The climate effect on the sale of hygiene and beauty products.

Empirical Paper Abstract

This article analyzes the effect of climate variables on the sales of hygiene and beauty products, for its realization meteorological data used public data bases from the national institute of meteorology while sales data were collected through 262 pharmacies in southern Brazil over 5 years, representing more than 80 million transactions and providing the statistical robustness required. Using the fixed-effects panel data model, a methodology characterized by the combined use of time series and cross-sections, it is estimated that the variables with the greatest influence on sales are temperature and precipitation. The main hypothesis tested in this study, that climatic variables have a significant effect on sales, could be confirmed for some categories, with different influences between them.

Track: Big Data and Applied Retail Analytics: Retail metrics analysis, marketing metrics, retail ROI, customer analytics, retail predictive models, optimization models, dashboards, business intelligence, use of structured and unstructured data for retail decision.

Keywords: Retail; Climate; Drugstore; Pharmacies; Sales Performance; Consumer Behavior, Marketing.

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1. Introduction

A market or pharmacy was just a place where buyers and sellers gather to buy and sell their products. Today, according to Kotler (2006), it is possible to describe these stores as a set of buyers and sellers who transact a particular type of product or service. In this scenario, companies act to stimulate interest in their own products, to achieve the organization's goals. For Bernanke (2009), the demand of a market is associated with the rational allocation of consumer income between different products, and for hygiene and beauty products there is no

difference, pharmacies compete against each other for the limited resources available in the Market.

Everyone seeks to understand the demand and which elements can affect it, among others, the following may be considered: desires and needs of individuals; purchasing power; availability of services; complementary or substitute products; opportunity costs. Looking at the drug market, it is easy to see how individuals' needs can easily influence market demand, an outbreak of flu will increase the demand for flu medicines, syrups and tissues. The same is true for purchasing power and service availability, shifting demand up or down. Complementary and substitute products can act as an opportunity for the segment when well exploited or become a threat if not mapped in time. Finally, opportunity cost involves all the effort expended for the customer to make a purchase.

2. Literature Review

Climate related issues have been widely discussed in the most diverse areas of study since the United Nations Conference on the Human Environment in 1972, when leaders from major countries met to discuss the global environmental degradation. Since then, many researchers try to measure the effects of climate on the economy.

In a study presented by Solomou and Wu (1999), the effect of climate on agricultural production in Germany, France and the United Kingdom over a period of 60 years is analyzed. For the authors, climate is responsible for two thirds of the variation in agricultural production in the region. Richard Tol (2000) analyzed the impact of climate change on water and energy consumption, tourism and agricultural productivity in the Netherlands. Among other findings, the study points out that a long period of pleasant weather stimulates domestic tourism in the same year and international tourism the following year. The same study also indicates that water consumption increases considerably during hot days, but does not change significantly over long periods of dry weather.

Margulis (2010) points that climate change in Brazil may cause a reduction between 0.5% and 2.3% in GDP by 2050. Electricity production would also be affected; in the northeast, decreasing rainfall may cause a reduction in hydroelectric power generation, affecting production capacity by approximately 30% by 2100. In agriculture, the main crops, except for sugarcane, may suffer yield reduction in the coming years, especially soybeans (32%), corn (15%) and coffee (18%). In contrast, Camargo et al (1986) analyzes soybean production in the state of São Paulo and cites the thermal factor as indicative of the choice of the product to be cultivated, as well as the variable factors related to scarcity or excess rainfall. This case

indicates that the ability to accurately predict climate phenomena can prevent such losses from directly impacting business.

The north American economist Veblen (1899) was the first to note that the rational economic behavior of individuals may be influenced by psychological effects. According to the author, fear and social status are variables capable of influencing the consumption pattern of individuals. More recently, Mason and Wilkinson (1993), indicate that consumer behavior is influenced by the following factors: Economy, climate, demography, seasonality, market trends and the marketing compound.

Climate-related variables also appear for Levy (2012), the author shows that in the United States, during the hurricane season, many families are preparing for the phenomenon by stocking bottles of water, plywood, batteries, generators and food in general. The author also points out that it is common for large companies to use climate forecasts to plan delivery times, promotions and discounts. Complementarily, Levy also mentions that during cold or rainy periods supermarkets tend to sell less meat, but on warmer days, a temperature increase of 7˚C, for example, triples meat sales and increases consumption of lettuce by 50%.

The first researcher to study the impact of climatic variables on retail consumption was Steele (1951), the author still notes that previously some studies had already published from the perspective of energy and agricultural production areas. Steele's study correlated precipitation, wind, temperature, and snow with sales at department stores in the United States between 1940 and 1948. The result indicates that cold, rain and snow are variables that reduce overall sales according their intensities, with temperature being the most relevant coefficient. The reduction in consumption was attributed to the following main reasons: Discomfort to visit the store, consumers physically avoid bad weather conditions, psychological effects and lesser merchandising appeal.

For Starr-Mccluer (2000), climate variables can influence individuals' buying behavior in three ways: Climate can make shopping experience easier or harder; The climate complements a number of outdoor recreational activities; Some goods complement climate-related activities. To conclude this chapter, Larsen (2006) considers that it is obvious that climatic variables exert an effect on the demand for products. Even if its full size is not yet known, the author believes that if climate predictions improve in the future, it will be possible to help companies and individuals better plan their spending and investments in an uncertain climate environment.

3. Methodology

To solve this theoretical gap, the research proposes a regression method to identify the climate effect on the sale of hygiene and beauty products. A regression is a statistical technique used to measure the interference of one or more independent variables in a dependent variable, allowing to estimate a straight equation where it is possible to obtain results of the dependent variable by changes in the independent variable and has the purpose of estimating the relationship between two quantities and the relationship between the independent and dependent variables. The most widely used estimation method is that of ordinary least squares, which seeks to minimize the sum of the squares of the vertical distances of each point of the sample in relation to the estimated line.

Gujarati (2011) indicates that three types of data can be used for applied analysis: Time series, cross sections and data panels. In time series, data of one or more variables are observed over time, in cross section the data are related to one or more variables for several sample units, since the use of panel data allows to explore together the variations along of time and different units or individuals. This last one methodology can be characterized by the combined use of time series and cross-sections, thus allowing a more complete and efficient estimation of the econometric models. It should be remembered that the estimation of panel models becomes more complex due to the heterogeneity of individuals, such as different economic structures between cities or regions.

As climatic conditions and sales have different behaviors for each region observed and also over the time, it wouldn't be possible to construct a regression through simple time series or a cross-sections models. The solution found was to use a panel data model, allowing a complete and efficient estimation. So this study follows a model for panel data presented by Hendry (1995) that suggests the exposes of the main theory or hypothesis, specification of the mathematical model of the theory and the econometric model, estimation of the parameters and the hypothesis testing. Given the literature review, which indicates that the weather conditions can influence the pattern of consumption in several areas, and the main hypothesis that includes the sale of hygiene and beauty products in this context, it is possible to suggest a preliminary equation, where Y_i is the estimated sale, β_0 the constant and γ is the vector of n variable X of the individual.

$$Y_i = \beta_0 + \gamma\, X_{i_n} \quad (1)$$

Soon it is possible to include the climate variables and sales history on the same structure, where γAs_i is the coefficient of the average individual sales, $\delta Temp_i$ is the coefficient for average individual temperature and $\varepsilon Prec_i$ is the coefficient of individual accumulated precipitation. The signs (positive or negative) follow a preliminary data analysis, that indicate lower sales in periods of low temperature or heavy rainfall.

$$Y_i = \beta_0 + \gamma As_i + \delta Temp_i - \varepsilon Prec_i \qquad (2)$$

Several other variables, which could not be measured in this study, can influence the outcome of the proposed model. For the model to consider inaccurate relationships over variables, the unobserved effect will be defined in the equation three by u.

$$Y_i = \beta_0 + \gamma As_i + \delta Temp_i - \varepsilon Prec_i + u \qquad (3)$$

When working with a regression model in panel data, there are some estimation techniques that can be considered, in this paper the effects were tested in three econometric models: Pooled, Fixed Effects and Random Effects. In order to determine the most appropriate model, there are three hypotheses that should be tested through the tests of Chow, Breusch-Pagan and Hausman. After determining the estimation model, the effects of cross section[1] should be added in the main equation represented by E_{CS} whose *i* is the individual and *t* is time period for the previously defined variables.

$$Y_{it} = \beta_0 + \gamma As_{it} + \delta Temp_{it} - \varepsilon Prec_{it} + E_{CSit} + u \qquad (4)$$

With mathematical and statistical models defined, data is required to find numerical values. Two main sources of data were used is this case, the first one, sales were collected through 262 pharmacies in southern brazil during the period five years, representing more than 80 million transactions and providing a high statistical robustness. In order to bring a deeper analysis, the database were segmented into 18 categories as presented in table 1.

[1] The cross-sectional effects are used to represent the distinct behavior among the individuals over the variables, in this case different regions.

Per second, the climatic data were obtained through the national institute of meteorology, an agency of the ministry of agriculture, livestock and supply, whose objective is to provide meteorological information to the Brazilian society and assist in the decision-making process in multiple areas. It can be observed several types of variables such as temperature, humidity, wind speed and direction, atmospheric pressure and precipitation. During the preliminary analysis, precipitation and temperature were the only selected variables, ensuring the best statistical consistency to the model.

Table 1 – Product categories

Categorie	Description
Dermocosmetics	Intermediate products between medicines and cosmetics (anti-aging, skin cleansers, moisturizers, firming, depigmenting and anti-acne)
Children's	Diaper, wet wipe, bath and post bath child care and diaper rash cream
Body Care	Moisturizing creams, sun protection and suntan lotions
Hair Care	Shampoo, hair dye, conditioner, comb cream and spray, treatment ampoule, hair wax and bleach
Deodorants	Aerosol, roll-on, stick and cream deodorant
Make Up	Eye, face, lip and accessory makeup
Oral Care	Toothbrush and toothpaste, mouthwash, dental floss, orthodontics and prosthetic care
Child Nutrition	Infant nutrition, dairy compound, food supplement, baby food, porridge mix and milk powder
Facial Treatment	Cleansers, firming, tonic, anti-aging cosmetics and face moisturizers
Men's Care	Condoms, razors, shaving, lubricating, shaving gel and foam
Hands and Feet	Nail polishes, hand and foot creams, antiseptic gel, pliers, acetone and talcum powder;
Intimate Hygiene	External pad, daily protector, intimate soap, inner pad and handkerchief
First Aid	First aid accessories, syringe, nebulizer, pressure device and thermometer
Soaps	Bar and liquid soap, bath accessories and mineral salts
Geriatric	Incontinence diaper, underwear, pad and adult wet wipe
Pregnant	Anti-stretch marks, breast absorbers, body care and moisturizing lotion for pregnant women and breastfeeding accessories
Nutricosmetics	Combination of vitamins, minerals, amino acids, dried plant extracts and other nutrients as the same cosmetic goals
Hair Accessories	Hair clips, brush, comb and cap
Orthopedic	Socks, thermo gel and hot water bag, wrist, knee and ankle brace

After collecting data from the two sources of research, it was necessary to cross the both bases and create a single panel. The total amount of precipitation is evaluated in relation to the vertical depth of water on a horizontal projection of the soil surface, being considered in this study the total precipitation recorded during a week for each region. Values close to zero indicate the absence of rain during the period and represents the minimum precipitation for all regions, the recorded mean was 35 mm while the maximum values reach up to 334 mm in a single week. Different from the previous variables, for temperature is considered the average value observed over seven days for each of the regions.

To determine the most appropriate model of analysis, Chow, Breusch-Pagan and Hausman tests were performed. The Chow test, which compares the least squares group method with the fixed effects model, showed p-value less than 0.05, indicating that the fixed effects model would be the most adequate. The Breusch-Pagan test, which confronts the least squares group with random effects model, also presented a low p-value, indicating that between these two models, the use of random effects would be the most appropriate. Finally, the Hausman test compared the two models with the best result, indicating that the best fit model was the fixed effects model, since p-value was zero.

Table 2 – Chow, Breusch-Pagan and Hausman tests analysis

Test	Comparative	P-Value	Interpretation
Chow	Pooled or fixed effects	0,0000	Fixed effects
Breusch-Pagan	Pooled or random effects	0,0266	Random effects
Hausman	Fixed or random effects	0,0000	Fixed effects

With the definition of the fixed effects model as the most adequate, the objective now is to present the main results found throughout this study, identifying the relationship between climatic variations and a possible impact on the sale of hygiene and beauty products.

4. Result analysis

In this section we will analyze the results obtained through this research, for that we will start with the descriptive statistics of the regressions, present in Table 3. The R^2 statistic represents how much the model is explanatory for the results in each of the product categories analyzed, being able to explain 76% of total sales and up to 95% for makeup and dermocosmetics. Durbin-Watson statistics points the absence of self-correlation, while Prob. F test, which measures the significance of all parameters simultaneously, indicate a high degree of significance in all for all categories, highlighting the relevance of the model.

Table 3 – Statistical description of results

Category	Coeficiente						Statistic		
	Constant	Average Sale	Precipitation	Prob.	Average Tempe-rature	Prob.	R^2	Prob. F	Durbin Watson
Total Sales	**16,2368**	**0,8020**	**-0,0242**	**0,0000**	**0,2313**	**0,0000**	**76,41%**	**0,0000**	**2,1060**
Deodorants	0,9620	0,8245	-0,0215	0,0477	0,9088	0,0000	94,22%	0,0000	2,1355
Body Care	-15,5119	0,6962	-0,0614	0,0370	2,3306	0,0000	73,51%	0,0000	2,1085
Orthopedic	78,2085	0,0808	-0,0264	0,0239	-1,0237	0,0000	91,14%	0,0000	2,1450
Geriatric	75,8540	0,3334	0,0240	0,0336	-0,5275	0,0000	87,46%	0,0000	2,1443
Make Up	21,0883	0,8268	-	-	-0,1976	0,0288	95,09%	0,0000	1,9375

Hair Accessories	8,3814	0,8262	-	-	0,4718	0,0001	91,20%	0,0000	1,8758
Hair Care	19,6779	0,7147	-	-	0,4632	0,0000	94,93%	0,0000	1,9154
Men`s Care	25,7404	0,6981	-	-	0,2324	0,0194	91,28%	0,0000	2,0302
First Aid	46,8418	0,5847	-	-	-0,2791	0,0003	95,12%	0,0000	2,0730
Soap	23,4612	0,6692	-	-	0,5039	0,0000	91,84%	0,0000	2,0193
Facial Treatment	30,9284	0,7784	-	-	-0,4601	0,0000	93,96%	0,0000	2,0649
Dermocosmetics	18,8901	0,9523	-0,0566	0,0000	-	-	95,23%	0,0000	2,1648

With a statistically valid model, we begin the interpretation of the results. Besides the total sales, only 4 categories (i.e., Deodorants, Body Care, Orthopedic and Geriatric) present a simultaneous correlation between the precipitation and temperature variables. On the other hand, 7 categories presented correlation only for precipitation (i.e., Make Up, Hair Accessories, Hair Care, Men`s Care, First Aid, Soap and Facial Treatment) and 1 category only for temperature (i.e., Dermocosmetic). Other categories didn't present significant correlation for any of the climate variables (i.e., Oral Care, Intimate Hygiene, Children's, Nutricosmetic, Pregnant, Children Nutrition and Hands and Feet.

Advancing to the analysis of climate variables, the positive coefficient for precipitation indicates that on rainy weeks the sale tend to be higher, except for geriatric products, where the observed behavior is the opposite. The same interpretation is valid for temperature, but with more diverse results, having a positive effect on the Total Sale, Deodorant, Body Care, Hair Accessories, Hair Care, Men's Care and Soap, but a negative effect for the others categories of products. With simultaneous influence of two variables, a two-dimensional graph is not able to exemplify the behavior in relation to temperature and precipitation. For this, a three-dimensional surface chart is presented, where the vertical axis represents the variation in sales, the horizontal axis the precipitation and the depth the average temperature. To facilitate the analysis of the results, the absolute values were replaced by a 100% based index.

Figure 1 – Total Sales Model

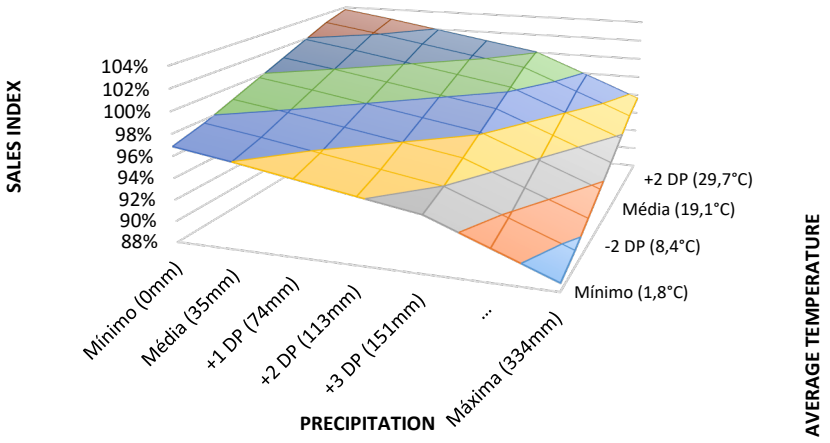
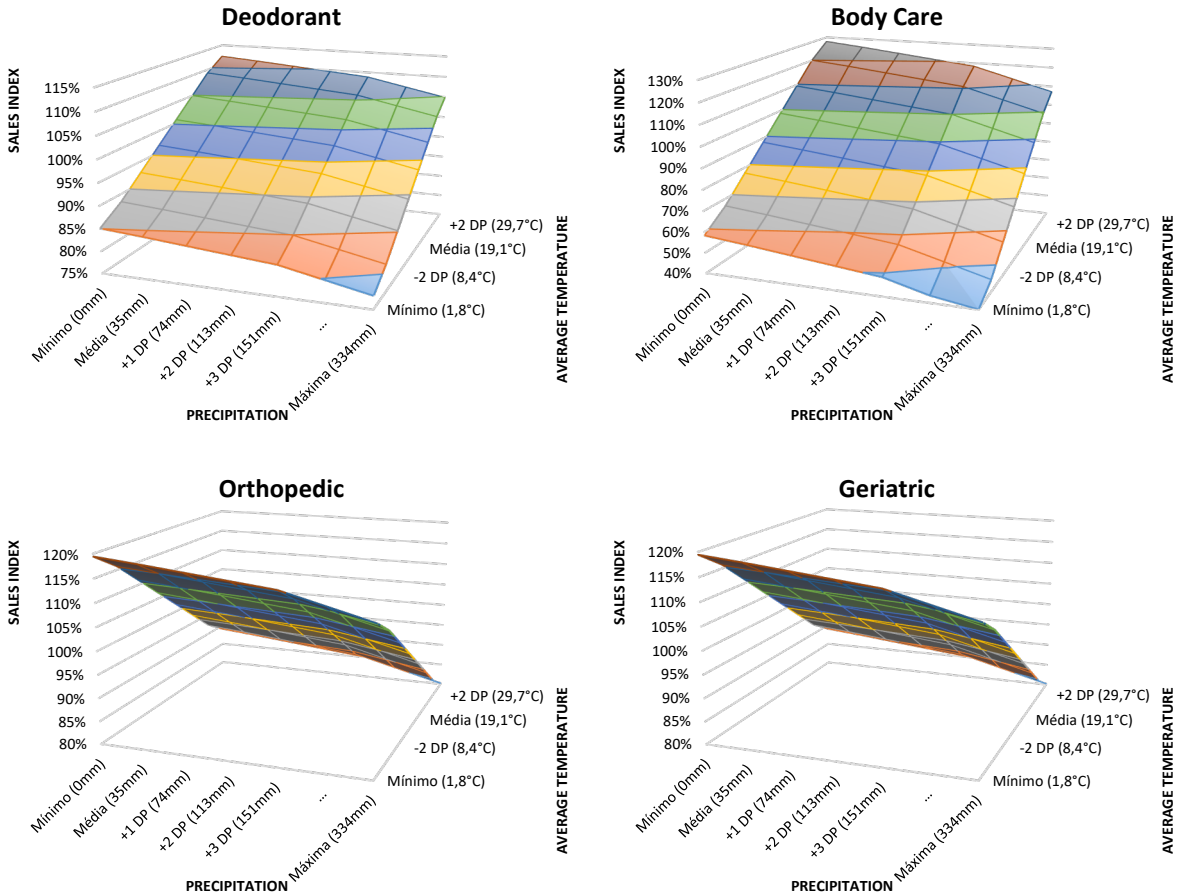


Figure 1 shows the total sales behavior in relation to the two climate variables, where sales are maximized in rainless and hot weeks. Thus, under favorable weather conditions, sales can reach up to 104% of the expected, while over a week of rainy and cold weather, sales could fall to 88% of forecast. The difference between the extreme ends of the chart is up to 16%, which can have a significant impact on companies if they are not prepared for these outages. In summary, it is estimated that the 1˚C variation in temperature causes a 0.2% increase in total sales and each millimeter of precipitation reduces by just 0.02%. Following the graphical analysis of Deodorants, Body Care, Orthopedic and Geriatric, all with simultaneous correlation for precipitation and temperature, but different interpretations.

Figure 2 – Deodorant, Body Care, Orthopedic and Geriatric Model

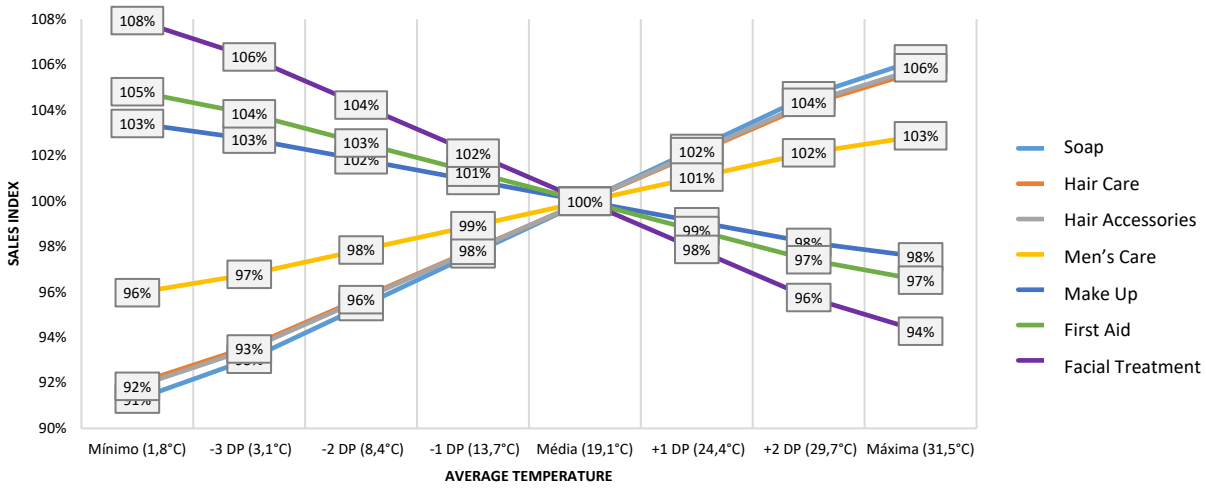


The top two graphs in Figure 2 show the observed behavior of deodorant and body care sales in relation to climate variables, where the interpretation of the results is very similar to Total Sales model. The main difference is in the intensity, where the amplitude of the extreme points for Deodorant is almost 40%, in Body Care reaches 90%, being the category with the

greatest climate effect, mainly stimulated by the increase in sunscreen consumption in periods of greatest heat. From the bottom, it's possible to observe the temperature exerting different effect for Orthopedic and Geriatric categories, estimating a higher sale in cold weeks. The only category that had a positive effect on precipitation was geriatric products, yet with low intensity.

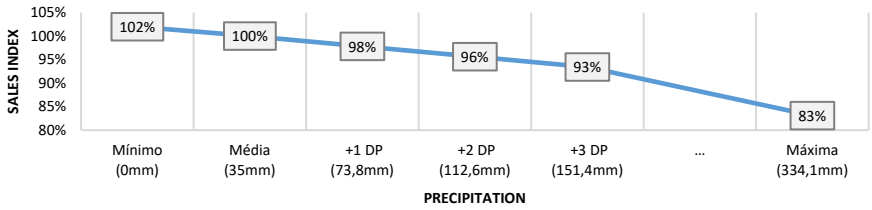
The analysis for Makeup, Hair Accessories, Hair Products, Men's, First Aid, Soaps and Facial Treatment through Figure 3 was made considering only temperature variable, since there wasn't significant correlation for precipitation. For Hair Accessories, Hair Care, Men's and Soaps, the positive sign indicates that sales tend to be higher on warmer days; on the other hand, the negative sign found for Makeup, First Aid and Facials shows that in these categories the Sale will be higher on cold days. Still, it is possible to observe the intensity of the effect, the greater the slope the greater will be the variation in sales. In Facial Treatment, it is estimated for a 1 degree increase in temperature a reduction of 0.46% of sales, for First Aid and Makeup the reduction would be 0.27% and 0.19% respectively. In the opposite direction, it is possible to estimate that for the same temperature variation, there would be an increase in sales of 0.5% for Soaps, 0.47% for Hair Accessories, 0.46% for Hair Care and 0.23% for Male.

Figure 3 – Simple correlation model for temperature



With a significant correlation for only one of the climate variables, sales in the Dermocosmetics category show a downward trend in rainy weeks, as shown in figure 4. It is possible to estimate a 0.05% drop for each millimeter of rain, while the value for R^2 indicates that 95.23% of sales can be explained by the model.

Figure 7 – Dermocosmetic Model



The composition of products may explain this lack of correlation in some categories, where the sales tend to be constant throughout the year, such as the consumption of toothbrushes, diapers or rash cream.

5. Conclusion

The main hypothesis tested in this study, that climatic variables have a significant effect on the sale of hygiene and beauty products, could be confirmed for some categories, with different influences between them. To reach these results, some difficulties had to be overcome, such as the existence of external factors and difficult to measure, such as promotional actions, migratory effect between regions and other changes in demand not related to the variables addressed. Second point, the existence of diverse seasonality throughout the panel, such as lower demand on Sundays and holidays, festive seasons, holidays, paydays and Christmas. Third, the difficulty in finding available data for the panel's elaboration, few public data have regional segmentation or with the necessary periodicity. Therefore, the contribution of this study is firstly applied to pharmaceutical retailing and observation of the regional behavior of the sale of medicines, after which various articles and academic studies have been found on the subject, but in other areas or regions.

Finally, it is possible to conclude that rain and temperature are two significant variables and exert a direct influence on the sales behavior of some categories of products, so it is essential to include them in the calculation of the demand of the sector for better management of purchases, inventories and decrease of losses due to excess and overdue. There is also the possibility of evolving the theme in studies for the creation of new economic tools, such as climate insurance, with the purpose of protecting mainly small industry and retail, more susceptible to the effects of the climate due to its regional performance.

From the climate data point of view, there would be no restriction or limitations for extrapolation data, it would be advisable only to carry out a pilot test, matching the values

found. Considering the transactional sales panel, the study is limited only the establishments where the data were collected, even if it presents statistical consistency. The limitation of the analysis occurs because it is not possible to guarantee the homogeneous or equivalent behavior of the data in establishments where the study was not carried out, this because the sample does not represent the total sales, only a portion of the market and that behaves of determined way. Therefore, extrapolation of results to establishments, cities or circumstances not observed are not recommended. On the other hand, the model presented throughout the study can easily be used for the development of new studies and researches.

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