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Abstract

The purpose of this study is to find the expenditure elasticity of demand for leisure travel abroad by aviation for Swedish Households. The study uses household expenditure survey data compiled by Statistics Sweden in 2012. The independent variable ”Flight” has numerous values of zero, as many households spend no money this type of travel. Having zero values for the dependent variables leads to the so-called censored variable problem where a regular OLS regression leads to a downward bias. This is a well-known problem for expenditure survey data that is dealt with using a Tobin Model. This study finds elasticity values ranging from 2.612 to 2.933. Unfortunately, the models were rejected when the errors of the models failed the tests for Normality and Homoskedasticity. Suggestions for further research and improved models are made.

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1 Introduction

One of the main market-based instruments available to policy makers has always been taxation. Concern over global warming has incurred a debate on whether aviation travel should internalize social costs that are created through the release of carbon dioxide. Classic economic models advocate for the use of taxes to be implemented in this manner in order to minimize externalities and maximize social benefit. The natural opponents to such taxes are of course the aviation industry and the BASIC countries as they see the threat of taxes as an attack on their business model(Navarro, 2016). They argue that such a tax would result in a large loss of jobs to the economy and the benefits of the tax don't outweigh the losses it would incur.

Determining whose arguments deserves most merit depends on numerous factors. Analysis of the impact of taxation usually begins with understanding the effect on demand. Some of the important factors are the income elasticity of demand and the price elasticity of demand for aviation travel. Using elasticity values, economists can identify the appropriate amount of tax to offset the externalities whether it is in a pigouvian form or another. Therefore, finding the right level of elasticity plays a central role in the analysis of the impact of taxes.

There have been studies attempting to determine the elasticity of demand for aviation travel, however, in practice it is rather sensitive to the country, area, sample, variables chosen, and model used among other things. Expenditure elasticity of demand is the percentage change in expenditure on a good or service given a percentage change in total expenditure (Mankiw, 2007).

The aim of this study is find an income elasticity of demand for Swedish households using detailed data provided by Statistics Sweden. This will be achieved by finding the slope of the share of Household Expenditure on Flights in relation to Total Household Expenditure using a Tobit Model.

The first section of this paper will summarize the previous literature conducted on the subject and provide some background for context. The second part examines the data and explains the chosen methodology. The third part discusses the model. In the fourth part the results are presented and examined. Finally the paper will discuss the limitations and conclude.

2 Literature Review

One of the earliest studies on the subject of demand for aviation was done by Mutti and Murai (1977) who estimate the demand function of the aviation market as a whole. They analyse how airlines can raise revenues and profits through a combination of cost cutting and raising airfares. In their study the importance of price and income elasticity is paramount to getting the balance right. They estimate income and price elasticity for a number of different countries with a wide range of results. The income elasticity for the United Kingdom was the relatively high at 4.38 while the lowest was The Netherlands with 1.77. The overall income elasticity was estimated to be 1.89. This would suggest that flying is indeed a luxury good, which it most likely was during the time period surveyed. Fare elasticity, which is essentially the price elasticity of demand, was estimated to be -0.89 meaning that it is inelastic with regard to price.

Brons et al. (2002) examine the price elasticity of demand for passenger air travel using a meta-analysis. They analyze shared and non-shared factors that affect price elasticity. Focus is placed on the importance of substitutes that affect price elasticity. Their result show that price elasticity is higher in the long run, as theorized, whereas business passengers are about 0.6 points less price sensitive than non-business. However, over time and distance passengers seem to become less price sensitive. Another important finding is that income should not be omitted as a variable as it creates and upwards bias in price sensitivity.

Chi and Baek (2012) look at the demand for passenger travel using a dynamic demand analysis. They modify the typical demand function based on price of modes of transport, budget and others and instead model demand based on price of air-travel, income, population, the NASDAQ index and seat capacity. They assume that in the US there are no real good substitutes for air travel. They then analyze this demand function using a Johansen co-integration test and vector error correction model.

Through econometric modelling Chi and Baek (2012) come to the conclusion that income and air-fare are weakly exogenous variables. In other words, these variables can change the demand for passenger travel on their own. They also affect the other variables modelled while the other variables to not affect them. Income was found to be the strongest variable affecting demand with an elasticity greater than 3.5 while price of airfare had an elasticity of roughly 1.5. They also concluded that their study showed that a non-dynamic model does a poor job of analyzing the market demand for aviation services.

Gallet and Doucouliagos (2014) use a meta-analysis/meta-regression technique to estimate of income elasticity of air travel. They look at 51 peer-reviewed and non-peer reviewed (working papers) to deduce that income elasticity is 1.546 for international routes but only 0.633 when air fare is included in a dynamic specification model. Excluding air fare would induce an upward bias. Baseline domestic routes have an income elasticity of 1.186. They also control for publication selection bias, where authors try to make findings more significant than they are, but find no evidence of it.

Gallet and Doucouliagos (2014) point out that income elasticity indicates whether a market is mature or not. Values that are higher than unity indicate that the market is not mature and that the good in question is a luxury. A value between 0 and 1 indicate a normal good and a rather mature market whereas a value of 0 would indicate a fully mature market. This has important policy implications when considering appropriate levels of taxation.

Leander (2015) examines the income and price elasticity of aviation transport in Sweden using household expenditure data as a proxy for income data. Her results show an income elasticity of -2.04 and a price elasticity of -2.53. However, she cautions using her results, as she doubts their accuracy, citing problems with limited data and proxies. Her paper is largely a policy analysis of how costs of CO2 emissions can be internalized in practice and by what amount through the use of her estimate for income and price elasticity.

Leander (2015) models a simple pooled OLS regression using expenditure deciles and time series data for 2003-2008 and 2012. She tests whether fixed or random effects models would have been more appropriate and finds that neither would have improved the model.

Her regression is modelled as such:

$$lnQ_{it} = \eta_E lnE_{it} + \eta_P lnP_t + \beta + \epsilon_{it} \tag{1}$$

where η_E and η_P are income and price elasticity respectively.

The data seems to suggest that the income effect is rather strong (Leander, 2015), e.g. a rise in income gives rise to a disproportionally large share of expenditure on flights resulting in a larger share at higher levels of income. However, at lower level of the expenditure scale the share seems more constant.

This paper will differ from the study by Leander (2015), as it is more empirical in its approach compared to Leander (2015) policy review and analysis. It uses detailed micro-data provided by SCB rather than the aggregated data used by Leander (2015). While there is an overlap in the studies, this study proposes an alternative model.

However, the work done by Leander (2015) is the essentially the springboard for this study. Her data comes from the same source, the SCB, but is aggregated. Her econometric modelling is therefore simpler. However, her method and ideas are still well done and correct.

3 Background and Policy Implications

Aviation travel makes up a relatively small proportion of total greenhouse gas emissions when compared to other forms of travel. However, it is very resource intensive in the sense that it releases a lot of CO2 per mile travelled. It is also one of the fasted growing industries for passenger travel. As Leander (2015) points out, in Sweden there is a large debate ongoing about placing a tax on aviation travel. Leander (2015) makes the point that a high income elasticity would imply that taxation would less effective at curbing emissions if compared to having a high price elasticity. Being price sensitive would mean taxes would significantly reduce consumption of aviation travel. However, there is less that can be done in terms of policy when increasing consumption is driven by income growth. No government that would want to be re-elected would sacrifice income growth for reducing the amount of travel by aviation.

This study does looks only at income elasticity and ignores price elasticity as there is no readily available accurate data on the price of aviation travel. However, for policy-makers this study would still be interesting if it were to find a low income elasticity. This would mean there is a higher chance that placing carbon-taxes on aviation travel could be an effective viable option.

4 Data

This study derives the expenditure elasticity of aviation travel from a 2012 Swedish Household Expenditure Survey conducted by Statistics Sweden. The households are randomly selected to participate in the survey. The survey asks participants to fill out their annual expenditure on goods and services as well as basic information pertaining to characteristics of the household and the individuals residing within them.

The data provided by Statistics Sweden for each year comes in two data-sets; one at the household-level with 2871 households and the other at the individual-level with 7070 individuals. The individual-level data contains information on age, sex, level of education, type of work and rank in household. The household-level data has information about the type of household, the region it is in, size of household, household income, number of individuals residing in the household, and total household expenditure.

5 Methodology

In order to use the information provided by both datasets simultaneously the household-level and the individual-level are merged using unique identification numbers that link which individuals belong to which household. This allows information on individuals such as age or level of education to be used as regressors as well as household expenditures from the household-level dataset. The merging process conveniently identifies the rank of the individuals in the household and their respective characteristics.

This method of merging does have its drawbacks. The number of individuals in a household has a positive correlation of 0.362 with total expenditure level. There is no way of knowing who is responsible for a certain expenditure decision in a household unless it is a single person household. However, the data does identify a head of household and rank of a person in a household. Many multi-person households will likely have the first and second ranked person making the expenditure decision. This aspect has to be taken into consideration when specifying the regressors used in the model.

In this study to find the income elasticity of demand for aviation travel for leisure purposes, the Total Household Expenditure is chosen as the indicator for income rather than Total Household Income. Total Household Income can has a higher variation and can even be negative or close to zero. Negative income implies the household is going into debt. It is by definition impossible to have a negative income and still spend money on goods and services unless the household has savings, receives government aid or takes private loans. This form of income will be captured by the data in Total Household Expenditure. Using Total Household expenditure also eliminates the issue of having flight expenditures that are higher than income.

For this study the expenditure on flight travel in relation to total expenditure is of prime interest. However, Statistics Sweden has no category for Total Flight Expenditure. They have bundled expenditure on leisure flight travel together abroad with expenditure on hotels abroad. This is unfortunate as there is no way to disentangle the two. The data also only considers leisure travel and not business flights but considering that business travel is almost independent of income this is in fact a convenience. These limitations are not optimal but I assume that as a proxy for flight expenditure it is close enough and that expenditure on flight travel and hotels will be roughly proportional. Therefore, the elasticity should not be too affected and be reasonably close to the true value. In the rest of the study this category will be referred to as Flight Expenditures to keep the aim in focus.

It is important to note that Statistics Sweden provided data for 2003 to 2009, however, those years are deemed surplus requirement for this study as the data is unbalanced. In layman terms this means that it is not the same households that fill in the survey every time during the survey periods. Therefore, the data is best treated as cross-sectional rather than panel. For this study only the data for year 2012 will be used as it is a sufficiently large random sample and the latest data available. Furthermore, without price data across years annual comparisons lose meaning as the average flight prices could theoretically vary significantly.

The data shows that almost half of the households spend no money of Flight Expenditures in 2012. Having 0 values is a problem that is inherent in studies that use household expenditure data (Aristei and Pieroni, 2008). A basic approach would be to implement a simple OLS regression as used by Leander (2015). In this case, however, it would result in a downward bias (Cameron and Trivedi, 2009). An alternative method would be to disregard the 0 values and implement the regression on the positive values, but discarding roughly half of the data would violate the random sampling assumption that is critical for inference (Amemiya, 1973). To deal with this issue Tobin (1958) devised a model that deals with these biases. It is his model that forms the basis for this study. Therefore, a fundamental understanding of the Tobit Model is necessary for its implementation.

6 The Tobit Model

6.1 Understanding zero expenditures and why they should not be ignored

When choosing an appropriate model for the consumption of flight expenditure it is helpful to understand the consumers decision making process. Costs for flights have come down a lot in the last few decades making long distance leisure travel accessible to more people than ever(Thompson, 2013). However, flight tickets are still a substantial budget outlay for most people, especially larger families. In the cases where we have a budget constraint situation that results in zero expenditure on flights we will have a corner solution. In this case zero expenditure is a limiting factor for the amount a family would spend on flights.

Another factor that could skew the data towards zero expenditures on Flight Travel is that a household's budget might only allow for an exotic holiday abroad every so often; maybe only every second year or third year. For example, in a given year there might be a probability of 0.5 that the household spends nothing on flight travel, however, the long-term average expenditure is a small positive value.

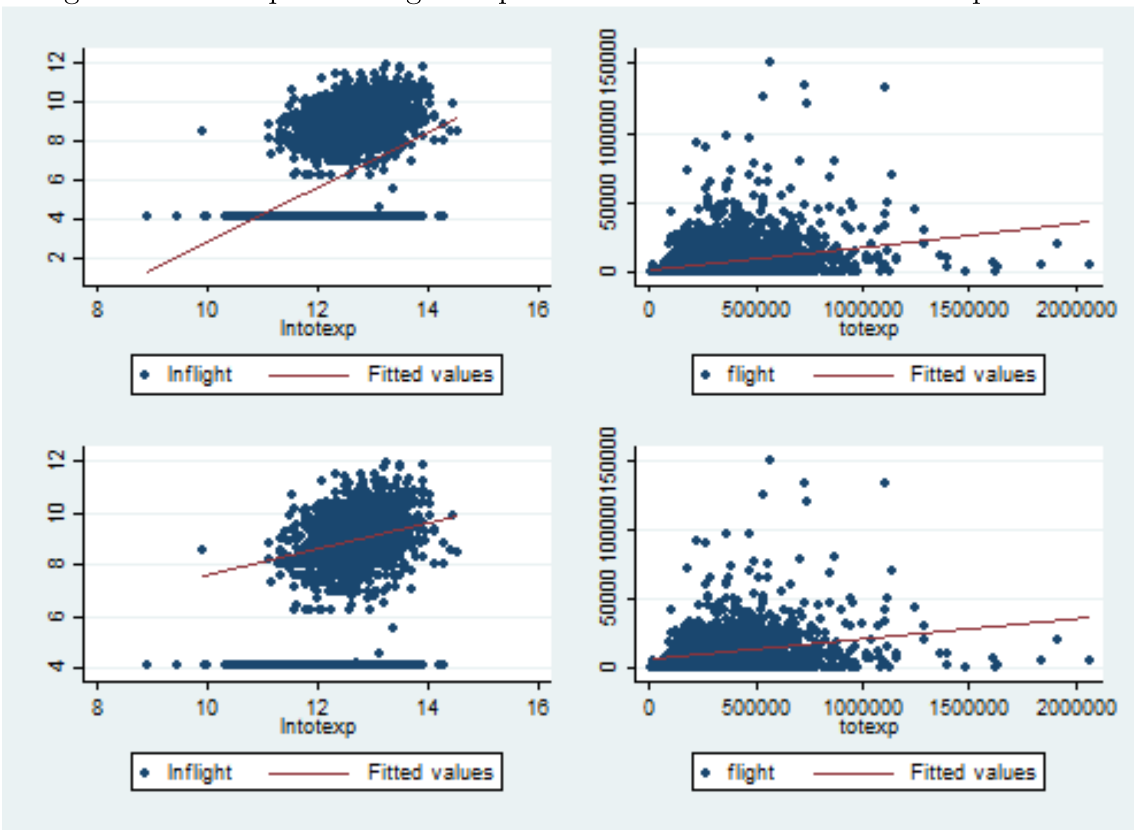
To use the Tobit Model it is important to consider why the dependent variable might theoretically have negative values. A large proportion of Swedish households and families are known to have a summer houses spread around the vast country side. Many households actively invest and spend their vacations in them. It could therefore be argued that to make them travel abroad via aviation travel one would even have to pay them. Their willingness to pay for a holiday abroad is negative as they would prefer staying by their summer houses by the lake and forests.

6.2 Theory behind the Model

This study analyses the Flight Expenditure in relation to Total Household Expenditure. A simplistic method of estimating the elasticity would be to regress the log form of Flight Expenditure, $\ln \chi_i$, as the dependent variable and the log form of Total Expenditure, $ln\epsilon_i$, as the independent variable to provide the expenditure elasticity.

$$\ln \chi_i = \beta + ln\epsilon_i \tag{2}$$

Figure 1: Scatterplot of Flight Expenditure and Total Household Expenditure.



However, due to the nature of the data used in this study, the main reason that this model would not work is that it suffers from the censored data problem. The zero expenditure limit on flight expenditure creates a bias as it leads to an overestimation of demand at lower levels. A simple scatter plot with a line of best fit of the data in log form illustrates the problem as can be seen in Figure 1.

To deal with this so-called censored sample problem, Tobin (1958) developed a modification of the Truncated Regression Model and Probit Model that allowed an unbiased estimation. His model makes use of a latent variable. A latent variable is a variable that is not directly observed but rather inferred from other variables that are observed Amemiya (1973). The latent variable is assumed to have a linear relation to a vector of influencing variables F_i and undetectable factors ϵ_i (Pawlowski and Breuer, 2012). This latent variable can also be negative in contrast to observed variables (Cameron and Trivedi, 2009).

The Tobit Model makes rigid assumptions about the conditional data distribution and functional form. The model rests on the assumption of normality and homoskedasticity of the error terms. Furthermore, the conditional mean is different from the OLS because of the censoring and therefore inference must be made accordingly.

The model of the latent variable is as such,

$$s_i = \beta F_i + \epsilon_i \tag{3}$$

Where i is an individual household, s_i is the latent variable and F_i are the vectors of the influencing variables and ϵ_i are the unobserved influences that is iid $N(0, \sigma^2)$.

If a household i spends money on leisure flight travel s_i then the latent variable has a the positive value s_i. The observed household expenditure $i(s_i)$ is different from the unobservable variable s_i as it cannot attain a negative value. When the latent variable is negative then the household will not spend any money on leisure flight travel.

s_i^* is the latent variable. In other words zero expenditure share on leisure travel is the lower limit which creates a censored variable bias.

$$s_i = \begin{cases} s_i^*, & \text{if } (s_i^* > 0) \\ 0, & \text{if } (s_i^* \leqslant 0) \end{cases} \tag{4}$$

Following the footsteps of Tobin (1958) and Pawlowski and Breuer (2012) the likelihood function is expressed as shown below. It consists of the product of the probability that households do not spend money on leisure flight travel $[Pr = (s_i = 0)]$ and the product of the probability that they do $[Pr = (s_i = s_i^*)]$.

$$L(\beta, \sigma_e) = \prod_{censored} Pr(s_i = 0) \prod_{uncensored} Pr(s_i = s_i^*) \tag{5}$$

Or in more detail using similar notation to Caudill and Mixon Jr (2009)

$$L(\beta, \sigma_e) = I_i \left(\frac{s_i - F_i\beta}{\sigma} \right) + (1 - I_i)(1 - \left(\frac{1 - F_i\beta}{\sigma} \right) \tag{6}$$

Where I_i is a dummy variable equal to 1 if $y > 0$ and 0 if $y = 0$, is the density function and is distribution function of a standard normal random variable. The Tobit regression uses a maximum likelihood (ML) estimator (Cameron and Trivedi, 2009) . The density function used to find the ML consists of a part for the censored variables and non-censored variables. For the estimator to be consistent, the assumptions of normality and homoskedasticity should not be violated (Pagan and Vella, 1989). Therefore, these properties must be tested for as well.

7 The Model

This Tobit Model makes use of various explanatory variables. In its simplest form the model has only total expenditure as the independent variable. Such a simplistic model could suffer from omitted variable bias (Amemiya, 1973). Therefore, the model tests other variables that could theoretically influence the amount of money spent on leisure travel by flights. The variables tested for significance are Total Household Expenditure, Region, Level of Education, Type of Work, and Age.

A quick overview of the sample of individuals will help provide an understanding for the rational for testing certain explanatory variables. Slightly more half of the sample is female and the average age is 36. Almost 59.5 percent of heads of households are men. The mean spent on flight travel per year is 2,446 SEK with the average income of 133,033 SEK making it 1.84 percent of the budget. This is not a large amount but the standard deviation of flight travel expenditure is rather high with 5595 SEK. As 0 SEK is the lower limit for expenditure on flights we can see from this data alone that the data is skewed and not normally distributed.

Total Household Expenditure contains by definition the expenditure on flight travel abroad by households. This creates a problem when Total Household Expenditure is used as an explanatory variable as one would be partly explaining changes expenditure on Flight travel using Flight travel itself. To avoid this conceptual error the amount of expenditure on flight travel will be subtracted from Total Household Expenditure when using it as a covariate in a regression.

Certain outliers are also removed from the sample. The average household has a share of expenditure on flights of 1.97% with a standard deviation of 4.32%. The average household that actually spends money on aviation travel abroad has a share of expenditure on flights of 4.14% with a standard deviation of 5.51%. It is be considered highly unlikely that a household would therefore spend more than 25% of the total household expenditure on flight travel abroad. Such a huge share is more likely the result of a data entry mistake or a mistake made by the survey participant in estimating expenditures. This results in only 6 outliers being removed so it will not affect the results significantly.

Regions where people live can logically affect expenditure on flights. The regions are separated by the SCB into categories according to density. The baseline region is Stockholm, which is the densest populated in Sweden. Regions 3, 4, 5, and 6 are decreasing in density. Region 3 has over 90000 people living with a 30km radius of the town centre. Region 4 has between 27000 and 90000 people living within a 30km radius of the town centre and more than 300000 within a 100km radius. Region 5 is like 4 except it has less that 300000 people within a 100km radius. Region 6 is the least dense with under 27000 people living within a 30km radius of the town centre. Region 8 and 9 are the cities and surrounding areas of Gothenburg and Malmo respectively.

This study speculates that distance to major airports is a important factor that affects a households choice for Flight Expenditures. Households that are in one of the three largest cities with international airports, Stockholm, Gothenburg, and Malmo, will find it far more convenient to fly abroad than households that have a long journey to the airport. There, is of course a risk that households in cities have higher incomes than households in less densely populated regions, however, given the relatively low income inequality in Sweden this effect will probably be weak at best.

Statistics Sweden has divided the variable Type of Work into 9 different categories.

Table 1: Type of Work

Number Label	**Description**
1	Employed
2	Self-employed in limited company
3	Self-employed in non-limited company
4	Farmer
5	Student
6	Unemployed
7	Pensioner/Stay-at-home partner
8	Other work
9	Don't know/Doesn't want to respond

Statistics Sweden has divided the variable Level of Education into 6 different categories.

Table 2: Level of Education

Number Label	Description
1	Pre-high School education that is less than 9 years
2	Pre-high School education that is 9 years or similar
3	High-School education
4	Post High-School education less than 3 year
5	Post High-School education more than 3 year
6	Post-doc education
9	Lacking Information/Other

For the categories Level of Education, Type of Work, and Age, this study chooses to test only these individual characteristics on the Head of the Household. This is mainly done for two reasons. The first being that the head of the household is most likely to weigh heavily in big decisions such as whether or not to travel abroad on a holiday and how much to spend on it. The second is that, by definition, all households have at least one person in them. There are fewer households with two people and so on. Therefore, the sample size decreases with every extra person included in the model which significantly lowers the chances of getting results that have strong significance (a low p-value).

It is important to note that there are many variables in the dataset provided by Statistics Sweden that are not included in the regression models used in this paper. These variables are excluded because when tested they were not significant enough to be interesting. For example Sex of the head of the household played never significant when adding virtually any other variables to the model. So, for the sake of simplicity and clarity, they are ignored in this paper but have been tested nevertheless.

8 Results

It bears repeating that the relationship of interest for this study is how responsive a household's Flight Expenditure is given a change in Household Income, which is approximated by Total Household Expenditure. However, there are numerous variations to the basic model that can provide similar yet different interpretations. This section explores these models and the interpretation of their results.

8.1 Results of a Tobit regression

The simplest model specification is:

Model 1

$$Flight_i = \alpha + \beta_1 Totexp_i + \epsilon \tag{7}$$

Where the independent variable $Flight_i$ is the expenditure the household i spends on flights annually, α is the constant, β_1 is the coefficient of the regressor Totexp, which is the household's i total annual expenditure, and ϵ is the error term.

The result of this regression for Model 1 is shown in Table 3. A strongly significant positive value of 0.0278 for the regressor is in line with what could be expected. A change in Total Household Expenditure of 1000 SEK will result in the household spending 27.8 SEK more on Flights abroad. The constant is also strongly significant yet negative at -11657 SEK.

Model 2 adds regions in which households reside. The coefficients for the regions are conveniently in line with expectations. One would expect decreasing proximity to a major airport would decrease a households propensity to consume aviation travel. This effect can be seen by the data as a household that is in Region 6, which is the least densely populated, will spend approximately 9664 SEK less on flights abroad than a household residing in Region 1, which is Stockholm. Households in Gothenburg and Malmo have no significant difference in how much they spend on flights as can be seen by looking at Region 8 and Region 9.

Model 2

$$\begin{aligned} Flight_i = \alpha + \beta_1 Totexp_i + \beta_2 Reg2 + \beta_3 Reg3 + \beta_4 Reg4 + \beta_5 Reg5 \\ + \beta_6 Reg6 + \beta_8 Reg8 + \beta_9 Reg9 + \epsilon \end{aligned} \tag{8}$$

Model 3 adds level of education of the head of the household as a regressor. Intuitively, the more educated the head of the household is, the more they will spend on travelling by flight. This could be because increased education could be correlated with more interest learning about other cultures. A Household with a head of household with more than 3 years post high school education will spend roughly 9,923 SEK more than someone with less than 9 years per high school education. This is a rather large difference. For the variable Edu6, which is post-doc level education there are too few sample observations.

Model 3

$$
\begin{aligned}
Flight_i = \alpha + \beta_1 Totexp_i + \beta_2 Reg2 + \beta_3 Reg3 + \beta_4 Reg4 + \beta_5 Reg5 + \beta_6 Reg6 \\
+\beta_8 Reg8 + \beta_9 Reg9 + \beta_{10} Edu2 + \beta_{11} Edu3 + \beta_{12} Edu4 + \beta_{13} Edu5 \\
+\beta_{14} Edu6 + \beta_{15} Edu9 + \epsilon
\end{aligned} \tag{9}
$$

Model 4 looks at whether the number of individuals in a household plays a role. Intuitively, a larger household will have more expenditures as it has more people to take care of. One way to deal with this issue would be to perform the Tobit regression using Flight Expenditure per capita and Total Household Expenditure per capita. However, this is tricky as it assumes that every member of a household has an equal weight in decision making. Instead, this study adds the number of individuals as a regressor. We see that for every extra person in a household, spending on aviation travel decreases by 969 SEK. This highly significant result should be interpreted a bit more carefully, as it is likely that this is due larger families having a larger number of non-income earners. Hence, this value is likely increasing in size for every extra person by an increasing amount. That is to say, one child won't change much in terms of costs but having 5 will cost so much it is more likely to be prohibitively expensive. Because families often plan holidays abroad together it is easy that things becomes an all or nothing situation.

Model 4

$$
\begin{aligned}
Flight_i = \alpha + \beta_1 Totexp_i + \beta_2 Reg2 + \beta_3 Reg3 + \beta_4 Reg4 + \beta_5 Reg5 + \beta_6 Reg6 \\
+\beta_8 Reg8 + \beta_9 Reg9 + \beta_{10} Edu2 + \beta_{11} Edu3 + \beta_{12} Edu4 + \beta_{13} Edu5 \\
+\beta_{14} Edu6 + \beta_{15} Edu9 + \beta_{16} Totind_i + \epsilon
\end{aligned} \tag{10}
$$

Model 5 tests if the age of the head of the household is of any significance. Age is significant , however, the sign of the coefficient is negative which feels counter-intuitive as wealth tends to increase with age. For every year older the head of the household gets, expenditure on Aviation travel abroad decreases by 81 SEK. This is not a big effect and therefore is not that interesting.

Model 5

$$
\begin{aligned}
Flight_i = \alpha + \beta_1 Totexp_i + \beta_2 Reg2 + \beta_3 Reg3 + \beta_4 Reg4 + \beta_5 Reg5 + \beta_6 Reg6 \\
+\beta_8 Reg8 + \beta_9 Reg9 + \beta_{10} Edu2 + \beta_{11} Edu3 + \beta_{12} Edu4 + \beta_{13} Edu5 \\
+\beta_{14} Edu6 + \beta_{15} Edu9 + \beta_{16} Totind_i + \beta_{17} Age1_i + \epsilon
\end{aligned} \tag{11}
$$

Table 3: Tobit Regression. Dependent Variable: Flight Expenditure

Regressor	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**
Totexp	0.0278***	0.0275***	0.0269***	0.0280***	0.0285***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Region3		-3208***	-2986***	-2985***	-2859***
		(1045)	(1037)	(1038)	(1038)
Region4		-5393***	-4459***	-4462***	-4116***
		(1276)	(1278)	(1278)	(1282)
Region5		-7816***	-7699***	-7757***	-7289***
		(1963)	(1955)	(1955)	(1958)
Region6		-9664***	-8612***	-8453***	-8197***
		(1952)	(1948)	(1949)	(1949)
Region8		850	596	473	449
		(1448)	(1437)	(1438)	(1437)
Region9		779	796	846	940
		(1720)	(1708)	(1707)	(1706)
Edu2			4159*	4861**	2633
			(2131)	(2149)	(2263)
Edu3			5262***	5653***	4312**
			(1893)	(1900)	(1946)
Edu4			6015***	6367***	4490*
			(2382)	(2387)	(2458)
Edu5			9923***	10210***	8732***
			(1930)	(1935)	(1989)
Edu6			6259	6147	5286
			(4637)	(4637)	(4638)
Edu9			2855	4410**	309
			(2035)	(2108)	(2480)
Totind				-969***	-1253***
				(370)	(381)
Age1					-81***
					(25)
cons	-11657***	-8709***	-14313***	-13064***	-7444***
	(805)	(1092)	(2035)	(2086)	(2739)
N	2858	2858	2858	2858	2858
R^2	0.0067	0.0084	0.0102	0.0104	0.0107

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

8.2 The Model in Logs

In economics the demand elasticity of income is defined as the percentage change in demand given a percentage change in income (Mankiw, 2007). Transforming the dependent variable, Flight, into a log form as well as the independent variable, Total Household Expenditure(Totexp) is a means of studying this relationship. The models used in this section are virtually identical to the non-log models used above, except for the aforementioned transformations.

However, the log-transformation of Flight Expenditure is slightly tricky due to the problem the number 1 being the minimum for a log when dealing with only positive numbers. The problem is dealt with by changing the zero values to a value that is just slightly smaller than the minimum value of flight expenditure (Cameron and Trivedi, 2009).

There is also another rationale for using a value just below the minimum. The data has a large clump at a rather large value and then half of the values are on the zero flight expenditure line. However, intuition suggests that there should be a gradual slope starting from some low total expenditure point and the rising to meet the large clump. Theoretically, if we assume that values are censored at just below the minimum then we allow the possibility that given perfect knowledge of true willingness to pay exists we would see this slope. Using this technique suggested by Cameron and Trivedi (2009) would take this into account.

Looking at the simplest model, Model 1 in Table 4, it can be seen that the elasticity is high and strongly significant. The coefficient value of 2.612 means that for every percentage point increase in Total Household Expenditure there is a 2.612 percent increase on expenditures on Flight. This is not an altogether surprising result as it would seem reasonable to assume that travelling via aviation is a luxury for most households. This value is on the high end of the elasticities found in previous studies by Brons et al. (2002).

In the second specification, Model 2, regions are included in the regression. The results mirror the non-log results in terms of significance. A household in the least dense region decreases its expenditure on Flight Travel by by 2.224%. The expenditure elasticity of demand does not change significantly at 2.596.

Adding the level of education as a factor we see Model 3. The coefficients have the expected positive sign as education should positively correlate with a higher interest in travelling and experiencing different cultures. Increasing levels of education show a strong increase in demand for aviation travel with 2.505% more spent on aviation travel for people with more than 3 years of post-high school education. For post-doc education the results are insignificant as the sample size is too small, with only 21 people having a degree at that level.

Model 4 provides an important result as it takes into account the size of the household. For every extra person living in a house there is a decrease in the propensity to consume flight travel by 0.491%. This might not seem much but it does indicate that the intuition that larger families will fly less seems to be true. A larger family might make scheduling holidays more difficult among many other possible reasons.

Finally, with Model 5, we see that the age of the head of the household is significant. However, the effect, while strongly significant, is so small that it is of little interest. For every 10 years of increase in age there is a drop in demand of 0.26 percent.

Table 4: Tobit Regression. Dependent Variable: Log-Flight Expenditure

Regressor	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**
Log-Totexp	2.612***	2.596***	2.492***	2.860 ***	2.933***
	(0.170)	(0.169)	(0.170)	(0.184)	(0.185)
Region3		-0.769***	-0.717***	-0.707***	-0.663***
		(0.254)	(0.252)	(0.250)	(0.246)
Region4		-1.360***	-1.128***	-1.136***	-1028***
		(0.310)	(0.309)	(0.308)	(0.308)
Region5		-2.083***	-2.054***	-2.072***	-1.918***
		(0.477)	(0.473)	(0.471)	(0.471)
Region6		-2.224***	-1.996***	-1.911***	-1.826***
		(0.468)	(0.466)	(0.464)	(0.463)
Region8		0.448	0.367	0.319	0.312
		(0.353)	(0.349)	(0.347)	(0.346)
Region9		0.092	0.096	0.112	0.141
		(0.420)	(0.416)	(0.413)	(0.412)
Edu2			1.067**	1.365***	0.632
			(0.516)	(0.517)	(0.544)
Edu3			1.549***	1.693***	1.247***
			(0.459)	(0.458)	(0.469)
Edu4			2.069***	2.211***	1.597***
			(0.576)	(0.574)	(0.590)
Edu5			2.505***	2.592***1	2.097***
			(0.469)	(0.468)	(0.480)
Edu6			1.285	1.144	0.840
			(1.131)	(1.125)	(1.123)
Edu9			0.763	1.485	0.142
			(0.491)	(0.507)	(0.597)
Totind				-0.493***	-0.590***
				(0.091)	(0.094)
Age1					-0.026***
					(0.006)
cons	-28.225***	-27.325***	-27.644***	-31.271***	-30.271***
	(2.158)	(2.154)	(2.154)	(2.272)	(2.273)
N	2858	2858	2858	2858	2858
R^2	0.0240	0.0302	0.0359	0.0388	0.0405

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$ b

8.3 Goodness-of-fit: R^2 and the pseudo-R^2 in a Tobit regression

It is common practice to use R^2 when trying to estimate the goodness-of-fit/explanatory power for a regular OLS regression. The R^2 ranges from 0 to 1, where a value of 0 or close to 0 means the Model performs poorly at explaining the dependent variable and a 1 means the model is a perfect fit (Wooldridge, 2010).

However, there is no R^2 with a Tobit Model. Stata reports only a so called pseudo-R^2. Veall and Zimmermann (1996) report that is it normal that the Pseudo-R^2 is always lower than the OLS-R^2. Stata provide a pseudo-R^2, which are the ones shown in the regression tables in this paper, and is computed as such:

pseudo-$R^2 = 1 - L1/L0$

where $L0$ and $L1$ are the constant-only and full model log-likelihoods, respectively. Furthermore, because the log likelihood is the log of a density and the density function can be greater than 1 the log likelihood can be positive or negative. It is entirely possible for a Tobit Model to have a negative or a positive pseudo-R^2, which is not the case with an OLS-R^2.

Veall and Zimmermann (1996) test various Pseudo-R^2 that have been proposed by researchers. While they state that their is no consensus about which Pseudo-R^2 performs most like the OLS-R^2 they identify a measure pattern by McKelvey and Zavoina (1975) as the choice that they consider the best. This paper is will not delve into this method, however, it is a suggestion that it be used in similar future research. The Pseudo-R^2 reported by Stata is sufficient at this point as it is not central to the research at hand. However, if it were to be interpreted as an OLS-regression one would come to the false conclusion that the model performs poorly in terms of explanatory power as values between 0.0306 and 0.0483 are very low.

8.4 Testing for normality and heteroskedasticity of the Tobit Model

In order for any inference to be done on the Tobit Model it must be tested for non-normality and heteroskedasticity. The standard Tobit Estimator is not consistent if the errors are not normally distributed. The tests used for OLS models cannot be used for censored data models (Wooldridge, 2010). Instead conditional moment tests developed by Pagan and Vella (1989) are used where generalized residuals are used in a regression based test (Cameron and Trivedi, 2009).

Drukker et al. (2002) explains the intuition behind the test developed by Pagan and Vella (1989). The interested reader is recommended to read the article but an explanation here would be too technical for this paper and might lead to confusion.

The various model specifications are all tested for normality and heteroskedasticity. Table 5 shows the results of the tests. Normality and heteroskedasticity have been strongly rejected for all specifications. Despite the Tobit Model having results that match reasonably well with expected values and intuition the failure of normality and heteroskedasticity has serious consequences. Cameron and Trivedi (2009) point out that there are various methods that might correct these issues.

This study checked whether Robust Standard Errors would improve the model and maybe lead to better results in terms of the heteroskedasticity issue. However, when used they did not significantly change any results. Tables 10, 11, and 12 in the appendix show the results with the Robust Standard Errors.

Table 5: Results of Test for Normality and Heteroskedasticity with Robust Standard Errors, Respectively

Model	**Norm-nR^2**	**p-value**	**Het-nR^2**	**p-value**
1	1525.4	0.00	2446.8	0.00
2	2864.0	0.00	2864.0	0.00
3	2307.1	0.00	1509.4	0.00
4	1994.6	0.00	2035.6	0.00
5	1377.3	0.00	1421.2	0.00

9 A Sensitivity Analysis using an OLS regression

The model used in this study is a Tobit regression, however, it is interesting to appreciate the difference had a classic Ordinary Least Squares regression been used instead. Also, as the aim of the study is to find the elasticity of demand for aviation travel, the model will be a log-log form. The variable for Sex of person has shown to be insignificant in every model specification and will therefore be left out. Left out are Level of Education and Type of Work as this table is mostly for comparison purposes and therefore sufficient with the chosen variables.

Table 5 summarizes the regression outputs. If we ignore the fact these results are biased due to the censored variables then the inference would be as follows. Highly significant results for expenditure elasticity of flight travel of between 1.38-1.41 indicates that it is an elastic relationship as it is greater than 1. The baseline region for Model 2, and 3 are people living in Stockholm. The results show that households living in decreasingly densely populated regions will spend a smaller percentage of income on aviation travel. Regions 8 and 9 for Malmo and Gothenburg, respectively, show no significant difference. The age of the head of household (AGE) is not significant in this model.

Table 6: OLS Regression: Dependent Variable: Log Flight Expenditure

Regressor	**Model 1**	**Model 2**	**Model 3**
Log-Totexp	1.416***	1.404***	1.4083***
	(0.07)	(0.07)	(0.07)
Region3		-0.378***	-0.382***
		(0.12)	(0.12)
Region4		-0.656***	0.665***
		(0.14)	(0.14)
Region5		-0.881***	-0.888***
		(0.21)	(0.21)
Region6		-1.020***	-1.026***
		(0.21)	(0.21)
Region8		0.204	0.202
		(0.17)	(0.17)
Region9		0.079	0.077
		(0.20)	(0.20)
Age1			0.001
			(0.002)
cons	-11.332***	-10.855***	-10.950***
	(0.95)	(0.95)	(0.96)
N	2864	2864	2864
R^2	0.1087	0.1274	0.1275

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

10 Discussion

Initial results of the Tobit Model applied to the flight data has shown promise, however, there are limitations to this study. The results of the Tobit regression were roughly in line with expectations. The expenditure elasticity of demand, while relatively high in relation to previous research by Brons et al. (2002), was within a reasonable range from 2.612 to 2.933. The coefficients for the covariates for regions with different densities had the expected negative signs and were significant. In general, the more educated the head of the household is the more the household will spend on leisure aviation travel. Having more individuals in a household decreases the expenditure on flights. However, when the errors were tested for normality and heteroskedasticity all the models were strongly rejected.

The Tobit Model that has the highest number of significant explanatory variable is Model 5. This model had an expenditure elasticity of 2.933. This value is relatively high compared to previous research but it is not unrealistic. If this value would be right it would imply that for every 1 percent increase in income, approximated by Total Household Expenditure, there would be a 2.933% increase in expenditure on flight travel abroad. This would point to flight travel being a luxury good and that growth in income will lead to a large increase in spending on aviation travel. Furthermore, depending on the region where the households reside, the expenditure could be a great deal lower. A household in the least densely populated region in Sweden decreases its expenditure on Flight Travel by between 1.826% in Model 5. On the other hand a household with a well-educated head of household (Edu5) will increase its expenditure on Flight Travel by 2.097%. It is important to remember that nothing can be said about the elasticity of a highly educated head of household in a very sparsely populated regions based on this model. To find the strength of that relationship would require a regression with an interaction variable. This is not done in this study. Bigger families have a lower propensity to consume leisure aviation travel by approximately 0.590% for every extra person. However, this relationship is unlikely to be linear and is not a big effect in total. The effect of the change in age of the head of the household is so small it might as well be ignored.

Previous research by Leander (2015) based on similar data had found an expenditure elasticity of demand of -2.04. The Tobit Models used in this study find elasticities between 2.612 and 2.933. A nave OLS model used as a comparison provides estimates of 1.4. A high elasticity could have numerous explanation, however, it would suggest that flight travel is a very popular product in the Swedish consumer basket.

The high expenditure elasticity of demand should be a worrying signal for policy-makers. With increasing income, expenditures will increase and a proportionally higher percentage of that increase will go to aviation travel. A carbon tax is unlikely to dampen demand and will likely be an ineffective policy instrument. This paper has similar finding to previous literature in the sense that income elasticity of demand for aviation travel in highly elastic. The results found here are on the high end of the spectrum. More research in this area is needed, however, policy makers should take note that there efforts in this area could prove to be futile in terms of reducing CO2 emissions.

It is well known in econometric literature that it is meaningless to make any inference on a regression with error terms that that are not homoskedastically distributed. As Caudill and Mixon Jr (2009) point out the maximum likelihood estimator will be inconsistent. Using Pagan and Vella (1989) method that makes use of an nR^2

statistic, both normality and heteroskedasticity are rejected. Essentially, it would be wrong to draw any certain conclusions from the results.

A limitation to future research that wants to use a similar method is that Statistics Sweden has stopped gathering this type of data due to having a too low response rate from households. The year used in this paper, 2012, is at the time of writing, the last year Statistics Sweden will have conducted such a survey.

However, this research can serve as a stepping stone for future work. A double-hurdle model such at the ones developed by Heckman (1979) or Cragg (1971) could be tested to see if it yields an improvement. Alternatively, Drukker et al. (2002) developed a boot-strap method as an alternative method of testing for normality in a Tobit mode. Furthermore, it would be advisable for future research to use a pseudo-R^2 that is more interpretable than the current default Stata output after a Tobit regression.

11 Conclusion

The aim of the study was to find an estimate for the Income Elasticity of Aviation travel for Swedish Households. The Household Expenditure Data provided by Statistics Sweden contained a lot of zero values for the dependent variable so a Tobit Model was deemed the most appropriate way of dealing with the so-called censored variable issue. No previous literature has attempted to deduce income elasticity of aviation travel using household expenditure data at the time of writing this paper.

Unfortunately, the Tobit Model performed poorly when tested for to see whether the errors were normally and homoskedastically distributed. All models tested using Pagan and Vella (1989) method were strongly rejected. This has serious consequences as no consistent inference can be done and results become inconclusive.

However, all is not lost in this area of research. The use of Household Expenditure Data can be used with other models that could have different results. This paper has failed to provide satisfactory results, however, this is the nature of scientific studies. This research should be seen as a stepping-stone for future studies.

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Appendix

Table 7: Desctiptive Statistics

Variable	**Observations**	**Mean**	**Std. Dev.**	**Min**	**Max**
Flight	2871	6043	11883	0	150000
Total Expenditure	2864	322579	198703	7541	2058189
Age	2871	41	22	0	79
Total Individuals	2871	2.47	1.23	1	10
Total Income	2871	423886	287324	6300	4317520

Table 8: Desctiptive Statistics: Education Variable

Level of Education	**Frequency**	**Percentage**	**Cum. Percentage**
1	173	6.03	6.03
2	313	10.90	16.93
3	963	33.54	50.47
4	164	5.71	56.18
5	751	26.16	82.34
6	21	0.73	83.07
9	486	16.93	100.00
Total	2871	100.00	

Table 9: Desctiptive Statistics: Region Variable

Household Region	**Frequency**	**Percentage**	**Cum. Percentage**
1	578	20.13	20.13
3	1059	36.89	57.02
4	468	16.30	73.32
5	156	5.43	78.75
6	160	5.57	84.33
8	278	9.68	94.01
9	172	5.99	100.00
Total	2871	100.00	

Table 10: Results of Test for Normality and Heteroskedasticity with Robust Standard Errors, Respectively

Model	**Norm-nR^2**	**p-value**	**Het-nR^2**	**p-value**
1	1734.6	0.00	2533.4	0.00
2	2857.9	0.00	2857.9	0.00
3	2305.3	0.00	1543.6	0.00
4	1989.1	0.00	2019.8	0.00
5	1349.4	0.00	1398.9	0.00

Table 11: Tobit Regression with robust standard errors. Dependent Variable: Flight Expenditure

Regressor	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**
Totexp	0.0278***	0.0275***	0.0269***	0.0280***	0.0285***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Region3		-3208***	-2986***	-2985***	-2859***
		(1086)	(1082)	(1082)	(1077)
Region4		-5393***	-4459***	-4462***	-4116***
		(1300)	(1301)	(1300)	(1299)
Region5		-7816***	-7699***	-7757***	-7289***
		(2070)	(2051)	(2059)	(2065)
Region6		-9664***	-8612***	-8453***	-8197***
		(1829)	(1813)	(1810)	(1806)
Region8		850	596	473	449
		(1478)	(1454)	(1456)	(1455)
Region9		779	796	846	940
		(1767)	(1773)	(1773)	(1769)
Edu2			4159*	4861**	2633
			(2274)	(2280)	(2381)
Edu3			5262***	5653***	4312**
			(2070)	(2070)	(2105)
Edu4			6015***	6367***	4490*
			(2401)	(2405)	(2466)
Edu5			9923***	10210***	8732***
			(2162)	(2161)	(2208)
Edu6			6259	6147	5286
			(4760)	(4748)	(4801)
Edu9			2855	4410**	309
			(2213)	(2269)	(2631)
Totind				-969***	-1253***
				(367)	(379)
Age1					-81***
					(25)
cons	-11657***	-8709***	-14313***	-13064***	-7444***
	(1131)	(1233)	(2258)	(2323)	(2834)
N	2858	2858	2858	2858	2858
R^2	0.0067	0.0084	0.0102	0.0104	0.0107

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Table 12: Tobit Regression with robust standard errors. Dependent Variable: Log-Flight Expenditure

Regressor	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**
Log-Totexp	2.612***	2.596***	2.492***	2.860 ***	2.933***
	(0.161)	(0.159)	(0.161)	(0.174)	(0.175)
Region3		-0.769***	-0.717***	-0.707***	-0.663***
		(0.250)	(0.248)	(0.247)	(0.246)
Region4		-1.360***	-1.128***	-1.136***	-1028***
		(0.309)	(0.309)	(0.308)	(0.309)
Region5		-2.083***	-2.054***	-2.072***	-1.918***
		(0.491)	(0.487)	(0.488)	(0.491)
Region6		-2.224***	-1.996***	-1.911***	-1.826***
		(0.485)	(0.484)	(0.480)	(0.480)
Region8		0.448	0.367	0.319	0.312
		(0.333)	(0.329)	(0.327))	(0.327)
Region9		0.092	0.096	0.112	0.141
		(0.404)	(0.403)	(0.402)	(0.401)
Edu2			1.067**	1.365***	0.632
			(0.564)	(0.563)	(0.592)
Edu3			1.549***	1.693***	1.247**
			(0.507)	(0.505)	(0.517)
Edu4			2.069***	2.211***	1.597***
			(0.612)	(0.610)	(0.624)
Edu5			2.505***	2.592***1	2.097***
			(0.513)	(0.511)	(0.525)
Edu6			1.285	1.144	0.840
			(1.116)	(1.120)	(1.127)
Edu9			0.763	1.485	0.142
			(0.540)	(0.552)	(0.643)
Totind				-0.493***	-0.590***
				(0.092)	(0.095)
Age1					-0.026***
					(0.006)
cons	-28.225***	-27.325***	-27.644***	-31.271***	-30.271***
	(2.050)	(2.154)	(2.042)	(2.152)	(2.154)
N	2858	2858	2858	2858	2858
R^2	0.0240	0.0302	0.0359	0.0388	0.0405

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$ b