

The Analysis of Consumers' Preferences with the Application of Multivariate Models: Hedonic Regression and Multidimensional Scaling

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Abstract On durable goods markets declared behaviours of buyers rarely leads to the actual purchasing decisions. This fact poses a particular challenge for the analysis of the future reactions of consumers to the elements of the marketing mix. This study attempts to combine the results obtained from multidimensional scaling and hedonic modelling to assess both stated and revealed preferences with respect to the attributes of a specific durable good, namely a smartphone. The assessment of consumers' declared behaviours was obtained by analysing data from an on-line survey study with the application of multidimensional scaling. Simultaneously, the estimated hedonic model provided the information on consumers' revealed preferences. The combined use of both approaches allowed for broader insight into the issue of consumers' behaviours, particularly in relation to the existing market offer.

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1 Introduction

The analyses of consumer preferences provide tools to create better (more accurate and better targeted) offers which meet the needs of specific target groups (market segments). Especially in contemporary economic conditions, characterized by rapid technological change, escalating international competition, political and economic upheaval, the dominance of the customer and increasing market complexity, studying of the preferences of consumers has become a necessity to find new sources of competitive advantage. Therefore, it is very important to efficiently identify the actual preferences of consumers, and to efficiently use the information obtained in the process of product development. Effective analysis of preferences can significantly strengthen competitive advantages through the support of entrepreneurs in many functional areas. The knowledge of the expectations and needs of consumers might favourably influence the product design process (constructing the product and equipping it with the attributes and features that are most important to future potential consumers), product pricing (determining the price level which will be acceptable to the prospective buyers, and at the same time competitive on the given market), as well as market segmentation (taking into account consumers various expectations and formulating adequate, differentiated pricing strategies in segments).

On durable goods markets declared behaviours of buyers transpose rarely to the actual purchasing decisions. This study attempts to set together the results obtained from multidimensional scaling and hedonic modelling to assess both stated and revealed preferences with respect to the attributes of a specific good, namely a smartphone. Assessment of consumers' declared behaviours was obtained by analysing data from an on-line survey study with the application of multidimensional scaling. Simultaneously, the estimated hedonic model (based on the dataset consisting of the price lists from Polish Internet shops) provided the information on consumers' revealed preferences. The combined use of both approaches allowed for broader insights into the issue of consumers' behaviours, particularly in relation to the existing market offer.

2 Measurement of Consumer Preferences on Durable Goods Markets

The concept of preferences (preference relations) plays an extremely important role in economics, in particular in the theory of consumer behaviour, as well as in the theory of utility. Preference relations are the starting point in the study of individual choices of consumers and private demand, which is the basis for the analysis of market demand (see Båk, 2013; Netzer et al, 2008). Consumer preference analyses are conducted in order to obtain rating systems reflecting the needs and tastes of consumers based on which customers choose a particular product. The preference structure reflects the hierarchical structure of possible customer choices from a range of goods and services available on the market, and shows the ranking of different bundles of goods according to levels of utility, or the total satisfaction of consuming a good or service.

2.1 Stated and revealed preferences

Both stated and revealed preferences are important steps in the buying process of the consumer, called consumer decision cycle (see Fig. 1, Kotler et al (1999)). The process starts with the recognition of a need or problem that must be fulfilled by a particular product. Afterwards the consumer gains the awareness of the existence of a certain group of goods which meet his needs. In the next stage, the potential customer in order to become more familiarized with the product, performs a detailed research on the subject. He learns the features of a product and makes comparisons, using various information sources (including product specifications, reviews, opinions, and tests). The more valuable the good, the longer this phase of the process, as the customers on average are willing to spend more time analysing the more expensive purchases. In the following step (consideration), the consumer attempts to narrow down the number of potential products. At this stage the brands of the products play a particularly important role because they provide means to simplify the choice between the most likely purchases. Brand names convey information about various aspects of the product, such as reputation, reliability, quality, and also are synonyms of a certain prestige and even of social status and identity. Thus they reduce the risk involved in the buying process and increase the information efficiency of the purchase (see Keller and Lehmann, 2006). At this point the customer

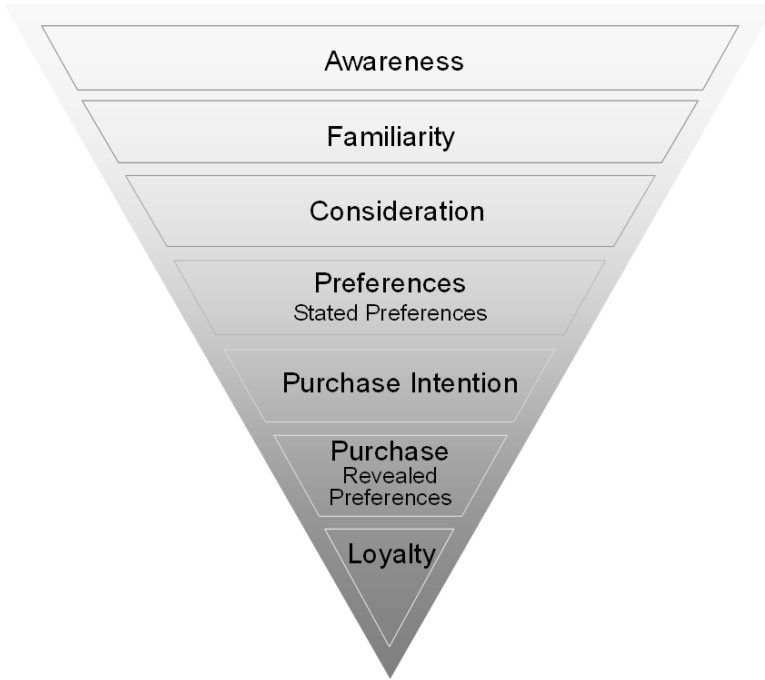


Fig. 1 Consumer decision cycle

can declare his preferences towards product brands and other characteristics, and based on them might later express the intention to purchase. The actual buying action, representing the revealed preferences, is made upon consideration of additional elements, such as for example budget constraints, affordability and timing. Provided that the bought product met the expectation of the consumer, the following steps might involve loyalty towards products or brands, endorsement, as well as future repurchase intentions.

The problem of measuring preferences is more complex and complicated on a durable goods market than on a fast moving consumer goods market.

Numerous studies show that even though stated preferences are positively correlated with purchase intentions, only a few percent of the declared intention of buying is actually implemented (see Cobb-Walgren et al, 1995; Morwitz and Schmittlein, 1992). To a large extent this is due to the specificities of markets of durable goods. First of all, the individual consumer is present on the market intermittently. Durable goods are characterized by a certain permanence and are long lasting which means that upon purchase the buyer in general is no longer active on a given market for a longer period of time (see De Gregorio et al, 1998). Therefore, from those consumers who recently bought a durable good, it is hard to obtain reliable information on their future intentions towards purchases on this very market. Secondly, the purchasing power of households on durable goods markets depends on the ratio of product price to the income size rather than the nominal income. The usually high prices of durable goods can prevent some potential consumers from a purchase which poses a major obstacle in translating declared preferences to actions. Moreover, the behaviours of consumers on the durables' markets depend highly on the general economic situation. The study conducted in Poland at the beginning of the economic crisis by MillwardBrown(Kopacz, 2008) showed that in cases of a worsening of the financial situation of households first resign from stimulants (such as alcohol, cigarettes) as well as entertainment and recreation activities (such as holidays, cinema, sports), and simultaneously postpone the earlier planned purchases of durable goods. In addition, the analysis is complicated by the existence of secondary markets for durable goods which enables the consumers to buy cheaper used goods (or even to rent them) instead of buying them on the primary markets. As a result, on durable goods markets one often faces the disparities between stated and revealed consumer preferences, which pose a particular challenge for analyses of the future reactions of consumers to the elements of marketing mix.

2.2 Smartphone market

The smartphone market is an example of a large, promising and dynamically growing market of durable goods. Two producers have the biggest market share globally: Samsung (25%) and Apple (19%)¹. On the Polish market the

¹ Based on www.idc.com (accessed: 12.07.2015).

undisputed leader is Samsung (38%). The market share of Apple, despite the high prestige and recognition of the brand, is much lower (3%).

Mobile devices play an increasingly important role in our lives. Smartphones, tablets, and even smartwatches have become an indispensable part of everyday life for a significant part of the population. According to the report of TNS Global (Mikowska, 2015) in the middle of 2015 in Poland about 60% of the population were owners of a smartphone device. The degree of the overall spread of such innovative devices in the population is still closely connected to the age of the users, and the differences between the age groups are significant. In the age group 15-19 years 91% of the respondents use smartphones, while in the group 20-29 years this percentage amounts to 88%. With age the proportion of smartphone owners is getting lower. In the next age group (30-39 years) the percentage drops to 79%, and among the people over 60 years old to 20%.

Despite the smartphone market development and a regular increase in the number of new smartphone users, it is a difficult market. First of all, the smartphone industry copes with problems of short product lifecycles and rapid technological advancements. Another problem is posed by the presence of imitations and substitutes. The market is characterized by strong brand loyalty and stiff competition which causes significant entry barriers. Hence companies need to be aware of consumer preferences and specific needs to stay competitive.

3 Market offer analysis. Hedonic model

The foundation of hedonic methods is formed by the so-called hedonic hypothesis which states that heterogeneous commodities are characterized by a set of relatively homogeneous attributes (characteristics) relevant both from the point of view of the customer and the producer (see Brachinger, 2002; Dziechciarz, 2004). The relationship between price of commodity (*PRICE*) and the set of its characteristics (*X*) described by the function *f* is called hedonic regression and may be described in the following general notation:

$$PRICE = f(X; \beta; \varepsilon), \quad (1)$$

where ε is the error term of the model. The estimate of the vector of parameters β obtained by estimation of a correctly specified hedonic regression model using the data set, allows to calculate the prices of individual characteristics of the given good (so-called hedonic prices or implicit prices). It is assumed that

Table 1 Descriptive statistics for the data set

Variable name	Min	Max	Average	Std. deviation	Share [%]
PRICE [PLN]	160	3569.50	946.13	675.99	
SCREEN [inch]	2	7	4.2952	0.7903	
STORAGE [GB]	0	64	8.8131	9.1181	
CAMERA [Mpix]	0.3	41	6.8911	4.0914	
LTE					28.35
GPS					94.40
ANDROID					81.10
WINDOWS					7.58
APPLE iOS					4.39
OTHER					6.92

the consumers derive utility from goods attributes, and therefore the hedonic prices reflect the willingness to pay for certain levels of attributes. In that context the hedonic model measures the hedonic prices which to some extent reveal the preferences of the consumers at an aggregate level.

3.1 Data set

The dataset consists of price lists available on the Internet website of one of the biggest Polish price comparison service providers. The data set comprises 910 smartphone models of 27 different brands offered in Internet shops in Poland in February 2015. Each offer is described by price (PRICE [PLN]) and the following characteristics: SCREEN - screen size [inch], STORAGE - internal storage [GB], CAMERA - camera resolution [Mpix]. The categorical variable SYSTEM represents the operating system of a smartphone: ANDROID, WINDOWS, APPLE iOS and OTHER. Moreover the following dummy variables (take value 1 if feature is present and 0 otherwise) were used: LTE (Long-Term Evolution standard for wireless communication), GPS (Global Positioning System for navigation), as well as dummies representing the smartphone brands. Table 1 presents basic descriptive statistics for the data set.

Out of 27 brand name dummies present in the dataset 18 were statistically significant: ACER (11), ALCATEL (24), ALIGATOR (6), APPLE (40), ARCHOS (7), ASUS (6), BLACKBERRY (16), GIGABYTE (22), HTC (62), HUAWEI (37), LG (91), MOTOROLA (17), NOKIA (94), PRESTIGIO (41), SAMSUNG

(217), SONY (87), ZOPO (15), ZTE (7). The remaining 9 brands formed reference group: BE (9), GOCLEVER (25), KRUGER&MATZ (15), MANTA (6), MEDIA-TECH (10), MYPHONE (14), OVERMAX (16), TELEFUNKEN (6), WIKO (9). In parentheses the number of models representing this brand is given.

3.2 Estimation results

The results of the estimation of a hedonic model for smartphone prices are presented in Table 2. The best functional form turned out to be the model with the logarithm of PRICE (lnPRICE) as dependent variable and by taking the logarithm of the independent variables SCREEN and CAMERA and adding a quadratic term to STORAGE. This functional form was chosen with the Box-Cox transformation (see Box and Cox, 1964). The choice of independent variables was limited by data availability. Due to the heteroskedasticity of the error term the weighted least squares method proposed by White (1980) was applied for model estimation.

Almost all variables in the model are highly statistically significant (on the significance level lower than 0,01). Variables ARCHOS and PRESTIGIO are significant on the level 0,05. The signs of the obtained parameter estimates are in accordance with expectations. The goodness-of-fit of the model measured by the R^2 statistic is on the satisfactory level (above 90%).

4 The analysis of stated preferences. Multidimensional scaling

In this study two multidimensional scaling approaches were applied: The unfolding procedure (PREFSCAL) and PROFIT analysis (PROperty FITting). To perform the analysis SPSS and Statistica were used accordingly. Both methods are widely used for the analysis of consumer preferences (see e.g. Hair et al, 2014; Borg et al, 2013; Walesiak and Gatnar, 2004; Zaborski, 2003): The unfolding analysis allows for the presentation of points representing both the respondents and objects in a joint space. The obtained preference map is the basis for the assessment of the relations and interdependence between the objects and the respondents. PROFIT analysis creates a vector preference map, combining the perceptual map obtained by multidimensional scaling with the

Table 2 Hedonic model for smartphones (dependent variable: lnPRICE)

	Coefficient	Std. error	<i>t</i> -ratio	<i>p</i> -value
constant	3.789830	0.0911449	41.5802	0.0000
lnSCREEN	1.071200	0.0715286	14.9758	0.0000
lnCAMERA	0.340625	0.0215401	15.8136	0.0000
STORAGE	0.031558	0.0026559	11.8824	0.0000
STORAGE ²	-0.000348	5.15e-005	-6.7603	0.0000
ANDROID	-0.129963	0.0418294	-3.1070	0.0020
GPS	0.120036	0.0377096	3.1832	0.0015
LTE	0.149875	0.0233708	6.4129	0.0000
ACER	0.407796	0.0696455	5.8553	0.0000
ALCATEL	0.281955	0.0486903	5.7908	0.0000
ALIGATOR	0.419322	0.1334170	3.1429	0.0017
APPLE	1.145070	0.0544643	21.0242	0.0000
ARCHOS	0.136089	0.0664415	2.0483	0.0408
ASUS	0.528194	0.1754150	3.0111	0.0027
BLACKBERRY	0.806932	0.0899489	8.9710	0.0000
GIGABYTE	0.347101	0.0622432	5.5765	0.0000
HTC	0.707189	0.0531637	13.3021	0.0000
HUAWEI	0.383858	0.0439485	8.7343	0.0000
LG	0.354884	0.0324555	10.9345	0.0000
MOTOROLA	0.422555	0.0647447	6.5265	0.0000
NOKIA	0.288791	0.0443453	6.5123	0.0000
PRESTIGIO	0.087313	0.0372924	2.3413	0.0194
SAMSUNG	0.512381	0.0316429	16.1926	0.0000
SONY	0.500371	0.0376554	13.2882	0.0000
ZOPO	0.170541	0.0560743	3.0413	0.0024
ZTE	0.431813	0.0857847	5.0337	0.0000
Std. Error of Regression	1.847	Adjusted <i>R</i> ²	0.9085	
<i>F</i> (25, 884)	362.237	<i>p</i> -value (<i>F</i> test)	0.0000	

data on the preferences towards the surveyed objects from the point of view of their characteristics. This method puts together the results of multidimensional scaling and multiple regression analysis.

4.1 On-line survey data

The data of the on-line survey was gathered in February 2015 among Wrocław University of Economics students. The questionnaire was focused on measuring consumers' preferences towards smartphone characteristics and possible

applications of the device. The sample consisted of 451 respondents selected due to their accessibility and proximity (convenience sampling).

The respondents were expected to assess popular brands of smartphones important characteristics, as well as the common usage patterns of the device. Thus, in order to evaluate the analyzed criteria, each respondent has created his individual rankings of:

- the brand names (question: *Order the following 10 brands of smartphones from the most to the least preferred: Apple, Blackberry, GoClever, HTC, Huawei, LG, Motorola, Nokia, Samsung, Sony*).
- the criteria, that would be taken into account while purchasing smartphone (question: *Order the attributes of smartphones from the most to the least important: price, battery life, storage, camera, internet access, OS, screen resolution, screen size, design, brand*).
- the common usage patterns of smartphones (question: *Order the applications of a smartphone from the most to the least important: calls, sms/mms, social media, internet, work, e-mail, navigation, mobile banking, music, photos, games, movies, reading*).

Moreover, the respondents have assessed the brand names of smartphones by rating 5 brand attributes (prestige, design, modernity, support, and reliability) on a numeric 5-point scale (5 - highest rate, 1 lowest rate).

4.2 Preference maps

Brand name preference analysis Analysis of the respondents' preferences towards brands of smartphones allowed for identification of the most and least preferred brand names (see Fig. 2(a)). The group of highly rated brands include Samsung and Apple, as well as Sony and Nokia. Quite often the respondents indicated HTC, LG and BlackBerry as their favourite brands. In turn, the least popular brands include Motorola, Huawei and GoClever.

The obtained results of stated consumers' preferences can be combined with the results of revealed preferences from the hedonic regression described in section 3.2. The estimated parameters for various brands in the hedonic model can be interpreted as brand premiums - the surplus amounts the consumers are willing to pay just because a smartphone is of a certain brand. Table 3 presents the brand premiums for the brand names which were assessed by the respondents. For example, the most valued brand is Apple. The smartphones

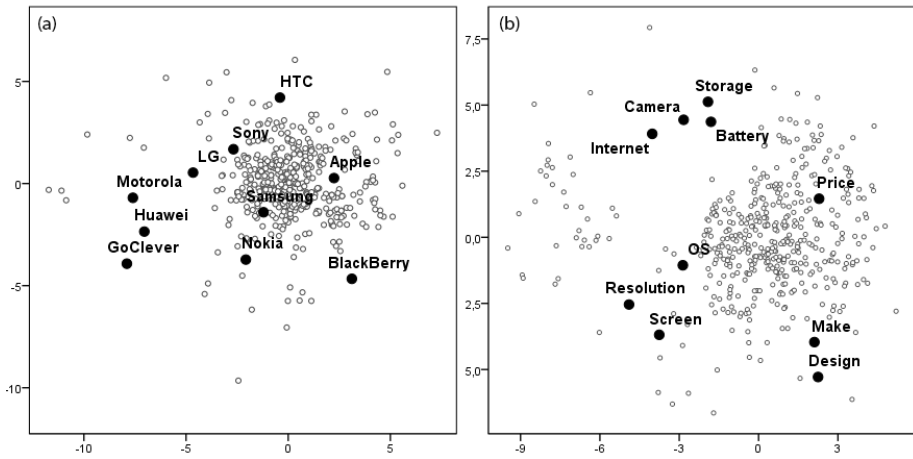


Fig. 2 Preference maps for smartphone brand names (a) and smartphone characteristics (b)

from this producer on average are about 215% more expensive in comparison to the smartphones with brands from the reference group, *ceteris paribus*. When comparing the results from Fig. 2(a) and Table 3, a few interesting findings may be observed. Since the sample in the survey study was not representative, we discuss the obtained results as examples of interpretation of the proposed theoretical construction, but do not intend to draw inferences for the whole population. For the majority of brands the results of both studies coincide - more preferred brands have higher premiums, and less appreciated brands are less valued. However, there are some exceptions. BlackBerry is on average quite expensive (about 125% price premium), even though a relatively small number of respondents indicate this brand as the preferred one. This could be the result of two symptoms. It is possible that in the analyzed market segment (students), the BlackBerry smartphone generally considered as the device designed for business applications, is simply not popular. Alternatively, it could be the case that BlackBerry is a niche brand - it is highly valued by a small group of very solid and dedicated consumers. The opposite situation may be observed in the case of the Nokia brand. It is appreciated by quite a number of consumers, whereas its brand premium is moderate (only about 34%). Possibly this cheap brand, enjoying the reputation of trustworthy and reliable, is especially popular in the student community. Interestingly, on the preference map (Fig. 2(a)) the

Table 3 Smartphone brand premiums

Brand name	Brand premium	Brand name	Brand premium
APPLE	214.27%	MOTOROLA	52.59%
BLACKBERRY	124.10%	HUAWEI	46.79%
HTC	102.83%	LG	42.60%
SAMSUNG	69.59%	NOKIA	33.48%
SONY	64.93%	GOCLEVER	-

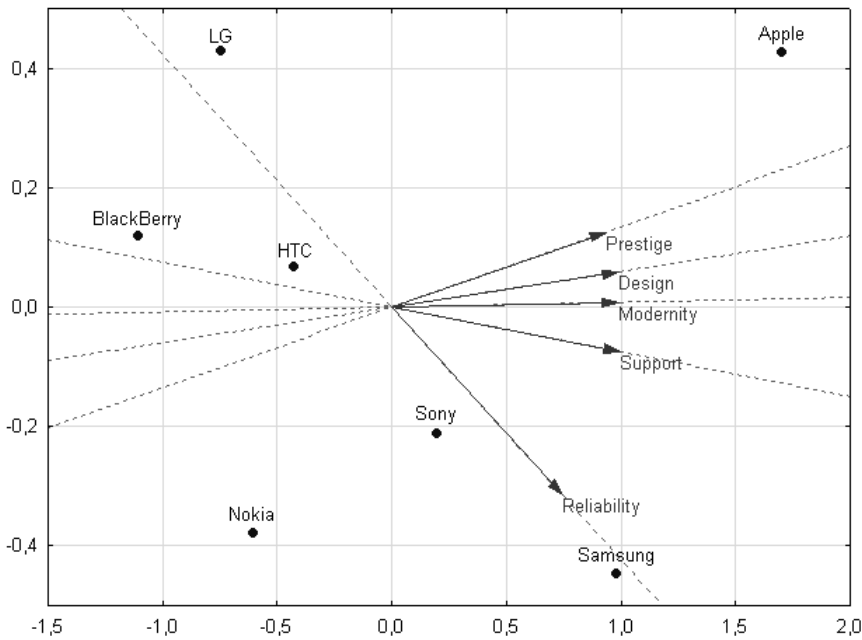


Fig. 3 Preference map for smartphone brands' attributes

smartphone brands are ordered on the X-axis, from the cheapest to the most expensive, with the exception of BlackBerry and Nokia.

An additional analysis of consumers' preference towards brands is possible by introduction of brand attributes (see Fig. 3). When assessing brand attributes like prestige, design, modernity, as well as support, Apple is unquestionable the leader, followed by Samsung and Sony. However, in terms of reliability, Apple is dominated by Samsung, Sony, and even Nokia.

Attributes preference analysis The most important criteria, that would be taken into account when purchasing a smartphone by participants of the survey, were the operating system, price and brand name (see Fig. 2(b)). There was a group of respondents who paid close attention to screen related attributes (size and resolution) as well. The other smartphone characteristics were considered less essential. The importance of the smartphone attributes expressed by the respondents may be juxtaposed with the corresponding hedonic prices presented in Table 3. For example, the analysis of the operating system indicated by the consumers shows that smartphones with the Android system are on average about 13% cheaper. In turn, the size of the smartphone screen positively influence the price - 1% increase in screen size on average increases the price by 1.07%, *ceteris paribus*.

Applications preference analysis Based on the preference map for the usual use patterns of a smartphone (see. Fig. 4), it can be concluded that by far the most frequently reported applications of the device are telephone calls and messages. Quite often the respondents have mentioned the importance of web browsing and social media activities as well. Interestingly, the previously cited study conducted by TNS showed that the average Polish smartphone owner spends almost three hours per day using the device. The activities that do not require Internet connection (phone calls, messages) take on average about 45 minutes a day. The remaining time - about two hours a day - is spent on Internet activities. The study measured in an objective manner the way the smartphone owners used their devices by means of specially developed mobile application which was installed on each user smartphone (Mikowska, 2015). This confirms the assumption that the behaviours and preferences declared by the respondents do not always accurately reflect their actual actions.

5 Conclusions

The inherent characteristics of the durable goods' markets increase the disparities between declared preferences of the consumers and their actual behaviours. Therefore, on those markets accurate measurement of preferences, as well as their analysis and drawing the correct conclusions is especially challenging. Consumers' preference analysis incorporating two different approaches - from the point of view of stated preferences in the consumer survey, and analyzing revealed preferences using data from the market offer - could provide additional

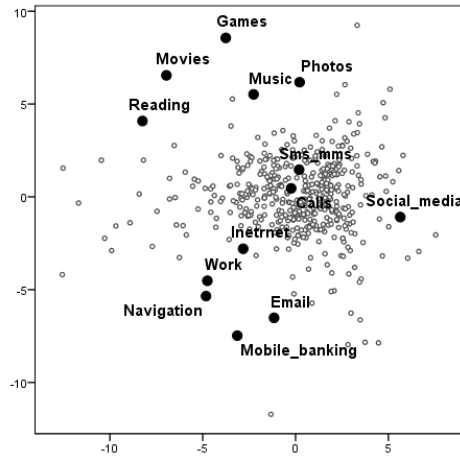


Fig. 4 Preference map for smartphone use patterns

information and valuable insights into the results. Comprehensive information acquired in this way (by measurement on two levels: consumer and product) can be used in the area of preparing pricing policy (determining the acceptable and competitive price levels), as well as product development (equipping the product with the features that are most important to potential consumers), both on the whole market and in its various segments (see Dziechciarz, 2005). It is worth noticing that in contrast to the survey study, hedonic analysis is relatively cheap, due to the availability of the data. Therefore, extending the classic questionnaire-based consumer preference analyses (such as conjoint analysis or multidimensional scaling) to include market data and hedonic modelling techniques brings not only additional dimensions to the results but also improve the cost-benefit ratio of the research.

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