PRICE DISCRIMINATION ON THE MARIJUANA MARKET: SCHWAG OR ENDO?

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Abstract:
This paper presents an example of price discrimination on the market for marijuana in the northern and western Czech Republic in 2006. It is based on a model of a multifirm market with emphasis on the existence of two types of firms and two qualities of a good. It is shown that in the case of a dealer of two qualities of marijuana there is an incentive to raise the price of the higher quality and reduce the price of the lower one. Price discrimination on the marijuana market is found in accordance with the predictions of the model and in the amount of about 50 CZK per gram.

Key words: *marijuana, vertical differentiation, price discrimination*

1. Introduction

Price discrimination is a well-established economic topic. Firms often look for ways how to drain a portion of the consumer surplus and reshape it into their own profit. If the firm cannot observe differences among consumers directly, price discrimination must be set by different tools which separate consumers automatically. For the purpose of this paper we work with Stigler's (1987) definition modified later by Clerides (2002) for a situation with more than one good. They define price discrimination as sales of two or more goods in a different price ratio to a ratio of their marginal costs. For a summary of theories regarding price discrimination see Armstrong (2007) or Stole (2007).

Empirical findings of different price discrimination mechanisms can be found in the seminal paper by Shepard (1991), who explored a retail market with gas, Goldberg (1995), Verboven (1996) and Goldberg & Verboven (2005) on an automobile market; another papers found evidence on the market with fishes (Graddy, 1995) cable television (Crawford & Shum, 2001), cereals (Nevo & Wolfram, 2002), ketchup (Besanko, Dube, & Gupta, 2003), cellular telephones (Miravete & Röller, 2003), Broadway theater tickets (Leslie, 2004), books (Clerides, 2004), yellow pages advertising (Busse & Rysman, 2005), paper towels (Cohen, 2007) or coffee (McManus, 2007).

This paper is based on a model of a multifirm market with a vertical product differentiation as a mean of price discrimination. This model was created by Gabszewicz & Thisse (1979, 1980) and improved by Shaked & Sutton (1982). It was most importantly transformed into a more suitable version with the first major application by Shepard (1991). Subsequently, the model is tested with data about prices of different qualities of marijuana in five cities in the northern and western Czech Republic in 2006. Finally, the results of this application are discussed along with a discussion about some limits of the model.

2. Model

The model assumes imperfect competition but not a monopoly, with short-run pricing. Other assumptions are exogenous structure of the market and the existence of two different qualities of marijuana; low quality (called "schwag", denoted with *l*) and high quality (called "endo", denoted with *h)*. Moreover, we assume that there are two kinds of sellers; those who sell only one quality (either *l* or *h*, denoted with *S*) and those who sell both (*D)*; that consumers have different incomes; each consumer prefers high quality and buys no more than one unit of marijuana. With same marginal costs it is clear that

$$p_h^S > p_l^S;\ p_h^D > p_l^D.$$

For extracting price discrimination we define

$$\Delta_D = (p_h^D - p_l^D) \geq 0;\ \Delta_S = (p_h^S - p_l^S) \geq 0$$

and

$$\Delta = \Delta_D - \Delta_S.$$

For deriving demand functions for this market see Gabszewicz & Thisse (1979, 1980). The rest of the model is from Shepard (1991). The assumption of same marginal costs is discussed in the next chapter.

Price discrimination means that prices p_h^D and p_l^D are not same as their counterparts p_h^S and p_l^S. This is because marginal cost of increasing a price of *h* is lower for the seller of both qualities since her consumer will switch to *l* rather than to no purchase. Moreover, she has an incentive to lower the price of *l* because she has lower inframarginal loss than the seller of only lower quality. Shepard (1991, p. 37) provides a full explanation of this.

Thus we can arrive with

$$\Delta_l = p_l^D - p_l^S \leq 0;\ \Delta_h = p_h^D - p_h^S \geq 0,$$

with equality

$$\Delta = \Delta_h - \Delta_l$$

and unequality

$$\Delta = \Delta_D - \Delta_S \geq 0,$$

which finally shows the price discrimination which can be estimated by a simple econometric model, specifically that

$$\Delta = \Delta_h - \Delta_l \geq 0.$$

3. Data and Results

The data were collected by a private researcher in 2006 in five major cities in the northern and western Czech Republic. The research was conducted during the summer months, particularly during the second half of June, July and August when any significant movements in demand or supply which could possibly affect the price were not expected. The data were collected through personal contacts and their contacts. Some observations were excluded because of a close relationship between the seller and the buyer/researcher, because this relationship can lead to lower prices and biased results.

Caulkins & Pacula (2006) concluded that in the U.S. more than half of the marijuana users received the drug for free. Czech survey by the Czech National Monitoring Centre for Drugs and Drug Addiction states that three quarters (72 %) of users recently obtained marijuana for free or by sharing (2009, pp. 91-93). These observations were excluded.

A total of 80 usable observations remained. Table 1 presents the description of the variables and the summary statistics of the data.

Table 1: Summary statistics of the data

	explanation	mean	SD	Q1	median	Q3
P	price in CZK	192,188	82,583	120	200	250
P_real	P/weight	196,545	86,236	120,909	217,391	261,801
mar	1 for high quality *h*	0,588	0,492	0	1	1
ven	1 for seller *D*	0,275	0,447	0	0	1
MV	mar*ven	0,138	0,344	0	0	0
zat	dummies for location (Zatec, Louny, Most, Podborany, Karlovy Vary)	0,275	0,447	0	0	0,75
lou		0,088	0,283	0	0	0
mos		0,1	0,3	0	0	0
pod		0,013	0,111	0	0	0
kvr		0,525	0,499	0	1	1
prf	1 if the seller is reported as a professional	0,250	0,433	0	0	0,75
time	1 if the sale was unusually short or under pressure	0,275	0,447	0	0	1

nat	1 for foreigners	0,1	0,3	0	0	0
grm	0 for one gram sale, 1 otherwise	0,075	0,263	0	0	0
dsc	1 for declared discount	0,113	0,316	0	0	0
plc	1 if the sale took place at a seller's place	0,288	0,453	0	0	1
weight	real weight of one declared gram	0,983	0,063	0,948	0,98	1,02

Now it is possible to test the model by estimating

$$P_i = \beta_0 + \beta_1 mar_i + \beta_2 ven_i + \beta_3 MV_i + \mathbf{B}\mathbb{Z}_{ij} + \epsilon_i,$$

where $\mathbb{Z}$ denotes control variables and $\mathbf{B}$ is a set of regression coefficients of these variables. If $\beta_1, \beta_2, \beta_3 = 0$, then P_i is p_l^S, an average price of marijuana *l* of a seller *S* without controlling for other variables. β_0 is then an average price of marijuana l of a seller S with controlling for other variables in $\mathbb{Z}$, from now $\overline{p_l^S}$.

Similarly, $\beta_1$is an average increase in price of marijuana h by a seller S over a price p_l^S, which we can denote as $\overline{\Delta_S}$, while

$$\overline{\Delta_S} = \left(\overline{p_h^S} - \overline{p_l^S}\right).$$

β_2 is an average increase in price of marijuana l by the seller D over the seller S, which we can denote as $\overline{\Delta_l}$, while

$$\overline{\Delta_l} = \overline{p_l^D} - \overline{p_l^S}.$$

Finally, β_3 is equal to the average price discrimination difference $\bar{\Delta}$. It is so because $\beta_2 + \beta_3$ represents the difference in the price of marijuana h of a seller D and its price of a seller S, which we can denote as $\overline{\Delta_h}$, for which we can show that

$$\overline{\Delta_h} = \overline{p_h^D} - \overline{p_h^S},$$

and due to the condition

$\bar{\Delta} = \overline{\Delta_h} - \overline{\Delta_l}$

it is obvious that

$$\bar{\Delta} = \beta_2 + \beta_3 - \beta_2 = \beta_3.$$

Thus, the model predicts that β_0 will be positive, β_1 nonnegative, β_2 nonpositive, $\beta_2 + \beta_3$ nonnegative and β_3 nonnegative, with all of them equal to zero would indicate perfect competition, which we do not expect in this particular case.

Results are shown in Table 2 (see Appendix "A"). The results are robust after standard heteroscedasticity and multicolinearity tests.

Results estimate the price discrimination (Δ) to be 45-55 CZK (20-79 CZK including standard deviations). This is in line with the predictions of the model. An increase in p_h^D over p_h^S is primarily responsible for this difference. Because $\Delta_h = p_h^D - p_h^S$

, $\Delta_h = p_h^D - p_h^S$ and because Δ_l (*ven*) is statistically insignificant and therefore cannot be distinguished from zero, it can be concluded that the size of Δ is determined primarily by the difference in a price of "endo" $p_h^D - p_h^S$. This conclusion about the insignificance of Δ_l can be found also in Shepard (1991).

The first relevant issue that can bias the results is the question of the assumption of the same marginal costs for vendors of both types. This should be of less importance since variables for professionals, foreigners and other variables which can explain the difference were included. Morover, the National Monitoring Centre says that sellers on the retail market are themselves producers of “endo” (2009) and the costs of it should be the same. So for an explanation of the price discrimination by different costs we would have to find different costs of "schwag" between sellers of types *D* and *S*. The differing costs hypothesis can be rejected, since the only difference between *D* and *S* is the presence of “endo” and this fact cannot itself increase the cost of “schwag” (since *D* sells "schwag" for more).

Another possible factor that may enter into a decision of a vendor is based on the information asymmetry between a seller and a buyer. Let us assume a possible difference in quality even among the lower or higher quality. And it is clear that there can be different levels of purity among “schwag” or “endo”. As Johnson & Golub (2007) noted, with an empirical research on drug markets there are problems difficult to overcome, especially with measurement of purity, so that the implicit assumption of homogeneity of both qualities may be violated and consumers distinguish for example between a purer “schwag” and a less pure one. Although it is possible to think of a corresponding proxy, it is possible to make a conclusion about irrelevance of a real purity for buyers from the institutional point of view. Users spontaneously created in the language designation for two or three qualities. The third and highest quality is mostly called „dank“ and it was not present in the research. So at least in the region of our research it is the logic of emergence and usage of “schwag/endo” labeling what can be itself a proof that the difference in the purity of the individual qualities is irrelevant for deciding buyers. For elaboration on this see Johnson et al. (2006) or Harrison et al. (2007).

Is it possible to assume that a seller knows the actual weight and the optimal marijuana prices p_l^D, p_l^S, p_h^S a p_h^D are in fact nominal (declared) prices divided by the weight. Fortunately, the data allows us to estimate a model

$$P\_real_i = \beta_0 + \beta_1 man_i + \beta_2 ven_i + \beta_3 MV_i + \mathrm{B}\mathbb{Z}_{ij} + \epsilon_i.$$

The results are shown in Table 3 (see Appendix “A”). They estimate the price discrimination to be 51-60 CZK (26-75 CZK including standard deviations). The standard deviation of the weight is 0,068 gram, the average of differences from one gram is 0,049 gram and there are two thirds (66,25 %) of observations with reduced weight, with an average reduction of 0,033 gram. One third (36,36 %) of dealers *D* sold one type of marijuana at real price lower than nominal price and the other at higher. These figures mean that a significant part of retailers sell more than one gram for the price of one gram, part of them are inconsistent in their actions and the average weight reduction of 33 milligrams can be considered a measurement error and not a deliberate reduction.

4. Conclusion

This paper continues in the works of authors who reveal price discrimination, especially with Shepard (1991) and her findings about a discriminatory price setting on a multifirm market with vertically differentiated product. The model of a retail market suggests that a vertical differentiation is sufficient for price discrimination and that dealers offering both lower and higher quality have an incentive to lower a price of the former and to raise a price of the latter. Important result of the present paper concerning the case of the marijuana market is a confirmation of the hypothesis that price differentials may not be present only due to differences in costs. However, it is important to include into consideration the limits of the assumption of same costs for retailers. It is possible that a part of the discriminatory behavior can be explained by the unavoidable subjectivity of costs.

There are mainly three limitations of the present analysis. First, the work is limited in time and space for a few months and for an area inhabited by no more than 150 thousand people. Adding some other larger towns and extend a time of the research would be a worthy extension of this work. Secondly, the work is compiled from five years old data. This is problematic for extrapolating the results to a current situation, especially on a market that is dynamic, institutionally unstable and moreover illegal. Other relevant variation of this work would be its application to a present data and a comparison of results. Third, this work estimates price discrimination from only 80 observations. It is a relatively high number for the marijuana market but econometric estimation with a higher number of observations would be significantly better and would eliminate some possible biases.

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Appendix "A"

Table 2: Regressions explaining price in CZK (P)

	(1)	(2)	(3)	(4)	(5)	med. reg.
const	**117,273*** **	**111,443*** **	**117,190*** **	**113,437*** **	**105,136*** **	**91,558*** **
	(10,229)	*(13,575)*	*(10,113)*	*(11,394)*	*(15,126)*	*(23,512)*
mar	**123,561*** **	**125,935*** **	**122,497*** **	**120,875*** **	**121,651*** **	**113,312*** **
	(12,983)	*(13,861)*	*(12,65)*	*(12,644)*	*(13,538)*	*(3,578)*
ven	**-15,455**	**-11,577**	**-24,275**	**-31,823***	**-28,963**	**-49,675*** **
	(17,717)	*(18,982)*	*(17,477)*	*(18,208)*	*(19,633)*	*(5,194)*
MV	**47,803***	**45,429***	**55,379** **	**55,454** **	**53,255** **	**68,507*** **
	(24,23)	*(25,01)*	*(23,612)*	*(23,174)*	*(23,861)*	*(6,323)*
zat		**2,243**			**3,608**	**-5,565**
		(13,541)			*(13,524)*	*(3,574)*
lou		**16,983**			**28,849**	**18,507**
		(20,028)			*(19,912)*	*(5,396)*
mos		**11,097**			**19,463**	**4,633**
		(19,511)			*(19,281)*	*(5,119)*
pod		**38,557**			**13,263**	**11,688**
		(50,671)			*(49,722)*	*(13,14)*
prf			**24,485***	**33,638** **	**36,33** **	**24,675*** **
			(12,388)	*(14,39)*	*(14,66)*	*(4,034)*
time				**27,739** **	**31,601** **	**15,26*** **
				(13,81)	*(14,739)*	*(3,896)*
nat				**32,32***	**38,869** **	**26,948*** **
				(17,756)	*(19,008)*	*(5,044)*
grm				**-31,128**	**-34,623**	**-3,752**
				(27,988)	*(28,742)*	*(7,621)*
dsc			**-35,815** **	**-39,809** **	**-35,175** **	**-16,558*** **
			(16,894)	*(16,65)*	*(17,162)*	*(4,607)*
plc				**-12,5**	**-15,69**	**-18,182*** **
				(11,607)	*(12,104)*	*(3,199)*
R^2	**0,681**	**0,685**	**0,708**	**0,734**	**0,745**	

*Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level, respectively, standard deviation is in parentheses.*

Table 3: Regressions explaining real price in CZK (P_real)

	(1)	(2)	(3)	(4)	(5)	med. reg.
const	**119,396*****	**112,575*****	**120,169*****	**116,115*****	**108,203*****	**122,18*****
	(10,874)	*(14,272)*	*(10,986)*	*(12,51)*	*(16,382)*	*(10,773)*
mar	**126,556*****	**129,059*****	**126,318*****	**124,898*****	**124,793*****	**119,418*****
	(13,802)	*(14,573)*	*(13,742)*	*(13,883)*	*(14,662)*	*(9,642)*
ven	**-16,53**	**-12,967**	**-22,94**	**-31,803**	**-30,841**	**-31,961****
	(18,834)	*(19,957)*	*(18,986)*	*(19,991)*	*(21,263)*	*(18,986)*
MV	**53,402****	**50,899***	**59,414****	**59,5838****	**57,726****	**62,64*****
	(25,757)	*(25,293)*	*(25,651)*	*(25,445)*	*(25,842)*	*(16,995)*
zat		**1,576**			**1,816**	**-3,369**
		(14,236)			*(14,647)*	*(9,632)*
lou		**32,698**			**44,140**	**37,567**
		(21,056)			*(21,566)*	*(14,183)*
mos		**8,951**			**16,718**	**6,08**
		(20,513)			*(20,882)*	*(13,733)*
pod		**42,065**			**11,239**	**5,502**
		(53,273)			*(53,851)*	*(35,414)*
prf			**15,5**	**23,619**	**27,031***	**6,868**
			(13,457)	*(15,799)*	*(15,877)*	*(10,441)*
time				**30,211***	**35,197****	**26,957****
				(15,163)	*(15,963)*	*(10,498)*
nat				**25,268**	**32,744**	**13,948**
				(19,495)	*(20,586)*	*(13,538)*
grm				**-26,146**	**-28,76**	**-12,3**
				(30,73)	*(31,128)*	*(20,471)*
dsc			**-31,754***	**-35,814***	**-30,522**	**-5,117**
			(18,352)	*(18,28)*	*(18,587)*	*(12,223)*
plc				**-10,935**	**-16,436**	**-19,091****
				(12,744)	*(13,109)*	*(8,621)*
R^2	**0,668**	**0,685**	**0,684**	**0,706**	**0,726**	

*Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level, respectively, standard deviation is in parentheses.*