

Code	Airport	Total Retail Revenue (excl. food and beverage revenue) (USD)	Percentage of Concession Revenue from Retail	2005 departing passengers (1,000)	Retail revenue per departing passenger (US$)	Satellite	Pier	Linear	
ITO	HILO INTL	$1,974,296.00	64.87%	620	4.91			X	
SFO	SAN FRANCISCO INTL	$39,616,823.00	86.91%	12,089	3.77	X			
LAX	LOS ANGELES INTL	$48,770,993.00	72.64%	21,241	3.16	X			
HNL	HONOLULU INTL	$17,141,477.00	78.10%	7,412	2.96		X		
EWR	NEWARK INTL	$0.00	N/A	11,527	2.39	X			
SJU	LUIS MUNOZ MARIN INTL	$6,211,061.00	78.00%	4,246	1.88			X	
MCO	ORLANDO INTL	$16,899,000.00	67.17%	15,047	1.67	X			
ORD	CHICAGO O'HARE INTL	$23,725,364.00	46.22%	31,189	1.65		X		X
BOS	GENERAL EDWARD LAWRENCE LOGAN	$12,169,464.00	69.28%	11,152	1.58	X		X	
DEN	DENVER INTL	$15,884,900.00	54.74%	19,749	1.47				X

In figure 3, a linear regression analysis was performed to investigate relationships between terminal configurations and retail and concession sales revenues.

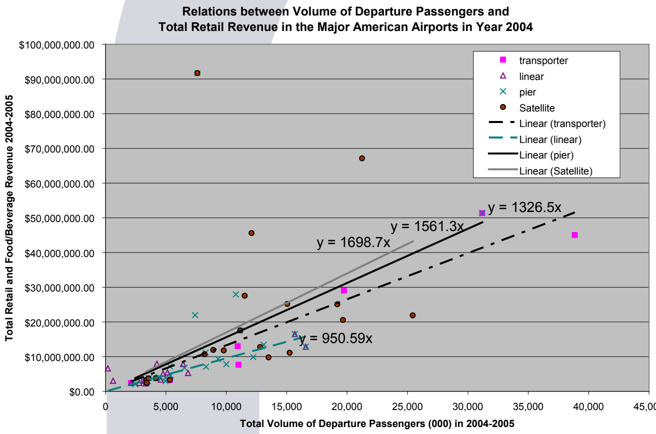


Figure 3: *Comparison of the Retail Revenue per passenger for the Main Terminal Configurations (Transporter, Linear, Pier and Satellite) for the 50 Major American Airports in Year 2004-2005 (Some airports have more than 1 type of configuration)*

The analysis of retail revenues generated from airports with different terminal layouts has shown that, on a per passenger basis, satellite terminals generate approximately USD 1.69, followed by pier terminals with USD 1.56, transporter terminals with USD 1.33, and linear terminals with USD 0.95. Airports with satellite terminal configurations tend to generate the most retail revenue per departing passenger, outperforming the US market average of USD 1.44 by approximately 17 per cent. This is largely due to the advantages automatically provided from the centralized location of the retail complex in the center of the satellite terminals. For airports with pier configurations, the connecting point between the piers and the main concourse can be an excellent location for retail business as well. The long walking distance in a linear configuration is perhaps the main reason that leads to the result showing lower retail revenues generated per departing passenger.

Discussion

Retail Concession Space Sizing

The optimum size for retail and concession space in the post-security area should be determined based on airport-specific characteristics. In the context of this paper, the characteristics affecting the geometric design of the retail space includes the retail/concession space per passenger and the volume of departing passengers that use or pass through a departure terminal. De Neufville and Odoni (2003) suggested that the total retail space in the departure terminal should be sized to accommodate the total number of passengers during peak periods. According to de Neufville and Odoni,

$$N_{max} = Q^* \, f_{penetration} * t_{dwell} * f_{peak} \qquad (1)$$

Where

Nmax = the maximum number of in-store passengers at any time,
Q = the average passenger flow rate (pax/hr),
fpenetration = target penetration,
tdwell = the average dwell time in shops (hr),
fpeak = the peaking factor.

Thus, the size of all retail stores, C, can be determined based on the estimated maximum number of in-store passengers at a given time (during peak hours):

$$C = N_{max} * c_{per\ pax} \qquad (2)$$

Where

C = the retail space (m2) required,
cper pax = the space (m2) required in the retail shop per in-store passenger.

The value for cper pax is suggested to be 4 m2, which includes approximately 1 m2 for personal space, 2 m2 for circulation, and 1 m2 for cashiers and checkout space (Freathy and O'Connell, 1998). However, modern design of airport terminal retail stores has changed quite considerably. For example, walk-through stores, particularly duty-free shops, have become very popular to maximize the storefront exposure and sales opportunities, and to minimize potential customers' walking distance to the retailers. Walk-through stores have reported an uplift in sales as a result of their layout and configuration, as demonstrated in Terminal 3 at Heathrow and in Terminal 1 at Sydney (URS, 2007). With walk-through stores, the value for cper pax can be decreased, because the space for walkways and corridors has become part of the store's circulation area.

Departure Lounge Sizing

Building upon the theories established by Wirasinghe and Shehata (1993), it is assumed that the passengers that arrive earlier tend to spend a longer time browsing concession and retail areas. Hence, passengers arrive at the departure lounge much closer to the actual time of boarding. In this theory, the cumulative passenger arrival curve will be more condensed and shifted to the right. Due to the intensity of arrival passengers, passengers will have less waiting time in the departure lounge. Therefore, less seating and less waiting areas are required in the sizing of the departure lounge. A smaller departure lounge can be adopted based on the minimum value suggested by the regulating bodies such as IATA and FAA. In general, at least 1.00 m2 lounge area per passenger to be boarded through a certain boarding gate is necessary to achieve a LOS C (IATA, 1995). Shared waiting areas with other gates can be arranged to reduce the total space required for departure lounge (de Barros and Wirasinghe, 1998).

Seats should be made available to approximately 50 per cent of the departure passengers in the lounge area (Wirasinghe and Shehata, 1993). According to Wirasinghe, departure lounge sizing can be expressed as

$$di = \alpha * [m1 * Si + m2 * (q-Si)] \qquad (3)$$

Where

di = the space (m2) required for the waiting lounge at a specific boarding gate,
α = the multiplier which accounts for passenger circulation and airline activities,
m1 = the space (m2) per sitting passenger,
m2 = the space (m2) per standing passenger,
Si = the number of seats in the lounge,
q = the cumulative number of passengers boarded.

It is possible to include a second-level seating area in the waiting lounge to reduce the footage required for boarding area, particularly to accommodate the departure of a higher number of passengers for NLA flights (de Barros and Wirasinghe, 1998). This option can be adopted in future for the gates specifically designated for NLA departures.

The size of the total departure lounge is the sum of the waiting areas at each individual boarding gate:

$$D = \Sigma \, di \text{ for all lounges from 0 to } i \qquad (4)$$

Target Shoppers

The target market of retail space in the post-security area is the total number of in-store passengers (N) who browse the retail shops. The penetration factor can be used to predict the number of in-store passengers, whereas the number of customers (PC) is a fraction of the total number of in-store passengers that actually purchase goods or services in these retail facilities. The passengers' expenses turn into revenues for the retail space tenants. In most airports, airport charges a minimum base rent in addition to a percentage of the sales revenue normally ranging from 20 per cent to 60 per cent of sales (De Neufville and Odoni, 2002). Adjusting the layout and size of the retail stores to maximize the penetration factor (fpenetration) and the volume of walk-through passengers can increase sales for the retailers, which, in turn, become revenue for the airport. The actual ratio (f) of in-store passengers turning into customers depends on the product diversity, staff services, sales tactics, in-store retail layout and retail management of the stores themselves (Freathy and O'Connell, 1998, Rowley and Slack, 1999, Pal and Byrom, 2003), but is not part of this study.

The total annual number of passengers, Nretail, is given by

$$Nretail = fpenetration * P \qquad (5)$$

and the annual number of passengers buying goods or services from retail shops, PC, is

$$PC = f * Nretail \qquad (6)$$

where
f = the fraction of in-store passengers buying goods or services.

Penetration Factor (fpenetration)

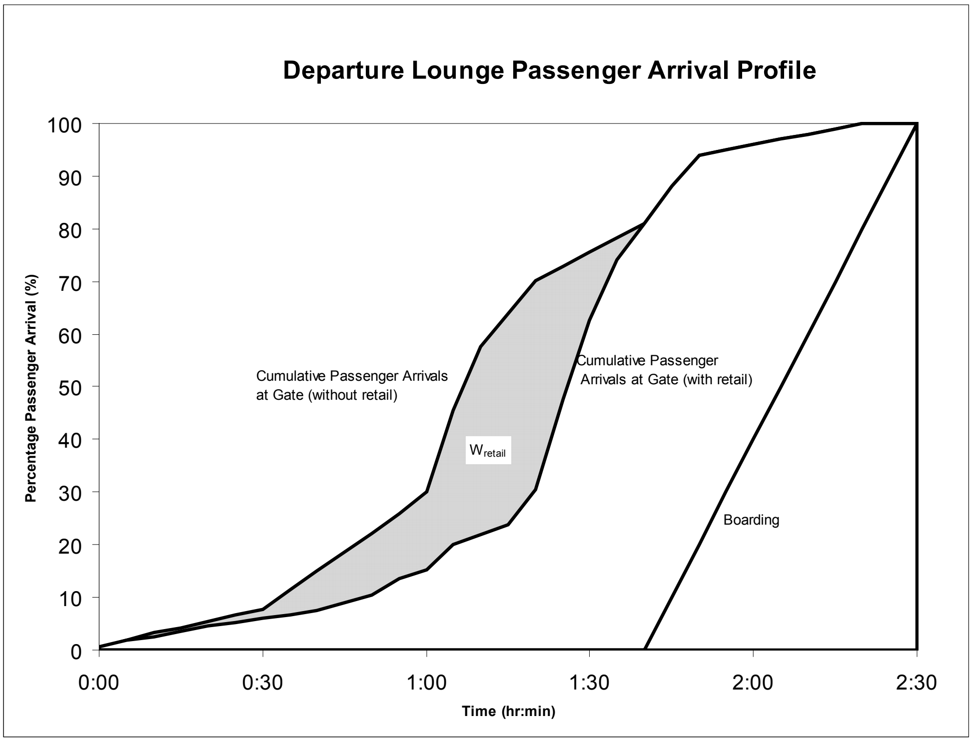
The penetration factor has not been widely discussed in literature. Theoretically, it can be derived from the cumulative arrivals curves at the departure lounge as illustrated in figure 4. The upper curve in figure 4 represents the cumulative arrivals at the departure lounge for a given flight, if passengers walk directly to the gate without stopping at retail. The lower curve represents the cumulative arrivals at the gate, if a number of passengers stop at the retail stores for an average time tdwell. The area in-between these two curves represents the total amount of passenger-hours spent at retail for a given flight. The penetration factor can then be defined as

$$fpenetration = Wretail \,/\, (tdwell \cdot qflight) \qquad (7)$$

where

Wretail = the area between the cumulative passenger arrival curves (with and without retail) at the boarding gate (Figure 2),
qflight = flight load: total number of passengers on the flight.

The cumulative passenger arrival pattern for all the individual flights in any given peak hour can be added together to estimate the penetration factor, and to size the retail area for the airport terminal. The maximization of the penetration factor can increase airport retail and concession revenue, as well as reduce space requirement in the departure lounge. The location, design and configuration of the retail shops are the main factors that influence the penetration factor, fpenetration.



Retail/Concession Location and Terminal Configuration

Centralized retail shops can minimize the average walking distance to the boarding gates, and, because of the central location, they are easily accessible to all passengers looking for different needs. Location of concession space is therefore closely linked to the airport terminal configuration. Amongst the four main terminal configurations, according to this study, the pier and satellite configurations will attract more passenger flows and sales, because their configurations can provide centralized retail space at the pier-connecting point (between the pier and the main concourse) and at the center of the satellite.

Annual Retail/Concession Revenues

The average expenses per customer, E, is not affected by the geometric design of the airport, but is affected by the retail shop operation, local economics and airport-specific factors. Revenues can be increased, if the total number of shoppers can be increased. The total annual retail revenues can be written as

$$RT = E * PC \qquad (8)$$

where

E = the average expenses per customer (USD).

Substituting for Nretail from Equation 5 into Equation 6,

$$Pc = f * P * fpenetration \qquad (9)$$

Substituting for fpenetration from Equation 7 into Equation 9,

$$Pc = f * P * Wretail /(tdwell * qflight) \qquad (10)$$

Finally, substituting for PC from Equation 10 into Equation 8,

$$RT = E * f * P * Wretail /(tdwell * qflight) \qquad (11)$$

The dwell time in the retail complex is the time available for shopping after the security check. However, a passenger wants to arrive the departure gate at x minutes in advance of the boarding time to anticipate a certain walking time from the retail complex to the boarding gate and a certain waiting time at the departure lounge before the actual boarding time. In fact, to assist passengers estimate these times for shopping, some airports, like London/Heathrow, have installed digital signs showing the minutes required for walking from the point of security check to the different boarding gates in the terminal. Therefore,

$$tdwell = ttotal - twalking - twaiting \qquad (12)$$

where

ttotal = the total time between the completion of security check and the announced boarding time
twalking = the travel time between center of retail complex to the boarding lounge
twaiting = the waiting time at the departure lounge for boarding; it is generally constant for all passengers; on average, it is equal to the time x

Therefore, the main equation relating geometric design and the retail/commercial revenues of the airport is obtained by substituting for tdwell from Equation 12 into Equation 11:

$$RT = E * f * P * Wretail /[(ttotal - twalking - twaiting) * qflight) \qquad (13)$$

It can be seen from Equation 13 that reducing the average walking distance and walking time between the retail areas and the departure lounge, shortening queues and processing times in the security check upstream, streamlining the boarding process and increasing boarding efficiency downstream can give passengers more time to enjoy the airport facilities, especially the post-security retail and concession stands. In reference to equation 13, this can increase the dwell time (tdwell) and the penetration factor (fpenetration) for departing passengers, and, ultimately, increase retail revenues. The airports' ability to attract traffic volume can increase the total number of departing passengers, P, which, in turn, can boost the total retail and concession revenues (RT).

Departure Lounge and Retail Area Sizing

The total size of the post-security airport terminal is:

$$A= \sum\{\alpha*[m1 *Si + m2* (q-Si)]\} + [Q* (Wretail / qflight) * fpeak *cper\ pax]+ K1 \qquad (14)$$

where

$$K1 = office\ space + space\ for\ other\ utilities \qquad (15)$$

In summary, the sizing of the departure lounge primarily depends on the cumulative boarding passenger volume (qi), the number of seats (Si), and the allotted seating and standing area per passenger (m1 and m2). The sizing of the retail and concession space is primarily affected by the peak hour passenger volume (Q*fpeak), the allotted space per passenger (cper pax), and the penetration factor.

When sizing the terminal space for retail and boarding, the cumulative effect of departing passengers during peak hours should be considered. The summation in the first term of Equation 14 considers the total departure space for all the boarding gates required during peak hours. A superimposition of the cumulative passenger arrival curves for all the flights in peak hours will provide a good estimate of the penetration factor, the maximum number of shoppers in peak hours, and the corresponding retail space required.

Conclusion

In conclusion, this paper has deconstructed all the major determinants affecting retail revenue in airport terminal design. With the introduction of the new definition of penetration factor in this paper, businesses can evaluate the number of shoppers and the size of the potential retail market. This paper has also introduced a major mathematical relationship between retail revenues and airport retail design.

As discussed above, the two main determinants to improve retail revenues are: (1) penetration factor, and (2) dwell time. Both of these variables depend on the processing rate at security checks upstream and on the boarding rate downstream. The airport terminal configuration and ratio of retail space over the entire retail and departure lounge area can also affect the penetration factor. Maintaining an optimal proportion between space for waiting lounge and retail space can maximize sales and minimize the initial capital investment for airports.

The geometric design and sizing of the departure terminal should be reassessed to increase the sales revenues for airport, in particular, the size, location and layout of the retail complex. Generally, the increase in retail size can increase the sales revenues, if the retail complex is situated in a centralized area that has the advantage to minimize the average walking time and distance. Due to the association with this advantage, satellite and pier terminals tend to generate a higher level of retail revenues, as shown in this study.

Due to the growing attention on airports' profitability and the rising role of retail income on airports' profits, airports tend to embrace post-security retail development. It is important that the post-security terminal space be used wisely to capture these retail business opportunities. With the belief that the success of an airport starts from the front-end design, future terminal design must consider more about retail operations and apply new business thinking, including those concepts introduced in this study.

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