CASE STUDY ABOUT THE OPTIMUM OFFER DIMENSION IN THE CONDITIONS OF AN UNPREDICTABLE DEMAND IN THE CASE OF A "TODAY'S MENU" SALE

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Abstract: *This paper used a classic subject of the mathematical and economic modeling: the "newsvendor". The purpose is to study a concrete practical case, which is frequently met in tourism industry: the optimal offer dimension in the case of an unpredictable demand, applied to sale optimization of the "today's menu".*

Key words*: newsvendor, mathematical and economic modeling*

INTRODUCTION

The issue of the uncertain demand constitutes a classic subject in the management of economical operations, being described in some general or particular situations through various mathematical models. A model that describes the administration of stocks with fixed prices, but characterized by the unsafe demand, is known as "newsvendor". Although the subject has a considerable history, the first rigorously scientific interpretations appear at the end of the 1880s and are attributed to F.Y. Edgeworth (1845-1926), a British economist, adept of the neoclassic economist theory **[2].** Why is it called "newsvendor"? The model describes the dilemma of the newsvendors, the sellers whose activity is described very well by this model. Even if the applicability of it can cover a large category of products, perishable products or those with an expiration date are subjected to a larger number of constraints when it comes to the supply policy. Therefore, the manager of a news stand will have a permanent dilemma in regards to the optimum supply, because the newspapers that are not sold today are practically unusable tomorrow, and on the other hand, insufficient supply would lead to loss (contrasting to imperishable products that have fewer limitations).

The list can grow. Christmas lights, baked goods or milk, season specific products, Easter eggs, designer clothes **[1]**, remote hotels that are supplied with perishable products, restaurants that serve "today's menu"—they function on the "newsvendor" principle.

The purpose of this paper is the concrete study from the industry of public alimentation or tourism, which consists of the offer optimization in a restaurant's "today's menu".

THE STAGE OF KNOWLEDGE

The initial model belongs to Edgeworth who publishes "The Mathematical Theory of Banking" in 1888. However, the term of "newsvendor" belongs to Morse and Kimball (1951) **[3]**, Edgeworth's focus being on the optimum cash supply in a bank counter to satisfy the random demand of the clients of a bank. One of the most important landmarks in the history of this subject is the modern interpretation of K.J. Arrow, an American economist, who alongside his collaborators, describes it in "Optimal Inventory Policy" in the year 1951. (An insufficiently known fact about this famous economist, who in 1972 won the Nobel Prize for Economy, is his tie with Romania. His parents emigrated to the USA from Iaşi county - Romania) [**7**].

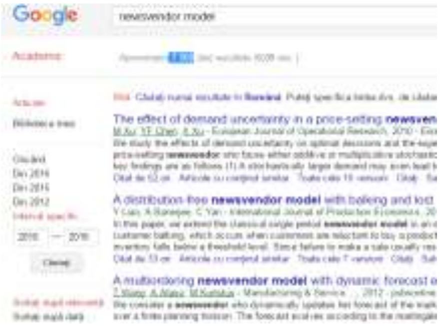

Figure 1. Google references for the terms "newsvendor model"

The applicability of this model is ample and actual. A personalized Google search of the term "newsvendor model" for the 2010-2016 timeframe resulted in 7560 results. These aspects prove the apparent inexhaustible applicability of this model (figure 1).

MATERIAL AND METHOD

We will shortly describe the model employed.

Starting from n = the stock supply, x = the demand, there are three possible cases of the supply demand problem:

I. The $n < x$ case. The supply stock does not meet the demand.

The case in which the supply stock (n) is lower than the existent demand (x) attracts the loss of the potential gain the seller would have had if the supply would have met the demand.

II. The $n > x$ case. The supply stock exceeds the demand.

The most financially disadvantageous case is when the supply (n) exceeds the demand (x), because the seller invests more than he gains.

III. The $n = x$ case (ideal). The supply stock is equal to the demand.

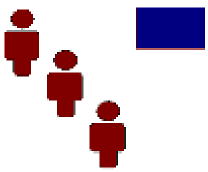	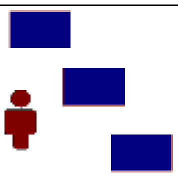	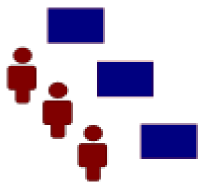
Figure 2. The supply stock does not meet the demand	**Figure 3. The supply stock exceeds the demand**	**Figure 4 .The supply stock is equal to the demand**
Source: personal graphics		

The ideal case is represented by the equality between the supply stock (n) and the demand (x), the seller selling all products and meeting the demand. Though this case is the subject of this study, it is ideal and rarely met.

The formula for average loss, which represents the objective function of the optimization problem is: $(\min)\ f(n)=\sum_{x=0}^{n} c_1(n-x)p+\sum_{x=n+1}^{\infty} c_2(x-n)p$, where p represents the probability of meeting the demand x. c_1, c_2 represent the the expenses and the unit profit **[4]**.

The case study is made for a restaurant in Timişoara which serves "today's menu" during working days. It has unit costs of c_1=10 lei (without fix costs) and the selling price is 19 lei, implying a difference of c_2=9 lei.

Without knowing the daily demand, a statistic of the people served daily during two months (working days) has been made, resulting in the dates included in the following table:

Table 1.

The number of servings during two months

Sales (people served daily)	Sales frequency (days)
< 35	1
40-44	9
45-49	11
50-54	9
55-59	6
> 60	2
TOTAL	**38 days**

RESULTS AND DISCUSSIONS

The problems that need a solution are the following:

a) predicting the loss in the situation where for a day 52 menus are prepared, but there are only 32 clients;

b) predicting the loss in the situation where for a day 52 menus are prepared, but the demand is for 62;

c) determining the average loss in the case where 40, 45, 50, 55 and 60 menus respectively are prepared.

The average of each interval as representative of its respective class is considered (table 2).

Table 2.

Problem data

No. of people served	32	42	47	52	57	62
No. of days	1	9	11	9	6	2

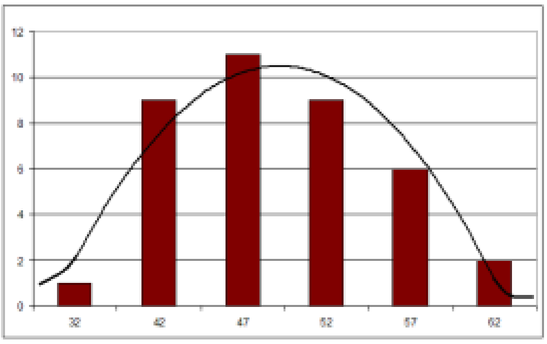

Figure. 5. The study of the phenomenon's normality

The dates regard the normal repartition, indicating a data classification around the average, the extreme values being low (indicating a slight asymmetry, SKEW=-0,3, KURT=-0,4).

a) $c_1(s-x)=10(52-32)=200\,\text{lei}$ b) $c_2(x-s)=9(62-52)=90\,\text{lei}$

$$\text{c) } f(40)=10(40-32)\cdot\frac{1}{38}+9(42-40)\cdot\frac{9}{38}+9(47-40)\cdot\frac{11}{38}$$

$$+9(52-40)\cdot\frac{9}{38}+9(57-40)\cdot\frac{6}{38}+9(62-40)\cdot\frac{2}{38}=84.76\text{lei}$$

$$f(45)=10(45-32)\cdot\frac{1}{38}+10(45-42)\cdot\frac{9}{38}+9(47-45)\cdot\frac{11}{38}+9(52-45)\cdot\frac{9}{38}+9(57-45)\cdot\frac{6}{38}+9(62-45)\cdot\frac{2}{38}=55.76$$

$$f(50)=10(50-32)\cdot\frac{1}{38}+10(50-42)\cdot\frac{9}{38}+10(50-47)\cdot\frac{11}{38}+9(52-50)\cdot\frac{9}{38}+9(57-50)\cdot\frac{6}{38}+9(62-50)\cdot\frac{2}{38}=52.24$$

$$f(55)=10(55-32)\cdot\frac{1}{38}+10(55-42)\cdot\frac{9}{38}+10(55-47)\cdot\frac{11}{38}$$

$$+10(55-50)\cdot\frac{9}{38}+9(57-55)\cdot\frac{6}{38}+9(62-55)\cdot\frac{2}{38}=78.00\text{lei}$$

$$f(60)=10(60-32)\cdot\frac{1}{38}+10(60-42)\cdot\frac{9}{38}+10(60-47)\cdot\frac{11}{38}$$
$$+10(60-50)\cdot\frac{9}{38}+10(60-57)\cdot\frac{6}{38}+9(62-60)\cdot\frac{2}{38}=117.00\text{lei}$$

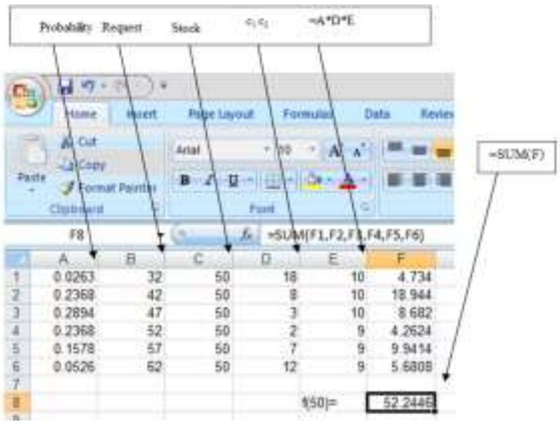

Figure 6. Calculation example (Microsoft Office Excel)
Source: *personal calculations*

According to the calculations, the recommended number of menus is 50, a situation in which the average loss is minimal.

CONCLUSIONS

The notion of loss indicated in the model will not always be interpreted literally; it will only be theoretical when the demand exceeds the offer. In this case only an eventual loss could appear.

The differences are relatively high in the case when the number of menus is modified, which justifies the necessity of optimization studies. Furthermore, these differences increase when the serving unit increases.

Another utility of this study represents the minimization of the occurrences of unpleasant situations when potential clients are turned down because the administrator does not take the risk of selling the appropriate number of menus, for (solid) fear of oversupply.

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