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Demand characterization for green and colored bell pepper:
Does color affect the substitution possibilities between local and imported bell pepper?

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Introduction

The US consumers have the options to buy green, red, yellow, and orange bell peppers. However, it is not clear if those products are complementary or substitute goods. If they are substitutes, what is the degree of substitution? Does that degree of substitution changes as the source changes (locally produced vs imported)? These are questions that should be of interest for producers, intermediaries, and policymakers. Thus, in the study, we aimed at quantifying the degree of substitution.

Figure 1: Consumption of bell pepper in the U.S. by color & source

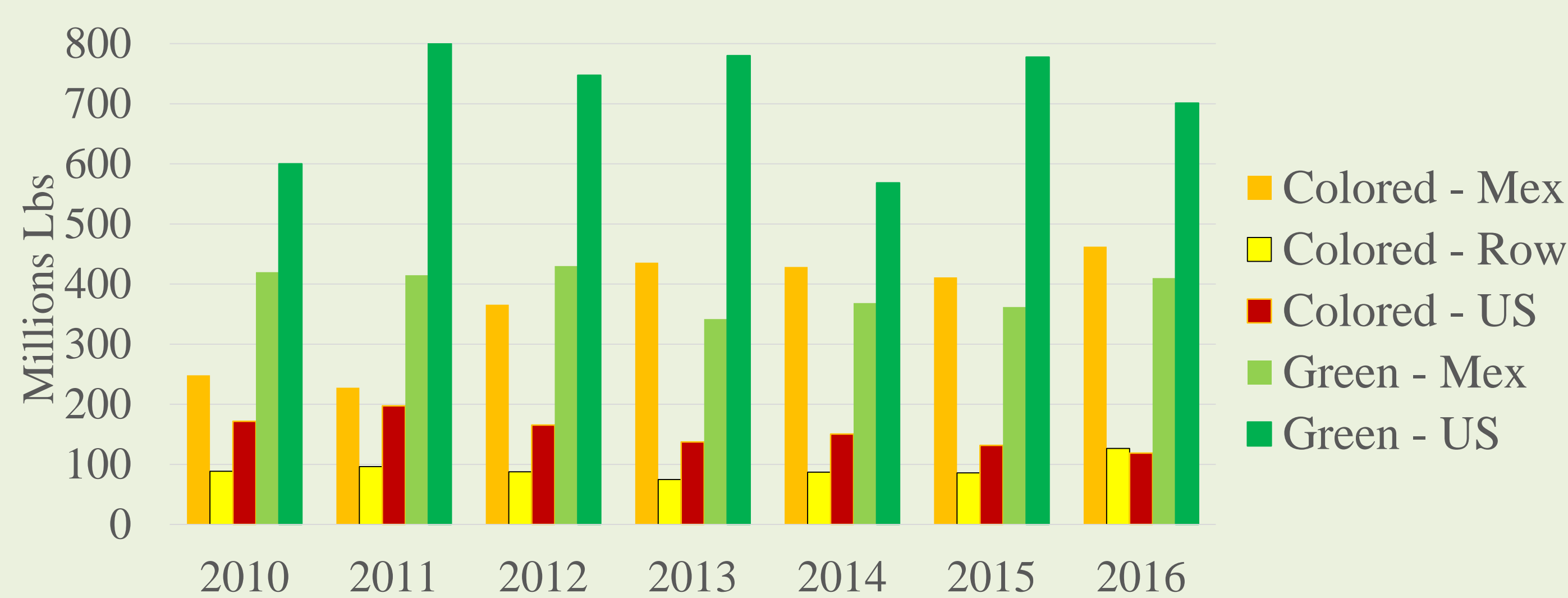


Figure 2: Monthly price of fresh bell pepper by source & color

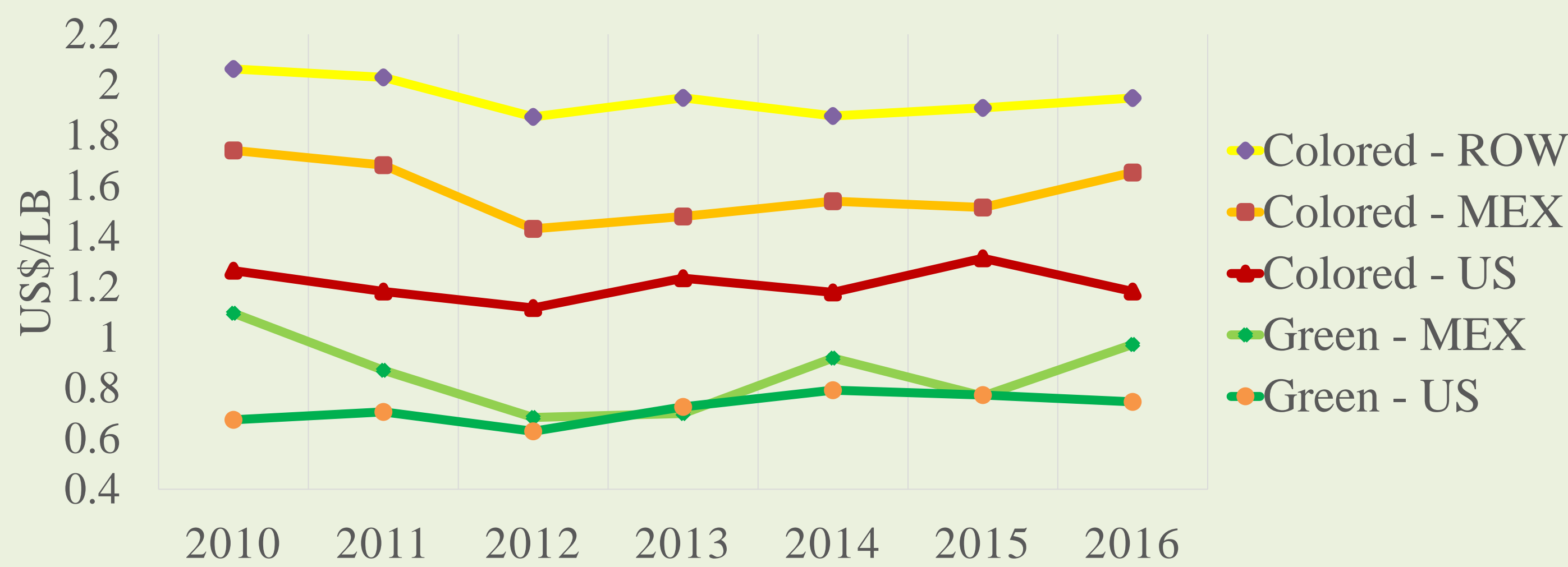


Figure 3: Budget allocation by source, color & year (2010-2016)

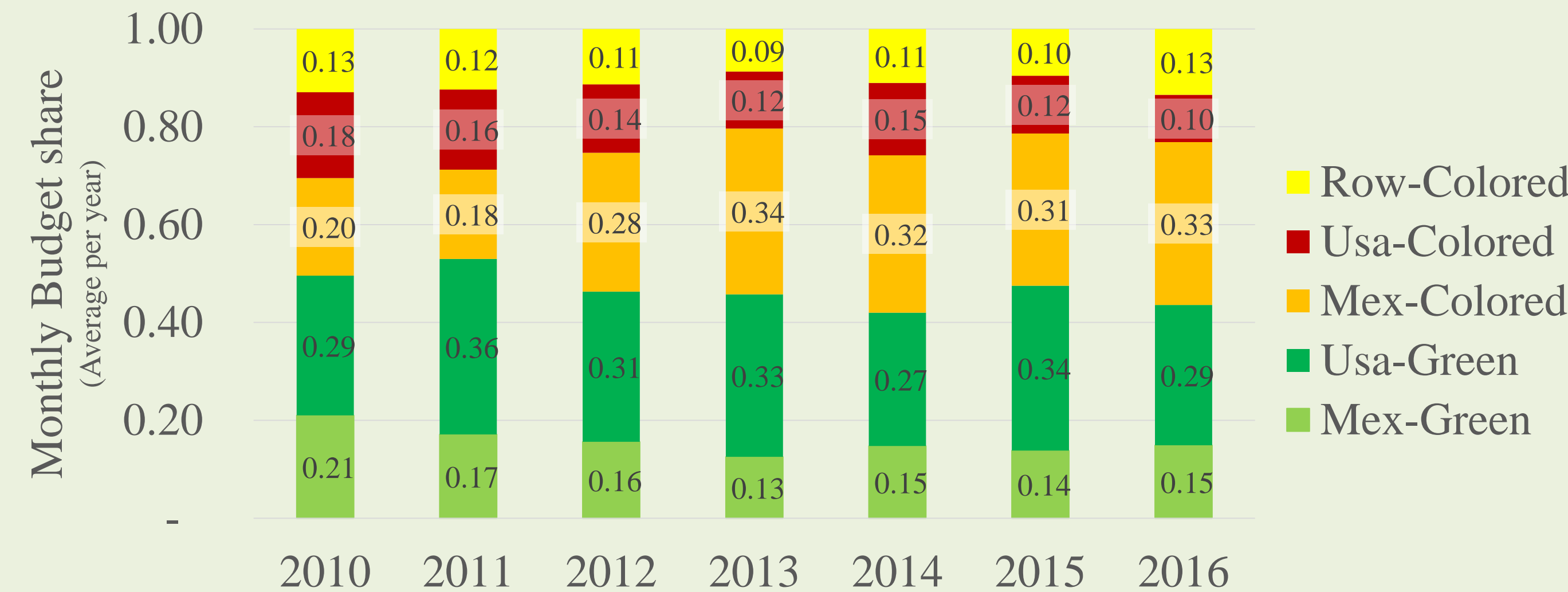
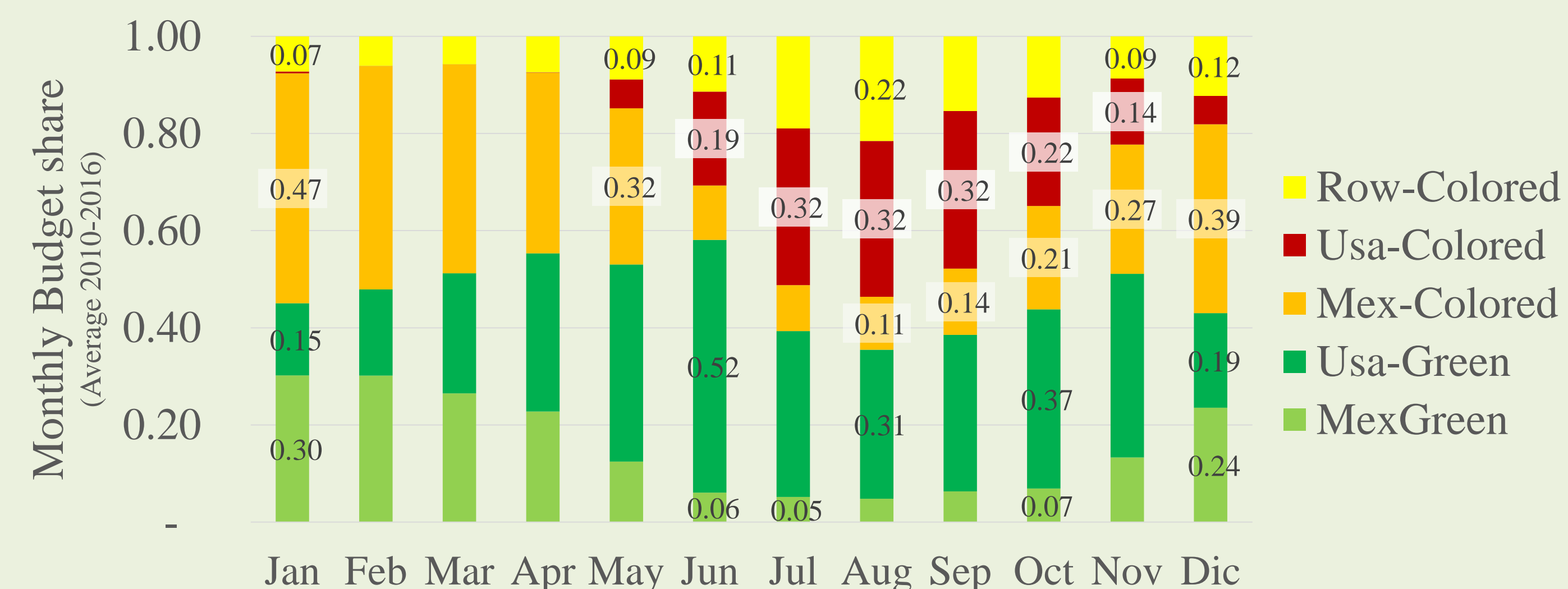


Figure 4: Budget allocation by source, color & month (2010-2016)



Theoretical and Empirical approach

Following Eales & Unnevehr (1991) a system of five equations, differentiating by color and source, are fitted to monthly data. The system is estimated using iterated seemingly unrelated regressions (ITSUR). The residuals serial correlation is treated following Anderson & Blundell (1982). The *LA-IAIDS model* is as follow:

$$w_i = a_i + \sum_j \gamma_{ij} \ln q_j + \beta_i \ln Q_t + \sum_{s=1}^{11} \delta_{is} D_s$$

To linearly-approximate the expenditure share equations, the quantity index is substituted by $\ln Q_t = \sum_j \bar{w}_j \ln q_{jt}$, where \bar{w}_j is the mean expenditure share for source-color j of bell pepper. D_s represents a monthly dummy variable, and δ_{is} captures the intercept shifts due to monthly-seasonal fluctuation.

Results and Discussion

The degree of substitution between sources depends on whether the bell pepper is green or colored.

The U.S. green bell pepper has a greater substitutability level than does the U.S. colored bell pepper. The level of substitution by color differs because, according to the scale flexibility, the U.S. colored-bell-pepper and the Mexican green-bell-pepper are perceived as luxury goods. Another plausible explanation could be the effect of seasonality, notice from figure 4 that the U.S. colored-bell-pepper has lower competition with other colored-bell-peppers during summer-fall, which is the period when the U.S. production is in season.

The negative cross-price flexibilities between colors indicate that the green and colored bell pepper are substitute goods. Although the majority of the cross-price flexibilities are negative, there is a group that is nearly zero or statistically zero, which implies that across sources there might be some level of complementarity.

The results indicate that locally produced green and colored bell peppers are equally substitutable. On the contrary, the Mexico's colored bell pepper is substituted by green bell pepper, while colored bell pepper seems complementary to the green.

The own-price flexibilities results show that the green-bell-pepper is more inflexible than the colored-bell-pepper. Thus, changes in own-quantity have a more significant impact on the prices of colored-bell-pepper than on the prices of green-bell-pepper.

Demand theory requires the following restrictions (R) in the LA-IAIDS:

$$R: \text{Adding up: } \sum_i a_i = 1; \sum_i \delta_{is} = 0; \sum_i \beta_i = 0$$

$$R: \text{Homogeneity: } \sum_j \gamma_{ij} = 0;$$

$$R: \text{Symmetry: } \gamma_{ij} = \gamma_{ji}$$

Derivation of the above equations respect to changes in $\ln q_j$, yield the own- and cross-price flexibilities ($f_{ij} = \% \Delta P_i / \% \Delta Q_j$):

$$f_{ij} = -\lambda_{ij} + \{\gamma_{ij} + \beta_i \bar{w}_j\} / \bar{w}_j$$

The scale flexibilities are derived from the homogeneity restriction:

$$f_i = -1 + \beta_i / \bar{w}_j$$

LA/IAIDS model results for bell pepper differentiated by color & source, 2010-2016 monthly

| Parameter(variable) | System of Equations | | | | | | | | | |
|--|---------------------|-----------|---------------------|-----------|-------------------|-----------|---------------------|-----------|---------------------|-----------|
| | Share MEX (Green) | | Share MEX (Colored) | | Share USA (Green) | | Share USA (Colored) | | Share Row (Colored) | |
| | Coefficient | Std. Err. | Coefficient | Std. Err. | Coefficient | Std. Err. | Coefficient | Std. Err. | Coefficient | Std. Err. |
| a_i (Intercept) | 0.100*** | (0.040) | 0.489*** | (0.051) | 0.241*** | (0.049) | -0.186*** | (0.047) | 0.355*** | (0.029) |
| $\gamma_{i_{mex_G}} (\ln q_{mex_G})$ | 0.086*** | (0.007) | -0.012** | (0.005) | -0.060*** | (0.006) | 0.005** | (0.002) | -0.019*** | (0.005) |
| $\gamma_{i_{mex_C}} (\ln q_{mex_C})$ | -0.012** | (0.005) | 0.078*** | (0.008) | -0.034*** | (0.006) | -0.006** | (0.003) | -0.025*** | (0.003) |
| $\gamma_{i_{usa_G}} (\ln q_{usa_G})$ | -0.060*** | (0.006) | -0.034*** | (0.006) | 0.144*** | (0.008) | -0.009*** | (0.003) | -0.040*** | (0.005) |
| $\gamma_{i_{usa_C}} (\ln q_{usa_C})$ | 0.005** | (0.002) | -0.006** | (0.003) | -0.009*** | (0.003) | 0.015*** | (0.003) | -0.005*** | (0.001) |
| $\gamma_{i_{row_C}} (\ln q_{row_C})$ | -0.019*** | (0.005) | -0.025*** | (0.003) | -0.040*** | (0.005) | -0.005*** | (0.001) | 0.090*** | (0.007) |
| $\beta_i (\ln Q_t)$ | -0.040** | (0.017) | 0.052** | (0.021) | 0.055*** | (0.021) | -0.107*** | (0.020) | 0.040*** | (0.010) |
| Adj. R^2 | .9246 | | .9280 | | .9007 | | 0.9210 | | 0.9042 | |
| Durbin Watson (DW) | 1.39 | | 1.30 | | 1.37 | | 1.76 | | 1.5 | |

Asterisk (*, **, and ***) denotes significance at 10%, 5%, and 1%, respectively. N=84 per each equation. DW values calculated before specifying the Autoregressive AR(1) matrix. The autoregressive parameters matrix and the seasonal coefficients are not presented due to space constrain.

LA-IAIDS flexibilities of bell pepper differentiated by source and color, 2010-2016

| | 1%ΔQ MexG | 1%ΔQ MexC | 1%ΔQ UsaG | 1%ΔQ UsaC | 1%ΔQ RowC |
|--------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|
| %ΔPrice | Coeff. | Coeff. | Coeff. | Coeff. | Coeff. |
| MexG | -0.565*** (0.057) | 0.018 (0.026) | -0.490*** (0.017) | -0.072** (0.034) | -0.057 (0.051) |
| MexC | -0.116*** (0.029) | -0.691*** (0.026) | -0.000 (0.039) | -0.277*** (0.039) | -0.112*** (0.022) |
| UsaG | -0.509*** (0.057) | -0.044 (0.039) | -0.072** (0.003) | -0.287*** (0.056) | -0.235*** (0.051) |
| UsaC | -0.002 (0.006) | -0.001 (0.005) | -0.277*** (0.034) | -0.992*** (0.008) | -0.000 (-0.04) |
| RowC | -0.125*** (0.038) | -0.068*** (0.014) | -0.287*** (0.039) | -0.133*** (0.019) | -0.179*** (0.066) |
| Scale | -1.320*** (0.108) | -0.787*** (0.080) | -0.846*** (0.066) | -1.763*** (0.132) | -0.585*** (0.088) |

Flexibilities were calculated using the mean share 16%, 28%, 31%, 14%, 11% in the period 2010-2016 for MexG, MexC, UsaG, UsaC, RowC, respectively.