



ASSESSING THE NON-AVIATION PERFORMANCE OF NORTH AMERICAN AIRPORTS

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ABSTRACT: Despite the growing importance of airports' non-aeronautical activities, the literature has paid very limited attention to the determinants of the airports' commercial success. This paper examines the different factors affecting non-aeronautical revenue and rent payments to US airports using a panel data set from 1999 to 2008. Unlike most prior studies, which only offer a descriptive analysis, this paper applies econometric data analysis techniques to estimate determinants of non-aeronautical revenue. The focus of our research is mainly on specialty retail and food & beverage (F&B) services, which, in addition to parking, are the major non – aviation activities at US airports. A better understanding of factors which generate revenue for specialty retail and F&B operators can help airports develop a more efficient investment and lease policy.

It was found that the same factors explain the performance of Specialty retail in both international and domestic terminals, while for F&B performance of domestic and international terminals explained by different factors. Moreover drivers of revenue and factors influencing rent payment are not the same in several cases. International passengers contribute the most to specialty retail while business passengers decrease F&B revenue per square foot in domestic terminals. For F&B in international terminals, passenger characteristics (i.e. transfer versus O&D) have no statistically significant influence. Terminals dominated by the low cost airlines have lower specialty sales and higher F&B revenue per square foot. Demographic factors like income per capita are also significant in explaining non-aeronautical revenues.

Key words: Airports, Commercial revenues, Panel data analysis.

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1. Introduction

The last decades saw a period of huge transformations in the airport industry. Changes in the ownership structure, the understanding of an airport's mission, the influence of new market players like LCC companies etc. changed the focus of airport management and lead to an increased focus on non-aeronautical revenue. Some airports have successfully refocused and others are now only on the eve of that.

As the contemporary airport environment is highly competitive, an airport is no longer a monopoly for both airlines and passengers, as they can quite easily prefer one airport to another. Airports need to be attractive and effective to survive. Thus while management has to pay attention to all the activities of an airport, non-aviation activities have become extremely important for airports to remain profitable and competitive.

There are a lot of articles dealing with airport efficiency and the role of non-aeronautical revenue, but most of them only have a descriptive character. There has been very little modeling of the underlying relationships, mostly because of the limitations of the data. In this paper we want to focus on the empirical estimation of factors which influence non-aeronautical revenue. We were fortunate to overcome the problem of data availability by having access to data from a large sample of US airports.

We next review the literature on this topic, and then describe our data set and finally carry out an econometric analysis on the main drivers of retail revenue.

2. Review of the literature

Prior researches investigated the relation between nonaviation revenues and its determinants from different points of view. The main variables usually mentioned were the size of an airport, the influence of different types of passengers, and type of the contract used.

2.1 Airport size

Non aviation revenue should increase more than proportional with size, because of the increased specialization that is possible with a larger retail area that can be supported at large airports. This also allows more specialty shops to reach a critical volume, who usually have higher margins than the simple traveler value stores. Using airport data for the UK, Italy and Germany Graham A.'s (2006) study showed that for airports with less than 4 million passengers commercial revenues represented 44%, 33% and 31% of the total revenues, whereas airports larger than 10 million passengers showed revenues between 57%, 46% and 39%. Graham A.(2008) concluded that large airports offer a much wider range of facilities, including specialty shops and food and beverage (F&B) outlets, which a smaller airport that do not reach the critical mass would find hard

to sustain. Large airports also tend to have more international (and especially intercontinental) passengers who are willing spend more.

2.2 Retail location planning

Shop location itself plays an important role in the process of the retail revenue generation.

Hernandez T. et al. (1998) stated that location has come to be appreciated much more as a potential source of competitive advantage. The intensity of competition in a number of markets, including the onset of saturation in some sectors, has led retailers to place far greater emphasis on the effective management of their store portfolios, and to plan these much more systematically in order to maximize the aggregate returns to their business.

Brueckner J.K. (1993) showed that the design of a shopping center can be viewed as a two-stage problem. First, the developer decides on the number and types of stores that the center will contain. Then, he or she decides on the amount of space that will be allocated to each of the chosen stores. Analytically, the first stage involves a discrete choice problem, while the second stage has continuous choice variables. The given stores' own sales rise as other stores grow in size because the shopping center is then more attractive to customers.

Hernandez T. et al. (1998) grouped the location planning techniques into three broad groups: *comparative* (where the essence is simple benchmarking against already established stores); *predictive*, which are the multivariate statistical techniques, using cumulative data on past store performances to ascertain future ones; and *knowledge based*, where statistical data is combined with programmed intelligence.

2.3 Structure of passenger flows

Tovar, B., Roberto Rendeiro Martirn-Cejas (2008) in a study based on data from Spanish airports found out that hubs and large tourist airports are expected to attract more international passengers than the small ones, and that commercial revenue increases in line with international passenger volume. Papatheodorou A. and Zheng Lei (2006) indicate that LCC passengers' contribution to non-aeronautical revenue is smaller for the large airports (with more than 3 mill. passengers) than for the small airports. The contribution of charter and full-service passengers are seen as comparable with LCC travelers in small airports. Torres E. et al (2005) who interviewed Asturias Airport travelers found out that business travelers on average spend less than vacation travelers. But if the boarding time is less than 45 min, business travelers tend to consume more than vacation travelers. Thus the percentage of passengers who will make a purchase is also affected by the time the potential shopper has available.

Kasarda J. (2008) pointed out that not only air passengers determine non.-aviation business. With the growing airport-linked businesses, airport employees are also using some of the airports' services, including housing, recreation, food services, retail, health, and child day care.

2.4 Demand vs. Supply side of Retail Space

International airports are facing a highly competitive environment and are increasingly required to be self-financing. If the operators of airports aims at maximizing commercial concession, then they may lower space allocated to the public facilities in response to increased passenger volume due to the limitation of the original space. However, the level of space allocated for public facilities in terminal buildings must be maintained at a certain level-of-service in order to be competitive. This could result in a shortage of commercial space so ideally, space for commercial and public facilities should be adjusted according to passenger volumes.

Chaug-Ing Hsu, Ching-Cheng Chao (2005) examined the relationships among concession revenue, passenger service level and space allocation for public facilities and commercial activities at international passenger terminals. The results of their study showed that to maintain the same public facility service level, the space required for commercial activities increases proportionally with passenger volume, while the concession revenue does not increase by the same proportion, and instead depends on the allocated locations. They showed that total commercial revenues can be maximized by allocating the stores with more concession revenue per square meter in the more accessible positions in the terminal building.

To maximize concession revenue, even given constant passenger volume, the required commercial space is not the same and its ratio to public facility space also differs for different public facility service levels. The ratio of commercial space to public facility space increases with reducing public facility service level. The airports that incorporate a high public facility service in their original design may reduce public facility space while increasing commercial space, thus increasing commercial concession revenue.

Thus, it is not just enough to look at the demand for retail services, but one must also see how many shopping opportunities are being offered. This is not the small question, because in the past airports have been laid out to provide a fast throughput of passengers, rather than to maximize the amount of time available for shopping between arrival and take off. Thus we must pay special attention to how much retail space can be made available at different airports.

Benjamin J.D. (1998) analysis revealed inelastic price demand and supply elasticities for retail space. Because demand and supply are price inelastic, shifts in demand (supply) were found to result in relatively large changes in rent and relatively small changes in quantity demanded (supplied). Rental prices were largely explained by the previous year's rental price and the current

year's vacancy rate, with higher vacancy rates resulting in lower rental prices. Demand for space was strongly influenced by the real level of retail spending; in particular, space demand seemed to rise slightly less than in proportion to increases in real retail sales. On the supply side, the supply of space was negatively affected by more stringent land-use regulation and less land availability, while capital costs, as measured by interest rates, did not appear to have a significant impact on supply.

2.5 Types of contracts

By type of contracts we mean the way in which retail and restaurant concessions are managed and what effect it has on performance. Hong-bumm Kim, Jee-Hye Shin (2001) revealed that mix contracts of MGR (Minimum guaranteed rate) and percentage of annual sales (paying either MGR or percentage of sales depending on which is greater) are effective for duty-free, retail and convenience shops, whereas the percentage of sales method might be more appropriate for F&B catering services. Tovar, B., Roberto Rendeiro Marturn-Cejas (2008) illustrated that among Spanish airports the ones that show an above average technical efficiency also have a higher level of outsourcing of such activities and also have higher commercial revenue. Consequently, they argue that airports who outsource are able to pay more attention to their core services and thus improve their competence, while outsourcing non aviation activities to specialists that are active at more than one location.

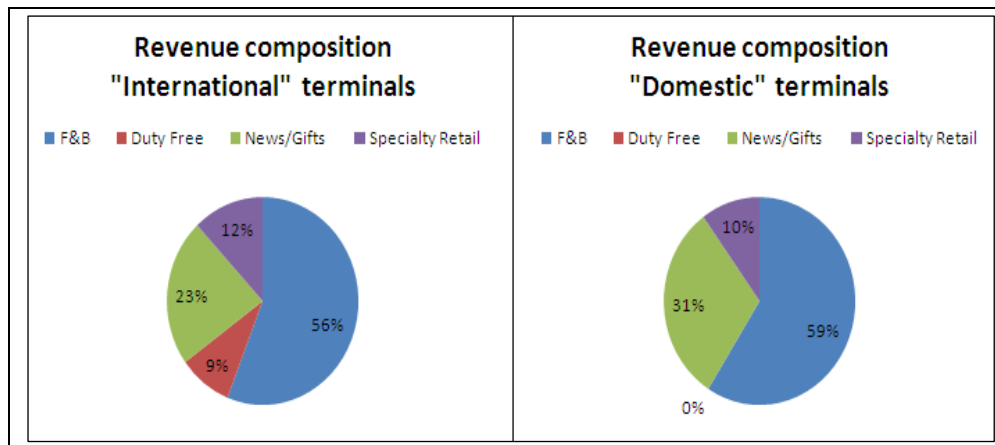
3. Data

In the analysis data from ARN Fact Book, which are published by the Armbrust Aviation Group (AAG) were used. The sample consists of 97 US airports during the years 1999 and 2008. All data is on a terminal-by-terminal basis and covers 272 terminals. The data includes Duty Free, Specialty Retail, News/Gifts, General services and F&B sales and space. For a part of airports dwell time data is available. Passengers data divided into different categories: enplaning, deplaning, international, domestic, O&D, transfer, business and leisure passengers volumes. To complete the analysis demographical data such as population and income per capita in the metropolitan area to which belongs the airport were also included.

3.1 Descriptive statistics

To answer the question what is the main source of non-aeronautical revenue (incomes from car parking and car rental services were not taken into account) we look at revenue composition in “international” and “domestic” terminals (Fig 1).

Figure 1. Revenue composition in the US airports.

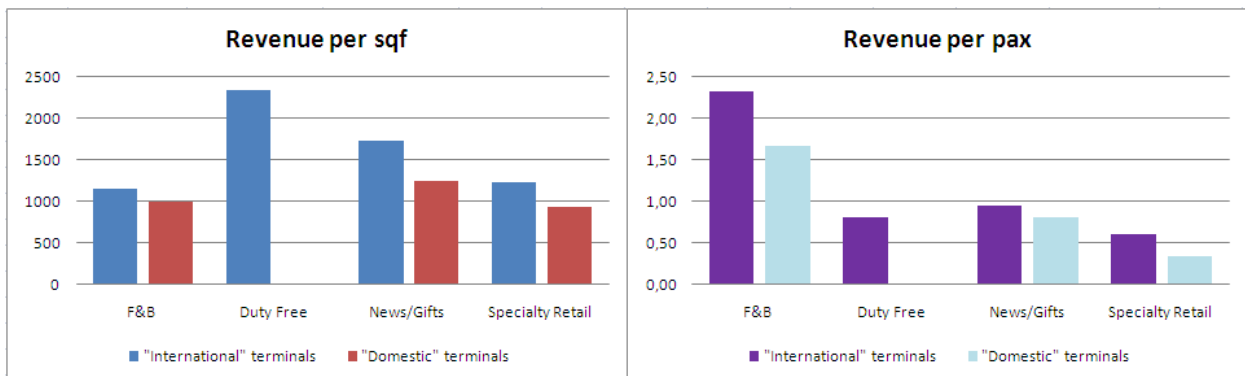


Source: ARN Fact Book

Duty free sales are one of the main sources of non-aeronautical revenue in Europe on the contrary in the US it's the less important source. Revenue from Food&Beverage accounts for the largest part of the revenue.

We also notice that the performance of international terminals in the case of revenue per square foot and revenue per passenger is better than the performance of domestic terminals in all types of non-aeronautical activities (Fig.2).

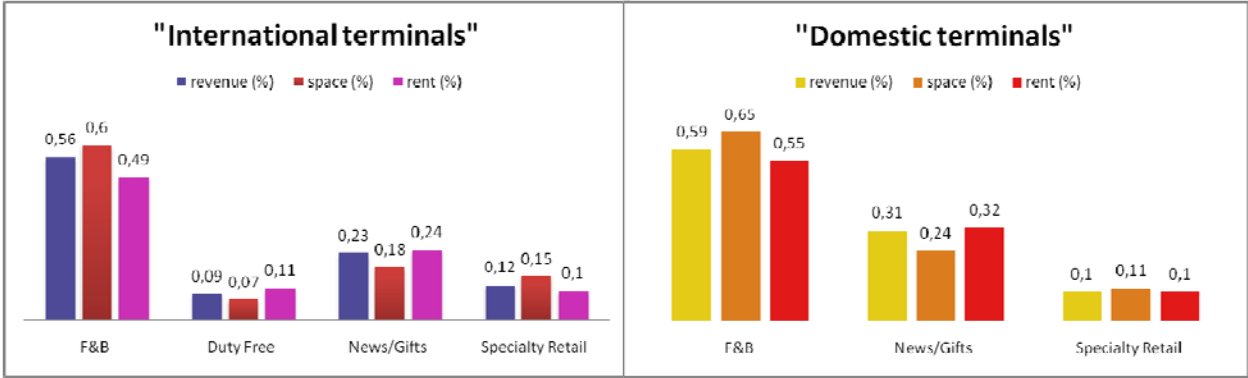
Figure 2. Non-aeronautical revenue per passenger and per square foot in US airports.



Source: ARN Fact Book

We were also interested in the question of most profitable and effective sources of revenue. Could it be so that several airport activities generate more revenue or brings larger share of incomes than the amount of space which they occupy (Fig 3).

Figure 3. Revenue vs. Space vs. Rent



Source: ARN Fact Book

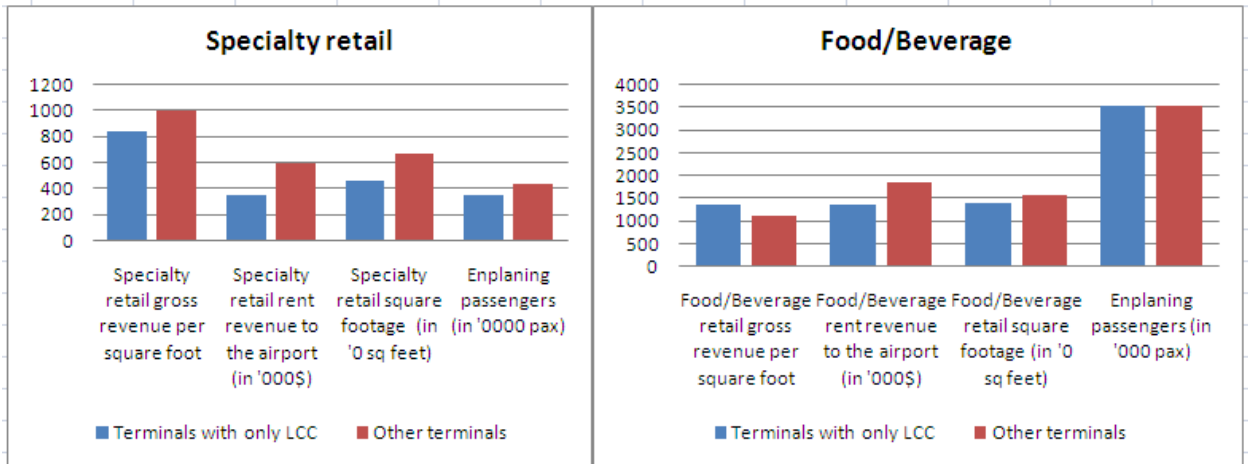
After closer look at this question we found out that share of generated revenue, rent and occupied space distributed mostly uniformly and in there is no source of revenue, development of which, brings definitely outstanding performance to the airports.

In our further empirical analysis we will focus on Specialty retail and Food&Beverage.

3.2 LCC terminals performance

Fig 4. illustrates differences in the performance of terminals with only LCC (list of LCC is presented in Appendix A) and terminals with only full service airlines or mix of full service and LCC.

Figure 4. Specialty retail and F&B in different types of terminals



Source: ARN Fact Book

Terminals with Low cost dominant airline have lower specialty sales per square foot and higher F&B revenue per square foot.

3.3 Sub sample construction

It's a well-known fact that US airports are very different from the European ones. Most of the traffic account for the domestic flights. In this way first question which was raised was whether we should analyze the whole sample, or separate analysis for international and domestic terminals should be done.

We ran Chow test in order to determine whether data can be pooled together (or whether the coefficients in a regression model are the same in separate subsamples of international and domestic terminals).

The criterion to define international terminals was the presence of international passengers.

The results of Chow test showed us that functions that determine the Specialty Retail Gross Revenue per square foot are the same in international and domestic terminals and we can estimate pooled model for Specialty Retail in our analysis.

According to the results of Chow test Pooled model is an inadequate specification for analysis of Food/Beverage Gross Revenue per square foot. Independent variables influence on F&B sales per square foot in different ways and we cannot pool both international and domestic terminals and will run separate regressions for these types of terminals.(the results of Chow test are presented in the Appendix B).

4. Empirical results

We start our analysis from the analysis of Specialty retail drivers. Two models were estimated with specialty revenue per square foot as a dependent variable (Model 1) and specialty retail rent payments (from each square foot) to the airport (Model 2).

According to the results of Chow test presented in the section 3 we can estimate pooled sample when we looked at Specialty retail sales.

Table 1. Random and Fixed-effects GLS regressions				
	Model 1 Random-effects GLS regression (838 observations)		Model 2 Fixed-effects GLS regression (473 observations)	
	Ln(Specialty Retail Gross Revenue per square foot)		Ln(Specialty Retail Rent Revenue to the Airport per square foot)	
	Coef.	Std. Err.	Coef.	Std. Err.
Ln(Specialty Retail Square Footage)	-0.32	(0.03)***	No	No
Ln (Number of departure passengers)	0.59	(0.05)***	No	No

Share of international passengers out of the total number of passengers	0.32	(0.15)*	- 0.39	(0.23)^
Ln (Income per capita in the metropolitan area where the airport is located)	1.03	(0.17)***	-0.61	(0.22)**
Ln (Population of the metropolitan area where the airport is located)	No	No	1.40	(0.48)**
Ln(Specialty Retail Gross Revenue per square foot)	No	No	0.81	(0.03)***
Const	-10.55	(1.84)***	-14.97	(5.86)**

“***” Significant at the 0.1% level. “**” Significant at the 1% level. “*” Significant at the 5% level. “^” Significant at the 10% level.

In Model 1 the coefficient in front of variable “Specialty Retail Square Footage” is negative, this means that the relation between square footage and revenue per square foot is negative, in other words marginal revenue decrease after increase in space.

Airport can increase space together with passengers volumes, but even if passengers level remains constant together with increase in specialty retail space specialization most probably will increase and more passengers will find the desired good that will cause increase in Specialty retail gross revenue.

Both dependent and independent variables are in natural logarithms, this shows that the relation between variables is not linear. To understand better this relation model which analyzing only space effects was estimated (Model 3).

Table 2. Random and Fixed-effects GLS regressions				
Specialty Retail Gross Revenue per square foot	Model 3 Fixed-effects GLS regression (1058 observations)		Model 4 Fixed-effects GLS regression (667 observations)	
	All terminals		Terminals with Specialty Retail Square Footage ≤ 5000	
	Coef.	Std. Err.	Coef.	Std. Err.
Specialty Retail Square Footage	-0.19	(0.03)***	-3.05	(0.38)***
(Specialty Retail Square Footage) ²	7.20E-06	(1.46E-06)***	0.001	(0.0002)***
(Specialty Retail Square Footage) ³	-7.10E-11	(1.67E-11)***	-1.34E-07	(2.66E-08)***
Const	1 642.59	(89.25)***	3050.40	(208.93)

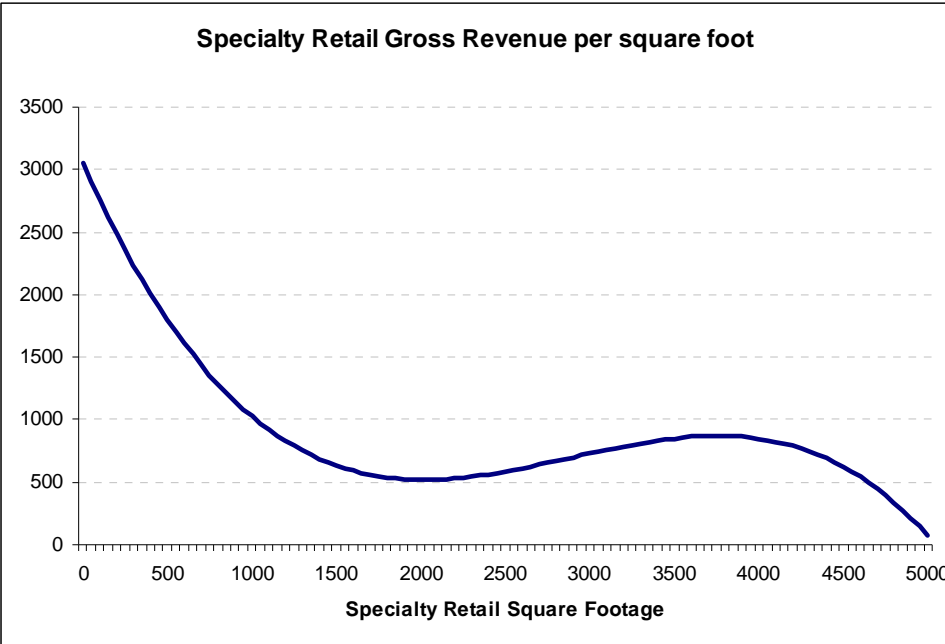
“***” Significant at the 0.1% level. “**” Significant at the 1% level. “*” Significant at the 5% level. “^” Significant at the 10% level.

The independent variables in model are Specialty Retail Square Footage in first, second and third degrees. The sign in front of the variables in first and third degrees is negative and in front of the square footage in second degree is positive. This means that with increase in space revenue per square foot decrease but after a certain level it starts to grow until it starts to decrease again. This effect is very similar to saturation effect. The airport needs to reach the critical mass in Specialty retail after this level almost every passenger can find the desired good and revenue will increase in the grater share than space, so revenue per square foot will increase.

This situation is similar with shopping mall concept. Shopping malls’ operators put in each mall one or several anchor stores, with very large variety of products in order to attract more customers. But airport or shopping mall cannot increase space indefinitely because passengers/ customers will even have no enough time to look at all stores this is why we see the decrease in revenue per square foot again after a period of growth.

In order to understand if this relation will be the same or not for different size airports Model 4 was estimated. The underlying logic was that probably hubs have completely different performance and small airports cannot reach the critical mass and have only decreasing relation between space and revenue per square foot. The sample was restricted to the terminals with specialty retail space less or equal to 5 000 square feet (largest Specialty retail area was accounted for 66 224 square feet), such terminal account for around 75% of the sample. After estimation same relation was received. Figure 9 illustrate this relation.

Figure 5. Specialty retail gross revenue per square foot



Source: ARN Fact Book data, author’s estimations

We see that after total specialty retail space achieved around 2 000 square feet level revenue per square foot starts to growth until 4 000 square feet level. So even small airport can improve their performance by increasing amount of space offered for specialty retail.

One point should be taken into account here, of course sometimes airport have space constrains but quite significant share of small regional airports have free space and they don't need to expand terminal capacity in order to offer more space for retail operators.

Except of space other factors influence Specialty retail revenue per square foot (Model 1). With increase in number of passenger the revenue per square foot increase. Different types of passengers have different spending patterns. Three shares were calculated in order to find the most important group of passengers for specialty retail: share of O&D to transfer passengers, share of international to domestic passenger and share of business to leisure passengers was included into regression. The only significant variable was share of international passengers in the airport; this mean that for specialty retail in the US airports only this categorization is the most important. The grater the share of international passengers in the airport the grater the specialty retail revenue per square foot. Several demographic factors were tested in the model. It was found out that income per capita in the metropolitan area where the airport is situated have statistically significant effect on the specialty retail revenue, the grater the income per capita the grater is the specialty retail revenue. This sound quite logical because in the US is traditionally high volumes of domestic traffic, the more reach the area the more passenger is able to spend in the airport. And even significant part of international traffic consist from Americans.

The next step in the analysis was understanding of factors which influence rent payment to the airport (Model 2). If these factors are the same the lease policy of airport is efficient, because retail operators and airport in this case will have the same target variables to increase their incomes and will develop their policy in the same direction.

As specialty retail rent payments largely depend on revenue generated by retail operators, specialty retail revenue per square foot was included as a control variable.

The estimation results shows that partly drivers of specialty retail revenue and rent payments (from specialty retail operations) are the same (Model 1 and Model 2).

Share of international passenger was significant only on 10% level. Income per capita had statistically significant effect on specialty retail rent payments to the airport, but the sign was negative. This mean that all else equal the grater the income per capita in the metropolitan area the less are rent payments. This statistical result is quite difficult to explain, one possible explanation for this could be that in the areas with higher income per capita airport had higher fix rates per square foot and smaller floating rates in the contract, so they generate less revenue than in the case of leasing contract with higher floating rate, but we cannot test this hypothesis because of lack of data on revenue composition.

Concerning demographical variables for rent payment per square foot population of the metropolitan area where the airport is situated was significant. The logic of airport could be here that if the population in the metropolitan area is higher it'll be more passengers in the airport, so they charge the higher rent.

Specialty retail account for less than 15% of non-aeronautical revenue in the US terminals and this number is much higher in the European airports. US airports should use (accelerate) the potential of this category of revenue. F&B account for more than 50% of the revenue and investigating of F&B performance was the next step of the research. First F&B performance in domestic terminals was analysed (Model5, Model 6).

Table 3. Random and Fixed-effects GLS regressions “Domestic” terminals				
	Model 5 Random-effects GLS regression (293 observations)		Model 6 Fixed-effects GLS regression (208 observations)	
	Ln(F&B Gross Revenue per square foot)		Ln(F&B Rent Revenue to the Airport per square foot)	
	Coef.	Std. Err.	Coef.	Std. Err.
Ln(F&B Square Footage)	-0.54	(0.04)***	No	No
Ln(Number of departure passengers)	0.83	(0.05)***	No	No

Share of business passengers out of total number of passengers	-0.39	(0.09)***	0.67	(0.20)**
Ln(Income per capita) in the metropolitan area where the airport is located	1.12	(0.21)***	1.99	(0.63)**
Ln(F&B Gross Revenue per square foot)	No	No	0.96	(0.12)***
Const	-12.32	(2.18)***	-22.79	(6.32)***

“***” Significant at the 0.1% level. “**” Significant at the 1% level. “*” Significant at the 5% level. “^” Significant at the 10% level.

The coefficient in front of F&B square footage is grater (in absolute terms) than the same coefficient in specialty retail model. This means that the revenue per square foot reduced more significant for F&B than for Specialty retail after increase in space.

To understand better this relation models similar to Model 3 and Model 4 were estimated (Model 7, Model 8).

Table 4. Fixed-effects GLS regressions “Domestic” terminals				
F&B Gross Revenue per square foot	Model 7 Fixed-effects GLS regression (404 observations)		Model 8 Random-effects GLS regression (294 observations)	
	All terminals		Terminals with F&B Square Footage ≤ 13 500	
	Coef.	Std. Err.	Coef.	Std. Err.
F&B Square Footage	-0.22	(0.06)***	-0.33	(0.14)*
(F&B Square Footage) ²	9.45E-06	(2.94E-06)***	0.00004	(0.00002)
(F&B Square Footage) ³	-1.00E-10	(3.90E-11)**	-1.27E-09	(1.21E-09)
Const	1 859.44	(258.07)***	1 687.32	(219.73)***

“***” Significant at the 0.1% level. “**” Significant at the 1% level. “*” Significant at the 5% level. “^” Significant at the 10% level.

First model for all domestic terminals was estimated. Again the coefficient in front of the variable “F&B Square Footage” grater (in absolute terms) than similar coefficient in Specialty retail model. Which shows again that with increase in space revenue per square foot decrease more dramatically for F&B than for Specialty retail. Possible explanation for this could be that if we increase Specialty retail space (holding the number of passengers constant) let assume this will be a new shop of retail operator, the specialization and variety of good offered will increase and more passengers find goods they need and spend money, the total revenue will increase but the revenue

from the second shop will be less than the revenue from the first shop this is why revenue per square foot will decrease.

In the case of increase in F&B space (holding the number of passengers constant) let assume this will be a new café, the additional number of passengers spending money in the second F&B café could be less than the number of passengers spending money in the second Specialty retail shop. Even if certain type of passengers didn't like sandwiches from the first F&B but was hungry they bought them after the second F&B café was opened part of the passengers switched from the first café to the second, because they like second café's sandwiches more. The level of customer satisfaction increased after the second café was opened, but total revenue from two F&B will be less than total revenue from two Specialty retail shops this is why revenue per square foot in the case of F&B decrease more dramatically.

The highest F&B area in the terminals included in the sample accounts to 51 570 square feet, but in many terminals F&B facilities occupies smaller space, around 75% of the sample have total F&B space less than 13 500 square feet. To understand if this relation is different in big and small airports the same model was estimated for the second subsample with restriction on F&B Square Footage be less than 13 500 square feet.

The result for small domestic terminals was completely different and shows that the level after which F&B sales per square foot starts to grow not exist at all for small terminals, that make optimisation of space allocated to F&B less efficient.

Model 5 shows that except of space number of passengers is important for F&B sales per square foot. Between two types of passenger categories (O&D/Transfer and Business/Leisure) only Business/Leisure category was important. The results shows that the grater the share of Business passengers in the terminal the less is revenue per square foot. The fact that almost all domestic flights are short-haul and all business passengers have food on board included in the price of the ticket explains this result. Income per capita in the metropolitan area where the airport is situated has statistically significant influence for the F&B revenue per square foot.

For F&B rent payments to the airport (Model 6) in addition to revenue per square foot income per capita and share of business pax had positive statistical effect.

Next step in the research was the analysis of F&B performance in international terminals. First space and revenue relation were analyzed (Model 9. Model 10).

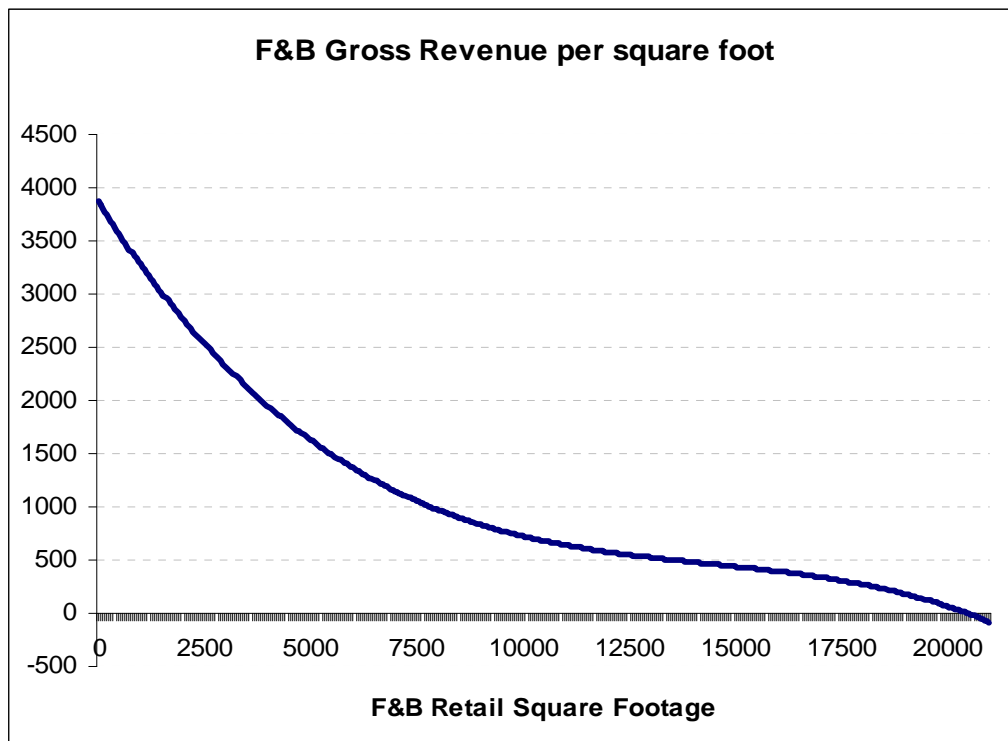
Table 5. Fixed-effects GLS regressions "International" terminals		
F&B Gross Revenue per square foot	Model 9 Fixed-effects GLS regression (749 observations)	Model 10 Fixed-effects GLS regression (550 observations)

	All terminals		Terminals with F&B Square Footage \leq 22 000	
	Coef.	Std. Err.	Coef.	Std. Err.
F&B Square Footage	-0.14	(0.01)***	-0.63	(0.10)***
(F&B Square Footage) ²	2.28E-06	(2.68E-07)***	0.00004	(9.74E-06)***
(F&B Square Footage) ³	-1.12E-11	(1.44E-12)***	-9.43E-10	(2.74E-10)***
Const	2 430.36	(130.69)***	3 866.42	(327.10)***

“***” Significant at the 0.1% level. “**” Significant at the 1% level. “*” Significant at the 5% level. “^” Significant at the 10% level.

Whole sample of international terminals and sub sample of international terminals with F&B square footage less than 22 000 square feet were estimated. For both samples relation is similar with relation observed for specialty retail. If we look not only on the signs of coefficients but on the graphical presentation of this relation one very important difference occurs. For specialty retail after Specialty retail Square footage achieved around 2 000 square feet point quite significant increase in Specialty retail revenue started (Figure 5). Figure 6 shows that for F&B the revenue per square foot decrease almost all the time with increase in space but with the different speed. So the gain from optimizing Specialty retail space is more obvious than gain from optimizing F&B space.

Figure 6. F&B gross revenue per square foot



Source: ARN Fact Book data, author’s estimations

Concerning other factors influencing F&B revenue per square foot in international terminals (Model 11) was found out that passengers contribute to revenue but there is no additional

contribution of different types of passengers (like international, business or transit passengers). Both income per capita and population have statistically significant influence on F&B revenue per square foot.

Table 6. Random and Fixed-effects GLS regressions “International” terminals				
	Model 11 Fixed-effects GLS regression (735 observations)		Model 12 Random-effects GLS regression (150 observations)	
	Ln(F&B Gross Revenue per square foot)		Ln(F&B Rent Revenue to the Airport per square foot)	
	Coef.	Std. Err.	Coef.	Std. Err.
Ln(F&B Square Footage)	-0.81	(0.03)***	No	No
Ln(Number of departure passengers)	0.80	(0.03)***	No	No
Share of business passengers out total number of passengers	No	No	0.38	(0.16)*
Ln(Income per capita) in the metropolitan area where the airport is located	1.39	(0.11)***	No	No
Ln(Population) of the metropolitan area where the airport is located	1.02	(0.35)**	No	No
Ln (Dwell time)	No	No	0.22	(0.10)*
Ln(F&B Gross Revenue per square foot)	No	No	1.09	(0.05)***
Const	-27.83	(4.51)***	-3.63	(0.51)***

“***” Significant at the 0.1% level. “**” Significant at the 1% level. “*” Significant at the 5% level. “^” Significant at the 10% level.

In the case of F&B rent payment to the airport in international terminals (Model 12) was found out that rent payment are higher if the share of business passengers is higher in the terminal. Dwell time has significant influence on F&B rent payments per square foot the grater is the dwell time the more is F&B rent payments per square foot.

5. Conclusion

The purpose of this study was to understand the main drivers of non-aeronautical revenue and rent payment accumulated from non-aeronautical activities of US airports. The focus of the research was mainly on Specialty retail revenue and Food&Beverage revenue.

Different passengers types contributes in the different ways to non-aeronautical activities. With increase in share of international passengers in the airport Specialty retail revenue per square

foot increase and with increase in share of business passengers decrease F&B revenue per square foot in domestic terminals.

Demographic factors like income per capita in the metropolitan area where the airport is situated are important factors in estimation and forecasting of non-aeronautical revenue.

With increase in space Specialty retail revenue per square foot and F&B revenue per square foot react on this in the different ways. With increase in space Specialty retail revenue per square foot decrease but after a certain point when the critical mass level is reached Specialty retail revenue per square foot starts to grow and it decline again after specialty retail space is expanded too much. F&B revenue per square foot declines more dramatically with increase in F&B space more over marginal revenue decline almost all the time during the increase of F&B space without period of reverse like in the case of Specialty retail.

Drivers of Specialty retail revenue and F&B revenue are partly different from factors influencing rental payments to the airport. It could be a potential for the increase in the efficiency of airports' non-aeronautical activities if lease rates will be settled in accordance with main drivers of non-aeronautical revenue.

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Appendix A

List of US LCC:

- 1) AirTran
- 2) Allegiant Air
- 3) Frontier
- 4) Horizon Air
- 5) JetBlue
- 6) Midwest
- 7) Southwest
- 8) Spirit
- 9) Sun Country
- 10) Ted
- 11) USA 3000
- 12) Virgin America

Appendix B

Chow test :

$$F(k, n - 2k) = \frac{\text{overall reduction in RSS when separate regressions are run} / \text{cost in degrees of freedom}}{\text{total RSS remaining when separate regressions are run} / \text{degrees of freedom remaining}}$$

	Residual sum of squares			Number of obs		
	Pooled model	International terminals	Domestic terminals	Pooled model	International terminals	Domestic terminals
Model A	532.84	330.41	199.49	912	532	380
Model B	280.55	159.60	109.83	1260	664	596

Model A

In Model A the dependent variable is natural logarithm of Specialty Retail Gross Revenue per square foot and independent variables are natural logarithms of total number of passengers and Specialty Retail Square Footage.

$$F(2,908) = \frac{(532.84 - (330.41 + 199.49))/2}{(330.41 + 199.49)/(912 - 4)} = 2.53$$

$$F(2,908)_{\text{crit.0.1\%}} = 6.96$$

The critical value of F at the 0.1% level with 2 and 908 degrees of freedom is around 6.96.

The reduction in the residual sum of squares is not significant at the 0.1% level, because critical value is higher than our F statistic calculated from the sample. We conclude what functions that determine the Specialty Retail Gross Revenue per square foot are the same in international and domestic terminals and we can estimate pooled model in our analysis.

Model B

In Model B the dependent variable is natural logarithm of Food/Beverage Gross Revenue per square foot and independent variables are natural logarithms of total number of passengers and Food/Beverage Square Footage.

$$F(2,908) = \frac{(280.55 - (159.60 + 109.83))/2}{(159.60 + 109.83)/(1260 - 4)} = 26.48$$

$$F(2,1256)_{\text{crit.0.1\%}} = 6.92$$

The critical value of F at the 0.1% level with 2 and 1256 degrees of freedom is around 6.92, because it less than calculated F which is 26.48 we reject the null hypothesis about equality of two sets of coefficients in regression models and will estimate separate regressions for the international and domestic terminals in the case of determinants of Food/Beverage Gross Revenue per square foot.

Appendix C

Hausman test :

If the random effect model is: $y_{it} = \mu + x'_{it}\beta + v_{it}$, where $i=1, \dots, N$; $t=1, \dots, T$.

$v_{it} = \alpha_i + \varepsilon_{it}$, where α_i are $iid(0, \sigma^2_\alpha)$ and independent of $\varepsilon_{it} iid(0, \sigma^2_\varepsilon)$ and x_{it} for all i, t .

Rewriting in matrix notation: $y = W\delta + v$.

Null hypotheses: $H_0 : E(\alpha_i | W_{it}) = 0$

Under the null hypotheses both Random effect GLS and FE estimator are consistent, whereas under the alternative only the fixed effect estimator is consistent. This means that if the null hypothesis is true there should not be a significant differences between the parameters. So, the

Hausman test statistic is:

$$H = (\beta^{est}_{RE} - \beta^{est}_{FE})' (Var_{FE} - Var_{RE})^{-1} (\beta^{est}_{RE} - \beta^{est}_{FE})$$

Under the null hypothesis the Hausman test statistic will have X^2 (chi-squared) distribution asymptotically.

In the following table you can find the equivalents of variables names used in the Tables 1-6 and in the Hausman test and Stata estimations.

Table 7. Variables names equivalence	
Name of the variable in the Tables 1-6	Name of the variable in the Hausman test and Stata estimations
Ln(Specialty Retail Gross Revenue per square foot)	ln_spec_gr~f
Ln(Specialty Retail Rent Revenue to the Airport per square foot)	ln_spec_re~f
Ln(F&B Gross Revenue per square foot)	ln_fb_gr_r~f
Ln(F&B Rent Revenue to the Airport per square foot)	ln_fb_rent~f
Ln(Specialty Retail Square Footage)	ln_spec_sqf
Ln(F&B Square Footage)	ln_fb_sqf
Ln (Number of departure passengers)	ln_enp_pax
Share of international passengers in total number of passengers	share_int
Share of business passengers in total number of passengers	share_busi~s
Ln (Income per capita in the metropolitan area where the airport is located)	ln_inc_per~p
Ln (Population of the metropolitan area where the airport is located)	ln_populat~n

Ln (Dwell time)	ln_dwell t~n
Specialty Retail Square Footage in the second degree	spec_sqf_2
Specialty Retail Square Footage in the third degree	spec_sqf_3
F&B Square Footage in the second degree	fb_sqf_2
F&B Square Footage in the third degree	fb_sqf_3
Constant term	_cons

Model 1

Fixed-effects regression:

```

Fixed-effects (within) regression      Number of obs      =      838
Group variable (i): id_terminal       Number of groups   =      181

R-sq:  within = 0.2382                 Obs per group: min =      1
       between = 0.1927                 avg =      4.6
       overall = 0.2774                 max =      8

corr(u_i, Xb) = -0.1816                F(4,653)           =      51.06
                                           Prob > F           =      0.0000

```

```

-----+-----
ln_spec_gr~f |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-----+-----
ln_spec_sqf  |  -.3793632   .034731   -10.92  0.000   - .4475611   - .3111654
ln_enp_pax   |   .6331699   .0686226    9.23  0.000    .4984223    .7679174
share_int    |   .2966816   .2147373    1.38  0.168   - .1249773    .7183404
ln_inc_per~p |   1.144902   .2036463    5.62  0.000    .7450212    1.544782
_cons        |  -11.95992   2.256799   -5.30  0.000   -16.39137   -7.528459
-----+-----
sigma_u      |   .67764805
sigma_e      |   .58623232
rho          |   .57195299   (fraction of variance due to u_i)
-----+-----
F test that all u_i=0:      F(180, 653) =      3.80          Prob > F = 0.0000

```

Random-effects GLS regression:

```

Random-effects GLS regression      Number of obs      =      838
Group variable (i): id_terminal       Number of groups   =      181

R-sq:  within = 0.2375                 Obs per group: min =      1
       between = 0.1981                 avg =      4.6
       overall = 0.2847                 max =      8

Random effects u_i ~ Gaussian       Wald chi2(4)       =      253.19
corr(u_i, X) = 0 (assumed)         Prob > chi2        =      0.0000

```

```

-----+-----
ln_spec_gr~f |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-----+-----
ln_spec_sqf  |  -.3209155   .027153   -11.82  0.000   - .3741343   - .2676966
ln_enp_pax   |   .5862915   .0483256   12.13  0.000    .491575     .681008
share_int    |   .3151827   .1505809    2.09  0.036    .0200495    .6103159
ln_inc_per~p |   1.031322   .1691244    6.10  0.000    .6998444    1.3628
_cons        |  -10.54806   1.840359   -5.73  0.000   -14.1551    -6.941021
-----+-----
sigma_u      |   .55290556

```

```
sigma_e | .58623232
rho | .4707689 (fraction of variance due to u_i)
```

Hausman test:

```
. hausman fixed
```

	---- Coefficients ----		(b-B)	sqrt(diag(V_b-V_B))
	(b)	(B)	Difference	S.E.
	fixed	.		
ln_spec_sqf	-.3793632	-.3209155	-.0584478	.0216554
ln_enp_pax	.6331699	.5862915	.0468784	.0487206
share_int	.2966816	.3151827	-.0185011	.1530931
ln_inc_per~p	1.144902	1.031322	.1135797	.1134406

b = consistent under Ho and Ha; obtained from xtreg
 B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Test: Ho: difference in coefficients not systematic

```
chi2(4) = (b-B)'[(V_b-V_B)^(-1)](b-B)
          = 8.77
Prob>chi2 = 0.0671
```

The Hausman test statistic is equal to 8,77 with $P > X^2 = 0,0671$. We accept the null hypothesis on the 5% level of significance and choose random-effect model.

Model 2

Fixed-effects regression:

```
Fixed-effects (within) regression      Number of obs   =   473
Group variable (i): id_terminal        Number of groups =   121

R-sq:  within = 0.6839                  Obs per group:  min =    1
      between = 0.2382                    avg   =   3.9
      overall  = 0.4380                    max   =    8

corr(u_i, Xb) = -0.8386                  F(4, 348)       =  188.27
                                          Prob > F        =   0.0000
```

ln_spec_re~f	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
ln_spec_gr~f	.813385	.0310861	26.17	0.000	.7522448	.8745253
share_int	-.3908545	.2328403	-1.68	0.094	-.8488059	.0670969
ln_populat~n	1.395309	.4801902	2.91	0.004	.450869	2.339749
ln_inc_per~p	-.6057007	.2194243	-2.76	0.006	-1.037265	-.174136
_cons	-14.96915	5.857688	-2.56	0.011	-26.49007	-3.448221

```
sigma_u | 1.266386
sigma_e | .33918031
rho | .93306677 (fraction of variance due to u_i)
```

```
F test that all u_i=0:      F(120, 348) = 3.14      Prob > F = 0.0000
```

Random-effects GLS regression:

```

Random-effects GLS regression           Number of obs   =       473
Group variable (i): id_terminal        Number of groups =       121

R-sq:  within = 0.6767                  Obs per group: min =        1
        between = 0.7677                  avg =                3.9
        overall = 0.7878                  max =                8

Random effects u_i ~ Gaussian          Wald chi2(4)     =    1121.07
corr(u_i, X) = 0 (assumed)             Prob > chi2      =        0.0000

```

ln_spec_re~f	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
ln_spec_gr~f	.8664878	.0270091	32.08	0.000	.8135509	.9194247
share_int	-.3028431	.1435026	-2.11	0.035	-.5841032	-.0215831
ln_populat~n	.1030487	.0441266	2.34	0.020	.0165621	.1895353
ln_inc_per~p	-.1387367	.1386175	-1.00	0.317	-.4104219	.1329485
_cons	-1.049545	1.466633	-0.72	0.474	-3.924093	1.825002
sigma_u	.3697217					
sigma_e	.33918031					
rho	.54300285	(fraction of variance due to u_i)				

Hausman test:

```
. hausman fixed
```

	---- Coefficients ----			
	(b)	(B)	(b-B)	sqrt(diag(V_b-V_B))
	fixed	.	Difference	S.E.
ln_spec_gr~f	.813385	.8664878	-.0531028	.01539
share_int	-.3908545	-.3028431	-.0880114	.183362
ln_populat~n	1.395309	.1030487	1.29226	.4781584
ln_inc_per~p	-.6057007	-.1387367	-.4669639	.1700948

b = consistent under Ho and Ha; obtained from xtreg
B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Test: Ho: difference in coefficients not systematic

```

chi2(4) = (b-B)'[(V_b-V_B)^(-1)](b-B)
          =      20.98
Prob>chi2 =      0.0003

```

The Hausman test statistic is equal to 20,98 with $P > X^2 = 0,0003$. We reject the null hypothesis and choose fixed-effect model on the 1% level of significance.

Model 3

Fixed-effects regression

```

Fixed-effects (within) regression           Number of obs   =    1058
Group variable (i): id_terminal            Number of groups =     198

R-sq:  within = 0.0631                  Obs per group: min =        1
        between = 0.0022                  avg =                5.3

```

```

overall = 0.0157                                max = 9
corr(u_i, Xb) = -0.4295                        F(3,857) = 19.22
                                                Prob > F = 0.0000

```

spec_gr_re~f	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
spec_sqf	-.1942008	.0293137	-6.62	0.000	-.2517358	-.1366658
spec_sqf_2	7.20e-06	1.46e-06	4.94	0.000	4.34e-06	.0000101
spec_sqf_3	-7.10e-11	1.67e-11	-4.26	0.000	-1.04e-10	-3.83e-11
_cons	1642.589	89.25191	18.40	0.000	1467.411	1817.767
sigma_u	863.54807					
sigma_e	824.26159					
rho	.523264	(fraction of variance due to u_i)				

```

F test that all u_i=0:      F(197, 857) = 4.06      Prob > F = 0.0000

```

Random-effects GLS regression:

```

Random-effects GLS regression                Number of obs = 1058
Group variable (i): id_terminal             Number of groups = 198

R-sq:  within = 0.0588                      Obs per group: min = 1
       between = 0.0040                      avg = 5.3
       overall = 0.0189                      max = 9

Random effects u_i ~ Gaussian                Wald chi2(3) = 33.77
corr(u_i, X) = 0 (assumed)                  Prob > chi2 = 0.0000

```

spec_gr_re~f	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
spec_sqf	-.115335	.0207579	-5.56	0.000	-.1560197	-.0746503
spec_sqf_2	4.88e-06	1.06e-06	4.59	0.000	2.79e-06	6.96e-06
spec_sqf_3	-5.23e-11	1.31e-11	-3.99	0.000	-7.80e-11	-2.66e-11
_cons	1313.478	76.52159	17.16	0.000	1163.499	1463.458
sigma_u	598.56782					
sigma_e	824.26159					
rho	.34527	(fraction of variance due to u_i)				

Hausman test:

```
. hausman fixed
```

	---- Coefficients ----			
	(b) fixed	(B) .	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
spec_sqf	-.1942008	-.115335	-.0788658	.0206979
spec_sqf_2	7.20e-06	4.88e-06	2.32e-06	9.99e-07
spec_sqf_3	-7.10e-11	-5.23e-11	-1.87e-11	1.03e-11

```

b = consistent under Ho and Ha; obtained from xtreg
B = inconsistent under Ha, efficient under Ho; obtained from xtreg

```

```
Test: Ho: difference in coefficients not systematic
```

$$\begin{aligned}
\text{chi2(1)} &= (b-B)'[(V_b-V_B)^{-1}](b-B) \\
&= 14.52
\end{aligned}$$

Prob>chi2 = 0.0001

The Hausman test statistic is equal to 14,52 with $P > \chi^2 = 0,0001$. We reject the null hypothesis and choose fixed-effect model on the 1% level of significance.

Model 4

Fixed-effects regression:

```
Fixed-effects (within) regression          Number of obs   =       667
Group variable (i): id_terminal          Number of groups =       160

R-sq:  within = 0.1589                   Obs per group:  min =         1
        between = 0.1006                                     avg  =         4.2
        overall = 0.1507                                     max  =         9

corr(u_i, Xb) = -0.2235                   F(3,504)        =       31.75
                                                Prob > F        =       0.0000
```

spec_gr_re~f	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
spec_sqf	-3.05102	.3846067	-7.93	0.000	-3.80665	-2.29539
spec_sqf_2	.0011611	.000192	6.05	0.000	.0007839	.0015383
spec_sqf_3	-1.34e-07	2.66e-08	-5.03	0.000	-1.86e-07	-8.16e-08
_cons	3050.404	208.9343	14.60	0.000	2639.914	3460.893
sigma_u	935.1162					
sigma_e	941.6127					
rho	.49653844	(fraction of variance due to u_i)				

F test that all u_i=0: F(159, 504) = 3.02 Prob > F = 0.0000

Random-effects GLS regression:

```
Random-effects GLS regression          Number of obs   =       667
Group variable (i): id_terminal          Number of groups =       160

R-sq:  within = 0.1564                   Obs per group:  min =         1
        between = 0.1058                                     avg  =         4.2
        overall = 0.1571                                     max  =         9

Random effects u_i ~ Gaussian           Wald chi2(3)    =       108.14
corr(u_i, X) = 0 (assumed)             Prob > chi2     =       0.0000
```

spec_gr_re~f	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
spec_sqf	-2.616249	.3037629	-8.61	0.000	-3.211614	-2.020885
spec_sqf_2	.0010486	.000153	6.85	0.000	.0007486	.0013486
spec_sqf_3	-1.24e-07	2.13e-08	-5.80	0.000	-1.66e-07	-8.20e-08
_cons	2611.11	164.9629	15.83	0.000	2287.789	2934.431
sigma_u	627.53361					
sigma_e	941.6127					
rho	.30755101	(fraction of variance due to u_i)				

corr(u_i, Xb) = -0.2510 Prob > F = 0.0000

ln_fb_rent~f	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
ln_fb_gr_r~f	.9592547	.1176305	8.15	0.000	.7263934	1.192116
ln_inc_per~p	1.986626	.626117	3.17	0.002	.7471654	3.226088
share_busi~s	.6742399	.1994353	3.38	0.001	.2794378	1.069042
_cons	-22.79204	6.322101	-3.61	0.000	-35.30727	-10.27681
sigma_u	.53555448					
sigma_e	.41893972					
rho	.62037758	(fraction of variance due to u_i)				

F test that all u_i=0: F(82, 122) = 1.88 Prob > F = 0.0008

Random-effects GLS regression:

Random-effects GLS regression Number of obs = 208
 Group variable (i): id_terminal Number of groups = 83

R-sq: within = 0.4739 Obs per group: min = 1
 between = 0.8509 avg = 2.5
 overall = 0.8026 max = 6

Random effects u_i ~ Gaussian Wald chi2(3) = 562.48
 corr(u_i, X) = 0 (assumed) Prob > chi2 = 0.0000

ln_fb_rent~f	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
ln_fb_gr_r~f	1.061006	.0500389	21.20	0.000	.9629318	1.159081
ln_inc_per~p	.3239615	.2724186	1.19	0.234	-.2099692	.8578922
share_busi~s	.3386864	.1549132	2.19	0.029	.035062	.6423108
_cons	-5.879404	2.768174	-2.12	0.034	-11.30493	-.4538828
sigma_u	.28432449					
sigma_e	.41893972					
rho	.31535061	(fraction of variance due to u_i)				

Hausman test:

. hausman fixed

	---- Coefficients ----			
	(b)	(B)	(b-B)	sqrt(diag(V_b-V_B))
	fixed	.	Difference	S.E.
ln_fb_gr_r~f	.9592547	1.061006	-.1017515	.1064567
ln_inc_per~p	1.986626	.3239615	1.662665	.5637469
share_busi~s	.6742399	.3386864	.3355536	.1256039

b = consistent under Ho and Ha; obtained from xtreg
 B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Test: Ho: difference in coefficients not systematic

chi2(3) = (b-B)'[(V_b-V_B)^(-1)](b-B)
 = 10.75
 Prob>chi2 = 0.0132

The Hausman test statistic is equal to 10,75 with $P > \chi^2 = 0,0132$. We reject the null hypothesis and choose fixed-effect model on the 5% level of significance.

Model 7

Fixed-effects regression:

```
Fixed-effects (within) regression      Number of obs      =      404
Group variable (i): id_terminal       Number of groups   =      145

R-sq:  within = 0.0635                Obs per group: min =      1
      between = 0.0510                  avg   =      2.8
      overall = 0.0187                  max   =      7

corr(u_i, Xb) = -0.4745                F(3,256)           =      5.78
                                           Prob > F           =      0.0008
```

fb_gr_rev_~f	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
fb_sqf	-.2214313	.0574114	-3.86	0.000	-.33449	-.1083727
fb_sqf_2	9.45e-06	2.94e-06	3.22	0.001	3.66e-06	.0000152
fb_sqf_3	-1.00e-10	3.90e-11	-2.58	0.011	-1.77e-10	-2.37e-11
_cons	1859.444	258.0695	7.21	0.000	1351.235	2367.654
sigma_u	664.40062					
sigma_e	649.00022					
rho	.51172397	(fraction of variance due to u_i)				

F test that all u_i=0: F(144, 256) = 2.65 Prob > F = 0.0000

Random-effects GLS regression:

```
Random-effects GLS regression      Number of obs      =      404
Group variable (i): id_terminal       Number of groups   =      145

R-sq:  within = 0.0498                Obs per group: min =      1
      between = 0.0826                  avg   =      2.8
      overall = 0.0310                  max   =      7

Random effects u_i ~ Gaussian        Wald chi2(3)       =      16.55
corr(u_i, X) = 0 (assumed)          Prob > chi2        =      0.0009
```

fb_gr_rev_~f	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
fb_sqf	-.0875828	.0266571	-3.29	0.001	-.1398297	-.0353358
fb_sqf_2	3.57e-06	1.55e-06	2.30	0.021	5.28e-07	6.60e-06
fb_sqf_3	-4.24e-11	2.46e-11	-1.72	0.085	-9.07e-11	5.84e-12
_cons	1280.109	120.0879	10.66	0.000	1044.741	1515.477
sigma_u	339.55184					
sigma_e	649.00022					
rho	.21490429	(fraction of variance due to u_i)				

Hausman test:

. hausman fixed

	---- Coefficients ----			
	(b)	(B)	(b-B)	sqrt(diag(V_b-V_B))
	fixed	.	Difference	S.E.
fb_sqf	-.2214313	-.0875828	-.1338486	.0508475
fb_sqf_2	9.45e-06	3.57e-06	5.89e-06	2.50e-06
fb_sqf_3	-1.00e-10	-4.24e-11	-5.81e-11	3.03e-11

b = consistent under Ho and Ha; obtained from xtreg
 B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Test: Ho: difference in coefficients not systematic

$$\begin{aligned} \text{chi2}(1) &= (b-B)'[(V_b-V_B)^{-1}](b-B) \\ &= 6.93 \\ \text{Prob}>\text{chi2} &= 0.0085 \end{aligned}$$

The Hausman test statistic is equal to 6,93 with $P > X^2 = 0,0085$. We reject the null hypothesis and choose fixed-effect model on the 1% level of significance.

Model 8

Fixed-effects regression:

Fixed-effects (within) regression
 Group variable (i): id_terminal

Number of obs = 294
 Number of groups = 112

R-sq: within = 0.1518
 between = 0.0953
 overall = 0.0646

Obs per group: min = 1
 avg = 2.6
 max = 7

corr(u_i, Xb) = -0.6892

F(3,179) = 10.68
 Prob > F = 0.0000

fb_gr_rev_~f	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
fb_sqf	-.2462291	.2943049	-0.84	0.404	-.8269825	.3345243
fb_sqf_2	-.0000263	.0000502	-0.52	0.601	-.0001255	.0000728
fb_sqf_3	2.54e-09	2.38e-09	1.07	0.287	-2.15e-09	7.22e-09
_cons	2497.636	453.993	5.50	0.000	1601.769	3393.502
sigma_u	852.32669					
sigma_e	722.29803					
rho	.58201827	(fraction of variance due to u_i)				

F test that all u_i=0: F(111, 179) = 2.03 Prob > F = 0.0000

Random-effects GLS regression:

Random-effects GLS regression
 Group variable (i): id_terminal

Number of obs = 294
 Number of groups = 112

R-sq: within = 0.1221
 between = 0.1009
 overall = 0.0809

Obs per group: min = 1
 avg = 2.6
 max = 7

Random effects u_i ~ Gaussian

Wald chi2(3) = 16.61


```

fb_sqf_2 | 2.28e-06 2.68e-07 8.50 0.000 1.75e-06 2.81e-06
fb_sqf_3 | -1.12e-11 1.44e-12 -7.79 0.000 -1.40e-11 -8.36e-12
_cons | 2430.362 130.6867 18.60 0.000 2173.678 2687.047
-----+-----
sigma_u | 908.87751
sigma_e | 545.57863
rho | .73511415 (fraction of variance due to u_i)
-----+-----
F test that all u_i=0: F(173, 572) = 5.79 Prob > F = 0.0000

```

Random-effects GLS regression:

```

Random-effects GLS regression      Number of obs   =      749
Group variable (i): id_terminal   Number of groups =      174

R-sq:  within = 0.1766             Obs per group:  min =      1
        between = 0.0009           avg =      4.3
        overall = 0.0164           max =      8

Random effects u_i ~ Gaussian      Wald chi2(3)    =      43.35
corr(u_i, X) = 0 (assumed)         Prob > chi2     =      0.0000

```

```

fb_gr_rev_~f |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-----+-----
fb_sqf | -.0606594   .0094349   -6.43  0.000   -0.0791514  -0.0421674
fb_sqf_2 | 1.16e-06   2.10e-07    5.55  0.000    7.53e-07   1.58e-06
fb_sqf_3 | -6.55e-12  1.18e-12   -5.55  0.000   -8.86e-12  -4.23e-12
_cons | 1582.687   95.6611    16.54  0.000   1395.194   1770.179
-----+-----
sigma_u | 526.36632
sigma_e | 545.57863
rho | .4820829   (fraction of variance due to u_i)
-----+-----

```

Hausman test:

```
. hausman fixed
```

```

----- Coefficients -----
      |      (b)      (B)      (b-B)      sqrt(diag(V_b-V_B))
      |      fixed      .      Difference      S.E.
-----+-----
fb_sqf | -.1368915  -.0606594  -.0762321  .0093994
fb_sqf_2 | 2.28e-06  1.16e-06  1.12e-06  1.67e-07
fb_sqf_3 | -1.12e-11 -6.55e-12 -4.64e-12  8.17e-13
-----+-----

```

b = consistent under Ho and Ha; obtained from xtreg
B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Test: Ho: difference in coefficients not systematic

```

chi2(1) = (b-B)'[(V_b-V_B)^(-1)](b-B)
        = 65.78
Prob>chi2 = 0.0000

```

The Hausman test statistic is equal to 65,78 with $P > X^2 = 0,0000$. We reject the null hypothesis and choose fixed-effect model.

Model 10

Fixed-effects regression:

```

Fixed-effects (within) regression          Number of obs   =       550
Group variable (i): id_terminal           Number of groups =       144

R-sq:  within = 0.2113                    Obs per group:  min =        1
        between = 0.0022                  avg   =        3.8
        overall = 0.0070                  max   =        8

corr(u_i, Xb) = -0.6967                    F(3,403)       =       36.00
                                           Prob > F       =       0.0000
  
```

```

-----+-----
fb_gr_rev_~f |          Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-----+-----
      fb_sqf |   -0.6267896   .1031472    -6.08  0.000   -0.8295633   -0.4240158
      fb_sqf_2 |  .0000407   9.74e-06     4.18  0.000   .0000216   .0000598
      fb_sqf_3 |  -9.43e-10   2.74e-10    -3.44  0.001  -1.48e-09   -4.04e-10
      _cons |   3866.424   327.1004    11.82  0.000   3223.388   4509.46
-----+-----
      sigma_u |   1187.4368
      sigma_e |   511.68551
      rho |   .84339177   (fraction of variance due to u_i)
  
```

```

F test that all u_i=0:          F(143, 403) =      8.49          Prob > F = 0.0000
  
```

Random-effects GLS regression:

```

Random-effects GLS regression          Number of obs   =       550
Group variable (i): id_terminal           Number of groups =       144

R-sq:  within = 0.2110                    Obs per group:  min =        1
        between = 0.0023                  avg   =        3.8
        overall = 0.0071                  max   =        8

Random effects u_i ~ Gaussian          Wald chi2(3)    =       28.75
corr(u_i, X) = 0 (assumed)           Prob > chi2     =       0.0000
  
```

```

-----+-----
fb_gr_rev_~f |          Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-----+-----
      fb_sqf |   -0.2745472   .0831162    -3.30  0.001   -0.437452   -0.1116424
      fb_sqf_2 |  .0000174   8.25e-06     2.10  0.035   1.18e-06   .0000335
      fb_sqf_3 |  -3.98e-10   2.39e-10    -1.67  0.096  -8.66e-10   7.00e-11
      _cons |   2348.096   249.8298     9.40  0.000   1858.438   2837.753
-----+-----
      sigma_u |   782.31427
      sigma_e |   511.68551
      rho |   .70037677   (fraction of variance due to u_i)
  
```

Hausman test:

```
. hausman fixed
```

```

----- Coefficients -----
|          (b)          (B)          (b-B)          sqrt(diag(V_b-V_B))
|          fixed          .          Difference          S.E.
  
```

	b	B	b-B	(b-B)'[(V_b-V_B)^(-1)](b-B)
fb_sqf	-.6267896	-.2745472	-.3522424	.0610823
fb_sqf_2	.0000407	.0000174	.0000233	5.18e-06
fb_sqf_3	-9.43e-10	-3.98e-10	-5.45e-10	1.34e-10

b = consistent under Ho and Ha; obtained from xtreg
 B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Test: Ho: difference in coefficients not systematic

$$\begin{aligned} \text{chi2}(1) &= (b-B)'[(V_b-V_B)^{-1}](b-B) \\ &= 33.25 \\ \text{Prob}>\text{chi2} &= 0.0000 \end{aligned}$$

The Hausman test statistic is equal to 33,25 with $P > \chi^2 = 0,0000$. We reject the null hypothesis and choose fixed-effect model.

Model 11

Fixed-effects regression:

Fixed-effects (within) regression	Number of obs	=	735
Group variable (i): id_terminal	Number of groups	=	169
R-sq: within = 0.7318	Obs per group: min	=	1
between = 0.5028	avg	=	4.3
overall = 0.4925	max	=	8
corr(u_i, Xb) = -0.8722	F(4,562)	=	383.33
	Prob > F	=	0.0000

ln_fb_gr_r~f	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]
ln_fb_sqf	-.8066993	.0291324	-27.69	0.000	-.863921 - .7494776
ln_enp_pax	.7984019	.032087	24.88	0.000	.7353767 .8614271
ln_populat~n	1.019635	.3463298	2.94	0.003	.3393756 1.699893
ln_inc_per~p	1.3936	.1148932	12.13	0.000	1.167927 1.619273
_cons	-27.8252	4.509258	-6.17	0.000	-36.68226 -18.96814
sigma_u	1.00291				
sigma_e	.22387678				
rho	.95253484	(fraction of variance due to u_i)			

F test that all u_i=0: F(168, 562) = 11.43 Prob > F = 0.0000

Random-effects GLS regression:

Random-effects GLS regression	Number of obs	=	735
Group variable (i): id_terminal	Number of groups	=	169
R-sq: within = 0.7248	Obs per group: min	=	1
between = 0.6394	avg	=	4.3
overall = 0.6393	max	=	8
Random effects u_i ~ Gaussian	Wald chi2(4)	=	1667.11
corr(u_i, X) = 0 (assumed)	Prob > chi2	=	0.0000

ln_fb_gr_r~f	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
ln_fb_sqf	-.6997439	.024329	-28.76	0.000	-.7474279	-.6520599
ln_enp_pax	.7909132	.0264516	29.90	0.000	.7390691	.8427574
ln_populat~n	.0907432	.03284	2.76	0.006	.0263781	.1551083
ln_inc_per~p	1.457349	.0798173	18.26	0.000	1.30091	1.613788
_cons	-15.26342	.8812128	-17.32	0.000	-16.99057	-13.53627
sigma_u	.35260733					
sigma_e	.22387678					
rho	.71269691	(fraction of variance due to u_i)				

Hausman test:

. hausman fixed

	---- Coefficients ----			
	(b)	(B)	(b-B)	sqrt(diag(V_b-V_B))
	fixed	.	Difference	S.E.
ln_fb_sqf	-.8066993	-.6997439	-.1069554	.0160248
ln_enp_pax	.7984019	.7909132	.0074887	.0181629
ln_populat~n	1.019635	.0907432	.9288914	.3447693
ln_inc_per~p	1.3936	1.457349	-.0637489	.0826417

b = consistent under Ho and Ha; obtained from xtreg
 B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Test: Ho: difference in coefficients not systematic

$$\begin{aligned} \text{chi2}(4) &= (b-B)'[(V_b-V_B)^{-1}](b-B) \\ &= 81.55 \\ \text{Prob}>\text{chi2} &= 0.0000 \end{aligned}$$

The Hausman test statistic is equal to 81,55 with $P > \chi^2 = 0,0000$. We reject the null hypothesis and choose fixed-effect model.

Model 12

Fixed-effects regression:

Fixed-effects (within) regression
 Group variable (i): id_terminal

Number of obs = 150
 Number of groups = 62

R-sq: within = 0.3151
 between = 0.8988
 overall = 0.7808

Obs per group: min = 1
 avg = 2.4
 max = 6

corr(u_i, Xb) = 0.1659

F(3, 85) = 13.04
 Prob > F = 0.0000

ln_fb_rent~f	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
ln_fb_gr_r~f	1.016654	.1808752	5.62	0.000	.6570254	1.376282
share_busi~s	.1994211	.2438791	0.82	0.416	-.285476	.6843181
ln_dwelling_t~n	.2516983	.2291031	1.10	0.275	-.2038201	.7072167
_cons	-3.266183	1.41011	-2.32	0.023	-6.069859	-.462507

```

-----+-----
sigma_u | .29205726
sigma_e | .51061425
rho     | .24650705   (fraction of variance due to u_i)
-----+-----
F test that all u_i=0:      F(61, 85) =      0.69          Prob > F = 0.9352

```

Random-effects GLS regression:

```

Random-effects GLS regression           Number of obs   =      150
Group variable (i): id_terminal         Number of groups =       62

R-sq:  within = 0.3107                  Obs per group:  min =       1
        between = 0.9027                  avg   =       2.4
        overall = 0.7832                  max   =       6

Random effects u_i ~ Gaussian           Wald chi2(3)    =      527.39
corr(u_i, X) = 0 (assumed)              Prob > chi2     =      0.0000

```

```

-----+-----
ln_fb_rent~f |      Coef.   Std. Err.      z    P>|z|    [95% Conf. Interval]
-----+-----
ln_fb_gr_r~f |  1.086633   .0494569    21.97  0.000    .9896992    1.183567
share_busi~s |  .3772412   .1614299     2.34  0.019    .0608445    .693638
ln_dwll_t~n  |  .2197566   .1036171     2.12  0.034    .0166708    .4228424
      _cons  | -3.625734   .5098409    -7.11  0.000   -4.625004   -2.626464
-----+-----
sigma_u |      0
sigma_e |  .51061425
rho     |      0   (fraction of variance due to u_i)
-----+-----

```

Hausman test:

```
. hausman fixed
```

```

-----+-----
          ---- Coefficients ----
          |      (b)      (B)      (b-B)      sqrt(diag(V_b-V_B))
          |      fixed      .      Difference      S.E.
          |-----+-----
ln_fb_gr_r~f |  1.016654   1.086633   -.0699794   .1739823
share_busi~s |  .1994211   .3772412  -.1778201   .1828043
ln_dwll_t~n  |  .2516983   .2197566   .0319417   .2043324
-----+-----

```

b = consistent under Ho and Ha; obtained from xtreg
B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Test: Ho: difference in coefficients not systematic

```

chi2(3) = (b-B)'[(V_b-V_B)^(-1)](b-B)
         =      1.02
Prob>chi2 =      0.7958

```

The Hausman test statistic is equal to 1,02 with $P > \chi^2 = 0,7958$. We accept the null hypothesis and choose random-effect model.