



Research article

The law of demand and the loss of confidence effect: An experimental study

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ARTICLE INFO

Keywords:

Economics

Microeconomics

Demand function

Price elasticity of demand

Irrationality

Loss of confidence and experimental study

ABSTRACT

The aim of this article is to examine the possibility that a market demand function (curve) might not be monotonically decreasing in its entire domain according to the consumer theory neoclassical as assumed by the law of demand (for normal goods). This may happen due to limited rationality of (some) consumers and the anchor price effect. When a price of a good decreases to some point, the amount demanded might stop increasing due to the *loss of confidence effect*: consumers' unwillingness to buy a too cheap product. The existence of this effect was examined via questionnaire on a sample of 377 undergraduate university students from the Czech Republic, Ecuador and Spain. The main result of this experimental study is that the loss of confidence effect appeared at all three locations, which indicates that the law of demand may not be valid in its entire domain. Furthermore, the results of this study imply that a significant percentage of people make decisions of limited rationality even when facing a very simple task. In addition, statistically significant difference in rational behavior with respect to gender was found.

1. Introduction

In the economic theory, the market demand is a sum of individual demands for a given good. The *law of demand* states, that as a price of a good increases, quantity demanded decreases, and vice versa (*ceteris paribus*). Also, a demand function (curve) $P = f(Q)$ and its inverse, $Q = f^{-1}(P)$, are usually depicted monotonically decreasing (and convex), see Fig. 1a. Mathematically, the law of demand states that $\frac{\partial f}{\partial Q} < 0$ ($\frac{\partial f^{-1}}{\partial P} < 0$) in the whole domain of f . The negative slope of the market demand curve is discussed e. g. in Becker (1962). Mathematical derivation of the law of demand (its downward slope) based on revealed preferences and the utility theory can be found in e.g. Hildenbrand (1983) or Quah (2000). The economic theory states majority of goods are normal, with only rare exceptions to the law of demand in the form of (inferior) Giffen goods, luxury Veblen goods, or some necessary goods (such as medical equipment, medicaments, water or basic food), see e.g. Masuda and Newman (1981) or Veblen (1899), for which the slope of a demand curve is upward.

Although there is no empirical research on possibility of a demand curve with a positive slope for “normal” goods, there are theoretical studies that discuss a complex market demand model with externalities,

which include both positive and negative slope of a demand curve, see Guangping and Changjun (2015) or Akerlof et al. (2018), see also Fig. 1b.

Rationality can be defined in many ways. For Shugan (2006), rationality is “having the ability to reason”. Lipman (1991) defines rationality as “choosing the best procedure for deciding”, while Bernheim (1984) means by rationality “taking the best action under given conditions”.

In 1957, Simon Herbert, see Herbert (1957) came up with the idea of “bounded rationality”. He argues that most humans are only partly rational due to cognitive limitations of human mind and the tractability (complexity) of decision making problems. A discussion on consumers' rationality is a hot topic in the behavioral economics since 1970s early works of Amos Tversky, Daniel Kahneman or Richard Thaler, founders of modern behavioral economics, see e.g. Tversky and Kahneman (1974). The early history of behavioral economics is described in an unusually instructive way in Richard Thaler's book *Misbehaving*, see Thaler (2016). The book contains some examples of ‘irrational economic behavior’ of individuals. Thaler discriminates between *Econs*, individuals who are strictly rational and behaving accordingly to economic theories, and ordinary (imperfect) *Humans*, illustrating differences in their decision making. In general, behavioral economics is a branch of economics that studies effects of psychological, cognitive, emotional, cultural and other factors on economic decisions of individuals and aims at explaining how

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Received 25 July 2019; Received in revised form 22 August 2019; Accepted 15 October 2019

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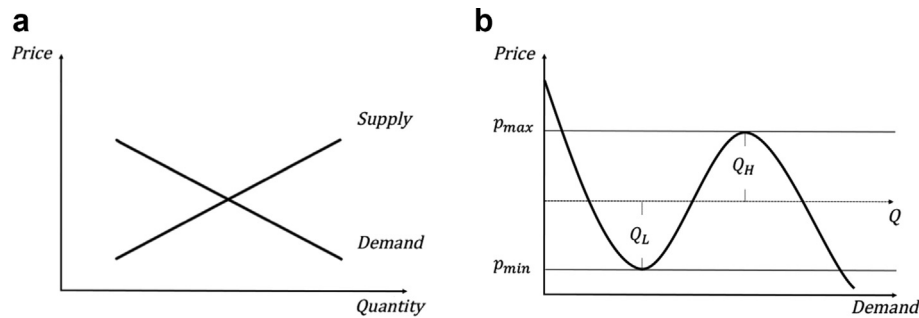


Fig. 1. a) A typical depiction of demand and supply functions, b) A (cubic) shape of a non-monotonic demand curve considered in Akerlof et al. (2018). Source: Authors.

those decisions vary from those implied by classical economic theory. The “limited rationality” of individuals is another possible explanation, see e. g. Infante et al. (2016) or Rabin (2013). The “limited rationality” can be understood as a lower level of rationality until it becomes irrational (although this depends on the context). These levels depend on psychological mechanisms such as preference, value, judgments and well-being, which should be used in the economy according to Hausman (2012).

In general, the irrational's evidence behavior of consumers is growing, see e.g. recent studies of Fehr and Tyran (2005), Kapeller et al. (2012), Shugan (2006) or Cummings et al. (2015). The law of demand seems reasonable and rational; however, it might not be true in reality. Do people (consumers) act always rationally? If at least some consumers are irrational, is the law of demand still valid? An empirical research on real behavior of true consumers dealing with their individual demand curves is missing in the literature.

To outline the research problem of this study, consider a situation where a consumer wants to buy a tablet. This good has certain parameters, and a consumer expects to pay something between 300–350 USD (the anchoring price). However, a shop-assistant offers a tablet satisfying all consumer's parameters for only 80 USD. Should the consumer buy it? The price seems too low. Isn't the tablet out of order? Isn't it inferior in terms of quality? The consumer hesitates whether to buy it or not, and may decide not to buy it due to his/her doubts with respect to quality of the offered product. This situation, when the price of a good is out of consumers' expected price range (more precisely, the price is much lower), which leads to good's rejection by a significant part of consumers. It's going to be called the *loss of confidence effect* thereafter. In the model situation above, the fall of the price doesn't result in the increase of demand of a tablet. The law of demand is not valid any more, though the offered good is “normal” (nor Giffen, nor Veblen) according to the economic theory. But does this effect exist in reality?

The answer can be found by designing an appropriate experiment. Therefore, the aim of this article is to examine whether a market demand function (curve) $P = f(Q)$ is decreasing over its entire domain. The method of the study is an experiment carried via a questionnaire. Respondents (university students) were asked whether they would buy a given good (a tablet) for a given (descending) price. Then, from individual responses a market demand curve was constructed and evaluated with respect to the law of demand. Also, (i)rationality of respondents was evaluated with regard to respondents' age and gender.

The organization of this paper is as follows: in section 1 the method of the study is described, in section 2 results are provided, and in section 3 a discussion of results is presented. Conclusions close the article.

2. Materials and methods

The method of the research was an experiment carried via an anonymous questionnaire, see Appendix A. The research was approved by the

Ethical committee of the Silesian University in Opava. At the beginning of the experiment, respondents (university students) were addressed with the following words: “Please, fill the questionnaire related to one of our faculty projects”.

The instructor did not provide any other explanation or instructions to reduce acquiescence bias (“yes saying”) to a minimum.

In the questionnaire itself, respondents were asked about their age and gender, and then were shown a picture of a tablet (Samsung Galaxy Tab4 10.1VE SM-T533) with its specification. Ten questions of the type: “Would you buy this tablet for (6000, 5000, 4000, 3000, 2000, 1500, 1000, 500, 300 and 100) CZK” with “YES” or “NO” answers followed (23 CZK = 1 USD). Respondents answered “YES” or “NO” to the question with the highest price, and proceeded immediately to questions with lower prices in the descending order. The whole experiment lasted only several minutes. Due to simplicity and swiftness of the experiment the only bias that might occur was an indifference bias (some respondents may not care to fill the survey properly, though they were verbally motivated to do so).

At the time of the experiment, the tablet was offered for 7023 CZK at the biggest Czech Internet online wholesaler *Heureka.cz*. The research was carried out among students of two courses (*Statistics and Mathematical methods in Economics*) at School of Business Administration, Silesian University in Opava, in the Czech Republic, in 2016. Only fully answered questionnaires were processed. From individual demand functions the market demand function was constructed as their sum. The total number of respondents was 121; including 89 women and 32 men. As for respondents age, 27 respondents were aged under 21 and 94 respondents were 21 and older.

The experiment was repeated in 2019 in Ecuador at Universidad Central del Ecuador, Escuela Politécnica Nacional and Universidad Nacional de Chimborazo; and in Spain at Universidad de Córdoba, Universidad Rey Juan Carlos and others. The experiment was conducted via online questionnaire similar to the one in Appendix A, the only change being a currency involved (US dollars and Euros respectively). Again, respondents were university students. In Ecuador, 142 respondents (68 women and 74 men) participated in the study, while the sample in Spain consisted of 114 respondents (69 women and 45 men).

In addition to the experimental derivation of the market demand curves (functions) at three aforementioned locations, the following two null hypotheses H_{01} and H_{02} dealing with respondents' rationality were tested by the *chi-square* test for independence.

- H_{01} : “There is no difference in rationality between men and women”.
- H_{02} : “There is no difference in rationality between younger and older students”.

The level of statistical significance α was set to be 0.01. All tables and figures thereafter are made by the authors.

3. Results

3.1. Results of the experiment – Czech Republic

Results of the study in the form of the market demand are provided in Table 1. Fig. 2 shows empirically derived market demand function and the inverse market demand function (the market demand function is not a function in terms of mathematical terminology in this case).

From the Table 1 and Fig. 2 it's clear that the market demand is not monotonous. The data points suggest the demand is decreasing from 2,000 CZK to 6,000 CZK as expected by economic theory. However, between 100 CZK and 1,500 CZK the demand is increasing, and not decreasing as would the law of demand suggest. The turning point is 1,500 CZK. This point, the loss of confidence occurred, at the price of approximately 21% of the price offered by Heureka.cz online shop.

Respondents, who answered “YES” for a certain price, and also for all lower prices, were considered rational (as well as several respondents who answered “NO” to all prices). Out of 121 respondents, 58% respondents were rational and 42% respondents irrational (in terms of the experiment). Men were slightly more rational than women, while differences in rationality between younger students (under 21) and older students (21 and above) were smaller. Numbers of rational and irrational respondents with respect to their gender and age are provided in Table 2.

At last, both null hypotheses from the previous section where evaluated:

- H_{01} : “There is no difference in rationality between men and women”.

The critical value $\chi^2_{0.01}(1) = 6.6$, test value $G = 1.08$; H_{01} cannot be rejected.

- H_{02} : “There is no difference in rationality between younger and older students”.

The critical value $\chi^2_{0.01}(1) = 6.6$, test value $G = 0.075$; H_{02} cannot be rejected.

Hence, in the case of respondents from the Czech Republic, the differences in rationality between men and women, and between younger and older students, were found statistically insignificant.

3.2. Results of the experiment – Ecuador

The results of the experiment carried out among Ecuadorian undergraduate university students are presented in Table 3 and Fig. 3a, b. It can be seen that the market demand is not monotonically decreasing, and the loss of confidence effect appears at the turning point of 150 USD (at approximately 49% of the price of the product at retailer's website).

Out of 142 respondents, 49% respondents were rational and 51% respondents irrational. Men were more rational than women, see Table 2, while differences in rationality between younger students (under 21) and older students (21 and above) were negligible.

The null hypotheses were evaluated with the following results:

- H_{01} : The critical value $\chi^2_{0.01}(1) = 6.6$, test value $G = 13.77$; H_{01} was rejected.

Table 1

Empirically derived data points of the demand curve (function), Czech Republic.

Price (CZK)	Quantity demanded	Price (CZK)	Quantity demanded
6 000	15	1 500	82
5 000	23	1 000	71
4 000	40	500	66
3 000	79	300	65
2 000	83	100	66

- H_{02} : The critical value $\chi^2_{0.01}(1) = 6.6$, test value $G = 0.049$; H_{02} cannot be rejected.

Hence, the difference in rationality between men and women was found statistically significant at $p = 0.01$ level.

3.3. Results of the experiment – Spain

The results of the experiment carried out among Spain undergraduate university students are presented in Table 4 and Fig. 4a, b. In analogy to results from the Czech Republic and Ecuador, the market demand is not monotonically decreasing, and the loss of confidence effect appears at the turning point of 120 Euros (at approximately 44% of the price of the product at retailer's website).

Out of 114 respondents, 59% respondents were rational and 41% respondents irrational. Men were more rational than women again, see Table 2, while differences in rationality between younger students (under 21) and older students (21 and above) were much smaller.

The null hypotheses were evaluated with the following results:

- H_{01} : The critical value $\chi^2_{0.01}(1) = 6.6$, test value $G = 8.64$; H_{01} is rejected.
- H_{02} : The critical value $\chi^2_{0.01}(1) = 6.6$, test value $G = 0.038$; H_{02} cannot be rejected.

Hence, in case of Spanish respondents, the difference in rationality with respect to gender was found statistically significant at $p = 0.01$ level.

4. Discussion

According to Rabin (2013) or Harstad and Selten (2013), little has been done to integrate insights of psychology on the limits of rationality into economics. The reason why the law of demand might not hold in its entire domains is that humans are not always totally rational (Thaler and Sunstein, 2009). The literature on human cognitive bias and its effects on decision making is vast and growing quickly every year, see e.g. Tversky and Kahneman (1974), Kahneman (2011), Dvorsky (2013), or Munger (2015). Ariely (2008) argues that when making a decision to buy certain good, an anchor price plays a vital role. The anchor price affects the way consumers perceive the value of a good hence forth, as they are comparing it to the anchor price.

The price of a product, when no other information about the product is available, provides signal about its quality, with the higher price obviously meaning the higher quality. Therefore, in such a situation, a low price product might be avoided by consumers due to is assumed inferior quality, and the law of demand becomes invalid. Though there is no paper in the scientific research questioning the law of demand validity known to authors, there is plenty of evidence of its invalidity for low prices coming from marketers and producers, see for example Tuttle (2012), D'Souza (2015), or Clancy (2019). Tuttle (2012) explains that product's low price provides two conflicting messages to consumers: “It is a bargain”, and “It is a product of bad quality”, and these two messages compete across the set of consumers. Moreover, Tuttle specifically mentions 80% sales as a threshold that can discourage some consumers. D'Souza (2015) explains the role of the anchor price, when no other information is available, and how consumers might avoid too low-priced products. Clancy (2019) provides an example of marketing strategy based on a large sale that failed to attract customers. To summon, findings of the aforementioned marketing experts indicate that consumers prefer modest prices close to the anchoring price, and are not generally inclined towards “too low” prices.

Therefore, the result of the presented study can be, to some extent, explained by the existence of the aforementioned anchor price. Customers buying a certain good (or service) have their own expectations of an appropriate price based on their previous experience and knowledge

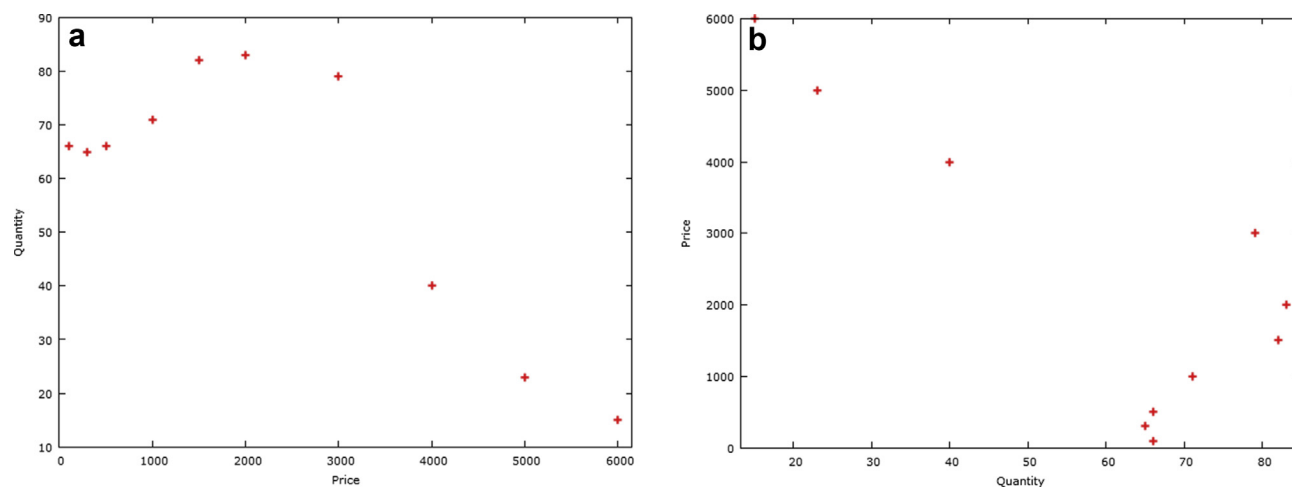


Fig. 2. a) Data points of the inverse of the demand function of the experiment. The Czech Republic, price in CZK. b) Data points of the demand curve of the experiment. The Czech Republic, price in CZK.

Table 2

Numbers of rational and irrational respondents with respect to gender and age for the Czech Republic, Ecuador and Spain.

Respondents	Rational/ Irrational CZE	Rational/Irrational ECU	Rational/ Irrational ESP
men	21/11	47/27	34/11
women	49/40	22/46	33/36
under age of 21	15/12	15/17	24/16
21 years and more	55/39	54/56	43/31

Note: The number 21/11 in the second row and column means that 21 men from the Czech Republic were rational, and 11 men were irrational, and so on in the rest of the table.

Table 3

Empirically derived data points of the demand curve (function), Ecuador.

Price (USD)	Quantity demanded	Price (USD)	Quantity demanded
250	18	100	70
230	21	70	57
200	43	50	62
180	52	30	61
150	76	20	67
120	67		

(an anchor price, or reference price), or prices paid by other people. If the real price is close to their expectations, or slightly below it, they are likely to buy the product. A price significantly higher than an expected one will probably discourage from a purchase. On the other hand, much lower price might lead to customers' confusion. Why is it so cheap? Does it have some flaws? Is it out of order? Is its quality acceptable? Generally, this situation occurs when a cognitive structure of an individual is in a conflict with reality.

That's why a large portion of respondents refused to buy the tablet for a price too low, though they had answered "YES" for a higher price for the *same* item already. This was verified by seven questionnaires that contained explanation of "NO" answer for the lowest prices. Respondents unanimously wrote: "The price is too low; it must be a piece of junk."

It should be noted that the anchor price effect does not provide the

Table 4

Empirically derived demand curve (function), Spain.

Price (Euro)	Quantity demanded	Price (Euro)	Quantity demanded
250	29	100	76
230	36	70	69
200	53	50	67
180	60	30	65
150	74	20	66
120	73		

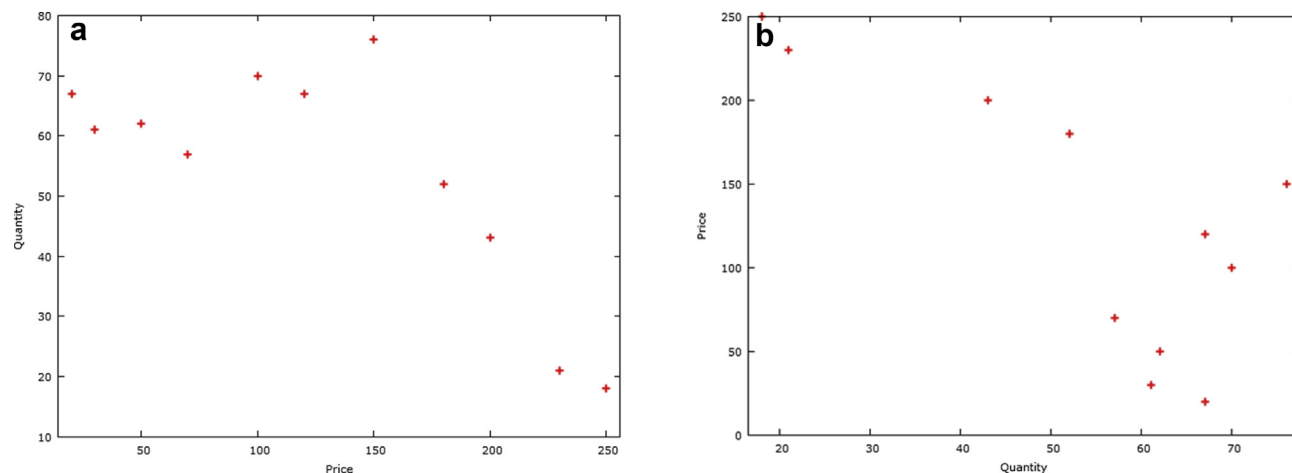


Fig. 3. a) Data points of the inverse of the demand function of the experiment. Ecuador, price in USD. b) Data points of the demand curve of the experiment. Ecuador, price in USD.

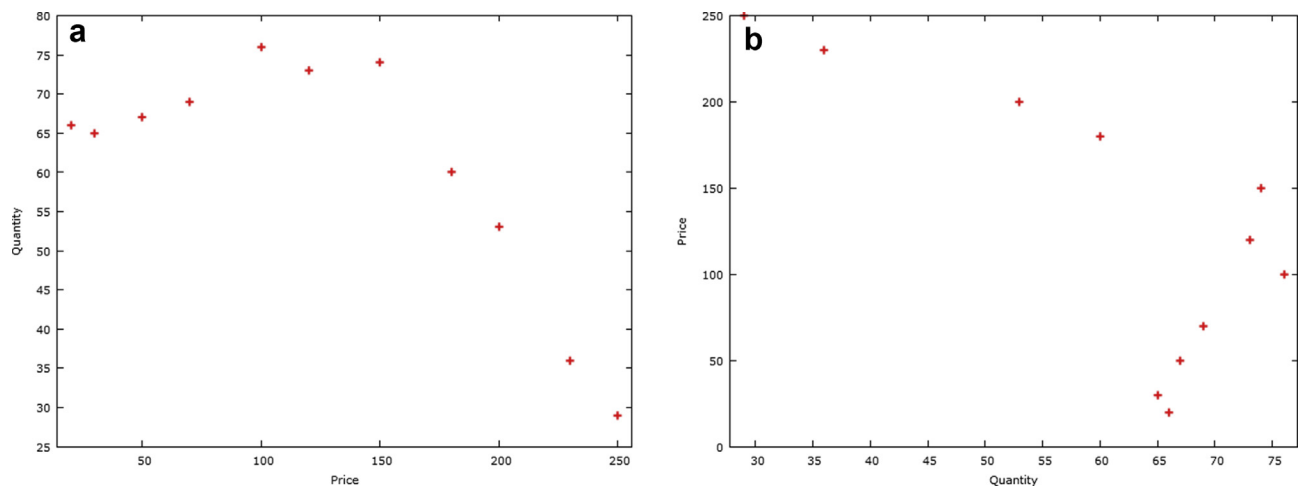


Fig. 4. a) Data points of the inverse of the demand function of the experiment. Spain, price in Euro. b) Data points of the demand function of the experiment. Spain, price in Euro.

sole explanation of our results, as in our experiment respondents were provided specification of the product and its color picture. The anchor price effect demonstrates itself particularly in cases when a price is the only signal of quality.

Our findings contradict “conventional economic wisdom” that a demand curve has negative slope. Becker (1962, p. 6) argues that the fundamental theorem of rational behavior, that market demand curves are negatively inclined, is also valid for less rational consumers. He admits that some individual demand curves might not be negative, but he believes that by averaging over large number of consumers (time, price, households, etc.), erratic behavior cancels out. However, he does not consider a possibility that a demand curve might have a negative slope over one part of its domain, and a positive slope over another.

Nevertheless, it could be possible that for (very) large samples of consumers the loss of confidence effect cancels out as predicted by Becker (1962), though there is no empirical research yet that would suggest it is the case. Without doubt, other experiments of a much larger scale could shed more light on the problem.

As for our choice of university students as respondents, they are a suitable population cohort due to their sociodemographic profile, since they are popular subjects of economic and sociological experiments (Chen and Dubinsky, 2003; Lin, 2007; Bart et al., 2005). In addition, university students have great availability to cooperate and intelligence, and are users familiar with new technologies such as tablets and the Internet. Therefore, filling out a survey about buying a tablet should seem natural. Tablets are widely used in schools and universities to facilitate learning processes. For example, the Universidad Politécnica Salesiana from Ecuador offers each student a tablet similar to the one used in our experiment. Moreover, the main consumers of technology according to statistics provided by companies are young people (Svoboda, 2019).

5. Model

Based on empirical findings presented in the previous section, a new model of a market demand including the loss of confidence effect is proposed.

- For rational consumers, the demand Q_R is described by monotonically decreasing function $Q_R = f(P)$ as usual.
- For less rational (irrational) consumers, the demand Q_I is described by a function that should reflect the loss of confidence effect. It can be assumed that the demand function attains its maximum Q_A when a price of a good is equal to an anchor price P_A (the expected price by consumers), while the demand decreases with the increasing distance from the anchor price P_A . Let us denote such function $Q_I = g(P, P_A)$.

Let α be the number of rational consumers, let β be the number of irrational consumers. Then the overall demand Q is given as the linear combination of both demands:

$$Q = \alpha Q_R + \beta Q_I \quad (1)$$

Fig. 5 provides illustrative example of relation (1) when demand functions are linear and in the form of hyperbola. The line (a) corresponds to the standard decreasing market demand; the curve (b) reflects the loss of confidence effect and anchoring effect: it decreases with the growing distance to the anchor price P_A . And finally, the curve (c) is a composition of (a) and (b) and corresponds to the situation when a market demand is generated by both rational and irrational consumers.

6. Conclusions

The law of demand is a statement about the market demand curve, and this experiment provides only a new (simplified) model of real markets, therefore, its results should be considered with caution. The aim of this paper was to carry out an experiment in order to demonstrate that a demand function presented in microeconomics literature might not be decreasing in its entire domain due to the lower extent of rationality (or “limited rationality”) of some customers who distrust prices that are too low.

The presented research shows that some students are “imperfect economists”, or “humans” in Thaler’s sense, in some situations, which

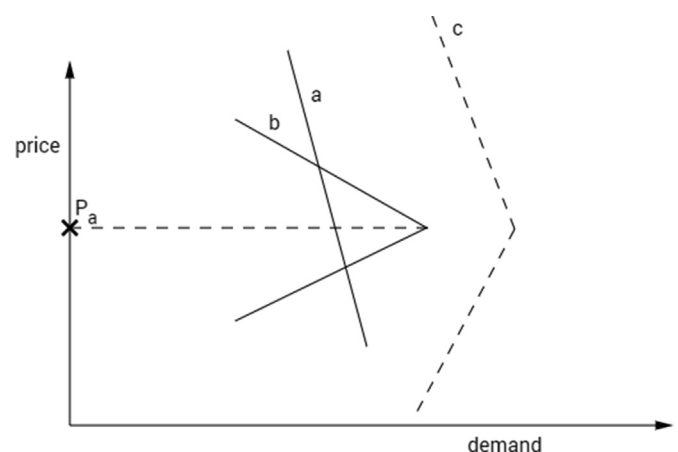


Fig. 5. A market demand generated by rational and irrational consumers. Source: authors. Note: the position of the curve (c) is only illustrative.

could lead, along with the anchoring effect mentioned above, to violation of the law of demand in some situations.

The experiment was performed in three countries, the Czech Republic, Ecuador and Spain, with university students being respondents of the questionnaires. At *all* three locations the same effect of the loss of confidence was found, strongly suggesting that for prices perceived by respondents (consumers) to be too low (when compared to an anchor price), the law of demand might not be valid indeed. Due to the nature of the experiment, respondents provided their responses rather quickly, and it is known that “fast thinking” is susceptible to various kinds of cognitive biases, see e.g. Kahneman (2011). Hence, it would be interesting to compare results with an experiment where respondents would take more time (thus involving the more logical “slow thinking”) for their answers.

Furthermore, the study revealed that around 45% of undergraduate students were not able to make rational decision even when facing an easy task such as buying a given product. In addition, statistically significant differences in rationality between men and women were found for respondents from Ecuador and Spain (but not for respondents from the Czech Republic).

Declarations

Author contribution statement

Jiří Mazurek: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Carlos Fernández, Cristina Pérez: conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Wrote the paper.

Funding statement

This work was supported by the Ministry of Education, Youth and Sports Czech Republic within the Institutional Support for Long-term Development of a Research Organization in 2019.

Competing interest statement

The authors declare no conflict of interest.

Additional information

Supplementary content related to this article has been published online at <https://doi.org/10.1016/j.heliyon.2019.e02685>.

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