( ) Graduação (X) Pós-Graduação

PRICE VOLATILITY AND ELASTICITY MEASUREMENTS OF SOME VEGETABLES IN THREE SUPPLY CENTERS OF BRAZIL DURING THE PERIOD FROM 2017 AND 2021

Cindy Lee Cajachagua Pucuhuaranga
Universidad Nacional Autónoma Altoandina de Tarma (UNAAT),
Escola Superior de Agricultura "Luiz de Queiroz" da Universidade de São Paulo (ESALQ/USP)
cindy.desideratacp10@gmail.com

Risely Ferraz Almeida
Escola Superior de Agricultura "Luiz de Queiroz" da Universidade de São Paulo (ESALQ/USP)
riselyferrazpecege@gmail.com

ABSTRACT

Vegetables consumption has increased in recent years due to the predisposition of people to have a healthy diet, which includes the ingestion of fibers, vitamins and minerals present in Fruits and Vegetables. In Brazil, the five vegetables with highest consumption are: lettuce, tomato, carrot, onion and potato. In this investigation we calculated the price volatility and the price elasticities measures (price elasticity of supply, price elasticity of demand or price inelasticity) of these five vegetables in three supply centers: CEAGESSP, CEASAMINAS, and CEASA/RJ, and from 2017 to 2021. The results indicate that all the evaluated products had similar price volatility behavior or pattern from 2019 to 2021 in the three supply centers. Moreover, the years with higher instabilities of prices were 2020 for potato and carrot, 2019 for lettuce and 2018 for onion. In addition, the result shows that price elasticity or inelasticity had independent behavior per supply center, however in this research we identified some periods of inelasticity where the price does not influence the quantity demanded or supplied of the evaluated product.

Keywords: Vegetables; Price volatility; Elasticity of supply; Elasticity of demand; EIGEDIN.

RESUMO

O consumo de hortaliças tem aumentado nos últimos anos devido à predisposição das pessoas a ter uma alimentação saudável, que inclui a ingestão de fibras, vitaminas e minerais presentes nas Frutas e Hortaliças. No Brasil, as cinco hortaliças com maior consumo são: alface, tomate, cenoura, cebola e batata. Nesta investigação foram calculadas as medidas de volatilidade de preços e elasticidades de preços (elasticidade-preço da oferta, elasticidade-preço da demanda ou inelasticidade-preço) dessas cinco hortaliças em três centros de abastecimento: CEAGESSP, CEASAMINAS e CEASA/RJ, e de 2017 a 2021. Os resultados indicam que todos os produtos avaliados tiveram padrão de volatilidade de preços semelhante desde 2019 a 2021 nos três centros de abastecimento. Além disso, os anos com maiores instabilidades de preços foram 2020 para batata e cenoura, 2019 para alface e 2018 para cebola. Em adição, o resultado mostra que a elasticidade ou inelasticidade do preço teve comportamento independente para cada centro de abastecimento, porém nesta pesquisa identificamos alguns períodos de inelasticidade onde o preço não influencia a quantidade demandada ou ofertada da hortaliça.

Palavras-chave: Hortaliças; Volatilidade dos preços; Elasticidade da oferta; Elasticidade da demanda; EIGEDIN.

1 INTRODUCTION

Brazil is the 13th largest producer of vegetables in the world, this according to the data of the Food and Agricultural Organization (FAO), 2015. Among the vegetables with high production in Brazil are found: garlic, onions, potatoes, and tomatoes (Camargo et al., 2015; NAN, 2020). However, its habitants, on average, do not consume the minimum daily amount of fruits and vegetables recommended by the World Healthy Organization (WHO), which is 400g or 6 to 7% of a total calories diaries of approximately 2300 Kcal (Claro et al., 2007; Nolasco et al., 2017).

The ingestion of fruits and vegetables are part of healthy eating patterns (Pessoa et al., 2015) that is why in the last decade, one of the priorities around the world is promote their consumption. According to different studies food demand depends on preferences or lack of access for socioeconomic or logistical reasons, being the last two the most recurrent in developing countries (Nolasco et al., 2017).

In this studied, we calculated the price volatilities and price elasticities of five vegetables (lettuce, tomato, potato, onion, and carrot) from the Vegetable Sector (VS), and in three different supply centers: CEAGESSP, CEASAMINAS and CEASA/RJ, which are the top three of supply centers with greater commercialization of vegetables in 2018 (CONAB, 2018).

This study has two hypotheses: (i) due to the price volatilities in the fruits sector during the year, there are a pattern for each product, and (ii) the price elasticities of demand or supply are highly variable depending on the product within the Vegetable Sector (VS). The aim of the present study is identifying the price volatility and elasticity measures for vegetables with the highest production in Brazil in the period between 2017 and 2021, providing information to companies of the VS.

2 LITERATURE REVIEW

The price volatility is the variation of commodity price changes around their mean value. At the present time, it is an ongoing concern because it may have a negative impact at the macroeconomic level on growth and poverty as reported by some economists. Thus, it is important to know the evolution of price volatility in order to develop different instruments and design appropriate policies to transfer risk or at least to lessen the extent of world market price volatility (Huchet et al., 2011).

Additionally, in agribusiness, it is important to do a demand and supply analysis cause the results of this studies allows to make any significant business decisions regarding market performance and market activities (Vukadinović et al., 2017). The elasticity is one of those analyzes, and is an economic instrument that measure the rate at which quantities of a product respond to price changes; the percentage at which a one percent change in prices will cause a certain percentage change in quantities (Jacob, 2014; Vukadinović et al., 2017; Rosales; Mercado, 2020).

There are four different elasticities measurements: price elasticity of demand, income elasticity of demand, price elasticity of supply and cross price elasticity (Mankiw, 2001). The size of the price elasticities is important from a policy perspective, cause if the price elasticity is absolutely greater than one, any increase in the price will lead to a reduction in the quantity exported, so the governments have to stabilize the income of farmers with subsidies (Noel; Jones, 1988). In the same way, it is relevant in marketing to stablish the optimal price. In general, the purpose of elasticity is to understand the market's response to changes in prices (Tiago; Queiroz, 2011), and in this study we focused two measures: price elasticity of demand and price elasticity of supplied.

3 METHODOLOGICAL PROCEDURES

Data collecting characterization

We selected five vegetables to be studied (lettuce, tomato, potato, onion, and carrot). A set of different databases were used depending of the variable studied in these five products. To analysed the price volatility, we used the data from the ’Boletim Hortigranjeiro’, available on the website: https://www.conab.gov.br/info-agro/hortigranjeiros-prohort/boletim-hortigranjeiro, to obtain prices from years 2017, 2018 and 2019. Moreover, the CONAB (National Supply Company) database, available on the website: https://portaldeinformacoes.conab.gov.br/mapeamentos-agricolas.html, were used to get the prices of years 2020 and 2021. For all the calculus, the units for these prices were reais per kilograms (R$/Kg). All the prices were corrected by the index IPCA (Índice de Preços ao Consumidor Amplo), which measure the inflation of a set of products sold in retail, using the online calculator, available in: https://www.ibge.gov.br/estatisticas/economicas/precos-e-

custos/9256-indice-nacional-de-precos-ao-consumidor-amplo.html?=&t=calculadora-do-ipca.
To analyzed the price elasticities, we utilized the previous data and complement with information of the quantity sold. The quantity sold from years 2017, 2018 and 2019 were estimated by the bar graphs from the Boletim Hortigranjeiro and using the WebPlotDigitizer online tool, available at: https://apps.automeris.io/wpd/, while data from years 2020 and 2021 were download from the CONAB database. The calculus of quantities used the kilogram unit in all the cases.

Price volatility

Price volatility could be defined as price variability around a central value. So, it is the tendency of individual prices to vary from its mean value. Thus, volatility is often defined as high deviations from a global tendency (Huchet et al., 2011). In this study, we calculated the historical volatility, based on past prices of the last five years, using Coefficient of Variation (CV) **(Equation 1)**, which is described in the investigations of Huchet et al., 2011; Bellemare, 2014 and Traore and Diop, 2021.

$$\mathbf{CV} = \frac{\mathit{Standard\ deviation}}{\mathit{Mean}} = \frac{\sqrt{\dfrac{\sum_{i=1}^{n}(P_i - \bar{P})^2}{n}}}{\bar{P}} \qquad \textbf{(Equation 1)}$$

where n indicates the number of prices to be analyzed, which are twelve (one per month), P_i is the value of each price and $\bar{P}$ is the annual mean price changes.

This measure was calculated per year from 2017 to 2021 and for each of the ten products selected previously. The areas studied include three distribution centers: CEAGESSP (Sao Paulo), CEASAMINAS (Belo Horizonte), and CEASA/RJ (Rio de Janeiro).

Elasticity measurements

In this research we calculated three measures: price elasticity of demand, price elasticity of supply and income elasticity of demand. To obtain these measures we used the same data than to calculate the price volatility plus data of the quantity sold. We evaluated the same ten foods selected.

Price elasticity of demand

The price elasticity of demand or the elasticity of demand measures the responsiveness of consumers to a change in price (Barkley, A. 2016). Sometimes price elasticities of demand are reported as negative numbers. It because the percentage change in quantity will always have the opposite sign as the percentage change in price. In the present study, we used the absolute value for dropping the minus sign and report the results as positive numbers when we are comparing price elasticities of demand of a specific product, but we maintain the negative sign when we are trying to differentiate the price elasticities of demand from the price elasticities of supply. Thus, the price elasticity of demand is mathematically defined as the percentage at which a one percent change in prices will cause a certain percentage change in quantities **(Equation 2)** (Mankiw, G. 2001; 2008).

$$\boldsymbol{e}_{\mathbf{d}} = \left|\frac{\%\Delta Q_d}{\%\Delta P}\right| \quad \textbf{(Equation 2)}$$

where $\boldsymbol{e}_{\mathbf{d}}$ is the price elasticity of demand or coefficient of demand, $\%\Delta Q_d$ is the percentage change in quantity demanded and $\%\Delta P$ is the percentage change in price. To facilitate the calculation of the price elasticity of demand we used the midpoint method **(Equation 3)** (Mankiw, G. 2008).

$$\boldsymbol{e}_{\mathbf{d}} = \left|\frac{\dfrac{Q_2 - Q_1}{\left(\dfrac{Q_1 + Q_2}{2}\right)}}{\dfrac{P_2 - P_1}{\left(\dfrac{P_1 + P_2}{2}\right)}}\right| \quad \textbf{(Equation 3)}$$

where $\boldsymbol{e}_{\mathbf{d}}$ is the price elasticity of demand, Q_1 is the quantity demanded at time 1, Q_2 is the quantity demanded at time 2, P_1 is the price at time1, and P_2 is the price at time 2 (Mankiw, G. 2008). We can interpret the $\boldsymbol{e}_{\mathbf{d}}$ as follows: if the $\boldsymbol{e}_{\mathbf{d}}$ is greater than one the demand is elastic, so the quantity demanded changes by a larger percentage than does price; if $\boldsymbol{e}_{\mathbf{d}}$ is equal to 1, the demand is unitary elastic, so the percentage increase in quantity demanded is equal to percentage decrease in price; and if the $\boldsymbol{e}_{\mathbf{d}}$ is less than 1, the demand is inelastic which means that quantity demanded is relatively insensitive to price (McConnell, C. 2003; Mankiw, G. 2008; Besanko and Braeutigam, 2010).

Price elasticity of supply

The price elasticity of supply measures how much the quantity supplied responds to changes in the price. It because sometimes producers of a good offer to sell more of it when the price of the good rises (Mankiw, G. 2008). Thus, economists compute the price elasticity of supply as the percentage change in the quantity supplied divided by the percentage change in the price

(Equation 4). In addition, the price elasticity of supply is never negative, since price and quantity supplied are directly related (McConnell, C. 2003).

$$\boldsymbol{e}_{\mathbf{s}} = \frac{\%\Delta Q_S}{\%\Delta P} \quad \textbf{(Equation 4)}$$

where $\boldsymbol{e}_{\mathbf{s}}$ is the price elasticity of supply or coefficient of supply, $\%\Delta Q_S$ is the percentage change in quantity supplied and $\%\Delta P$ is the percentage change in price. In the same way that the price elasticity of demand, the price elasticity of supply can be calculated by the midpoint method **(Equation 5)** (Mankiw, G. 2008).

$$\boldsymbol{e}_{\mathbf{s}} = \frac{\dfrac{Q_2 - Q_1}{\left(\dfrac{Q_1 + Q_2}{2}\right)}}{\dfrac{P_2 - P_1}{\left(\dfrac{P_1 + P_2}{2}\right)}} \quad \textbf{(Equation 5)}$$

where $\boldsymbol{e}_{\mathbf{s}}$ is the price elasticity of supply, Q_1 is the quantity supplied at time 1, Q_2 is the quantity supplied at time 2, P_1 is the price at time 1, and P_2 is the price at time 2 (Mankiw, G. 2008). The degree of price elasticity or inelasticity of supply is measure by the $\boldsymbol{e}_{\mathbf{s}}$. If the $\boldsymbol{e}_{\mathbf{s}}$ is greater than one the supply is elastic, which means that producers are relatively responsive to price changes. If the $\boldsymbol{e}_{\mathbf{s}}$ is equal to 1 the supply is unit elastic, which indicates that the quantity produced change in the same percentage that the price. On the other hand, if the $\boldsymbol{e}_{\mathbf{s}}$ is less than 1, the supply is inelastic, so the producers are relatively insensitive to price changes (McConnell, C. 2003; Mankiw, G. 2008).

4 DISCUSSION AND DATA ANALYSIS

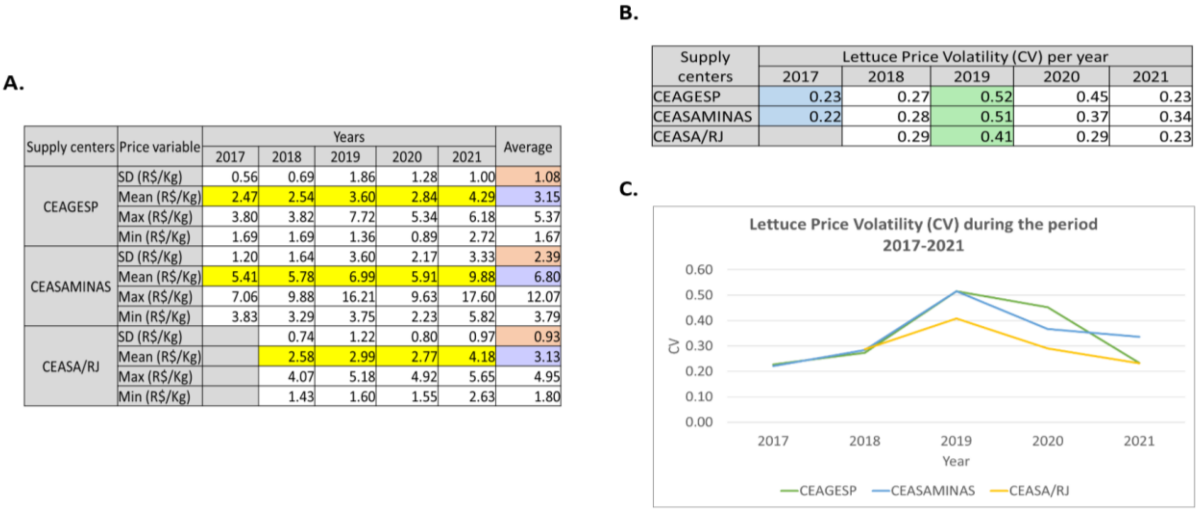
The results of price volatilities and price elasticities are analyzed per food. We showed the results in tables containing four statistic measures: standard deviation (SD), mean, maximum value (Max) and minimum value (Min) to have a context in data set (price volatilities and price elasticities calculated), per supply center (CEAGESSP, CEASAMINAS or CEASA/RJ) and from 2017 to 2021.

LETTUCE

Price volatilities of lettuce

Analyzing the results, we concluded that the average prices suggest that lettuce, during these five years, tend to be cheaper in CEASA/RJ and more expensive in CEASAMINAS. Furthermore, the prices in the three supply centers have been increasing from 2019 to 2021 **(Figure 1A, Mean).** On the other hand, the prices ranged between 2.47 and 4.29 R$/Kg in CEAGESP, between 5.41 and 9.88 R$/Kg in CEASAMINAS and between 2.58 and 4.18 R$/Kg in CEASA/RJ **(Figure 1A, Min and Max).** Moreover, the SD data indicates that during the five years the dispersion of prices were higher in CEASAMINAS (ranged from 1.20 to 3.33 R$/Kg), so it is the supply center more unstable for lettuce market, contrary to CEASA/RJ (ranged from 0.74 to 1.22 R$/Kg) which was the more stable market **(Figure 1A, SD).**

About the lettuce price volatilities, these results were showed as Coefficients of Variation (CV) in a table. The higher values of price volatilities were found in 2019 (CV ≥ 0.40) and highlighted in green color while the lower values were presented in 2017 (CV ≤ 0.25) and highlighted in sky blue color. So, of the five evaluated years, 2019 was the year with higher instability and 2017 the more stable year for the lettuce market **(Figure 1B).** Price volatilities data of the five studied years are displayed in a graph. Comparing data of the three supply centers, we concluded that the price volatility of lettuce has similar behavior from 2018 to 2021 **(Figure 1C).**



A.

Supply centers	Price variable	Years					Average
		2017	2018	2019	2020	2021	
CEAGESP	SD (R$/Kg)	0.56	0.69	1.86	1.28	1.00	1.08
	Mean (R$/Kg)	2.47	2.54	3.60	2.84	4.29	3.15
	Max (R$/Kg)	3.80	3.82	7.72	5.34	6.18	5.37
	Min (R$/Kg)	1.69	1.69	1.36	0.89	2.72	1.67
CEASAMINAS	SD (R$/Kg)	1.20	1.64	3.60	2.17	3.33	2.39
	Mean (R$/Kg)	5.41	5.78	6.99	5.91	9.88	6.80
	Max (R$/Kg)	7.06	9.88	16.21	9.63	17.60	12.07
	Min (R$/Kg)	3.83	3.29	3.75	2.23	5.82	3.79
CEASA/RJ	SD (R$/Kg)		0.74	1.22	0.80	0.97	0.93
	Mean (R$/Kg)		2.58	2.99	2.77	4.18	3.13
	Max (R$/Kg)		4.07	5.18	4.92	5.65	4.95
	Min (R$/Kg)		1.43	1.60	1.55	2.63	1.80

B.

Supply centers	Lettuce Price Volatility (CV) per year				
	2017	2018	2019	2020	2021
CEAGESP	0.23	0.27	0.52	0.45	0.23
CEASAMINAS	0.22	0.28	0.51	0.37	0.34
CEASA/RJ		0.29	0.41	0.29	0.23

Figure 1. Statistic measures and price volatility from 2017 to 2021 regarding the lettuce. A. Calculation of SD, Mean and Maximum and Minimum values per supply center and from 2017 to 2021. **B.** Data showing price volatilities as CV in a table**. C.** Price volatilities were showed in a graph.

Price elasticities measurements of lettuce

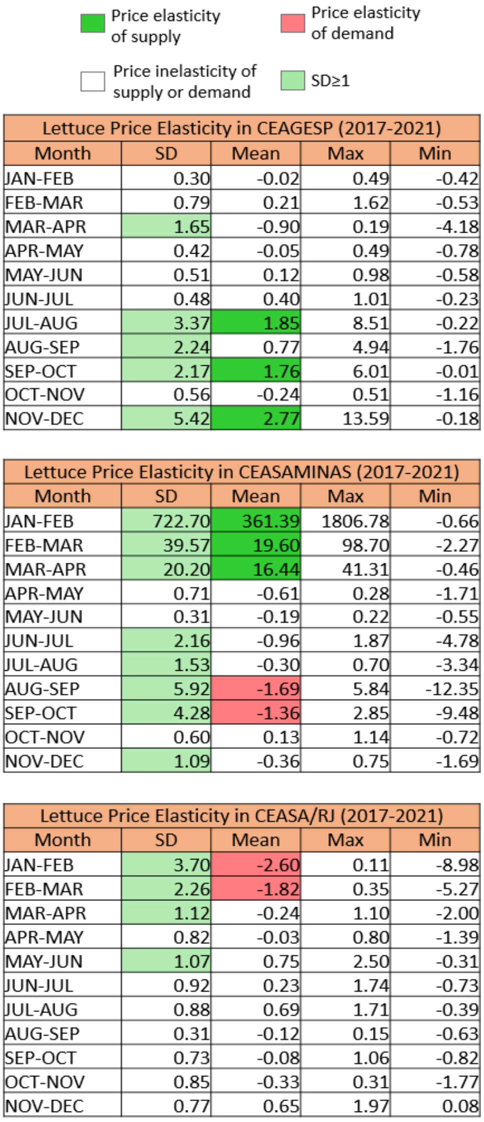
Price elasticities measurements variables from 2017 to 2021 were presented in three separated tables, one per supply center. According to our analysis the price elasticities of lettuce have different behaviours in each supply center. However, the CEAGESP did not have periods of price elasticity of demand (e_d) and in CEASA/RJ we did not recognize periods of price elasticities of supply (e_s).

In CEAGESP we have three squares in green color, so there is e_s (where $e_s \geq 1$) from July to August, from September to October and from November to December. Therefore, during this time there is a tendency to increase or decrease the fruit supply by producers depending to the price in the market.

On the other hand, in the CEASAMINAS there were four months with e_s (where $e_s \geq 1$) from January to April. In addition, this supply center had three months of e_d (where $|e_d| \geq 1$) from August to October, period where the consumers were influenced by price.

In contrast, in the CEASA/RJ, the e_d (where $|e_d| \geq 1$) was present in three months comprising one period from January to March.

Comparing the three supply centers there were not common characteristics respect to e_d or e_s. Additionally, evaluating the SD of all the three tables we deduced that we have two periods of high stability (with low values of SD and presence of price inelasticity), in the three supply centers: from April to May and from October to November **(Figure 2).**



🟩 Price elasticity of supply
🟥 Price elasticity of demand
☐ Price inelasticity of supply or demand
🟩 SD≥1

Lettuce Price Elasticity in CEAGESP (2017-2021)				
Month	SD	Mean	Max	Min
JAN-FEB	0.30	-0.02	0.49	-0.42
FEB-MAR	0.79	0.21	1.62	-0.53
MAR-APR	1.65	-0.90	0.19	-4.18
APR-MAY	0.42	-0.05	0.49	-0.78
MAY-JUN	0.51	0.12	0.98	-0.58
JUN-JUL	0.48	0.40	1.01	-0.23
JUL-AUG	3.37	1.85	8.51	-0.22
AUG-SEP	2.24	0.77	4.94	-1.76
SEP-OCT	2.17	1.76	6.01	-0.01
OCT-NOV	0.56	-0.24	0.51	-1.16
NOV-DEC	5.42	2.77	13.59	-0.18

Lettuce Price Elasticity in CEASAMINAS (2017-2021)				
Month	SD	Mean	Max	Min
JAN-FEB	722.70	361.39	1806.78	-0.66
FEB-MAR	39.57	19.60	98.70	-2.27
MAR-APR	20.20	16.44	41.31	-0.46
APR-MAY	0.71	-0.61	0.28	-1.71
MAY-JUN	0.31	-0.19	0.22	-0.55
JUN-JUL	2.16	-0.96	1.87	-4.78
JUL-AUG	1.53	-0.30	0.70	-3.34
AUG-SEP	5.92	-1.69	5.84	-12.35
SEP-OCT	4.28	-1.36	2.85	-9.48
OCT-NOV	0.60	0.13	1.14	-0.72
NOV-DEC	1.09	-0.36	0.75	-1.69

Lettuce Price Elasticity in CEASA/RJ (2017-2021)				
Month	SD	Mean	Max	Min
JAN-FEB	3.70	-2.60	0.11	-8.98
FEB-MAR	2.26	-1.82	0.35	-5.27
MAR-APR	1.12	-0.24	1.10	-2.00
APR-MAY	0.82	-0.03	0.80	-1.39
MAY-JUN	1.07	0.75	2.50	-0.31
JUN-JUL	0.92	0.23	1.74	-0.73
JUL-AUG	0.88	0.69	1.71	-0.39
AUG-SEP	0.31	-0.12	0.15	-0.63
SEP-OCT	0.73	-0.08	1.06	-0.82
OCT-NOV	0.85	-0.33	0.31	-1.77
NOV-DEC	0.77	0.65	1.97	0.08

Figure 2. Lettuce price elasticities from 2017 to 2021. Tables showing four statistic measures of all the orange price elasticities data: standard deviation (SD), mean, maximum value (Max) and minimum value (Min). Values of $\mathbf{e_d}$ are in red color, values of $\mathbf{e_s}$ are in green color, values of price inelasticity are in white color and valued with SD ≥ 1 are in light green color.

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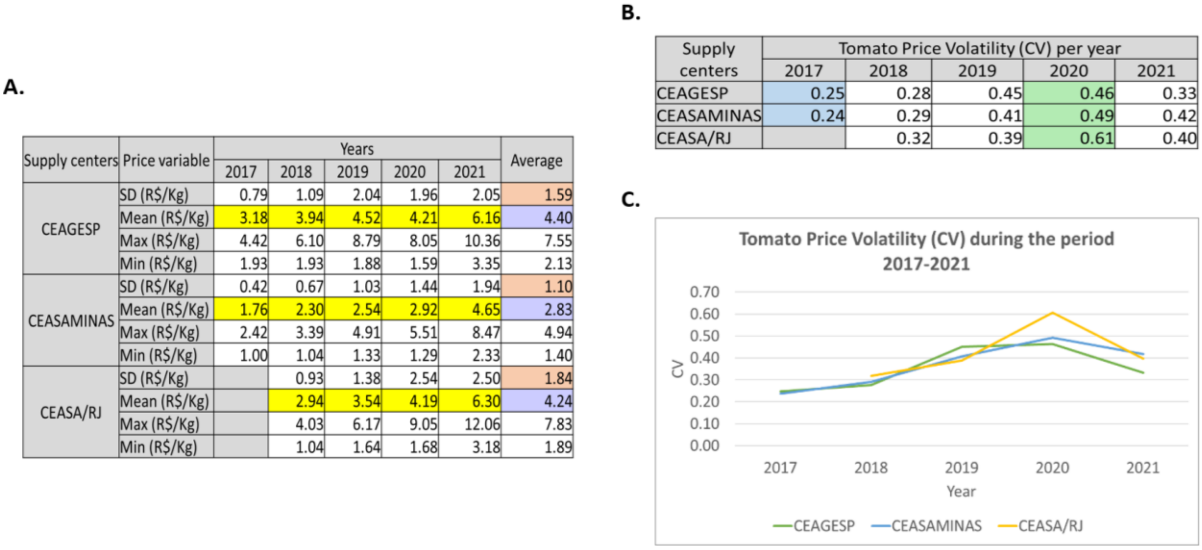
TOMATO

Price volatilities of tomato

Analyzing the results, we concluded that the average prices suggest that tomato, during these five years, tend to be cheaper in CEASAMINAS and more expensive in CEAGESP. Furthermore, the prices in the three supply centers have been increasing from 2019 to 2021 **(Figure 3A, Mean).** On the other hand, the prices ranged between 3.18 and 6.16 R$/Kg in CEAGESP, between 1.76 and 4.65 R$/Kg in CEASAMINAS and between 2.94 and 6.30 R$/Kg in CEASA/RJ **(Figure 3A, Min and Max).** Moreover, the SD data indicates that during the five years the dispersion of prices were higher than 1.00 R$/Kg since 2019 in the three supply centers, also in 2020 and 2021 the CEASA/RJ have SD ≥ 2.50 R$/Kg which represents the highest values and therefore it is the more unstable market **(Figure 3A, SD).**

About the tomato price volatilities, these results were showed as Coefficients of Variation (CV) in a table. The higher values of price volatilities were found in 2020 (CV ≥ 0.45) and highlighted in green color while the lower values were presented in 2017 (CV ≤ 0.25) and highlighted in sky blue color. So, of the five evaluated years, 2020 was the year with higher instability of prices and 2017 the more stable year for the tomato market **(Figure 3B).** Price volatilities data of the five studied years are displayed in a graph. Comparing data of the three supply centers, we concluded that the price volatility of tomato has similar behavior from 2018 to 2021 **(Figure 3C).**



Supply centers	Price variable	Years					Average
		2017	2018	2019	2020	2021	
CEAGESP	SD (R$/Kg)	0.79	1.09	2.04	1.96	2.05	1.59
	Mean (R$/Kg)	3.18	3.94	4.52	4.21	6.16	4.40
	Max (R$/Kg)	4.42	6.10	8.79	8.05	10.36	7.55
	Min (R$/Kg)	1.93	1.93	1.88	1.59	3.35	2.13
CEASAMINAS	SD (R$/Kg)	0.42	0.67	1.03	1.44	1.94	1.10
	Mean (R$/Kg)	1.76	2.30	2.54	2.92	4.65	2.83
	Max (R$/Kg)	2.42	3.39	4.91	5.51	8.47	4.94
	Min (R$/Kg)	1.00	1.04	1.33	1.29	2.33	1.40
CEASA/RJ	SD (R$/Kg)		0.93	1.38	2.54	2.50	1.84
	Mean (R$/Kg)		2.94	3.54	4.19	6.30	4.24
	Max (R$/Kg)		4.03	6.17	9.05	12.06	7.83
	Min (R$/Kg)		1.04	1.64	1.68	3.18	1.89

Supply centers	Tomato Price Volatility (CV) per year				
	2017	2018	2019	2020	2021
CEAGESP	0.25	0.28	0.45	0.46	0.33
CEASAMINAS	0.24	0.29	0.41	0.49	0.42
CEASA/RJ		0.32	0.39	0.61	0.40

Figure 3. Statistic measures and price volatility from 2017 to 2021 regarding the tomato. A. Calculation of SD, Mean and Maximum and Minimum values per supply center and from 2017 to 2021. **B.** Data showing price volatilities as CV in a table**. C.** Price volatilities were showed in a graph.

Price elasticities measurements of tomato

Price elasticities measurements variables from 2017 to 2021 were presented in three separated tables, one per supply center. According to our analysis the price elasticities of tomato have different behaviours in each supply center.

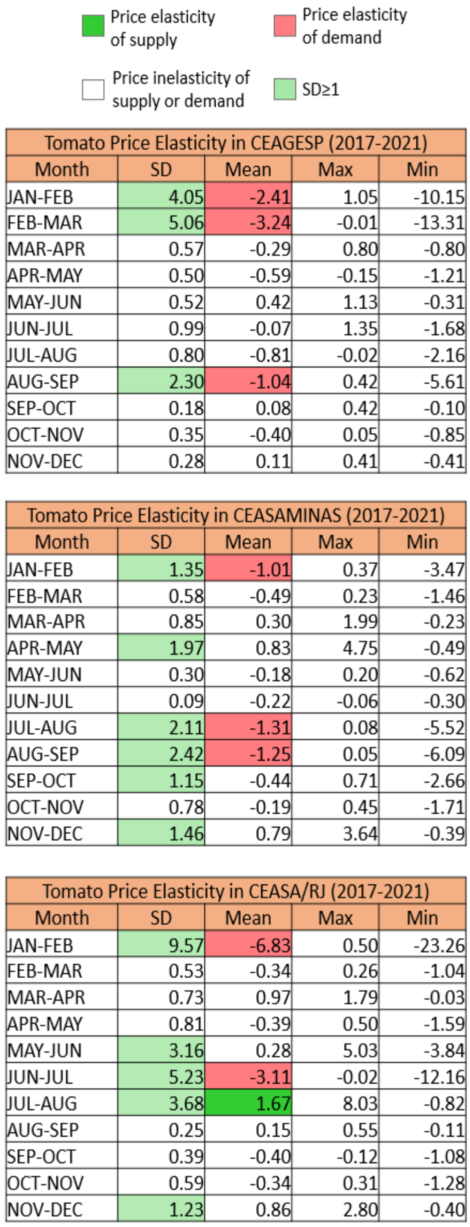
However, the CEAGESP and CEASAMINAS did not have periods of price elasticities of supply (e_s), but CEASA/RJ had both, price elasticities of supply (e_s) and price elasticity of demand (e_d).

In CEAGESP we have three squares in red color, so there is e_d (where $|e_d| \geq 1$), and the periods were from January to March and from August to September. Therefore, during this time there is a tendency of consumers to increase the demand when the prices decrease.

On the other hand, in the CEASAMINAS there were two period of e_d (where $|e_d| \geq 1$), from January to February and from July to September. Thus, the demand of this vegetable is influenced by the price of the product.

In contrast, in the CEASA/RJ, the e_d (where $|e_d| \geq 1$) was present in two periods, from January to February and from June to July. In addition, the e_s (where $e_s \geq 1$) was present in one period from July to August.

Comparing the three supply centers, is common that e_d was present in one period from January to February. Additionally, evaluating the SD of all the three tables we deduced that we had two periods with high stability (with low values of SD and presence of price inelasticity) in the three supply centers from March to April and from October to November **(Figure 4).**



🟩 Price elasticity of supply
🟥 Price elasticity of demand
☐ Price inelasticity of supply or demand
🟩 SD≥1

Tomato Price Elasticity in CEAGESP (2017-2021)				
Month	SD	Mean	Max	Min
JAN-FEB	4.05	-2.41	1.05	-10.15
FEB-MAR	5.06	-3.24	-0.01	-13.31
MAR-APR	0.57	-0.29	0.80	-0.80
APR-MAY	0.50	-0.59	-0.15	-1.21
MAY-JUN	0.52	0.42	1.13	-0.31
JUN-JUL	0.99	-0.07	1.35	-1.68
JUL-AUG	0.80	-0.81	-0.02	-2.16
AUG-SEP	2.30	-1.04	0.42	-5.61
SEP-OCT	0.18	0.08	0.42	-0.10
OCT-NOV	0.35	-0.40	0.05	-0.85
NOV-DEC	0.28	0.11	0.41	-0.41

Tomato Price Elasticity in CEASAMINAS (2017-2021)				
Month	SD	Mean	Max	Min
JAN-FEB	1.35	-1.01	0.37	-3.47
FEB-MAR	0.58	-0.49	0.23	-1.46
MAR-APR	0.85	0.30	1.99	-0.23
APR-MAY	1.97	0.83	4.75	-0.49
MAY-JUN	0.30	-0.18	0.20	-0.62
JUN-JUL	0.09	-0.22	-0.06	-0.30
JUL-AUG	2.11	-1.31	0.08	-5.52
AUG-SEP	2.42	-1.25	0.05	-6.09
SEP-OCT	1.15	-0.44	0.71	-2.66
OCT-NOV	0.78	-0.19	0.45	-1.71
NOV-DEC	1.46	0.79	3.64	-0.39

Tomato Price Elasticity in CEASA/RJ (2017-2021)				
Month	SD	Mean	Max	Min
JAN-FEB	9.57	-6.83	0.50	-23.26
FEB-MAR	0.53	-0.34	0.26	-1.04
MAR-APR	0.73	0.97	1.79	-0.03
APR-MAY	0.81	-0.39	0.50	-1.59
MAY-JUN	3.16	0.28	5.03	-3.84
JUN-JUL	5.23	-3.11	-0.02	-12.16
JUL-AUG	3.68	1.67	8.03	-0.82
AUG-SEP	0.25	0.15	0.55	-0.11
SEP-OCT	0.39	-0.40	-0.12	-1.08
OCT-NOV	0.59	-0.34	0.31	-1.28
NOV-DEC	1.23	0.86	2.80	-0.40

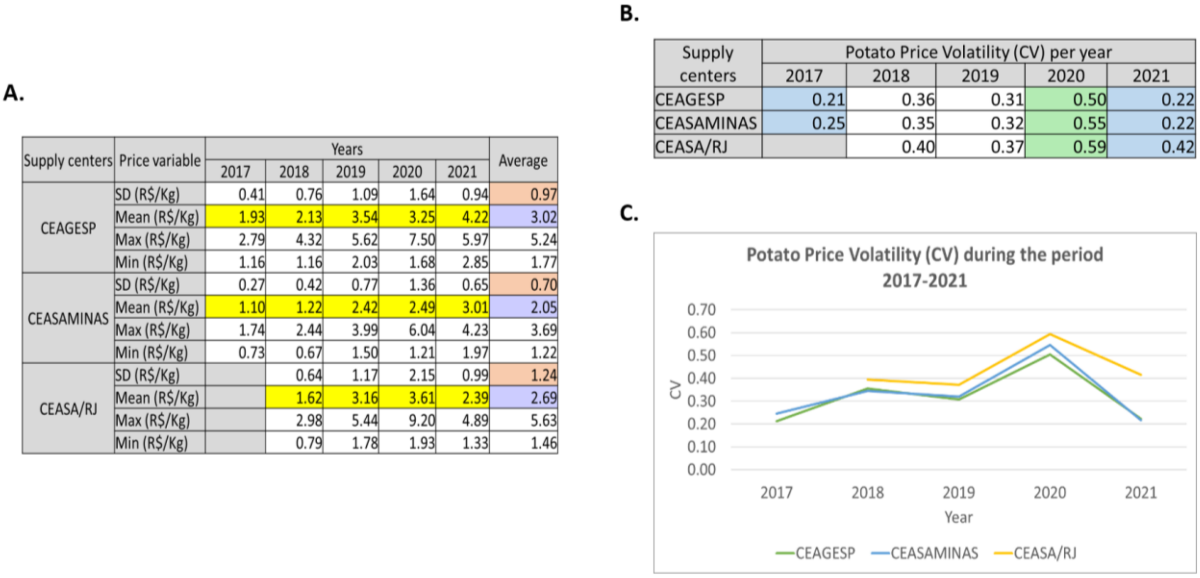
Figure 4. Tomato price elasticities from 2017 to 2021. Tables showing four statistic measures of all the orange price elasticities data: standard deviation (SD), mean, maximum value (Max) and minimum value (Min). Values of $\mathbf{e_d}$ are in red color, values of $\mathbf{e_s}$ are in green color, values of price inelasticity are in white color and valued with SD ≥ 1 are in light green color.

POTATO

Price volatilities of potato

Analyzing the results, we concluded that the average prices suggest that potato, during these five years, tend to be cheaper in CEASAMINAS and more expensive in CEAGESP. Furthermore, the prices in the three supply centers have been increasing from 2017 to 2021 **(Figure 5A, Mean).** On the other hand, the prices ranged between 1.93 and 4.22 R$/Kg in CEAGESP, between 1.10 and 3.01 R$/Kg in CEASAMINAS and between 1.62 and 3.61 R$/Kg in CEASA/RJ **(Figure 5A, Min and Max).** Moreover, comparing the SD data of the three supply centers, we concluded that the center with the lowest SD values is CEASAMINAS indicating that it is the more stable market for potato. In addition, 2020 was the year with higher SD values in comparison to the other years **(Figure 5A, SD).**

About the potato price volatilities, these results were showed as Coefficients of Variation (CV) in a table. The higher values of price volatilities were found in 2020 (CV ≥ 0.50) and highlighted in green color while the lower values were presented in 2017 and 2021 (CV ≤ 0.45) and highlighted in sky blue color. So, of the five evaluated years, 2020 was the year with higher instability of prices and 2017 and 2021 the more stable years for the potato market **(Figure 15B).** Price volatilities data of the five studied years are displayed in a graph. Comparing data of the three supply centers, we concluded that the price volatility of tomato has similar behavior from 2018 to 2021 **(Figure 5C).**



A.

Supply centers	Price variable	Years					Average
		2017	2018	2019	2020	2021	
CEAGESP	SD (R$/Kg)	0.41	0.76	1.09	1.64	0.94	0.97
	Mean (R$/Kg)	1.93	2.13	3.54	3.25	4.22	3.02
	Max (R$/Kg)	2.79	4.32	5.62	7.50	5.97	5.24
	Min (R$/Kg)	1.16	1.16	2.03	1.68	2.85	1.77
CEASAMINAS	SD (R$/Kg)	0.27	0.42	0.77	1.36	0.65	0.70
	Mean (R$/Kg)	1.10	1.22	2.42	2.49	3.01	2.05
	Max (R$/Kg)	1.74	2.44	3.99	6.04	4.23	3.69
	Min (R$/Kg)	0.73	0.67	1.50	1.21	1.97	1.22
CEASA/RJ	SD (R$/Kg)		0.64	1.17	2.15	0.99	1.24
	Mean (R$/Kg)		1.62	3.16	3.61	2.39	2.69
	Max (R$/Kg)		2.98	5.44	9.20	4.89	5.63
	Min (R$/Kg)		0.79	1.78	1.93	1.33	1.46

B.

Supply centers	Potato Price Volatility (CV) per year				
	2017	2018	2019	2020	2021
CEAGESP	0.21	0.36	0.31	0.50	0.22
CEASAMINAS	0.25	0.35	0.32	0.55	0.22
CEASA/RJ		0.40	0.37	0.59	0.42

C.

Figure 5. Statistic measures and price volatility from 2017 to 2021 regarding the potato. A. Calculation of SD, Mean and Maximum and Minimum values per supply center and from 2017 to 2021. **B.** Data showing price volatilities as CV in a table**. C.** Price volatilities were showed in a graph.

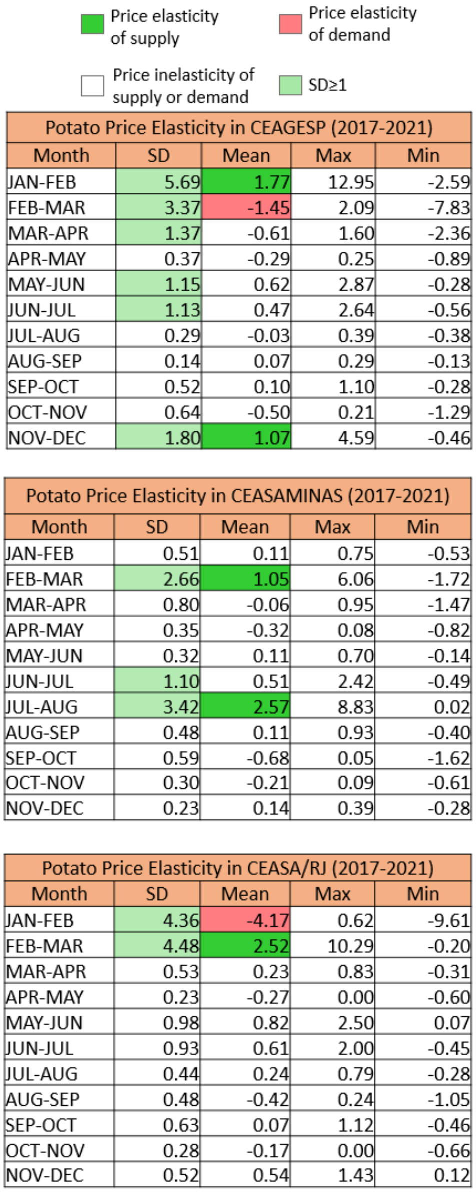
Price elasticities measurements of potato

Price elasticities measurements variables from 2017 to 2021 were presented in three separated tables, one per supply center. According to our analysis the price elasticities of potato have different behaviours in each supply center. The CEASAMINAS did not have periods of price elasticity of demand (***e*d**). However, the CEAGESP and CEASAMINAS had both: price elasticities of supply (***e*s**) and price elasticity of demand (***e*d**).

In CEAGESP we have one square in red color, so there is ***e*d** (where |***e*d**| ≥ 1), comprising the months February and March. Thus, during these months the consumers increase the demand when vegetable prices decrease. In addition, this supply center had two periods of ***e*s** (where ***e*s** ≥ 1) from January to February and from November to December.

On the other hand, in the CEASAMINAS there were two period of ***e*s** (where ***e*s** ≥ 1) from February to March and from July to August. Thus, the supply of this vegetable is influenced by the price of the product.

In contrast, in the CEASA/RJ, the ***e*d** (where |***e*d**| ≥ 1) was present in one period, from January to February. In addition, the ***e*s** (where ***e*s** ≥ 1) was present in one period from February to March. Comparing the three supply centers there were not common characteristics respect to ***e*d** and ***e*s**. Additionally, evaluating the SD of all the three tables we deduced that we have two periods of high stability (with low values of SD and presence of price inelasticity), in the three supply centers: from March to July and from August to November. Both periods encompass nine months which means that potato is a stable market in reference to the price product in most of the year **(Figure 6).**



🟩 Price elasticity of supply
🟥 Price elasticity of demand
☐ Price inelasticity of supply or demand
🟩 SD≥1

Potato Price Elasticity in CEAGESP (2017-2021)				
Month	SD	Mean	Max	Min
JAN-FEB	5.69	1.77	12.95	-2.59
FEB-MAR	3.37	-1.45	2.09	-7.83
MAR-APR	1.37	-0.61	1.60	-2.36
APR-MAY	0.37	-0.29	0.25	-0.89
MAY-JUN	1.15	0.62	2.87	-0.28
JUN-JUL	1.13	0.47	2.64	-0.56
JUL-AUG	0.29	-0.03	0.39	-0.38
AUG-SEP	0.14	0.07	0.29	-0.13
SEP-OCT	0.52	0.10	1.10	-0.28
OCT-NOV	0.64	-0.50	0.21	-1.29
NOV-DEC	1.80	1.07	4.59	-0.46

Potato Price Elasticity in CEASAMINAS (2017-2021)				
Month	SD	Mean	Max	Min
JAN-FEB	0.51	0.11	0.75	-0.53
FEB-MAR	2.66	1.05	6.06	-1.72
MAR-APR	0.80	-0.06	0.95	-1.47
APR-MAY	0.35	-0.32	0.08	-0.82
MAY-JUN	0.32	0.11	0.70	-0.14
JUN-JUL	1.10	0.51	2.42	-0.49
JUL-AUG	3.42	2.57	8.83	0.02
AUG-SEP	0.48	0.11	0.93	-0.40
SEP-OCT	0.59	-0.68	0.05	-1.62
OCT-NOV	0.30	-0.21	0.09	-0.61
NOV-DEC	0.23	0.14	0.39	-0.28

Potato Price Elasticity in CEASA/RJ (2017-2021)				
Month	SD	Mean	Max	Min
JAN-FEB	4.36	-4.17	0.62	-9.61
FEB-MAR	4.48	2.52	10.29	-0.20
MAR-APR	0.53	0.23	0.83	-0.31
APR-MAY	0.23	-0.27	0.00	-0.60
MAY-JUN	0.98	0.82	2.50	0.07
JUN-JUL	0.93	0.61	2.00	-0.45
JUL-AUG	0.44	0.24	0.79	-0.28
AUG-SEP	0.48	-0.42	0.24	-1.05
SEP-OCT	0.63	0.07	1.12	-0.46
OCT-NOV	0.28	-0.17	0.00	-0.66
NOV-DEC	0.52	0.54	1.43	0.12

Figure 6. Potato price elasticities from 2017 to 2021. Tables showing four statistic measures of all the orange price elasticities data: standard deviation (SD), mean, maximum value (Max) and minimum value (Min). Values of $\mathbf{e}_d$ are in red color, values of $\mathbf{e}_s$ are in green color, values of price inelasticity are in white color and valued with SD ≥ 1 are in light green color.

ONION

Price volatilities of onion

Analyzing the results, we concluded that the average prices suggest that onion, during these five years, tend to be cheaper in CEASAMINAS and more expensive CEASA/RJ. Furthermore, the prices in the three supply centers have been increasing from 2017 to 2021 **(Figure 7A, Mean).** On the other hand, the prices ranged between 2.01 and 3.82 R$/Kg in CEAGESP, between 1.54 and 3.54 R$/Kg in CEASAMINAS and between 2.64 and 3.96 R$/Kg in CEASA/RJ **(Figure 7A, Min and Max).** Moreover, comparing the SD data of the three supply centers, we concluded that the center with the lowest SD values is CEASAMINAS indicating that it is the more stable onion market. In addition, 2018 was the year with higher SD values in comparison to the other years **(Figure 7A, SD).**

About the onion price volatilities, these results were showed as Coefficients of Variation (CV) in a table. The higher values of price volatilities were found in 2018 (CV ≥ 0.55) and highlighted in green color while the lower values were presented in 2017 (CV ≤ 0.20) and highlighted in sky blue color. So, of the five evaluated years, 2018 was the year with higher instability of prices and 2017 the more stable year for the onion market **(Figure 7B).** Price volatilities data of the five studied years are displayed in a graph. Comparing data of the three supply centers, we concluded that the price volatility of tomato has similar behavior from 2018 to 2021 **(Figure 7C).**

Supply centers	Price variable	Years					Average
		2017	2018	2019	2020	2021	
CEAGESP	SD (R$/Kg)	0.33	1.82	0.89	1.16	0.97	1.03
	Mean (R$/Kg)	2.01	3.00	3.60	3.33	3.82	3.15
	Max (R$/Kg)	2.47	7.73	5.27	5.37	5.72	5.31
	Min (R$/Kg)	1.16	1.16	2.26	1.73	2.79	1.82
CEASAMINAS	SD (R$/Kg)	0.24	1.49	0.63	1.01	1.03	0.88
	Mean (R$/Kg)	1.54	2.40	3.07	3.04	3.54	2.72
	Max (R$/Kg)	1.90	6.31	4.03	4.70	5.53	4.49
	Min (R$/Kg)	0.91	0.98	2.09	1.59	2.52	1.62
CEASA/RJ	SD (R$/Kg)		1.49	0.58	1.27	1.07	1.10
	Mean (R$/Kg)		2.64	3.31	3.61	3.96	3.38
	Max (R$/Kg)		6.49	4.43	5.32	5.93	5.54
	Min (R$/Kg)		1.21	2.30	1.88	2.70	2.02

Supply centers	Onion Price Volatility (CV) per year				
	2017	2018	2019	2020	2021
CEAGESP	0.17	0.61	0.25	0.35	0.25
CEASAMINAS	0.16	0.62	0.21	0.33	0.29
CEASA/RJ		0.56	0.17	0.35	0.27

Figure 7. Statistic measures and price volatility from 2017 to 2021 regarding the potato. A. Calculation of SD, Mean and Maximum and Minimum values per supply center and from 2017 to 2021. **B.** Data showing price volatilities as CV in a table**. C.** Price volatilities were showed in a graph.

Price elasticities measurements of onion

Price elasticities measurements variables from 2017 to 2021 were presented in three separated tables, one per supply center. According to our analysis the price elasticities of onion have different behaviours in each supply center.

The CEASAMINAS did not have periods of price elasticity of demand (e_d), the CEASA/RJ did not have periods of price elasticities of supply (e_s), and the CEAGESP had both: price elasticities of supply (e_s) and price elasticity of demand (e_d).

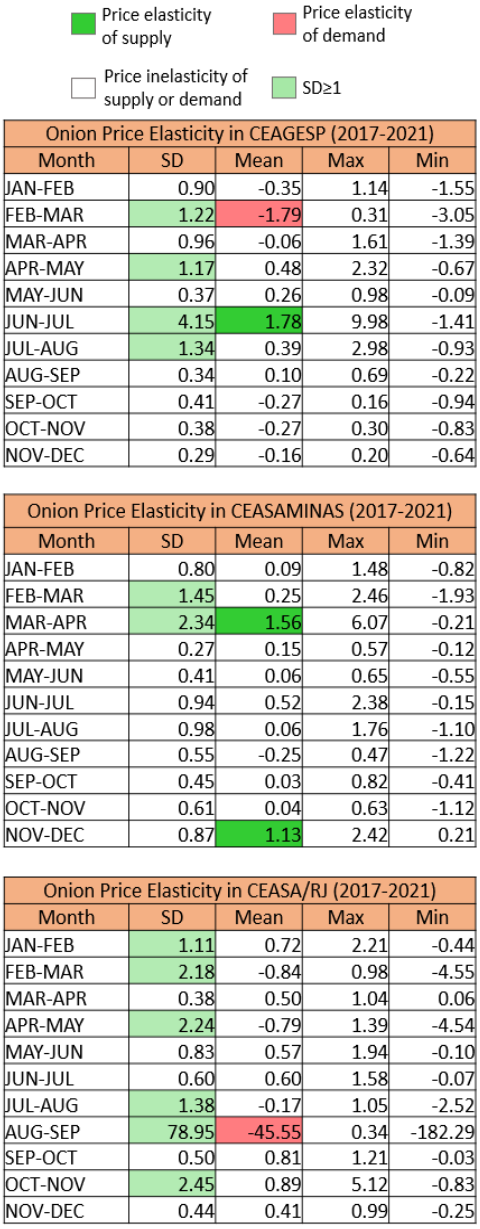
In CEAGESP we have one square in red color, so there is e_d (where $|e_d| \geq 1$), comprising the months February and March. Thus, during these months the consumers increase the demand of onion when prices decrease. In addition, this supply center had one periods of e_s (where $e_s \geq 1$) from June to July.

On the other hand, in the CEASAMINAS there were two periods of e_s (where $e_s \geq 1$) from

March to April and from November to December. Thus, in these months the supply of this vegetable is influenced by the price of the product.

In contrast, in the CEASA/RJ, the e_d (where $|e_d| \geq 1$) was present in one period, from August to September.

Comparing the three supply centers there were not common characteristics respect to e_d and e_s. Additionally, evaluating the SD of all the three tables we deduced that we have four periods of high stability (with low values of SD and presence of price inelasticity), in the three supply centers: from January to February, from April to June, from July to August and from September to November. These periods encompass nine months which means that onion is a stable market in reference to the price product in most of the year **(Figure 8).**



🟩 Price elasticity of supply
🟥 Price elasticity of demand
☐ Price inelasticity of supply or demand
🟩 SD≥1

Onion Price Elasticity in CEAGESP (2017-2021)				
Month	SD	Mean	Max	Min
JAN-FEB	0.90	-0.35	1.14	-1.55
FEB-MAR	1.22	-1.79	0.31	-3.05
MAR-APR	0.96	-0.06	1.61	-1.39
APR-MAY	1.17	0.48	2.32	-0.67
MAY-JUN	0.37	0.26	0.98	-0.09
JUN-JUL	4.15	1.78	9.98	-1.41
JUL-AUG	1.34	0.39	2.98	-0.93
AUG-SEP	0.34	0.10	0.69	-0.22
SEP-OCT	0.41	-0.27	0.16	-0.94
OCT-NOV	0.38	-0.27	0.30	-0.83
NOV-DEC	0.29	-0.16	0.20	-0.64

Onion Price Elasticity in CEASAMINAS (2017-2021)				
Month	SD	Mean	Max	Min
JAN-FEB	0.80	0.09	1.48	-0.82
FEB-MAR	1.45	0.25	2.46	-1.93
MAR-APR	2.34	1.56	6.07	-0.21
APR-MAY	0.27	0.15	0.57	-0.12
MAY-JUN	0.41	0.06	0.65	-0.55
JUN-JUL	0.94	0.52	2.38	-0.15
JUL-AUG	0.98	0.06	1.76	-1.10
AUG-SEP	0.55	-0.25	0.47	-1.22
SEP-OCT	0.45	0.03	0.82	-0.41
OCT-NOV	0.61	0.04	0.63	-1.12
NOV-DEC	0.87	1.13	2.42	0.21

Onion Price Elasticity in CEASA/RJ (2017-2021)				
Month	SD	Mean	Max	Min
JAN-FEB	1.11	0.72	2.21	-0.44
FEB-MAR	2.18	-0.84	0.98	-4.55
MAR-APR	0.38	0.50	1.04	0.06
APR-MAY	2.24	-0.79	1.39	-4.54
MAY-JUN	0.83	0.57	1.94	-0.10
JUN-JUL	0.60	0.60	1.58	-0.07
JUL-AUG	1.38	-0.17	1.05	-2.52
AUG-SEP	78.95	-45.55	0.34	-182.29
SEP-OCT	0.50	0.81	1.21	-0.03
OCT-NOV	2.45	0.89	5.12	-0.83
NOV-DEC	0.44	0.41	0.99	-0.25

Figure 8. Onion price elasticities from 2017 to 2021. Tables showing four statistic measures of all the orange price elasticities data: standard deviation (SD), mean, maximum value (Max) and minimum value (Min). Values of $\mathbf{e_d}$ are in red color, values of $\mathbf{e_s}$ are in green color, values of price inelasticity are in white color and valued with SD ≥ 1 are in light green color.

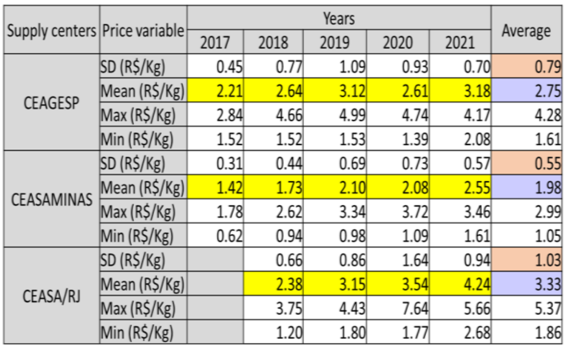
CARROT

Price volatilities of carrot

Analyzing the results, we concluded that the average prices suggest that carrot, during these five years, tend to be cheaper in CEASAMINAS and more expensive CEASA/RJ. Furthermore, the prices in the three supply centers have been increasing from 2017 to 2021 **(Figure 9A, Mean).** On the other hand, the prices ranged between 2.21 and 3.18 R$/Kg in CEAGESP, between 1.42 and 2.55 R$/Kg in CEASAMINAS and between 2.38 and 4.24 R$/Kg in CEASA/RJ **(Figure 9A, Min and Max).** Moreover, comparing the SD data of the three supply centers, we concluded that the center with the lowest SD values is CEASAMINAS indicating that it is the more stable carrot market. In addition, the center with the highest SD values from 2017 to 2019 was CEAGESP then in 2020 and 2021 the highest SD values were present in CEASA/RJ **(Figure 9A, SD).**

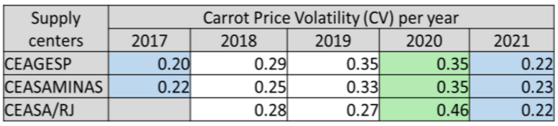
About the carrot price volatilities, these results were showed as Coefficients of Variation (CV) in a table. The higher values of price volatilities were found in 2020 (CV ≥ 0.35) and highlighted in green color while the lower values were presented in 2017 and 2021 (CV ≤ 0.25) and highlighted in sky blue color. So, of the five evaluated years, 2020 was the year with higher instability of prices and 2017 and 2021 the more stable years for the carrot market **(Figure 9B).** Price volatilities data of the five studied years are displayed in a graph. Comparing data of the three supply centers, we concluded that the price volatility of carrot has similar behavior from 2019 to 2021 **(Figure 9C).**

A.



Supply centers	Price variable	Years					Average
		2017	2018	2019	2020	2021	
CEAGESP	SD (R$/Kg)	0.45	0.77	1.09	0.93	0.70	0.79
	Mean (R$/Kg)	2.21	2.64	3.12	2.61	3.18	2.75
	Max (R$/Kg)	2.84	4.66	4.99	4.74	4.17	4.28
	Min (R$/Kg)	1.52	1.52	1.53	1.39	2.08	1.61
CEASAMINAS	SD (R$/Kg)	0.31	0.44	0.69	0.73	0.57	0.55
	Mean (R$/Kg)	1.42	1.73	2.10	2.08	2.55	1.98
	Max (R$/Kg)	1.78	2.62	3.34	3.72	3.46	2.99
	Min (R$/Kg)	0.62	0.94	0.98	1.09	1.61	1.05
CEASA/RJ	SD (R$/Kg)		0.66	0.86	1.64	0.94	1.03
	Mean (R$/Kg)		2.38	3.15	3.54	4.24	3.33
	Max (R$/Kg)		3.75	4.43	7.64	5.66	5.37
	Min (R$/Kg)		1.20	1.80	1.77	2.68	1.86

B.



Supply centers	Carrot Price Volatility (CV) per year				
	2017	2018	2019	2020	2021
CEAGESP	0.20	0.29	0.35	0.35	0.22
CEASAMINAS	0.22	0.25	0.33	0.35	0.23
CEASA/RJ		0.28	0.27	0.46	0.22

C.

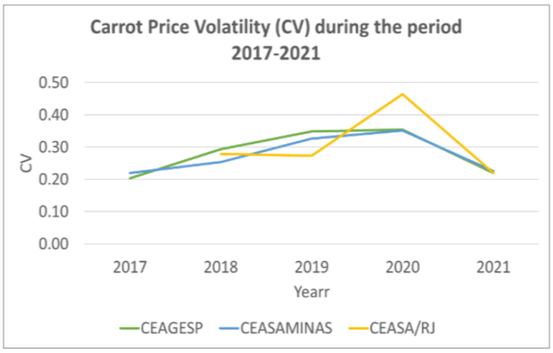


Figure 9. Statistic measures and price volatility from 2017 to 2021 regarding the potato. A.

Calculation of SD, Mean and Maximum and Minimum values per supply center and from 2017 to 2021. **B.** Data showing price volatilities as CV in a table**. C.** Price volatilities were showed in a graph.

Price elasticities measurements of carrot

Price elasticities measurements variables from 2017 to 2021 were presented in three separated tables, one per supply center. According to our analysis the price elasticities of carrot have different behaviours in each supply center.

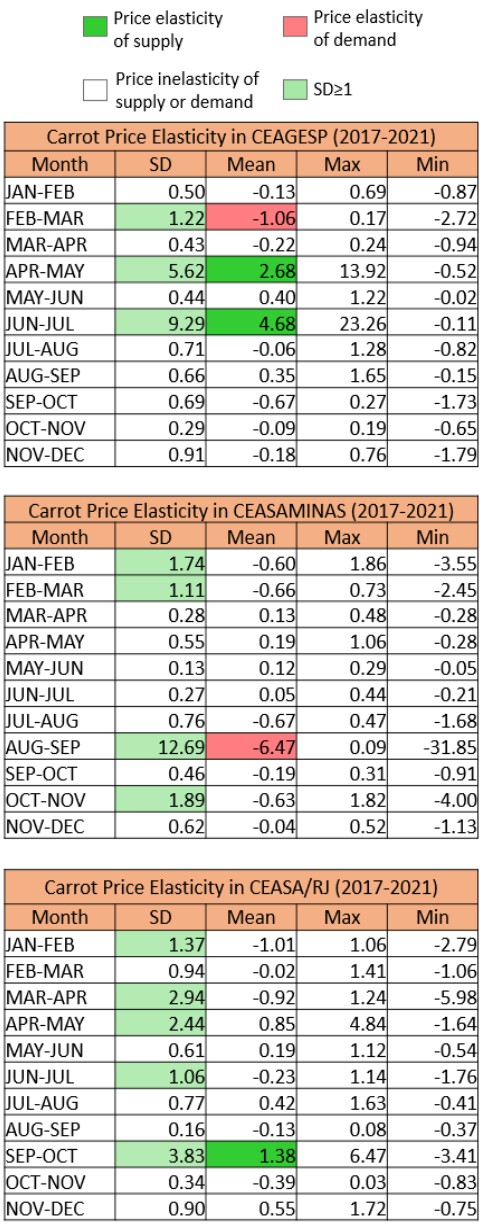
The CEASAMINAS did not have periods of price elasticities of supply ($\boldsymbol{e}_{\mathbf{s}}$), the CEASA/RJ did not have periods of price elasticity of demand ($\boldsymbol{e}_{\mathbf{d}}$) and the CEAGESP had both: price elasticities of supply ($\boldsymbol{e}_{\mathbf{s}}$) and price elasticity of demand ($\boldsymbol{e}_{\mathbf{d}}$).

In the CEAGESP we have two squares in green color which means the presence of $\boldsymbol{e}_{\mathbf{s}}$ (where $|\boldsymbol{e}_{\mathbf{s}}| \geq 1$) and comprising two periods from April to May and from June to July. Thus, during these months the supply of carrot by producers was influenced by the price of the product. In addition, there is one square in red color indicating the presence of $\boldsymbol{e}_{\mathbf{d}}$ (where $|\boldsymbol{e}_{\mathbf{d}}| \geq 1$), comprising the months February and March.

In the CEASAMINAS we found one red square indicating that there is $\boldsymbol{e}_{\mathbf{d}}$ (where $|\boldsymbol{e}_{\mathbf{d}}| \geq 1$) and comprising the months August and September. Thus, during these months the consumers increase the demand of carrot when prices decrease.

On the other hand, in the CEASA/RJ, the $\boldsymbol{e}_{\mathbf{s}}$ (where $|\boldsymbol{e}_{\mathbf{s}}| \geq 1$) was present in one period, from September to November.

Comparing the three supply centers there were not common characteristics respect to $\boldsymbol{e}_{\mathbf{d}}$ and $\boldsymbol{e}_{\mathbf{s}}$. Additionally, evaluating the SD of all the three tables we deduced that we have five periods of high stability (with low values of SD and presence of price inelasticity): from January to February, from March to April, from May to June, from July to August and from October to December. These periods encompass ten months which means that carrot is a stable market in reference to the price product in most of the year **(Figure 10).**



🟩 Price elasticity of supply
🟥 Price elasticity of demand
☐ Price inelasticity of supply or demand
🟩 SD≥1

Carrot Price Elasticity in CEAGESP (2017-2021)				
Month	SD	Mean	Max	Min
JAN-FEB	0.50	-0.13	0.69	-0.87
FEB-MAR	1.22	-1.06	0.17	-2.72
MAR-APR	0.43	-0.22	0.24	-0.94
APR-MAY	5.62	2.68	13.92	-0.52
MAY-JUN	0.44	0.40	1.22	-0.02
JUN-JUL	9.29	4.68	23.26	-0.11
JUL-AUG	0.71	-0.06	1.28	-0.82
AUG-SEP	0.66	0.35	1.65	-0.15
SEP-OCT	0.69	-0.67	0.27	-1.73
OCT-NOV	0.29	-0.09	0.19	-0.65
NOV-DEC	0.91	-0.18	0.76	-1.79

Carrot Price Elasticity in CEASAMINAS (2017-2021)				
Month	SD	Mean	Max	Min
JAN-FEB	1.74	-0.60	1.86	-3.55
FEB-MAR	1.11	-0.66	0.73	-2.45
MAR-APR	0.28	0.13	0.48	-0.28
APR-MAY	0.55	0.19	1.06	-0.28
MAY-JUN	0.13	0.12	0.29	-0.05
JUN-JUL	0.27	0.05	0.44	-0.21
JUL-AUG	0.76	-0.67	0.47	-1.68
AUG-SEP	12.69	-6.47	0.09	-31.85
SEP-OCT	0.46	-0.19	0.31	-0.91
OCT-NOV	1.89	-0.63	1.82	-4.00
NOV-DEC	0.62	-0.04	0.52	-1.13

Carrot Price Elasticity in CEASA/RJ (2017-2021)				
Month	SD	Mean	Max	Min
JAN-FEB	1.37	-1.01	1.06	-2.79
FEB-MAR	0.94	-0.02	1.41	-1.06
MAR-APR	2.94	-0.92	1.24	-5.98
APR-MAY	2.44	0.85	4.84	-1.64
MAY-JUN	0.61	0.19	1.12	-0.54
JUN-JUL	1.06	-0.23	1.14	-1.76
JUL-AUG	0.77	0.42	1.63	-0.41
AUG-SEP	0.16	-0.13	0.08	-0.37
SEP-OCT	3.83	1.38	6.47	-3.41
OCT-NOV	0.34	-0.39	0.03	-0.83
NOV-DEC	0.90	0.55	1.72	-0.75

Figure 10. Carrot price elasticities from 2017 to 2021. Tables showing four statistic measures of all the orange price elasticities data: standard deviation (SD), mean, maximum value (Max) and minimum value (Min). Values of $\mathbf{e_d}$ are in red color, values of $\mathbf{e_s}$ are in green color, values of price inelasticity are in white color and valued with SD ≥ 1 are in light green color.

5 CONCLUSIONS

During the five evaluated years, four of the five vegetables (tomato, potato, onion, and carrot) were cheaper in CEASAMINAS. In relation to the lettuce, the supply center where the prices were lower was CEASA/RJ. On the other hand, tomato and potato were more expensive in CEAGESP. Moreover, onion and carrot were more expensive in CEASA/RJ, and lettuce were more expensive in CEASAMINAS.

About the price volatility, all the evaluated products had similar behavior from 2019 to 2021 in the three supply centers. In addition, comparing the CVs of the three supply centers, in the same year, we conclude that lettuce, potato, onion and carrot had similar price volatilities with differences ≤ 0.10, and tomato with differences ≤ 0.15. Furthermore, the years with higher stabilities of prices were 2017 for lettuce, tomato, onion, and carrot, and 2021 for potato. Moreover, the years with higher instabilities of prices were 2020 for tomato, potato, and carrot, 2019 for lettuce and 2018 for onion.

About the price elasticity or inelasticity, we concluded that all the evaluated market had independent behavior per supply center. Additionally, evaluating the means and SD results we suggest some periods where is likely to found price inelasticity (periods where the price does not influence the quantity demanded or supplied of the product). In banana, the periods were from May to June, from August to September and from November to December. In orange, from May to June. In apple, from March to April and from August to September. In papaya, from February to March and from November to December, and in watermelon, from May to June and from June to July.

In lettuce, the periods were from April to May and from October to November. In tomato, from March to April and from October to November. In potato, from March to July, and from August to November. In onion, involved the months January, February, April, June, July, August, September, and November. Finally, in carrot comprised the months January, February, March, April, May, June, July, August, October, and December.

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