Product failure tolerance determinants:

An exploratory study on the technological market

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Abstract

Technology plays an increasingly important role in consumers' lives and the use of technological products is a certainty for future consumers. Identifying the main determinants that influence the consumer's tolerance to a technological product failure is the objective of this exploratory study.

The state of the art of each individual topic addressed was analyzed: failure definition, main determinants of tolerance, brand value proposition, customer satisfaction and loyalty, and characteristics of product failures. Then, a survey was distributed where several product failure scenarios were proposed, in severity and consequence, and the extent to which it affects a future purchase intention was questioned.

From the results obtained, two determinants influenced the way a consumer reacts to a light product failure: age and education level. Older consumers showed lower tolerance to light product failures, while consumers with higher educational level were more tolerant to light product failure. Additionally, the level of tolerance shown was inversely proportional to the increase in failure severity, and the tolerance shown for failures that impact the user's health or that generate a monetary loss was minimal. Consumers appeared to be more tolerant to failures leading to time-related consequences. No other correlations were found considering the analyzed variables. The results were discussed and analyzed, and several hypotheses for future research are presented.

Keywords: Tolerance, Product failure, Consumer behavior, Product failure impact, Technology market

1. Introduction

In a time of increasing consumer sophistication and increasing business competitiveness, consumer satisfaction is of the utmost importance and fewer and fewer failures are tolerated.

This statement is positively confirmed in the technological market, composed of companies that produce devices and equipment that provide the platform for a growing technological market, such as smartphones.

This market is characterized by a constant need to innovate and to outdo the competitors'

product and the previous model. This unending cycle pressures companies and may lead to product development problems, generating future problems for the consumer.

Also, this market is characterized by its enormous size. For reference, global smartphone sales are expected to reach 1,6 billion by YE 2021.

This burning platform has also an effect to consumers, especially for those who weren't born in this technology era: nowadays, a smartphone is much more than a simple communication device: it is also your car or home key, your primary access to your bank account and it can also be your platform for moving around in a city center.

New technologies enable new services that are becoming essential for the consumer, and product failures may have disastrous consequences. Understanding the determinants that influence consumer's tolerance is of the utmost importance.

2. State of the Art
2.1 Product failure

It is considered a failure if the product does not meet the consumer expectations, resulting in consumer dissatisfaction, according to Oliver (1999). Failures can be differently perceived from the viewpoint of the evaluator, that is, failure lies in the eyes of the beholder.

Additionally, a product failure can have different characteristics and severity levels, ranging from light failures that enable the normal use of the equipment to catastrophic ones, rendering it useless and different consequences, presented in table 1:

Table 1 - Risk construct for evaluating product failure impact (Aydin, 2016)

Type of Risk	Description
Financial	Net loss of money
Social	Consumer's perception of how other will react to the purchase
Psychological	Disappointment or frustration felt if the product does not fit one's self-image
Physical	Product is unsafe, harmful or injurious
Product Performance	Loss incurred when a product underperforms
Time/convenience	Loss of time and inconvenience

2.2 Tolerance definition

Tolerance is a construct that defines how much displeasure a consumer can permit before acting against the company. The action to be taken is dependent on many factors, associated with determinants of the failure.

The main motivation to understand the importance of consumer tolerance is to study the impact of not investing in it and increasing the likelihood of losing a consumer. Failures are bound to happen in the technology-based product market, event with high R&D (Research and development) and quality control investment. Understanding consumer tolerance to product failure will prove to be a good investment for when a failure occurs.

2.2.1 Zone of tolerance

The construct of zone of tolerance has been targeted by many researchers. The view presented is based on the research by Johnston (1995); Parasuraman, Berry, Zeithaml (1991); Parasuraman et al. (1985) and V. A. Zeithaml, Berry, Parasuraman (1993) and assumes that consumers have a range of expected performance as presented in figure 1.

If the consumer evaluates the service within the zone of tolerance, the expectations are met and achieves a state of moderate satisfaction. Consumers will only achieve a positive disconfirmation, leading to a state of delight, if the results are above the "Desired" threshold.
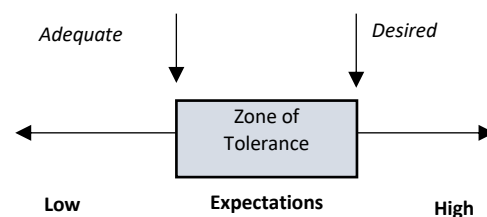

Figure 1 - Service Level Expectations as proposed by Parasuraman, Berry and Zeithaml (1991)

2.3 Tolerance determinants

Demographic determinants:

Demographic determinants are recommended as predictors in consumer models when the goal is to analyze consumer behavior, Sheth (1977), in order to produce a more global theory and four were proposed in this study: Age, Gender, Level of education and Income.

Psychographic determinants:

Psychographic are used to understand consumer behavior. The study of psychographic determinants offers a more accurate insight into consumer behavior, according to Varela-Neira, Vázquez-Casielles and Iglesias (2010); Kotler and Armstrong (2011) and Fuhr (2015).

Value proposition and marketing strategy:

Evaluating price and performance results in the concept of value. A product might have an exceptional performance, but if the price is too high, the value will decrease.

Consumer satisfaction and loyalty:

Once expectations are defined and the user experiences the equipment, one of three outcomes will occur: negative disconfirmation, leading to dissatisfaction with the product; expectations met, leading to moderate satisfaction with the purchase; and positive disconfirmation when the consumer's expectations are surpassed, leaving the consumer truly satisfied (delight). This last level of satisfaction is in the beginning of the process to achieve an independent condition – Loyalty.

Loyalty is a complex concept that materializes primarily as "an intention to rebuy a brand, considering only that brand and with no brand-related information seeking" (Newman and Werbel, 1973). Oliver (1999)'s definition of research is "A deeply held commitment to rebuy or re-patronize a preferred product/service consistently in the future, thereby causing repetitive same-brand or same brand-set purchasing, despite situational influences and marketing efforts having the potential to cause switching behavior."

The pinnacle of loyalty is the concept of "Ultimate Loyalty", also proposed by Oliver (1999). It can be understood as the definition of loyalty plus a "fervently desire to rebuy a product or service and will have no other" and "against all odds and at all costs".

Brand image, strategy and positioning:

Brand image has been defined as the consumer's mental picture of the brand and it includes symbolic meanings that consumers associate with the specific attributes of the product or service (Padgett and Allen 1997; Cretu and Brodie, 2007). A strong brand image is not only an excellent asset for a company, as it is expected to influence how a consumer reacts to a product failure derived from its strong effect on consumer expectations and satisfaction.

Net promoter score:

Net promoter score is a construct, proposed by Bain & Co.'s Fred Reichheld that encompass the overall feeling of a consumer towards a specific company. It is built upon the principle of grouping your consumers in "Detractors", "Passively Satisfied" and "Promoters" (Figure 2).

The different groups are created according to the answer for the question: "How likely is it that you would recommend our company to a friend or colleague?"", where 0 is "extremely unlikely to recommend" and 10 is "extremely likely to recommend". If the answer is between 0 and 6, the consumer is a Detractor; if 7 or 8 the consumer is Passively Satisfied and 9 and 10 are Promoters of the brand. Promoters are the most valuable consumers for a company and should be kept at all costs. They represent the brand and are ready to defend it to other potential consumers.
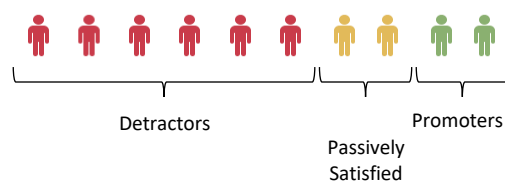

Figure 2 - Net Promoter Score representation

3. Methodology

Given the exploratory tone of the dissertation, the selected methodology for collecting data consisted of an online survey. After the collection of all the valid answers, a statistical analysis is carried out to analyze which determinants are statistical relevant for the study. This analysis supports the proposal to if there is in fact a set of determinants that can describe and predict how a consumer reacts to a product failure.

Survey development:

During the development, the survey was pre-tested with several versions being created and discussed. To choose the best option, without compromising the quality of the research, a focus group was conducted to assure that the presented questions were understandable, and the answers provided were in line with the research objective. There were some key outcomes from the focus group: No question about income was made, as it was considered a sensitive question. Also, there was not a common understanding of the concepts of loyalty, satisfaction or personal psychographic determinants between the members of the focus group, which led to the addition of the question about the Net Promoter Score and the simplification of the assessment of psychographic determinants.

Data collection:

The population consists of individuals aged 18 years or over. A non-probabilistic method was used for convenience sampling, which is based on the availability and accessibility of the respondents. In conclusion, 87 valid answers were collected.

4. Data analysis – Descriptive statistics

Gender:

From the 87 valid responses, 54 (62,1%) were from females and 33 (37,9%) were from males.

Age:

The age of respondents was divided in six tiers. The tier with the most frequency was from ages 28 to 37, with 33,3% of the answers. The second tier with most answers was from ages 18 to 27, with 24,1%. These results can be explained by the nature of the convenience sample and the use of digital platforms to share the online survey.

Education level:

Most of the respondents had some degree of higher education (92%). Results are presented in table 2:

Table 2 - Education level distribution

Education level	Absolute (#)	Frequency (%)
Primary School	0	0,0%
Basic Education	0	0,0%
High school	7	8,0%
Bachelor's degree	41	47,2%
Master's Degree	39	44,8%
Doctorate	0	0,0%
Other	0	0,05

Psychographic:

The psychographic question encompassed all the psychographic determinants into one, simple to understand, question: "Select, among the levels presented, which level best defines your attitude towards technology" (Table 3).

Table 3 - Psychographic analysis results

Attitude toward technology	Absolute (#)	Frequency (%)
1 – *"I am not interested"*	0	0,0%
2	0	0,0%
3	2	2,3%
4	1	1,1%
5	2	2,3%
6	7	8,0%
7	19	21,8%
8	21	24,1%
9	18	20,7%
10 – *"I actively seek latest news and updates"*	17	19,5%

This result supports the proposed hypothesis presented in the Introduction, where is stated

that technology has an increasingly higher impact in the average consumer daily lives and consumers need to demonstrate some level of interest to keep up with technology developments.

Perceived value proposition, consumer satisfaction, loyalty and brand perception:

The analysis of the NPS (Net Promoter Score) is of key importance for this exploratory study, given the set of determinants that are evaluated by this highly effective determinant: perceived value proposition, consumer satisfaction and loyalty, and brand perception. Results are presented in table 4.

Table 4 - Net Promoter Score results

NPS	Absolute (#)	Frequency (%)	Category
1 – "Extremely unlikely to recommend"	1	1,1%	Detractor
2	2	2,3%	Detractor
3	1	1,1%	Detractor
4	3	3,4%	Detractor
5	6	6,9%	Detractor
6	4	4,6%	Detractor
7	14	16,1%	Passive
8	20	23,0%	Passive
9	18	20,7%	Promoter
10 – "Extremely likely to recommend"	18	20,7%	Promoter

The NPS of the studied sample is +22 (Net Promoter Score results range from -100 to +100). The result is positive, showing a moderately positive satisfaction and perception of the owned technological hardware. Additionally, when compared to industry results, the NPS of the studied sample is significantly higher than similar industries, such as Computer Makers (+ 10,9) and Electronics (+5,3), which suggest that the studied sample is relatively satisfied with the owned technology products.

Failure characteristics:

For the questions about product failure scenarios (severity and consequences), an evaluation scale was proposed where the respondent had to choose the most probable behavior for each proposed scenario. The scale is as follows (Table 5):

Table 5 - Attitude towards the brand after the proposed failure scenario

Attitude level	Behavior
1	Would not consider this brand again
2	
3	Would reconsider if the problem was solved
4	
5	A future repurchase decision would not be affected

Failure severity results:

Three failure severity scenarios were proposed: light impact failure, exemplified in the survey as "reduced battery capacity", a moderate impact failure as "display problems, rendering part of it unreadable" and high impact, "equipment does not charge"
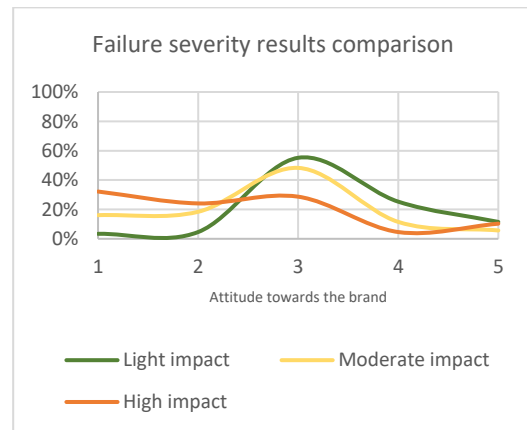

Figure 3- Failure severity results analysis

The level of tolerance shown is inversely proportional to the increase in the severity of the failure (Figure 3).

In the scenario of light and moderate failures, most consumers suggest that they would reconsider the brand if the problem was solved. For the scenario of high impact, most consumers

suggest they would not reconsider the same brand for future purchases.
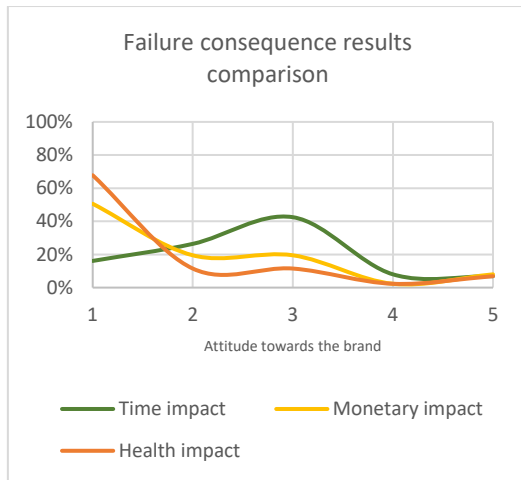
Failure consequence results:

Figure 4 - Failure consequence results comparison

A product failure can have varied consequences for the consumer, and for this exploratory study, three scenarios were proposed: Time, monetary and health impact. (Figure 4)

The first is related to a time loss, and it was exemplified as a "slowness in use". Results indicate that, from the studied sample, consumers show the highest level of tolerance against this consequence when compared to the other proposed product failure consequence scenarios. The modal answer was that consumers would reconsider the brand if the problem could be solved.

A product failure that led to a monetary consequence was exemplified with the sentence: "damaged other product due to a battery acid leak". From the studied sample, consumers show much lower levels of tolerance against this type of consequence than the previous scenario and 50,6% of the respondents stated that they would not consider this brand again if such product failure happened to their equipment (modal answer = 1). Compared to the analysis on failure severity (light, moderate, high) consumers were much harsher and showed less tolerance to this type of product failure, which suggest that a collateral damage from a product failure has an enormous impact on consumer tolerance, vastly superior to a

catastrophic product failure with no collateral damage.

Health related consequences were also presented and were associated with the sentence "Caused a burn/cut". This scenario was met with the lowest level of tolerance from any proposed scenario in the study and it reflects the utmost importance of consumer safety. From the studied sample, 67,8% of the respondents indicated they would not consider this brand again for future purchases (modal answer = 1).

Collateral product failure impact:

Additionally, scenarios which presented a direct collateral damage associated with the product failure received lower tolerance scores than a catastrophic scenario on the performance of the product. This association is recommended to be analyzed with further detail on future research on the subject.

Ultimate loyalty analysis:

Analyzing the result of respondents who answered that a future repurchase intention would not be affected, in the scenarios where most consumers indicated that they would not consider this brand again for future purchases (monetary and health impact), strongly suggests the existence of such Ultimate Loyal concept, aligned with Oliver's (1999) description of consumers that, even when faced against the highly impactful scenarios of product failures, would not consider changing to another brand "against all odds and at all costs".

4.1 Independent variables correlation with product failure tolerance

The analysis was carried out by analyzing each determinant (independent variables) against each behavioral question result (responses to product failure scenarios) using a simple linear regression analysis, conducted with a confidence interval of 95% and considering a p value <.05

The null hypothesis is the assumption that there isn't any relationship between the variable and the results. If the analysis returns a p-value < .05, there is a statistical relationship between the

variable and the result. Results are presented in table 6:

	p-value results					
	Severity of the failure			Consequence		
Variables	Light	Moderate	High	Financial related	Physical related	Time related
Demographic Variables						
Age	**0,02**	0,84	0,30	0,67	0,89	0,17
Gender	0,64	0,98	0,11	0,83	0,49	0,66
Education	**0,01**	0,20	0,31	0,88	0,79	0,24
Psychographic Variables						
Attitude towards technology	0,15	0,62	0,61	0,28	0,60	0,74
Perceived value and consumer loyalty						
NPS	0,72	0,14	0,87	0,92	0,58	0,80

Age:

According to the results, there is a statistical valid relationship (p=.02) between the independent variable age and the level of tolerance when faced with what is described as a light product failure

There is a negative relation between the age interval and tolerance against light product failure, suggesting that, from the studied sample, older respondents are less tolerant when they are faced with a light product failure, as shown in figure 5:
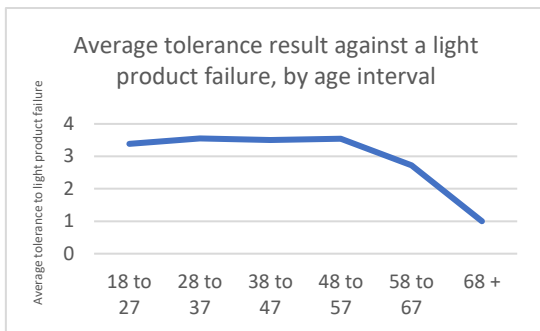

Figure 5 - Average tolerance against a light product failure by age interval

Gender:

Results were, overall, very similar between both genders across all questions, suggesting that the gender of the consumer does not affect its tolerance to a product failure. No statistical relevant relation was found between the gender of the respondent and its tolerance to product failure, in any of the proposed scenarios.

Education Level:

A statistical relevant relation between the education level and tolerance against light product failure was found (p=.01). This result concludes that, for the studied sample, respondents with higher levels of education are more tolerant against light product failures. Results are presented in figure 6:
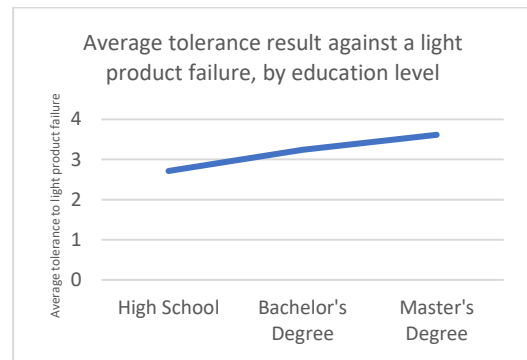

Figure 6 - Average tolerance against a light product failure by education level

Psychographic Variables:

The results obtained cannot be extrapolated as valid references on the impact of the complete set of psychographic variables proposed during the state of art chapter on tolerance against product failure but are valid for the analysis of the individual psychographic determinant "Interest".

No statistically significant relation was found between the level of interest of the consumer in the technological market and its tolerance against product failures. Additionally, by analyzing the results plotted in figure 7, there is no clear trend that suggests that the level of interest in technology has any impact on consumer tolerance to technological product failures.
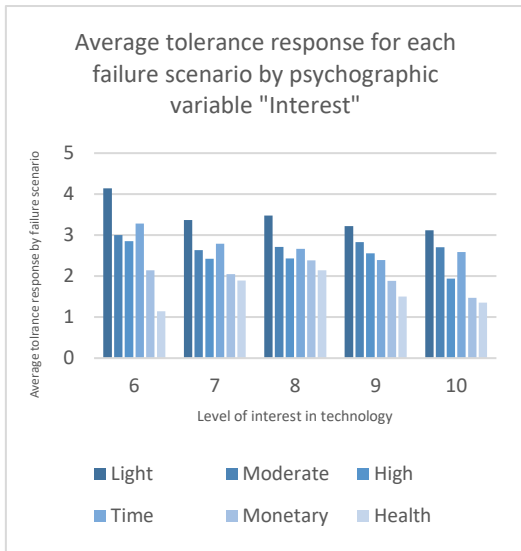
Figure 7 - Average tolerance response for each failure scenario by psychographic determinant Interest

Perceived value proposition, consumer satisfaction, loyalty and brand perception (Net Promoter Score):

No statistically significant relation was found between the Net Promoter Score and the measured tolerance against product failures for the studied sample.

Although the results were not statistically significant, on further analysis, two hypotheses are proposed, to be validated on future research on the subject: 1) Consumers that identify as being Passively Satisfied (NPS values of 7 and 8) are more tolerant against product failures than Detractors (NPS $\leq$6) and Promoters (NPS $\geq$9) and 2) Consumers that identify as being Passively Satisfied (NPS values of 7 and 8) have a wider zone of tolerance than Detractors (NPS $\leq$6) and Promoters (NPS $\geq$9).

5. Conclusions

A function was proposed that would mathematically determine the expected tolerance of a consumer when faced with a product failure, and is presented as Function a):

Function a): *Tolerance = f (Demographics, Psychographics, Value proposition, Loyalty, Product failure characteristics)*

However, during the survey validation, the key determinants were subject to changes, and the determinants analyzed in this exploratory research were not as shown in Function a). Consequently, is important to adequate the proposed equation to accurate reflect the scope of the concluded research, proposed as Function b).

Function b): *Tolerance = f (Age, Gender, Education, Interest, Net Promoter Score, Product failure characteristics)*

The findings of this research result in the rejection of the proposed Function b). It does not accurately represent the main determinants that were confirmed to impact the tolerance level of a consumer to product failure. So, and according to the data analysis performed throughout this study, the proposed function that can predict the level of tolerance of a consumer against product failures is Function c):

Function c): *Tolerance = f (Age, Education, Product failure characteristics)*

Additionally, it is important to remember that this function is valid for the scenario where the consumer was presented with a light product failure scenario. None of the additional failure scenarios, either through different severity levels or difference product failure consequences led to any statistical relevant results. Some hypothesis that justify why this result was achieved are proposed ahead.

The first proposed hypothesis is: Light product failure tolerance is affected by the age and education level of a consumer but the tolerance level of a consumer against more extreme failures is not affected by any set of determinants and is completely dependent of the characteristics of the product failure. This implies that consumer tolerance is very different between a light product failure scenario and all the other scenarios proposed and the tolerance that the consumer has for those, more extreme, scenarios is not correlated with any set of determinants. This would suggest that the tolerance level of a consumer when faced with a health-related consequence is not affected by any defined set of determinants and it is not possible to predict the consumer's tolerance before the failure occurs.

The second hypothesis is that consumer tolerance to more extreme product failure scenarios can be correlated with a set of determinants, but those determinants were absent or were not studied enough in this study. Determinants that were absent – for example income/wealth and field of study/occupational area – or determinants that were simplified – such as individual psychographic and loyalty related ones (explained throughout the state-of-the-art chapter) – are indeed determinants that impact how a consumer reacts to a product failure. It is also possible that consumer tolerance to product failure is affected by a set of determinants vastly different from the ones proposed throughout the study or in the proposed future research. For example, tolerance to product failure may be impacted if the consumer and brand share the same core values, such as ecology and environmental protection, animal welfare or a certain social cause.

The third hypothesis is: The chosen set of determinants is valid and affects how consumer reacts not only to light product failures but also to more extreme scenarios, but due to the non-probabilistic samples used and limited number of responses, no additional statistical relevant correlations were found. According to Hair et. al (1984), the size of the proposed sample is valid for the study and drawn conclusions are valid. However, additional answers would reinforce the conclusions drawn and possibly raise new additional scenarios.

Final Remarks:

This thesis had one key objective: Explore this previously unknown subject and discover what are the main determinants that affect how a consumer reacts to a product failure, specifically in the technology market. It is possible to conclude that with this study, and considering all limitations related to the non-probabilistic convenience sample approach, a valid literature was produced on this particular subject that can be used as starting point for researchers who want to further investigate it.

Findings demonstrate that the age and education level of a consumer impact its reaction to a light product failure, that consumers have dissimilar levels of tolerance when faced with various degrees of product failure severity and that the consequence of the failure plays an immense part on the tolerance level demonstrated by the consumers. Additionally, five research hypotheses are proposed throughout the study that enable a starting point for future research:

- **Hypothesis 1**: Consumers are less tolerant to non-catastrophic (i.e., product is usable) product failures that lead to collateral damages than catastrophic (i.e., product cannot be used) failures without collateral impacts.

- **Hypothesis 2**: Consumer are more tolerant to non-catastrophic technological product failures if they have a more intensive use of the product.

- **Hypothesis 3**: The field of study or working industry of the consumer impacts its tolerance against product failures.

- **Hypothesis 4**: Consumers that identify as being Passively Satisfied (NPS values of 7 and 8) are more tolerant against product failures than Detractors (NPS ≤6) and Promoters (NPS ≥9).

- **Hypothesis 5**: Consumers that identify as being Passively Satisfied (NPS values of 7 and 8) have a wider zone of tolerance than Detractors (NPS ≤6) and Promoters (NPS ≥9).

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