Calculation of Ramsey Prices for German Airports

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Abstract:

Ramsey pricing is considered to be a quasi-optimum pricing scheme designed for a multiproduct natural monopolist. Ramsey Prices are optimal for airports with cost recovery problems, but are inefficient for busy airports. If so then it is interesting to check if current charges are close to the optimal one, and if not then why do they differ?

A menu of landing fees for five German airports using a Ramsey pricing setup is calculated. The paper concentrates on fees for different distances and three types of aircrafts. New approach of different marginal cost for different aircrafts is used to estimate one of the main input of Ramsey pricing formula. Special attention devoted to interpretation of k coefficient of Ramsey formula. The calculated fees are compared with the actual weight based fees charged by the airports. We analyze tendencies of difference of current fees with calculated ones from point of dependence on different factors. We find a clear monotone dependence: the Ramsey prices increase with distance and MTOW faster than real fees. Gap between theoretical optimum and practice needs to be understood, and we make some policy implications based on results of calculation.

Key words: airport, charges, Ramsey pricing

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Introduction

In times of privatization and commercialization within the airport sector special emphasis is placed on the regulation of airports. While the strength of market power of airport differs from case to case, competition is often not strong enough to make regulation redundant (Niemeier, 2009, p. 2). Airports can derive market power from the potential absence of close substitutes due to planning and environmental restrictions as well as from their function as natural monopolies. Hence they face substantial sunk costs, such as costs of a runway addition, which also result in economies of scale ranging from three to twelve, possibly even 90 million passengers (Niemeier, 2009, p. 11, 12).[2] A fair regulation system should avoid the abuse of market power by airports and increase economic welfare.

While welfare economics suggests setting monopoly prices according to marginal costs in order to maximize economic welfare (first best solution), marginal-cost pricing will result in deficits if average total costs are above marginal costs (Mankiw, 2008). Based on the findings of Frank Plumpton Ramsey it has been argued that monopolists subject to a constraint on profit should charge inversely to the price elasticity of demand in order to maximize economic welfare (second best solution) (Baumol, Bradford, 1970, p. 267). To put is simply Ramsey pricing is a form of price discrimination where charges are set on the basis of the ability to pay.

Traditionally landing fees based on the weight of aircraft, usually the maximum take-off weight (MTOW), plus a passenger charge per departing passenger have been the major sources of revenue for airports. As a result of the attempts by the industrial organizations IATA and ICAO to standardize airport charges, charging structures are often similar around the world (Martin-Cejas, 1997, p. 321, 322). Niemeier argues that the "traditional weight-based system can be interpreted as an attempt to find a second best solution, because larger aircrafts with lower price elasticity pay more than small ones." However the current structure would only be an imperfect Ramsey pricing structure (Niemeier, 2009, p. 9). Therefore weight-related charges may lead to an inefficient use of capacity and over-investment resulting in welfare losses (Niemeier, 2009, Martin-Cejas, 1997). Contrary Ramsey prices are acknowledged as optimal at airports with free capacity. Because marginal costs are especially low at such airports, clearly below average costs, they are faced with costs recovery problems.

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[2] A third source of market power might be positive network effects as it can be beneficial for airlines to concentrate their operations at one airport (Niemeier, 2009, p. 11). For more detailed discussions on the airports' market power see Niemeier, 2009; Church and Ware, 2000; Hancioglu, 2008.

On the other hand a Ramsey-type charges structure might be inefficient for busy airports due to the rivalry for the users (Forsyth and Niemeier, 2003).

This paper examines whether the traditional charging systems of German uncongested airports meet the Ramsey requirements. While the structure of Ramsey-type prices was already compared to the current pricing structures of U.S. (Morrison, 1982) and Spanish airports (Martin-Cejas, 1997), taking the Ramsey pricing model developed by Morrison (1982) we furthermore try to optimize the estimation of the values of the single variables that have been used in previous studies.

Within this paper a menu of landing fees for five uncongested German airports using a Ramsey pricing setup is calculated. We concentrate on fees for different distances and three types of aircrafts with different capacity. The calculated fees are compared to the actual weight based fees charged by the airports.

The paper is structured as follows. Beginning with a brief literature review on Ramsey pricing, we then describe the applied model. The empirical part starts with the estimation of the variables before the results are presented in the three sections. Finally some concluding points are remarked.

Literature Review on Ramsey Pricing

The intuitive theory behind Ramsey pricing is rather simple. As mentioned in the introduction in conditions of economies of scale prices equal to marginal costs (P_{MC}) would drive the firm into deficit finance. However in the case of a multi-product firm it is usually not possible to identify individual average costs for separate goods since in most cases they are partly generated from common inputs. Charging the same amount for all goods in the way that total average costs are covered (P_C) may result in an inefficient allocation of resources and consequently in substantial deadweight losses. Therefore Ramsey pricing requires setting mark-ups that allow the firm to break even, while the prices for the separate goods are determined according to their elasticity (P_R) (Markova, 2008, p. 67, 68). Thus "services with relative elastic demand should generally have a lower than average proportionate mark-up, while the services with relative inelastic demand should have a higher than average mark-up over their marginal costs." (Markova, 2008, p. 68) Thereby, under the assumption of zero cross-elasticity, it allows an adequate allocation of capacity and lowers the deadweight loss.

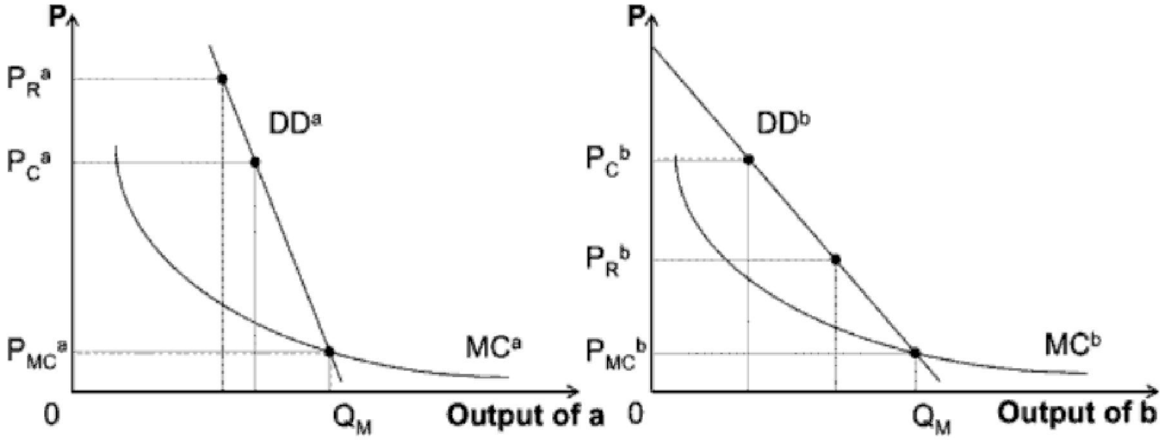

Figure 1: Efficient pricing for a multi-product natural monopoly

Baumol and Bradford (1970) found the roots of the Ramsey pricing schemes already in the 1870's. Even though there had not been any formal propositions they mention a number of authors who, with the establishment of the Railway and Canal Commission as well as the Interstate Commerce Commission in England, advocated prices that vary directly with demand inelasticity. However, as indicated by the name, the first formal mathematical solution to the optimal pricing problem for an industry in which marginal cost pricing does not provide sufficient returns was given by Frank Ramsey in 1927 (Baumol and Bradford, 1970, p. 278). While he developed his theorem in the context of taxation, further contributions were made by Boiteux (1956) who also applied it to natural monopolies (Laffont and Tirole, 2000). Baumol and Bradford (1970) themselves explore the implications of Ramsey pricing for regulatory policy in detail and conclude that Ramsey pricing is the *"[…] socially optimal pricing by a multi-product monopolist operating under a profit constraint […]"* (Baumol and Bradford, 1970, p. 268).

The Ramsey pricing schemes has been applied to a number of regulated industries. With regard to the airport sector a large contribution was made by Morrison (1982) who developed a Ramsey-type pricing model for uncongested airports subject to a profit constraint. He identifies two shortcomings of the current weight-based systems. Studies indicate that the elasticity of passengers' demand decreases with distance of flights (DeVany, 1974; Ippolito, 1981). However according to Morrison's results weight-related fees do not vary with the length of the flight. Secondly he finds that the current fees rise too rapidly with the weight and hence the size of the aircraft. Thus the "[…] imposition of Ramsey pricing would result in increased fees for 'small' planes on 'long' flights and decreased 'fees' for 'large' planes on ‘short’ flights.” (Morrison, 1982, p. 156) However, since the average flight would not be mispriced, welfare gains may be small. Overall according to Morrison Ramsey pricing would rather change the structure of current charges than their level. Moreover he states that if weight-based charges remain, takeoff weight is to be given preference to landing weight as the difference, fuel, would be a function of both size and range.

Similar results are found by Martin-Cejas (1997) who applied the Ramsey pricing scheme to Spanish airports. He emphasizes the relevance of the ability of prices paid by any user to reflect costs which they impose, because otherwise misdirected demand would result in an inefficient allocation of resources. However he also points out that the results of his analysis have to be interpreted with care as the parameters used for the variables might be outdated.

With reference to Laffont and Tirole (2000) Markova (2008, p. 91) points out the possibility of adjusting the Ramsey pricing formula to externalities. According to her, without regard to interdependences among services, the price should be lowered in case of positive externalities and raised in the opposite case.

The Model

As theoretically explained, Ramsey prices are derived by solving the problem of maximizing the difference between social benefits and social costs, given a revenue constraint (Morrison, 1982, p. 152).

Forming the Lagrangean, we have

$$\max_{Q_1 \ldots Q_n, \lambda} \Im = \int_0^{Q_1} P_1(Q_1)dQ_1 + \ldots + \int_0^{Q_n} P_n(Q_n)dQ_n - C(Q_1,\ldots,Q_n) + \lambda[\sum_{i=1}^{n} P_i Q_i - C(Q_1,\ldots Q_n) - F] \quad (1)$$

P_i - landing fee charged to aircraft in category i (a category is given by an aircraft type and length of flight)

Q_i - the number of landings by category i

$C(Q_i,\ldots,Q_n)$ - the total variable cost to the airport authority of the landings

F – fixed costs that might be covered

The First-order conditions are:

$$\frac{\partial L}{\partial Q_i} = P_i - \frac{\partial C}{\partial Q_i} + \lambda(P_i + Q_i \frac{dP_i}{dQ_i} - \frac{\partial C}{\partial Q_i}) = 0 \quad (2)$$

Solving (2) results in

$$\frac{P_i - \frac{\partial C}{\partial Q_i}}{P_i} = (\frac{\lambda}{1+\lambda})\frac{1}{\varepsilon_i} \quad i = 1,..,n \quad (3)$$

where ε_i is the (absolute value) elasticity of demand for landings with respect to the landings fee. Morrison (1982). This is the standard Ramsey pricing result, which indicates that the percentage markup of price over marginal cost should be inversely proportional to the elasticity of the demand (Baumol and Branford, 1970)

But one the main point that Morrison did was reformulation of the formula (3) in order to get estimative components.

Because the proportions are fixed (one airplane plus one landing equals one flight) the elasticity of the demand for landings is equal to the product of the elasticity of demand for passenger trips with respect to ticket price times the fraction which landing fees are of the flight (Layard and Walters, 1978, p262). It assumes both elasticity of number of flights with respect to the number of passengers and elasticity of price tickets with respect to airline cost is equal to one. Thus,

$$\varepsilon_i = \eta_i(\frac{P_i}{P_i + TC_i}) \quad i = 1,...,n \quad (4)$$

Combining expression (4) and (3) and solving it for price Morrison got:

$$(5) \quad P_i = \frac{\frac{\partial C}{\partial Q_i} + \frac{k}{\eta_i}TC_i}{1 - k/\eta_i} \quad i = 1,...,\eta$$

where $k = \lambda/(1+\lambda)$ - is the level to which constrain is binding.

P_i = landing fee charged to aircraft in category i (a category is given by an aircraft type and length of flight)

Q_i = the number of landings by category i

$C(Q_i,...,Q_n)$ = the total variable cost to the airport authority of the landings

η_i = the (absolute value) elasticity of demand for passenger trips of the ith category

TC_i = the cost of the flight for the ith category exclusive of landing fee.

The calculations of this paper are based on formula (5) which was developed and applied by Morrison (1982) and was also applied by Martin-Cejas (1997) for Spanish airports. However that formula was modified recently Laffont and Tirole (2000) Markova (2008, p. 91), we still consider it to be reliable since most of the suggested improvements were made with regard to special cases and have not had big resonance.

Calculations

One of the main questions that appear when it comes to empirical calculations is data availability. We used the data from different sources that are accumulated in database of GAP-project (Balance sheets of airports, charges of the airports, fleet mix data from Eurostat) to get data about costs of the airports. The latest data available is 2007. Fullness of database and criteria of uncongestity of the airports gave us the sample of the airports to use in calculation. These are: Bremen, Cologne, Nurnberg, Hamburg, Hannover.

All calculations are done ERJ-145,CRJ-900, A-320. This is due to the following criteria:

1. Structure of movements in the airports from the sample
2. Availability of data on these types of aircraft.

3 Wide range in capacity of the aircraft from point of MTOW and number of passengers, as we need as more differentiation as possible to get distinct statistically significant results.

The main problem that appears when it comes to Ramsey pricing formula is that most of the data that are needed to estimate price are themselves estimatable, but not reported. We will in following discuss the ways to get or estimate missing data.

ELASTICITY

As it is very problematic to estimate **elasticity** as it require big database, we needed to find latest source that can be used in calculations. Therefore we looked for available and suitable resources for finding information on the elasticity of demand for air travel. In December 2007, the company InterVistas published a report "Estimating Air Travel Demand Elasticities", from which were taken all the data on the elasticity, which are listed below in table 1 below.

Elasticities of demand for the flights			
Distance, km	Europe	Europe-America	Europe-Asia
500	-1.232	0	0
1000	-1.232	0	0
1500	-1.12	0	0
2000	-1.12	0	0
2500	-1.12	0	-0.72
5000	-	-0.96	-0.72

Table 1 Elasticities of demand for the flights considered, Source: Solution: Elasticity from “Estimating Air Travel Demand Elasticities” of InterVISTAS Consulting Inc, Dec 2007

COST OF FLIGHT ESTIMATION

Cost of flight used in the formula is also a calculated parameter. Usually used approach to calculate operating cost is through the block hours.

1) The total operating costs (total flight costs) for a given type of an aircraft and distance are estimated as follows:

   TC_i = operating cost per block hour for that aircraft type × the number of block hours per flight$\times 2$.

Operating costs per block hour in 2007 were taken from THE AIRLINE MONITOR COMMERCIAL AIRCRAFT DATA BASE, which contains data of block hour cost for 7 biggest American airlines. Weighted averages of the block hour costs were used in this study. Costs in the database are in US-dollars. The average EUR-USD exchange rate of 2007 was used in order to get costs in EUR (source eurostat.com). Block hour cost and some technical characteristics for the considered types of aircrafts presented in Table 2

	Total cost per block hour, EUR	**MTOW, t**	**Passanger capacity**
CRJ-900	1,642	36.5	86
B737-300	2,826	56.5	128
A-320	2,845	73.5	150

Table 2 Technical characteristics for the considered types of aircraft, Source: THE AIRLINE MONITOR COMMERCIAL AIRCRAFT DATA BASE

In the calculations 4 different types of flights were considered – 1, 2, 3, 4-hour flights. For the purposes of theoretical analysis a wider range of durations could be used, as it would provide higher differentiation of the results, and thus higher analytical inference. But as we are in constrains of relatively small aircraft due to airports' sample, 4 hour flight is maximum duration for 2 types of aircraft out of 3 (CRJ-900 and A320). As for Embraer -145 range of analysis bounded on 3 hour flight. The choice of this duration is connected to differentiation of current charges of the airports (domestic, European Union (EU), non-EU) and differentiation of elasticity (into Europe with distance less than 1500km, into Europe with distance more than 1500km, Europe-Asia). The correspondence between elasticity and length of flight that was used in all following calculations is represented in table 3:

	1 hour flight	2 hour flight	3 hour flight	4 hour flight
Elasticity of price for into Europe flights with distance no more than 1000 km	■			
Elasticity of price for into Europe flights with distance more than 1000 km		■		

Elasticity of price for Europe-Asia flights			■	■

Table 3. The correspondence between elasticity and length of flight. Painted cells show correspondence.

This correspondence is just assumption, and was chosen in order to use all available data of elasticity except for trans-Atlantic flight, that will lead to the variance of result, and so greater possibility for analysis of result.

The correspondence between length of flight and differentiation of current airport charges that was used in all following calculations is presented in table 4.

	1 hour flight	2 hour flight	3 hour flight	4 hour flight
Charges for domestic flights	■			
Charges for into EU flights		■		
Charges for Non-EU flights			■	■

Table 4. The correspondence between length of flight and differentiation of current airport charges.

It should be mentioned that this approach of calculating cost of flight leads to homogeneous costs across the airports. Most of the references use approach of distance of flight, and then calculate length of flight, including taxiing time, that is dependent of length of runway of the airport. But as this approach leads to need of using additional estimation from previous studies, using of which can be arguable (e.g. coefficient of taxiing time for British airport[3]), we chose approach of duration of flight.

The results of calculation of total cost of round flights are in the Table 5 and Diagram 1.

	Estimated cost of round flight for different aircrafts, EUR			
Duration of flight	1 hour flight	2 hour flight	3 hour flight	4 hour flight
ERJ-145	2,613	5,227	7,840	Na
CRJ-900	3,284	6,569	9,853	13,138
A-320	5,690	11,381	17,072	22,763

Table 5. Total cost of round flight for different aircrafts and different duration of flight

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[3] http://www.dft.gov.uk/consultations/archive/2002/fd/scot/tr/raedb/appendixeappendix2aircraftti1524

The results are pretty obvious and are proportional to block-hour cost. ERJ-140 is the smallest and the cheapest among aircrafts in the sample, while A-320 is the most expensive one.
This estimation was used in Ramsey price formula as total cost of flight.

MARGINAL COST

One of the most complex and difficult interpretive problems in the calculation of Ramsey prices are the marginal costs. The presence of marginal costs in the formula significantly reduces the chances of this formula to find wide practical application because they are unobservable and require estimation, even for direct participants of this business. The literature has accumulated quite a lot of ways to estimate the marginal cost but approach of Fredrik Carlson which he used in his work "Airport Marginal Cost Pricing: Discussion and an Application to Swedish Airports", 2002 seemed the most appropriate to us. The approach requires econometric estimation of cost function using within fixed-effect estimation. It should be mentioned that we use approach of corporate finance, rather than typical one of economists. The latter ones usually look at short-run marginal costs of airports from physical damage side, like harm of runway with every additional landing. (Starkie, Hogan, 2008). We assume that labor cost as well as all other aeronautical costs can be divided statistically on variable and fixed part through estimation of the cost function. Only this costs are appropriate to calculate Ramsey charges, that could be compared with total charges of the airports (both weight and passenger based).

The main problem of this approach is that airports do not report aeronautical and non-aeronautical costs separately, and the only information we could get from balance sheets was total operational costs, depreciation, labor costs. None of these can be direct approximation for aeronautical charges. To estimate them we assume constant revenue margin on both aeronautical and non-aeronautical sides. This is pretty weak assumption, but we failed to find any references to improve it. Moreover the main results of the paper are consistent with some manipulations of revenue margin.

Thus we have the following formula to estimate aeronautical costs:

$$= \quad \cdot \ \overline{}$$

The data structure is the following:

Dependent variable: Total aeronautical costs of the airport form 1998 to 2007, Source Eurostat. In following when we speak about total cost we mean total aeronautical costs, for simplicity.

Explanation variables: PAX , Total number of movements, Source Eurostat.

The representation of the cost function that was used by Fredrik Carlson was the following:

$$TC = c_1 Movements^{c_2}$$

Where TC – total costs of the airport, EUR

c_1, c_2 - parameters of estimation

Following the current model we found out that current representation of the cost function does not give model with high enough R-squared, but can be greatly improved with inserting PAX in the model. This investigation results in variable marginal cost of the airport across aircraft's types. One should mention that in spite of the fact that all previous references used approach of constant marginal costs across the aircraft types, different marginal costs seem to be more reasonable, as costs can vary with number of passengers and MTOW of the aircraft.

The final cost function has the following structure:

$$TC = c_1 Movements^{c_2} PAX^{c_3}$$

Estimation of the model was done in E-Views 3.1 programme, using technics of within-Fixed effect model. The result is listed below in Table 6,
where Bremen, Hamburg, Hamburg, Cologne and Nuernberg are dummy variables of airports.

```
Dependent Variable: LOG(TC)
Method: Least Squares
Sample: 1 50
Included observations: 50
=========================================================================
     Variable        Coefficient    Std. Error    t-Statistic     Prob.
=========================================================================
     LOG(MOV)         -0.424429      0.152520     -2.782780      0.0080
      BREMEN           8.925902      1.445566      6.174677      0.0000
     COLOGNE          10.09388       1.624083      6.215125      0.0000
     HAMBURG           9.081565      1.628582      5.576364      0.0000
     HANNOVER          9.867488      1.553336      6.352449      0.0000
    NUERNBERG          9.263313      1.520254      6.093267      0.0000
     LOG(PAX)          0.870774      0.066499     13.09456       0.0000
      Y_2007           0.070308      0.029322      2.397819      0.0210
=========================================================================
```

Table 6 Results from the estimation of the model

All the variables in the model are significant even with 1% significance level. R-squared is 99%. It should be metioned, that E-views report original R-squared, which is high due to individual specific effects. R-squared- within, reported by stata for current model is equal 71%, which can be juged as high. The intercept is not included in the model as all airports have dummies.

The greatest problem of this model is multicollinearity. That was predictable, as number of movements and PAX are highly correlated (r=92,6%). It leads to high level of standard errors. When two variables are highly correlated the effect of overestimating of one parameter and underestimating of other parameter can arise. So coefficients for these correlated variables may have wrong sigh or implausible magnitudes, but even extreme multicollinearity does not violate OLS assumptions. (Econometric analysis, William H. Greene, 5th edition, Prentice Hall 2002; Lecture notes on Advance econometric course, University of Notre-Dame, Richard Williams, 2009).

So regressions with multicollinearity can be generally used without any improvements for purposes of forecasting, but interpretation of the coefficient is not more possible. This fact explains why coefficient before number of movements has negative sign.

Our purpose is to use model for forecasting in general. It means that we can not follow standard procedure of getting cost function from the model by taking exponent, and then taking derivative to get formula for marginal costs. The only way to get unbiased marginal cost from this model is to implement following procedure:

1. Calculate according to the model log(TC) using estimated coefficients and actual data from database for every year and every airport
2. Calculate according to the model log(TC+2) for every type of the aircraft separately using estimated coefficients and actual data from the database, where number of movements is increased by 2 (as we calculate charges for round trip) and number of passengers is increased by capacity of the appropriate aircraft (we assume 80% sead-load factor).
3. Taking difference exp(log(TC+2))-exp(log(TC) we get marginal cost for every type of aircraft for different airports and years.

The result of estimating marginal costs are represented in table 7

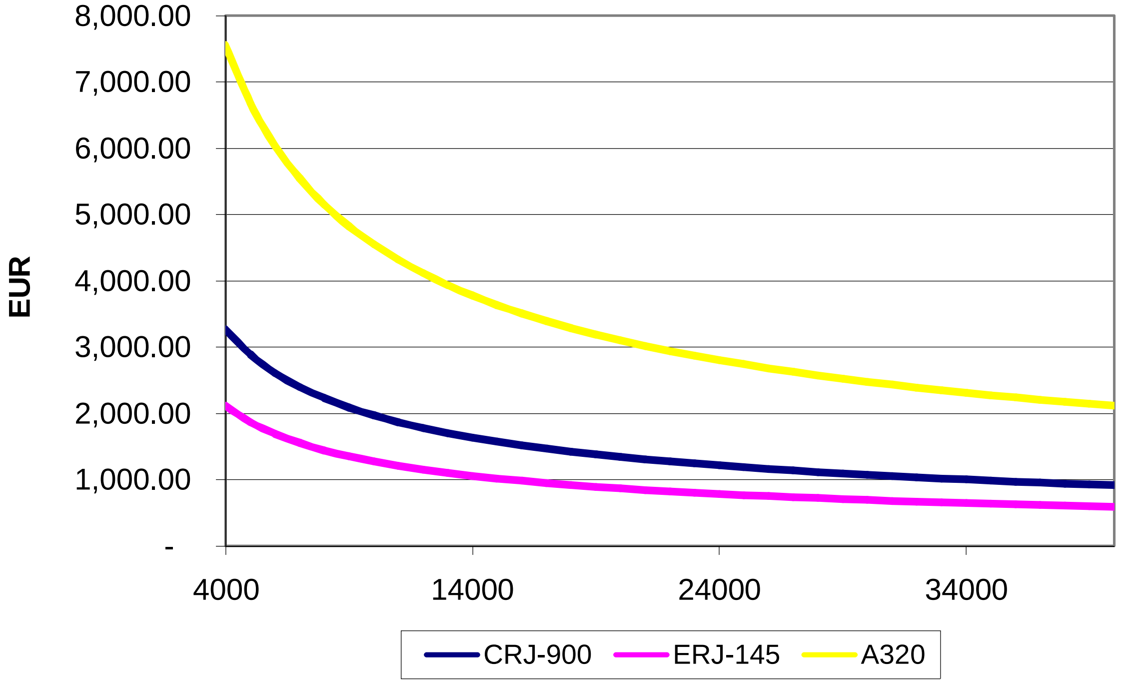
	Marginal cost for different type of aircrafts, EUR		
airport	CRJ-900	ERJ-145	A320
Bremen	958	618	2,221
Hannover	1,287	708	3,432
Cologne	1,174	665	3,060
Hamburg	347	174	989
Nuernberg	905	557	2,197

Table 7. Results of estimation of marginal costs

According to calculations Cologne and Hannover have highest marginal costs, when Hamburg has the lowest ones. This crucial difference in marginal costs is subject to explain.

Hamburg has the lowest average cost in the sample, thus has highest cost efficiency. The reason for that needs further analysis of Hamburg airport perhaps even in form of case study, that is not the purpose of current paper. The only interesting thing to emphasize about sources of differences is variety of fixed costs that are represented in the model in form of dummy coefficients. The lowest fixed costs are estimated in Bremen, when Hamburg has the second lowest ones. The highest levels of fixed costs are in Hannover in Cologhne. Marginal costs function for Bremen is represented in Figure 1

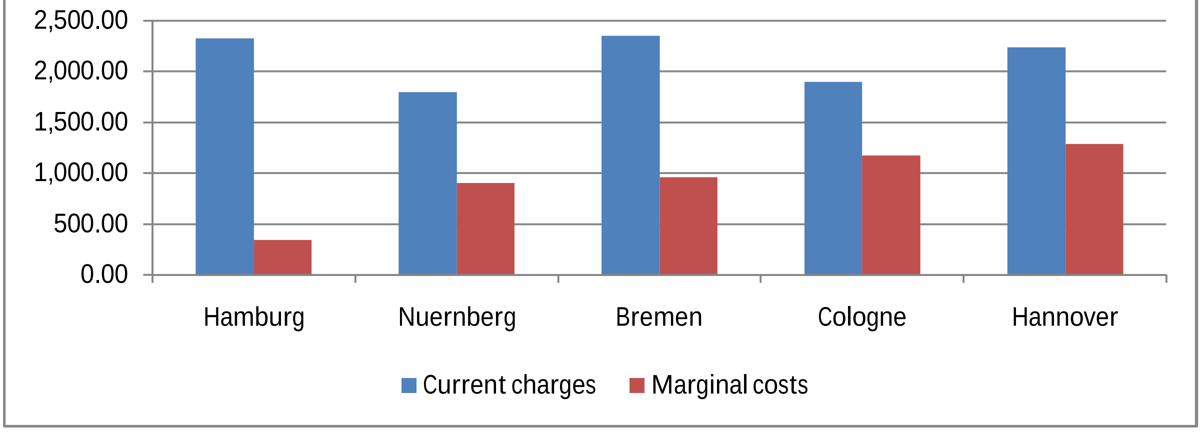
Figure 1. Marginal costs of Bremen airport for turnround movement for different types of aircrafts



The model assumes decreasing marginal costs of the airport that is pretty common assumption for uncongested airports. Number of movements of airport Bremen in 2007 is 36362.

Current charges and marginal cost of the airports are presented in Figure 2

Figure 2. Current charges and marginal costs for different airports, EUR (domestic flights)



From figure 2 it becomes obvious that none of the airports use marginal cost pricing. Furthermore there is no common dependence of current charges from marginal costs. Hamburg, with the highest current charges for CRJ-900 has the lowest marginal costs. It can be explained by difference of monopolistic power of the airports. We will take a deeper look on it in the next part of the paper.

UNKNOWN PARAMETER *k*

The last parameter to estimate in the formula is *k*. $k = \lambda/(1+\lambda)$, where λ is the Lagrange multiplier in the original maximization problem.

In the references, most of the authors just assume the value of k, but it is the parameter that has the most critical influence on the outcome (especially in absolute numbers) and therefore should be chosen with utmost care. *k* can be interpreted as the coefficient of monopoly power of the airport. The value of k depends on the extent to which the revenue constrain is binding. If the constrain is not binding, then k=0 and Ramsey pricing reduces to marginal costs pricing P=MC. At the other extreme, when revenue requirements is at maximum attainable level, the value of λ tends to infinity, and we get k=1, that reduces Ramsey pricing formula to P=MR, that is monopolistic pricing (Morrison, 1982).

In this connection, in this study it was decided to conduct a comparative analysis of the coefficients *k*, calculated from current prices for different durations of flights and different aircraft. The results are presented below.

Figure 3. K that equates current and Ramsey pricing for Bremen

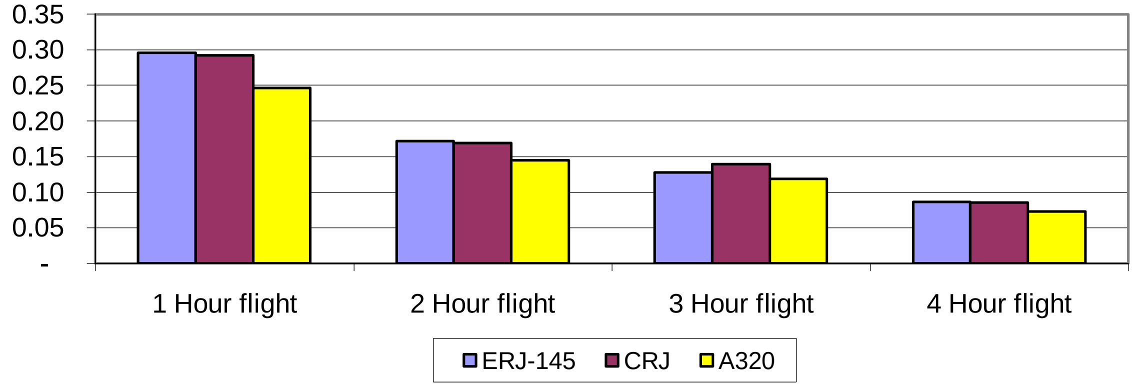


Figure 3 represents results of calculation k for Bremen airport. The first tendency (which is common for all airports) is that k decreases sufficiently with increasing distance of flight. This is a logical conclusion, ie, the regional airports have greater monopolistic power for short-distance flights, as they represents the final destination; airport is monopolist for airlines, as they can not substitute it with other city, as it will be totally different good to sell. Accordingly, for example, when calculating prices for airlines flying from Berlin, Nuernberg has actually monopolistic power, as the flight Berlin-Nuernberg can not be replaced for a flight to another nearby airport, as a matter of fact this would be a completely different direction. As for long distances, the monopolistic power of airports in pricing is significantly reduced and the prices are almost at the level of marginal costs; for example, an airline flying from New York to Germany can consider Frankfurt, Berlin and Dusseldorf as competitors.

It should be noted that such a trend of coefficient *k* is common for all airports.

The other tendency that is common for all airports and reflected in Figure 3 is that k, and so monopolistic power of the airports is in average among airports higher for small aircraft ERJ-145 and CRJ-900 than for A320. This fact does not have clear explanation and need further research. Two hypothesis, that can be a reason for the tendency are the following: this fact is really connected with tendency above, as small aircrafts are common for short-distance flights; it can be type of preventing airlines to switch from A320 to smaller aircrafts like CRJ-900 in case of demand shock. Generally it also can be explained by opportunity costs argument in sense that airports are tend to attract big aircrafts, thus include less monopoly power in the charges. However in case of our sample of uncongested airports the latter is a weak argument, as opportunity cost for uncongested airports is zero, possibly only with few exceptions in peak-hours.

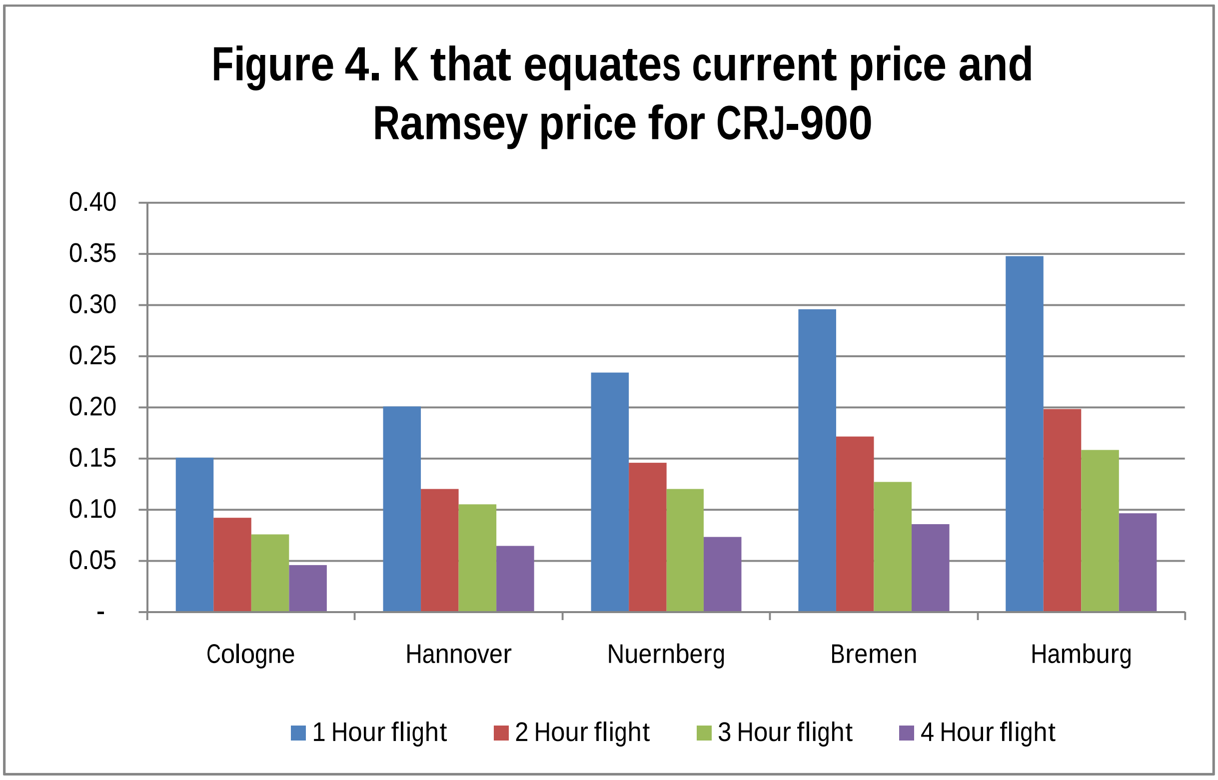


Figure 4. K that equates current price and Ramsey price for CRJ-900

Figure 4 reflects difference in *k* for different airports and different distances for CRJ-900. We can conclude that Cologne uses the smallest *k* in current pricing, so it's pricing is the closest among these airports to marginal cost pricing. Hamburg charges closer to monopolistic pricing than any other airport in the sample. This relation holds for all types of aircrafts. High and low values of *k* can be explained either by current charges or by marginal costs.

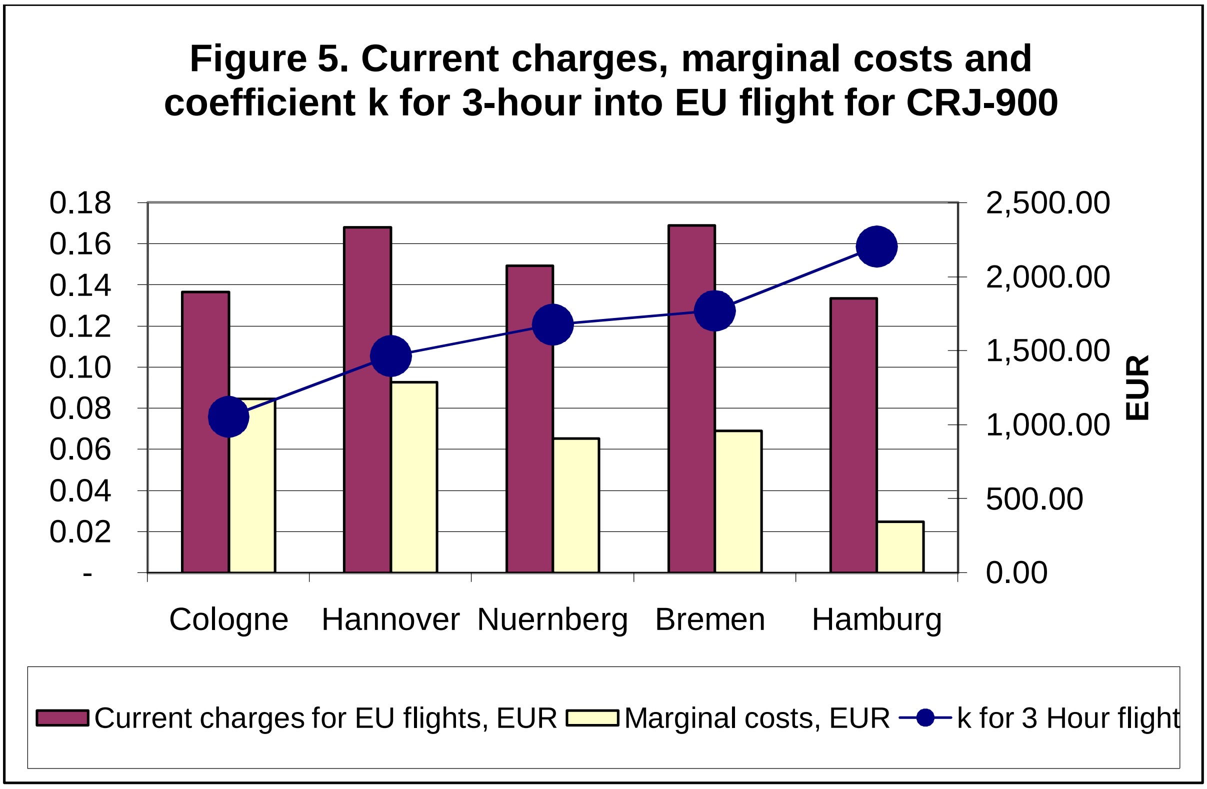


Figure 5. Current charges, marginal costs and coefficient k for 3-hour into EU flight for CRJ-900

Figure 5 can be used to understand why a certain airport has current *k*. In general coefficient *k* negatively correlated with marginal costs. Hamburg has relatively low current charges, but the lowest marginal costs determine the highest *k* of it for the sample. Bremen and Nuernberg, however, have nearly equal marginal costs but Bremen's charges are sufficiently higher, and in this context Bremen got it through realisation of monopolistic power – higher *k* coefficient. Hannover having the highest marginal cost just "can not afford" high coefficient *k*, as it would lead to too high charges relatively to other airports.

For the final calculations of Ramsey prices we use average of all *k* among all airports, aircraft types and duration of flights in the sample. This gives us the same level of magnitude of Ramsey prices as the current charges. This approach was used in the most of the references, including Morrison, 1982. So for the further analysis *k*=0,13.

Results

Using all previous estimations for inputs of formula (5) Ramsey prices was calculated for all airports for different aircrafts and duration of flights.

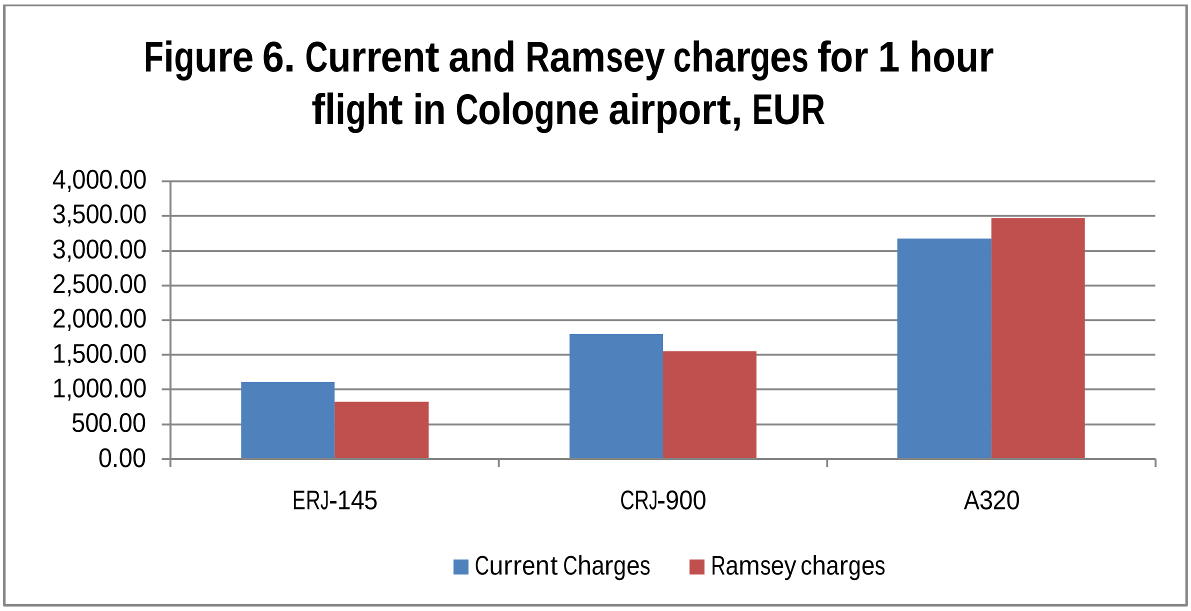
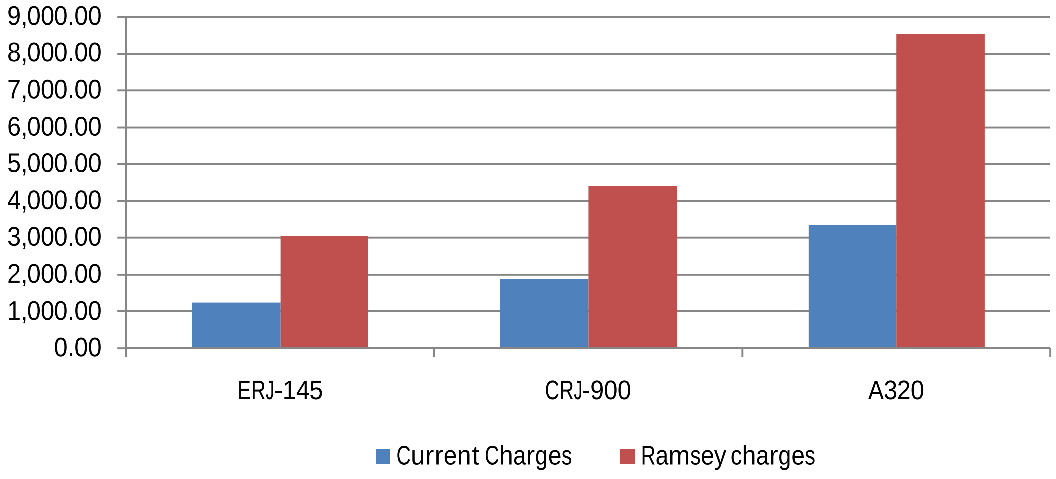


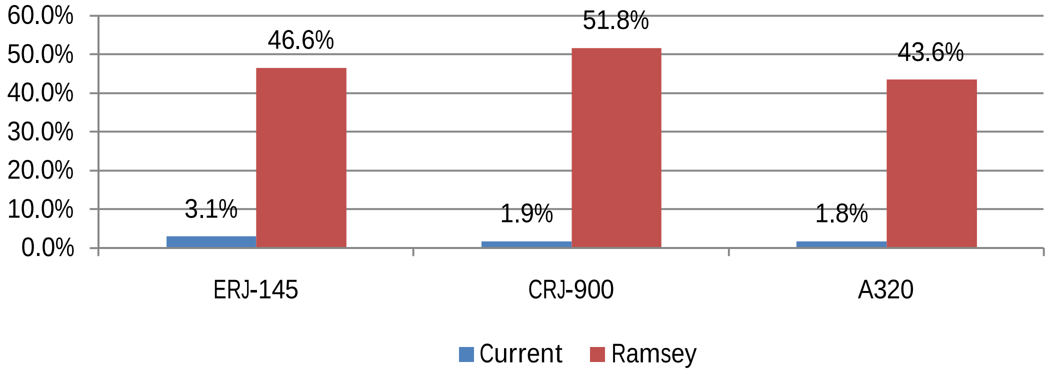
Figure 6 represents results of calculation of Ramsey prices in comparison with current charges of Cologne airport for 1 hour flight. In the market of short flights current charges are higher than Ramsey charges for ERJ and CRJ, but lower for A320. This tendency is common for all airports in the market 1 hour flights. So we can conclude that airports overcharge small aircrafts in the shot flight market but undercharge big aircrafts.

Figure 7. Current and Ramsey charges for 3 hour Flight in Cologne airport, EUR



With increase of the duration of flights Ramsey prices increase much faster than current charges. In the segment of 3 hour Asia-Europe flights Ramsey prices are around to be twice higher than current charges, that can be viewed form Figure 7. And the gap between current and Ramsey charges increases (both in absolute and relative scale) with increase of MTOW of the aircraft.

Figure 8. Average grow of charges with increasing time of flight on 1 hour, % per additional hour of flight



One of the main results is reflected on Figure 8: Current charges of the airports do not vary sufficiently with the length of the flight. This result is similar to the result of Morrison(1982), but in his calculation there was no differentiating of the current charges at all. In case of Germany this differentiation exists in charges of all airports, but it is far from being sufficient, if one follows Ramsey pricing. This result is consistent for all types of aircrafts in the sample.

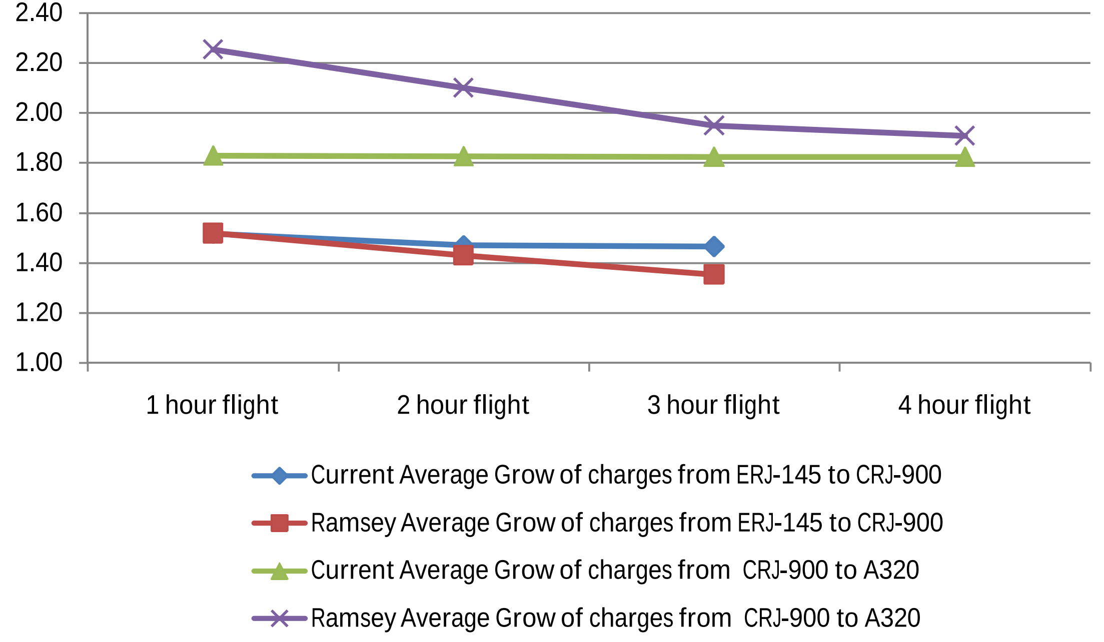


Figure 9. Average growth of current and Ramsey charges from one type of the aircraft to another

Figure 9 reflects relative change of current and Ramsey charges with changing the aircraft type. When it comes to change of CRJ-900 for A320 we see sufficient tendency that growth rate of Ramsey prices exceeds growth rate of current prices. As for change of ERJ-145 for CRJ900 the tendency is the opposite. In order to investigate dependence of growth rate with increase of MTOW we calculated average growth rate of charges per 1 ton increase of MTOW. The results are presented in Figure 10.

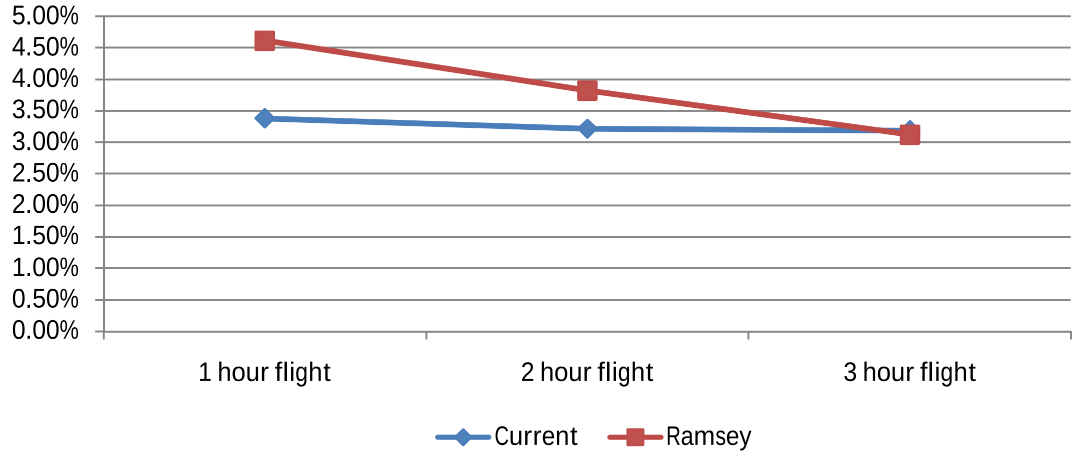


Figure 10. Average growth rate of charges with increase of weight of aircraft, % per MTOW

Figure 10 shows that in current charges all airports use nearly constant grow on level of 3.3% per 1 ton increase of MTOW in charges for all durations of flights. As for rate of increase of Ramsey charges, they show higher growth rate in all durations of flights, but assume different rate of growth for each segment of duration of flights. The highest rate is suggested for short distance flights that mean that Ramsey charges are sufficiently higher for big aircrafts than for small ones. The decrease of average rate of growth with increasing of distance of flight and already equals current growth rates in 3 hour flights market.

This result contradicts with results of Morrison (1982), who got "… current fees rise too rapidly with the weight…" As for our results, in average we get opposite situation, with only few exceptions for only particular change of aircrafts (e.g. Figure 9). This contradiction can be explained by big changes of structure of airport charges, as now variable part of charges is in most of the cases greater than fixed part.

Policy implications

Why Ramsey charges do not work and are there any policy implications from current results? Ramsey charges provide welfare maximum with respect to revenue constrain, however trough need of discrimination. The source of this discrimination is basically in the part of need of variation of charges with distance of flight. Formally landing of the same aircraft with the same number of passengers is one type of good, so charging different price for it would be interpreted as discrimination by the regulator. And if in case of the latter one this decision could be argued from the point of welfare maximization, as Ramsey pricing over performs all possible alternatives like k-degree price discrimination or differentiation (Braouzec, 2010), in case of airlines it would be even harder. At the moment, especially in cases of uncongested airports, airlines sometimes have more bargaining power in determining airports'' charges. Moreover concept of elasticity can even be reconsidered, as elasticity of airlines with respect to airports' charges can be much less than the one of passengers with respect to ticket prices. It can be explained by the fact that in spite of being relatively low proportion of airlines total costs, airport's charges is almost the only part of total cost that can be minimised and manipulated by airlines. Even if we can judge some of the cases of price discrimination in the recent years, like case of Charleroi airport for Ryanair in 2004, that was interpreted as state aid (Groeteke, Kereber, 2004) and possible discounts for major airlines from airports that are not of public concern, this discrimination is of the other type, as it makes one airline benefit entirely, while in case of Ramsey prising every airline would suffer from the discrimination, as it would pay different price for the same product, and thus this variant of charges development seems really unpromising. The only policy implication could be to increase gap between charges for domestic, EU and non-EU passengers, which is somehow proxy for the distance of flight, but still it can be arguable.

As for the second criteria of diversification of Ramsey prices – MTOW, Ramsey charges can be used as a base to determine real charges. Here no discrimination interpretation is possible, as landing of dissimilar aircrafts is a different good to sell. Instead of using nearly linear growth of charges with increase of MTOW airports should investigate optimal gap between charges through analysis of cost of aircrafts. In this particular case, when Ramsey charges grow faster than real ones in Cologne, the recommendation would be to increase charges for big aircrafts and lower them to the small ones. This recommendation is somehow in contradiction to the tendency of the airports to attract big aircrafts, but with zero opportunity costs of airports this decision should lead to welfare maximization. Basically we argue that airlines will not change big aircrafts for the small ones in this case, as big plane's flight are less elastic.

Conclusion

The problem of pricing of uncongested airports has received a lot of attention recently, but there was not empirical research with calculation of Ramsey prices and comparison analysis of them with current charges for German airports. In this paper new approach of estimation of inputs for Morrison's formula was introduced. First of all, assuming different marginal costs for different aircraft types is one the best improvement of calculation technique in comparison with references. Furthermore little attention was paid to interpretation of coefficient k that is calculated from current prices; in this paper analysis of k was done that gave representation of monopolistic power of airports in the sample. The monopolistic power of airports decreases with increasing distance of flights. The final calculation of Ramsey prices confirmed one of the main results of Morrison (1982), that landing fees should increase faster with the distance flown by the aircraft, than they increase now. It is remarkable that in 1982 there was no change of fees with increase of distance of flight but not now that can indicate introduction of scientific approach to current charges of the airports. As for second main result of Morrison about too rapid increase of current fees with weight of aircraft, it did not find proof in our results. In general case we got that current charges grow more slowly with weight of aircraft than Ramsey charges and the difference in rate of growth increases with rise of elasticity of passengers' demand. But the main problem of Ramsey charges is their impracticability, as discrimination cannot be accepted by regulator. We found no perspective in implementing Ramsey charges in real ones from the point of possible differentiation with increase of distance of flight. But still Ramsey approach can be used as a base for determining if not level, but structure of charges in the sense of differentiating with respect to MTOW.

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