INTRODUCTION

In the past decade, dairy alternative beverages have gained its market position as a robust competitor for conventional milk in the United States. Consumers have gradually turned away from conventional milk, leading the push towards plant-based milk products because a growing number of consumers beginning to believe that plant-based foods are healthier and more environmentally friendly than animal-based foods. As indicated by Singhal, Baker, and Baker (2017), the increasing sales trend of non-dairy beverages in westernized counties is due to consideration that foods labeled as natural are perceived to be the most healthy and appropriate nutritional choice.

Abstract

Dairy products, especially milk play a crucial role in assuring dietary quality for U.S. households. However, due to taste, nutrition, health and environmental concerns, households increasingly prefer to consume dairy alternative beverages instead of conventional milk in the U.S. This work is motivated by the need to take into consideration of intrinsic characteristics and differences of such characteristics when analyzing the changes of consumers' purchasing behavior of and willingness to pay for dairy alternative beverages and conventional milk products. After aggregating and organizing the purchase data of Nielsen Homescan and first-hand nutrition data, this study estimates both linear and semi-log hedonic pricing models. The results show that consumers exert the highest weights and assign highest evaluation on such qualitative characteristic as nutritional attributes which include calories, protein, fat, vitamin A and vitamin D in which protein is the most valued attribute and other characteristics such as package size, multi pack and brand. The hedonic pricing order and value of these qualitative characteristic are indicative of consumers' purchasing behavior and thus provide essential information for manufacturers to better differentiated their products and develop products catering to consumer's preferred attributes.

KEYWORDS

consumer preferences, dairy alternative beverages, hedonic pricing models, Nielsen Homescan data, qualitative characteristics

JEL CLASSIFICATION

Q11; Q13
by most consumers. Decloedt, Landschoot, Watson, Vanderputten, and Vanhaecke (2017) suggested that to address the ever-growing group of health-conscious consumers, more and more nutritional and health claims are being used on food products. Davis, Dong, Blayney, and Owens (2010) and Copeland and Dharmasena (2016) showed that per capita consumption of fluid milk in the United States has been dwindling over the past 25 years. While according to Allied Market Research, the global dairy alternative beverage market is expected to garner $21.7 billion by 2022, registering a compound annual growth rate (CAGR) of 13.3 percent during the period 2016–2022. Plant-based beverages can be generally classified in five categories: cereal-based (oat, rice, corn, spelled); legumes-based (soy, peanut, lupin, cowpeas); nut-based (almond, coconut, hazelnut, sunflower); pseudocereals-based (quinoa, teff, amaranth; Verduci et al., 2019). One of the main characteristics of these products is that even though they are not real milk products with animal origin, they are often fortified with certain nutrients such as protein, vitamin, and calcium to make them comparable with conventional milk. As is shown in Copeland and Dharmasena (2016), these beverages are designed not only to quench the thirst but also to provide numerous vitamins, minerals, proteins, and favorable fatty acids.

Soy milk and almond milk though are the leading categories in U.S. dairy alternative beverage market, they also face heavy competition from other dairy alternative beverage categories due to the availability of various flavors and tastes and fortification with multiple nutrients. And these milk alternatives vary in their composition of macro and micronutrients (Claeys et al., 2014). As indicated by Aggarwal, Rehm, Monsivais, and Drewnowski (2016), concerns with taste, nutrition, cost, and convenience are said to be key influences on food choices. They also found that taste and nutrition tend to be the most valued attributes among US adults during food shopping. It is because the variety of dairy alternative beverages are different from one another in terms of nutritional composition and price that consumers’ relative evaluations of these beverages with different nutritional content and pricing is of great importance to manufacturing and marketing these products. However, the nutritional composition of milk alternatives has received little attention from scientific research (Verduci et al., 2019). The lack of such information is a critical unmet need, because, these milk alternatives have the potential to contribute to food security, health, and nutrition of a population (Muehlhoff, Bennet, McMahon, & Food and Agriculture Organisation of the United Nations [FAO], 2014). Though dairy alternative beverages are popularly advertised as healthy and wholesome, little research has been done in understanding the consumers’ evaluation on and willingness to pay for the main nutritional components. The central question addressed in this article pertains to whether qualitative attributes especially macronutrients and micronutrients have significant effects on consumers’ willingness to pay for dairy alternative beverages, what are consumers’ subjective evaluations on these attributes and to what extent these attributes influence prices of the products.

As for nutritional contents in the products play an important role in making consumption choices, hedonic pricing model estimation can provide information about consumer’s cognition and preference on each qualitative attribute of agricultural products and their willingness to pay for each attribute. Consumers’ willingness to pay for purchasing the products (essentially the combination of different qualitative characteristics) and the satisfaction they received from consumption are greatly related to the companies’ marketing strategy and selling behavior. Based on the assumption that consumers’ utility is gained through consuming the intrinsic properties of a particular good rather than the simple quality and that intrinsic characteristics are combined to constitute the product’s market price, this paper contributes to provide manufacturers information about what and how qualitative advancement and differentiation can be made to produce and market better dairy alternative beverages to cater to consumers’ preferences. This is of great help to enhance market competitiveness and to expand market share of dairy alternative beverage companies. Also, the results of the study would have important implications for the targeting of nutrition education programs.

2 | LITERATURE REVIEW

Some existing literature about the nutritional components of dairy alternative beverages are mainly review articles. For example, Vanga and Raghavan (2018) outlined the differences of nutritional contents among various dairy alternative milks (including almond milk, soy milk, rice milk) and cow’s milk and through comparison noted that nutritionally soy milk is the best alternative for replacing cow’s milk in human diet. Sethi, Tyagi, and Anurag (2016) introduced the functional components of dairy alternative beverages and their health benefit of different products appeared in the market and the technological interventions that should be made to improve the quality and acceptability of plant-based milk alternatives. Mäkinen et al. (2016) gave an overview on the technology of production, nutritional properties, consumer acceptance and environmental impacts of dairy alternative beverages. Verduci et al. (2019) reviewed the different compositions in terms of macronutrients and micronutrients of milk from different mammalian species, including special milk formulas indicated for cow’s milk allergy, and of dairy alternative beverages. The empirical research about consumer preference on dairy alternative products embraces Laossal and Kallas (2019) who applied revealed preference discrete choice experiment to analyze consumers’ preferences toward dairy-alternative products in Catalonia using Home-Scan data of 343 households and the results showed that price was the major driving factor, followed by the original non-dairy beverage flavor attribute. With the elevated demand on plant-based alternative milk beverages in U.S., Dharmasena and Capps (2014) estimated the demand for soy milk, white milk, and flavored milk. In addition, Copeland and Dharmasena (2016) analyzed demand for dairy alternative beverages and the effect of increased demand for those products on dairy farmers’ welfare.

The concept of food hedonic pricing is first introduced by Waugh (1928) for analyzing the prices of vegetables. He argued that prices
Section 5 shows the estimated results of hedonic pricing models.

**3 | HEDONIC PRICING MODEL DEVELOPMENT**

Hedonic pricing models assume that the consumer maximizes utility by selecting products that maximize the sum of the utilities derived from each attribute (Rosen, 1974). Therefore, the price of each beverage in this study can be explained by the set of attributes of the product. $X = (X_1, X_2, ..., X_j)$ represents the qualitative characteristic combination. Qualitative characteristic information has close relationship with prices and hedonic pricing model thus is shown as:

$$P(X) = P(X_1, X_2, ..., X_j) = f(X) + \epsilon,$$  

where $\epsilon$ is the error vector, and $P$ is the observed price. If the relationship between prices and attributes is assumed to be linear, price of a good $i$ can be derived as the sum of the attribute values (Ladd & Suvannunt, 1996). Thus, the total value of each attribute is equal to the quantity of the attribute multiplied by the implicit price of that attribute (Gulseven & Wohlgenant, 2015). The linear and semi-log hedonic pricing models are constructed as follows:

$$P_i = \beta_0 + \sum_j \beta_j A_j + \sum_k D_k X_{ik} + \epsilon_i, \quad i = 1, 2, ..., 7$$  

(2)

$$\ln(P_i) = \beta_0 + \sum_j \beta_j A_j + \sum_k D_k X_{ik} + \epsilon_i, \quad i = 1, 2, ..., 7$$  

(3)

where $A_j$ is the amount of nutritional attribute $j$ contained in product $i$, $X_{ik}$ is other factors that might affect prices. $P_i$ is the monthly average price recorded in Nielsen database by different Universal Product Codes (UPC) that have been purchased from the year 2004 to 2015. These nutritional attributes include calories, fat, fiber, protein, calcium, vitamin A, etc. If the price attribute relationship is assumed to be in a semi-log form (Nimon & Beghin, 1999), then instead of price, the log-price of the product is defined regarding attributes as is shown in Equation (3). Similarly, as shown in Equation (2), $P_i$ is the monthly average prices of a beverage from year 2004 to 2015. The implicit prices are the coefficients to be estimated which are represented by $\beta_j$ and $D_k$. In the linear hedonic pricing model, the implicit prices or shadow prices can be shown as:

$$\frac{\partial P_i}{\partial A_j} = \frac{\partial f(X)}{\partial A_j} = \beta_j \quad \forall i, j$$  

(4)

$$\frac{\partial P_i}{\partial X_{ik}} = \frac{\partial f(X)}{\partial D_k} = D_k \quad \forall i, k$$  

(5)

Marginal effect of semi-log hedonic pricing model is derived as follows. First, solve for $P_i$ from Equation (3):
### Table 1: Description of dummy variables of package size and multi-pack

| Dummy variables | Soy milk | Almond milk | Rice milk | 2% milk | 1% milk | Whole milk | Fat-free milk |
|-----------------|----------|-------------|-----------|---------|---------|------------|---------------|
| \(D_{pkg\_size1}\) | 8 oz.    | 8 oz.       | 11 oz.    | size < 8 oz. \(^b\) | 8 oz.   | size < 8 oz. | size < 8 oz. |
| \(D_{pkg\_size2}\) | 8 oz. < size < 10 oz. | 10 oz. | 12 oz. | 8 oz. | 10 oz. | 8 oz. | 8 oz. |
| \(D_{pkg\_size3}\) | 10 oz. | 12 oz. | 14 oz. | 8 oz. < size < 10 oz | 10 oz. < size < 11 oz | 10 oz. | 10 oz. |
| \(D_{pkg\_size4}\) | 10 oz. < size < 11 oz. | 16 oz. | 16 oz. | 10 oz. | 10 oz. < size < 11 oz | 10 oz. < size < 11 oz | 10 oz. < size < 11 oz |
| \(D_{pkg\_size5}\) | 11 oz. | 32 oz. | 32 oz. | 10 oz. < size < 11 oz | 14 oz. | 12 oz. | 11 oz. |
| \(D_{pkg\_size6}\) | 12 oz. | 48 oz. \(^a\) | 48 oz. | 11 oz. | 16 oz. | 14 oz. | 12 oz. |
| \(D_{pkg\_size7}\) | 15 oz. | 64 oz. | 64 oz. | 12 oz. | 32 oz. | 16 oz. | 14 oz. |
| \(D_{pkg\_size8}\) | 15 oz. < size < 16 oz. | 128 oz. \(^a\) | 14 oz. | 52 oz. | 20 oz. | 16 oz. |
| \(D_{pkg\_size9}\) | 16 oz. | 16 oz. | 52 oz. < size < 64 oz. | 24 oz. | 20 oz. |
| \(D_{pkg\_size10}\) | 32 oz. | 20 oz. | 64 oz. | 32 oz. | 32 oz. |
| \(D_{pkg\_size11}\) | 32 oz. < size < 48 oz | 24 oz. | 94 oz. | 32 oz. < size < 52 oz. | 32 oz. < size < 52 oz. |
| \(D_{pkg\_size12}\) | 48 oz. | 32 oz. | 96 oz. | 52 oz. | 52 oz. \(^a\) |
| \(D_{pkg\_size13}\) | 64 oz. \(^a\) | 32 oz. < size < 52 oz. | 97 oz. \(^a\) | 52 oz. < size < 64 oz. | 52 oz. < size < 64 oz. |
| \(D_{pkg\_size14}\) | 128 oz. | 52 oz. < size < 64 oz. | 128 oz. | 96 oz. | 94 oz. |
| \(D_{pkg\_size16}\) | 64 oz. | 128 oz. \(^a\) | 96 oz. | 128 oz. |
| \(D_{pkg\_size17}\) | 94 oz. | 128 oz. |
| \(D_{pkg\_size18}\) | 96 oz. |
| \(D_{pkg\_size19}\) | 97 oz. | 128 oz. |
| \(D_{pkg\_size20}\) | 128 oz. |

\(D_{multi1}\): 1\(^{st}\) Pack \(D_{multi2}\): 2 packs \(D_{multi3}\): 3 packs \(D_{multi4}\): 4 packs \(D_{multi5}\): 6 packs \(D_{multi6}\): 12 packs \(D_{multi7}\): 5 packs \(D_{multi8}\): 18 packs

Note: 1. \(multi\) its value represents number of units in multipack; 2. \(multi\) packs (i.e. \(multi\) > 1) is total units for a product; 3. \(size\_amount\) is package size (numeric size of the product).

\(^a\)The base category of package size dummies and multi-pack dummies for almond milk, soy milk, rice milk, 2% milk, 1% milk, whole milk and far-free milk; The base category of multi-pack dummies for the seven products is \(D_{multi1}\).

\(^b\)For package size dummy variables that are in ranges, for example \(size\_amount\) < 8 oz., they are created because there are many package sizes that are not integers and for different types of beverages, the values vary a lot. In order to make the package sizes comparable from one beverage to another, we created some package size dummies that are in ranges.

\(^1\)1 is single serve.
| Variables                | Soy milk | Almond milk | Rice milk |
|--------------------------|----------|-------------|-----------|
| Pₓ₁                      | 0.4183   | 0.6369      | 0.4634    |
| ln(Pₓ₁)                  | -0.9638  | -0.5225     | -0.8698   |
| xₘ₅ⱼ                    | 105.5549 | 77.4778     | 136.6468  |
| fiber (g)                | 3.3218   | 3.0439      | 2.7584    |
| fat (g)                  | 1.4017   | 1.4773      | 0.2243    |
| protein (g)              | 6.6847   | 1.3351      | 1.9499    |
| VA (%)                   | 10.5025  | 14.2548     | 5.5119    |
| cal (%)                  | 32.6198  | 38.0099     | 31.2420   |
| cal (%)                  | 26.7098  | 22.9395     | 13.9236   |
| Deals                    | 0.2063   | 0.2476      | 0.1502    |
| brands                   | 0.2686   | 0.2479      | 0.1025    |
| pkge_size1               | 0.0052   | 0.0365      | 0.0024    |
| pkge_size2               | 0.0028   | 0.0038      | 0.0346    |
| pkge_size3               | 0.0145   | 0.0239      | 0.0381    |
| pkge_size4               | 0.0001   | 0.0383      | 0.1120    |
| pkge_size5               | 0.0103   | 0.7454      | 0.1836    |
| pkge_size6               | 0.0055   | 0.0302      | 0.0751    |
| pkge_size7               | 0.0038   | 0.1119      | 0.5304    |
| pkge_size8               | 0.0177   | 0.1319      |           |
| pkge_size9               | 0.0024   | 0.0488      |           |
| pkge_size10              | 0.0920   | 0.2890      |           |
| pkge_size11              | 0.0027   | 0.0515      |           |
| pkge_size12              | 0.0006   | 0.0253      |           |
| pkge_size13              | 0.8400   | 0.3667      |           |
| pkge_size14              | 0.0026   | 0.0506      |           |
| pkge_size15              |         |             |           |
| pkge_size16              |         |             |           |
| pkge_size17              |         |             |           |
| pkge_size18              |         |             |           |
| pkge_size19              |         |             |           |
| pkge_size20              |         |             |           |
| multi1                   |         |             |           |
| multi2                   | 0.0205   | 0.1415      |           |
| multi3                   | 0.0288   | 0.1672      |           |
| multi4                   | 0.0003   | 0.0166      |           |
| multi5                   |         |             |           |
| multi6                   | 0.0049   | 0.0696      |           |
| multi7                   |         |             |           |
| multi8                   | 0.0044   | 0.0662      |           |
| coupon                   | 0.0830   | 0.2759      |           |
| year2014                 | 0.1157   | 0.3199      |           |
| year2013                 | 0.0924   | 0.2897      |           |
| year2012                 | 0.1025   | 0.3033      |           |
| year2011                 | 0.0949   | 0.2932      |           |
|                | 2% milk | 1% milk | Whole milk | Fat-free milk |
|----------------|---------|---------|------------|---------------|
| **Mean**       | 0.2911  | 0.2399  | 0.3119     | 0.2725        |
| **SD**         | 0.1717  | 0.1031  | 0.1773     | 0.1486        |
| **Mean**       | -1.3313 | -1.4991 | -1.2669    | -1.3914       |
| **SD**         | 0.4257  | 0.3698  | 0.4377     | 0.4119        |
| **Mean**       | 129.7193| 110.7803| 149.7963   | 84.1034       |
| **SD**         | 8.8784  | 4.9886  | 4.3359     | 5.6029        |
| **Mean**       | 4.9600  | 2.6037  | 7.9789     | 0.0645        |
| **SD**         | 0.5683  | 0.5089  | 0.3079     | 0.5950        |

(Continues)
TABLE 2 (Continued)

| Variables | Soy milk | | Almond milk | | Rice milk |
|-----------|----------|-----------------|-----------------|-----------------|
|            | Mean     | SD   | Mean     | SD   | Mean     | SD   |
| $D_{\text{year}2010}$ | 0.0874 | 0.2825 | 0.0834 | 0.2767 |
| $D_{\text{year}2009}$ | 0.0767 | 0.2662 | 0.0930 | 0.2906 |
| $D_{\text{year}2008}$ | 0.0685 | 0.2527 | 0.0846 | 0.2785 |
| $D_{\text{year}2007}$ | 0.0572 | 0.2323 | 0.0810 | 0.2731 |
| $D_{\text{year}2006}$ | 0.0459 | 0.2093 | 0.0667 | 0.2497 |
| $D_{\text{year}2005}$ | 0.0264 | 0.1604 | 0.0727 | 0.2598 |
| $D_{\text{year}2004}$ | 0.0308 | 0.1728 | 0.0727 | 0.2598 |

\[
P_i = e^{(\beta_0 + \sum \beta_j A_j + \sum D_k X_k + \epsilon_i) + \sum \beta_m \text{multi}_{m} + \sum \beta_{18} \text{year} + \epsilon_i, \quad i = 1, 2, \ldots, 7} (9)
\]

\[
\partial P_i / \partial A_j = \beta_j e^{(\beta_0 + \sum \beta_j A_j + \sum D_k X_k + \epsilon_i) + \sum \beta_m \text{multi}_{m} + \sum \beta_{18} \text{year} + \epsilon_i, \quad i = 1, 2, \ldots, 7} (10)
\]

\[
\partial P_i / \partial X_k = D_k e^{(\beta_0 + \sum \beta_j A_j + \sum D_k X_k + \epsilon_i) + \sum \beta_m \text{multi}_{m} + \sum \beta_{18} \text{year} + \epsilon_i, \quad i = 1, 2, \ldots, 7} (10)
\]

Different from previous research, we also take into consideration of time effects on the price of each year by adding yearly dummies into the model. Therefore, all attributes are separated into nutritional attributes and other related attributes that might affect the prices, including package size, values of the multi-package, brands, coupon, and yearly dummies, etc. \( \beta_j \) denotes the intercept and \( \epsilon_i \) represents the stochastic error term. If we specify all the variables in the model, then the linear and semi-log hedonic pricing model in this research can be demonstrated as Equations (9) and (10) respectively:

\[
P_i = e^{(\beta_0 + \sum \beta_j A_j + \sum D_k X_k + \epsilon_i) + \sum \beta_m \text{multi}_{m} + \sum \beta_{18} \text{year} + \epsilon_i, \quad i = 1, 2, \ldots, 7} (6)
\]

\[
\text{As shown in Tables 2, the descriptive statistics of variables used in this analysis are listed. The number of variables varies mainly because for different products, their package sizes and multi-pack variables are generally higher than conventional fluid milk products.}
\]

Three types of dairy alternative beverages (almond milk, soy milk and rice milk) and the four most common types of milk products (whole milk, 1% milk, 2% milk and fat-free milk (or skim milk) are included in this work and monthly average price variable is acquired as follows. Monthly average price is the "unit price paid" as shown in the bottom of Figure 1. First, we obtain each product’s information from product files; and then we merge the information with trips files to acquire the dataset, which include variables of quantities sold, total price paid by consumers, coupon value, deal_flag, uc, multi_pack, product’s package size and size unit. As Figure 1 shows, the unit price paid (per unit cost) is calculated by first dividing the final price paid by the quantity variable. Final_price_paid is calculated by subtracting the value of variables "coupon value" from the value of "total_price_paid". Then, we average the unit prices paid in each month in each year to get the monthly average price per oz. and multiply by 8 to get monthly average price per 8oz. (unit monthly average price).
hedonic pricing models due to unavailability of proper database pertaining to such information. In this work, the nutritional variables are obtained from searching for the product label of different products. The USDA Nutritional Database and IRI nutrition information databases are widely used references for most food composition studies. However, even though USDA Nutritional Database includes 50 different categories for varieties of milk products, most of them are conventional milk, with little available information on dairy alternative beverages. Although IRI database has nutritional information of dairy alternative beverages, it uses different UPC system with Nielsen and the nutritional information recorded are not based on uniform unit. Therefore, the only way to obtain nutritional information is gathering the nutritional information directly from the products’ label by individual visual observations of beverage packages. The final dataset reflects the same set of qualitative information about characteristics that consumers have based on

| 2% milk | 1% milk | Whole milk | Fat-free milk |
|---------|---------|------------|--------------|
| Mean    | SD      | Mean       | SD           | Mean         | SD           |
| 0.0878  | 0.2830  | 0.0658     | 0.2479       | 0.0891       | 0.2849       |
| 0.0895  | 0.2854  | 0.0018     | 0.0424       | 0.0785       | 0.2690       |
| 0.0931  | 0.2905  | 0.1305     | 0.3368       | 0.1086       | 0.3111       |
| 0.0957  | 0.2942  | 0.0734     | 0.2607       | 0.0145       | 0.1194       |
| 0.0805  | 0.2721  | 0.1679     | 0.3738       | 0.0757       | 0.2645       |
| 0.0789  | 0.2696  | 0.1159     | 0.3201       | 0.0768       | 0.2663       |
| 0.0819  | 0.2741  | 0.1155     | 0.3197       | 0.0768       | 0.2663       |

FIGURE 1  Steps to derive variable-unit price paid
TABLE 3  Estimates of linear hedonic quality attributes

| Variables | Soy milk |       | Almond milk |       | Rice milk |       |
|-----------|----------|-------|-------------|-------|-----------|-------|
|           | Estimate | SE    | Estimate    | SE    | Estimate  | SE    |
| Intercept | 0.1648*** | 0.0082 | 0.2370***   | 0.0430 | 0.5850*** | 0.0734 |
| SCal      | 0.0003*** | 0.0000 | 0.0003      | 0.0002 | -0.0001   | 0.0004 |
| Sfat      | -0.0025*  | 0.0010 | 0.0111      | 0.0073 | -0.1080***| 0.0109 |
| SVA       | 0.0029*** | 0.0002 | 0.0072***   | 0.0007 | -0.0140***| 0.0020 |
| SCal      | 0.0008*** | 0.0001 | 0.0040***   | 0.0007 | 0.0043    | 0.0017*|
| SVC       | -0.0007***| 0.0001 | -0.0083***  | 0.0009 | 0.0056*** | 0.0007 |
| SFiber    | -0.0065***| 0.0014 | -0.0082**   | 0.0035 | 0.1504***  | 0.0067 |
| Sprotein  | 0.0248*** | 0.0009 | 0.2115**    | 0.0074 | 0.0079    | 0.0050 |
| Dbrands   | -0.0329***| 0.0024 | -0.1780***  | 0.0219 |          |       |
| Dpkge siz1| 0.4837*** | 0.0174 | 0.5736***   | 0.0291 | 0.2637**  | 0.0808 |
| Dpkge siz2| -0.0127   | 0.0321 | 0.4747***   | 0.0781 | 0.2635*** | 0.0330 |
| Dpkge siz3| 0.7651*** | 0.0097 | 0.0644      | 0.0529 | 0.1410*** | 0.0310 |
| Dpkge siz4| 0.1925*   | 0.0963 | 0.6390***   | 0.0510 | 0.2418*** | 0.0282 |
| Dpkge siz5| 0.7511*** | 0.0094 | 0.2877***   | 0.0470 | 0.0259    | 0.0227 |
| Dpkge siz6| 0.9296*** | 0.0172 |           |       | 0.1023*** | 0.0302 |
| Dpkge siz7| 0.6143*** | 0.0175 | -0.1234***  | 0.0145 | 0.0021    | 0.0244 |
| Dpkge siz8| 1.0393*** | 0.0089 |           |       |           |       |
| Dpkge siz9| 1.0874*** | 0.0258 |           |       |           |       |
| Dpkge siz10| 0.1648*** | 0.0036 |           |       |           |       |
| Dpkge siz11| -0.0387*  | 0.0184 |           |       |           |       |
| Dpkge siz12| 0.0507   | 0.0365 |           |       |           |       |
| Dpkge siz13|          |       |           |       |           |       |
| Dpkge siz14| -0.2098***| 0.0194 |           |       |           |       |
| Dpkge siz15|          |       |           |       |           |       |
| Dpkge siz16|          |       |           |       |           |       |
| Dpkge siz17|          |       |           |       |           |       |
| Dpkge siz18|          |       |           |       |           |       |
| Dpkge siz19|          |       |           |       |           |       |
| Dpkge siz20|          |       |           |       |           |       |
| Dcoupon   | -0.0226***| 0.0045 | -0.0431**   | 0.0147 | -0.0916***| 0.0196 |
| Dmulti2   | -0.0410***| 0.0069 | 0.0350      | 0.0799 | 0.0479    | 0.0264 |
| Dmulti3   | -0.0678***| 0.0058 |           |       |           |       |
| Dmulti4   | 0.3328*** | 0.0582 | -0.1444***  | 0.0433 |           |       |
| Dmulti5   |           |       |           |       |           |       |
| Dmulti6   | 0.0787**  | 0.0269 | -0.1336***  | 0.0389 |           |       |
| Dmulti7   | -0.0021   | 0.0545 |           |       |           |       |
| Dmulti8   | -0.1252*  | 0.0596 |           |       |           |       |
| Ddeals    | -0.0047   | 0.0028 | -0.0310    | 0.0096 | -0.0127   | 0.0094 |
| Dyear2014 | -0.0033   | 0.0043 | -0.0203    | 0.0134 | -0.0187   | 0.0144 |
| Dyear2013 | -0.0138** | 0.0043 | -0.0083    | 0.0150 | -0.0286   | 0.0149 |
| Dyear2012 | -0.0192***| 0.0042 | -0.0029    | 0.0146 | -0.0022   | 0.0142 |
| Dyear2011 | -0.0214***| 0.0041 | -0.0225    | 0.0149 | -0.0100   | 0.0147 |
| Dyear2010 | -0.0157***| 0.0041 | 0.0132**   | 0.0152 | 0.0033    | 0.0158 |
| Dyear2009 | 0.0354*** | 0.0097 | 0.0411**   | 0.0158 | -0.0395*  | 0.0154 |
|            | 2% milk |              | 1% milk |              | Whole milk |              | Fat-free milk |              |
|------------|---------|--------------|---------|--------------|------------|--------------|--------------|--------------|
|            | Estimate | SE           | Estimate | SE           | Estimate   | SE           | Estimate     | SE           |
| 0.5493***  | 0.0151  | -0.1870***   | 0.0161  | -0.3287***   | 0.0223     | -0.1298***   | 0.0102       |
| -0.0008*** | 0.0001  | 0.0016***    | 0.0001  | 0.0052***    | 0.0001     | 0.0004***    | 0.0001       |
| 0.0050***  | 0.0008  | -0.0124***   | 0.0009  | -0.1133***   | 0.0019     | -0.0016*     | 0.0007       |
| -0.0137*** | 0.0088  | 0.0188***    | 0.0005  | 0.0042***    | 0.0002     | -0.0005***   | 0.0001       |
| -0.0153*** | 0.0005  | -0.0071***   | 0.0003  | 0.0016***    | 0.0005     | 0.0012***    | 0.0001       |
| 0.0024***  | 0.0001  | 0.0028***    | 0.0004  | 0.0535***    | 0.0007     | -0.0013      | 0.0010       |
| 0.0383***  | 0.0011  | 0.0259***    | 0.0017  | 0.0140***    | 0.0006     | 0.0051***    | 0.0003       |
| -0.0142**  | 0.0008  | 0.4607***    | 0.0130  | -0.0163***   | 0.0008     | -0.0097***   | 0.0008       |
| 4.7131***  | 0.1284  | 0.5646***    | 0.0139  | 0.2580***    | 0.0019     | 0.7955***    | 0.0058       |
| 0.3929***  | 0.0045  | 0.6653***    | 0.0295  | 0.5022***    | 0.0004     | 0.2563***    | 0.0118       |
| 0.6927***  | 0.0127  | 0.5145***    | 0.0111  | 0.1775***    | 0.0100     | 0.2685***    | 0.0269       |
| 0.2448***  | 0.0007  | 0.5282***    | 0.0186  | 0.2333***    | 0.0105     | 0.2806***    | 0.0554       |
| 0.3801***  | 0.0101  | 0.3219***    | 0.0069  | 0.4032***    | 0.0049     | 0.5783***    | 0.0054       |
| 0.6159***  | 0.0287  | 0.1791***    | 0.0013  | 0.3508***    | 0.0056     | 0.5051***    | 0.0164       |
| 0.4985***  | 0.0046  | 0.0499***    | 0.0081  | 0.2344***    | 0.0019     | 0.3474***    | 0.0031       |
| 0.4566***  | 0.0078  | 0.0852***    | 0.0007  | 0.2397***    | 0.0112     | 0.1781***    | 0.0012       |
| 0.3681***  | 0.0018  | 0.0754***    | 0.0360  | 0.1671***    | 0.0329     | 0.0819**     | 0.0269       |
| 0.1835***  | 0.0170  | 0.2332*      | 0.0052  | 0.1141***    | 0.0014     | 0.3477***    | 0.0227       |
| 0.7159***  | 0.0389  | 0.0577***    | 0.0064  | 0.2144***    | 0.0155     | 0.3097***    | 0.0296       |
| 0.1770***  | 0.0012  | -0.1327***   | 0.0134  | 0.1412***    | 0.0343     | 0.0619***    | 0.0057       |
| 0.1197***  | 0.0149  | 0.1031***    | 0.0124  | -0.1827***   | 0.0459     | 0.0953***    | 0.0008       |
| 0.2673***  | 0.0321  | -0.1870***   | 0.0161  | 0.0480***    | 0.0010     | 0.0953***    | 0.0008       |
|            | 0.0619***| 0.0057       |         |              |            | 0.0688*      | 0.0278       |
| 0.2638***  | 0.0344  |              |         |              |            | 0.1763***    | 0.0047       |
| 0.0949***  | 0.0009  |              |         |              |            | 0.0508***    | 0.0099       |
| 0.0766*    | 0.0321  |              |         |              |            |              |              |
| 0.1492***  | 0.0057  |              |         |              |            |              |              |
| 0.0373***  | 0.0106  |              |         |              |            |              |              |
| -0.0208*** | 0.0025  | -0.0146***   | 0.0019  | -0.0204***   | 0.0027     | -0.0148***   | 0.0023       |
| -0.0543*** | 0.0040  | -0.0395***   | 0.0040  | -0.0487***   | 0.0061     | -0.0581***   | 0.0041       |
| 0.0503***  | 0.0100  | 0.1009***    | 0.0046  | 0.0756***    | 0.0141     |              |              |
| -0.0245    | 0.0126  | 0.3165***    | 0.0304  | -0.5040***   | 0.0686     |              |              |
| -0.2638*   | 0.1285  | 0.2274***    | 0.0207  | -0.1304***   | 0.0451     |              |              |
| -0.0093*** | 0.0013  | -0.0141***   | 0.0010  | -0.0092***   | 0.0013     | -0.0121***   | 0.0012       |
| 0.0113***  | 0.0020  | 0.0154***    | 0.0020  | 0.0091***    | 0.0019     | 0.0185***    | 0.0018       |
| -0.0031    | 0.0020  | -0.0060***   | 0.0020  | -0.0070***   | 0.0019     | 0.0106***    | 0.0017       |
| -0.0145*** | 0.0019  | -0.0107***   | 0.0020  | -0.0101***   | 0.0019     | -0.0032      | 0.0018       |
| -0.0134*** | 0.0019  | -0.0051***   | 0.0017  | -0.0142***   | 0.0017     | -0.0057***   | 0.0017       |
| -0.0411*** | 0.0019  | -0.0323***   | 0.0019  | -0.0408***   | 0.0019     | -0.0284***   | 0.0018       |
| -0.0542*** | 0.0019  | -0.0539***   | 0.0078  | -0.0578***   | 0.0200     | -0.0423***   | 0.0026       |

(Continues)
their products’ label. After obtaining the first-hand data of detailed qualitative characteristics, we merge this with Nielsen based on the products’ barcode, or UPC to construct the complete dataset for estimating hedonic pricing models.

Besides the price variable and nutritional variables, we attempt to find out other factors that might exert impact on the prices of those products. The first group of such variables includes package size and multi-pack. We also consider that the available deal/coupon when consumers purchase the products should affect prices. Therefore, we select two variables which are deal_flag_uc and coupon_value. “deal_flag_uc” is a dummy variable which indicates if the panelist received a deal. Also if the panelist used a coupon, they enter the amount discounted. If coupon_value and deal_flag_uc are both zero, there is no deal on the purchase. In addition, in order to take into consideration of the time effects on the prices, we add yearly dummies. Since the format of original data file in which households’ purchase information is recorded by their trip date, it is very common that the purchase may happen many times each month or no purchase activities within a month. That’s one reason why we aggregate the data into UPC level. Another imperative variable considered to affect price is brand. Therefore, a brand dummy is added which equals 1 if it is a store brand and equals zero if it is a national brand.

5  |  EMPIRICAL RESULTS AND DISCUSSION

Applying the model developed in Section 3 and using the data file we constructed in Section 4, we acquired estimates for all the variables considered for each product. The results of linear and semi-log hedonic regressions are shown in Tables 3 and 4 respectively. In this section, we discuss the empirical results derived from hedonic pricing models in detail and compare and contrast our estimations with those observed in the extant literature.

**TABLE 4** Estimates of log hedonic quality attributes

| Variables | Soy milk | Almond milk | Rice milk |
|-----------|----------|-------------|-----------|
|           | Estimate | SE          | Estimate  | SE          | Estimate  | SE          |
| Intercept | -1.3413*** | 0.0165      | -0.9270*** | 0.0635      | -0.6950*** | 0.1463      |
| X_Kcal    | 0.0001   | 0.0001      | 0.0002    | 0.0003      | -0.0018*  | 0.0007      |
| X_fat     | 0.0033   | 0.0021      | 0.0649*** | 0.0108      | -0.1857*** | 0.0217      |
| X_VA      | 0.0056*** | 0.0004      | 0.0060*** | 0.0010      | 0.0248***  | 0.0040      |
| X_cal     | 0.0025*** | 0.0003      | 0.0056*** | 0.0011      | 0.0098**  | 0.0033      |
| X_VD      | -0.0011*** | 0.0003     | -0.0136*** | 0.0013     | 0.0141***  | 0.0013      |
| X_fiber   | -0.0018*** | 0.0029     | -0.0089   | 0.0052      | 0.1401***  | 0.0133      |
| X_protein | 0.0357*** | 0.0018      | 0.1514*** | 0.0109      | 0.0136     | 0.0099      |
| D_brands  | -0.0623*** | 0.0048     | -0.3464*** | 0.0436      | -0.3464*** | 0.0436      |
| D_pkge_size1 | 0.8931*** | 0.0349     | 0.7588*** | 0.0430      | 0.7094***  | 0.1610      |
| D_pkge_size2 | 0.1949**  | 0.0643     | 0.6859*** | 0.1154      | 0.6611***  | 0.0657      |
| D_pkge_size3 | 1.1565*** | 0.0194     | 0.5649*** | 0.0618      | 0.5649***  | 0.0618      |

Note: p-value = .05 for rejecting the null hypothesis; ***, ** and * indicate significance at 0.001, 0.01, 0.05 levels, respectively.
### Table 4

Estimates of log hedonic quality attributes

| Variable          | Estimate | SE   | Variable          | Estimate | SE   | Variable          | Estimate | SE   | Variable          | Estimate | SE   |
|-------------------|----------|------|-------------------|----------|------|-------------------|----------|------|-------------------|----------|------|
| Intercept         | -1.3413**| 0.0019 | Intercept         | -1.0243***| 0.0018 | Intercept         | -0.0081***| 0.0017 |
| Fiber             | 0.0357***| 0.0018 | Fiber             | -0.0498***| 0.0017 | Fiber             | -0.0703***| 0.0020 |
| Protein           | 0.1514***| 0.0109 | Protein           | -0.0660***| 0.0020 | Protein           | -0.0609***| 0.0018 |
| Kcal              | -0.0011***| 0.0001 | Kcal              | -0.0709***| 0.0020 | Kcal              | -0.0643***| 0.0017 |
| Soy milk          |          |      | Soy milk          |          |      | Soy milk          |          |      |
| Almond milk       |          |      | Almond milk       |          |      | Almond milk       |          |      |
| Rice milk         |          |      | Rice milk         |          |      | Rice milk         |          |      |
| 2% milk           | 0.8931***| 0.0349 | 2% milk           | 0.7588***| 0.0430 | 2% milk           | 0.7094***| 0.1610 |
| 1% milk           | 1.1565***| 0.0194 | 1% milk           | 0.5649***| 0.0618 | 1% milk           |          |      |
| Whole milk        |          |      | Whole milk        |          |      | Whole milk        |          |      |
| Fat-free milk     |          |      | Fat-free milk     |          |      | Fat-free milk     |          |      |
| brands            |          |      | brands            |          |      | brands            |          |      |
| year2004          | 0.0475   | 0.0291 | year2004          | 0.0545   | 0.0291 | year2004          | 0.0545   | 0.0291 |
| year2005          | -0.0531***| 0.0198 | year2005          | -0.0531***| 0.0198 | year2005          | -0.0531***| 0.0198 |
| year2006          |          |      | year2006          |          |      | year2006          |          |      |
| year2007          | -0.0323***| 0.0044 | year2007          | -0.0323***| 0.0044 | year2007          | -0.0323***| 0.0044 |
| year2008          | 0.2175***| 0.0165 | year2008          | 0.0532   | 0.0164 | year2008          | 0.0532   | 0.0164 |
| Fat-free milk     |          |      | Fat-free milk     |          |      | Fat-free milk     |          |      |
| 2% milk           | 0.8763***| 0.0189 | 2% milk           | 0.0756***| 0.0233 | 2% milk           | 0.0756***| 0.0233 |
| 1% milk           | 1.3765***| 0.0490 | 1% milk           | 0.6397***| 0.1182 | 1% milk           | 0.6397***| 0.1182 |
| Whole milk        |          |      | Whole milk        |          |      | Whole milk        |          |      |
| Fat-free milk     |          |      | Fat-free milk     |          |      | Fat-free milk     |          |      |

The hedonic results generally conform to our expectations. It is rarely witnessed in the existing literature that applies hedonic pricing method incorporate as many variables as in our research, but both model forms of hedonic regressions we developed still fit well for dairy alternatives and conventional milk data. In terms of model performance, it can be observed from Tables 3 and 4 that F test for each hedonic pricing model has p < .001 indicating that the model fits the data well; the adjusted R-squared is greater than 0.5 in terms of all semi-log hedonic pricing models also prove that the models have good fitness; RMSE for each model is small enough (around 0.1) to claim that the both model forms fit well for the data.

Regardless of the functional forms, almost all the nutritional variables are significant with only few exceptions. Compared with soy milk which has all the nutritional variables significant in linear functional form, fat content is not significant for almond milk and protein is not significant for rice milk. There are several possible explanations. First, there might have some confounding variable we do not consider in the models and thus affecting the significance of some coefficients; second, rice milk is launched much later than soy milk and almond milk in the market, thus by the year 2015 there are not enough purchase data for rice milk in Nielsen Homescan database. Also rice milk product categories and brands are significantly less than soy milk and almond milk. The lack of product and purchase information and thus restricted samples might cause insignificant effect of protein on prices.

As indicated by the intrinsic meaning of hedonic pricing model, the estimated coefficient for each characteristic variable shows consumers’ willingness to pay for the specified characteristic keeping other variables constant, thus being a reflection of consumers preference toward it. As intuition suggests, if consumers’ acceptance of a product is discouraged due to the presence of a given attribute, their willingness to pay for that attribute should be negative; as a result, the implicit price attached to such attribute may be negligible, or even negative. The estimated coefficient $\beta_j$ in linear hedonic
| Variables | Estimate | SE | Estimate | SE | Estimate | SE |
|-----------|----------|----|----------|----|----------|----|
| $D_{\text{pkg size}4}$ | 0.4572* | 0.1926 | 0.0890 | 0.0781 | 0.7195*** | 0.0563 |
| $D_{\text{pkg size}5}$ | 1.1361*** | 0.0188 | 0.8575*** | 0.0753 | 0.1699*** | 0.0452 |
| $D_{\text{pkg size}6}$ | 1.1577*** | 0.0345 | 0.4334*** | 0.0695 | 0.4754*** | 0.0601 |
| $D_{\text{pkg size}7}$ | 0.8083*** | 0.0350 | 0.5269*** | 0.0115 | 0.1473*** | 0.0485 |
| $D_{\text{pkg size}8}$ | 1.3573*** | 0.0178 | 0.1104*** | 0.0024 | 0.5987*** | 0.0037 |
| $D_{\text{pkg size}9}$ | 1.3775*** | 0.0515 | -0.1833*** | 0.0214 | 1.0189*** | 0.0079 |
| $D_{\text{pkg size}10}$ | 0.3612*** | 0.0071 | 0.5269*** | 0.0115 | 0.1473*** | 0.0485 |
| $D_{\text{pkg size}11}$ | -0.0823* | 0.0368 | 0.0115 | 0.0034 | 0.5987*** | 0.0037 |
| $D_{\text{pkg size}12}$ | -0.0446 | 0.0729 | 0.0115 | 0.0034 | 0.5987*** | 0.0037 |
| $D_{\text{pkg size}13}$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| $D_{\text{pkg size}14}$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| $D_{\text{pkg size}15}$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| $D_{\text{pkg size}16}$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| $D_{\text{pkg size}17}$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| $D_{\text{pkg size}18}$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| $D_{\text{pkg size}19}$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| $D_{\text{pkg size}20}$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| $D_{\text{coupon}}$ | -0.0423*** | 0.0091 | -0.0316 | 0.0217 | -0.2683*** | 0.0391 |
| $D_{\text{multi2}}$ | -0.0603*** | 0.0137 | 0.1594 | 0.1181 | 0.0651 | 0.0526 |
| $D_{\text{multi3}}$ | -0.1840*** | 0.0115 | 0.0214 | 0.0217 | -0.2683*** | 0.0391 |
| $D_{\text{multi4}}$ | 0.2898* | 0.1164 | 0.0121 | 0.0021 | 0.0105 | 0.0021 |
| $D_{\text{multi5}}$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| $D_{\text{multi6}}$ | -0.0393 | 0.0538 | -0.2495*** | 0.0575 | 0.0000 | 0.0000 |
| $D_{\text{multi7}}$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| $D_{\text{multi8}}$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| $D_{\text{deals}}$ | -0.0134* | 0.0057 | -0.0255 | 0.0142 | -0.0347 | 0.0187 |
| $D_{\text{year}2004}$ | -0.0076 | 0.0086 | -0.0040 | 0.0198 | -0.0423 | 0.0001 |
| $D_{\text{year}2005}$ | 0.0539** | 0.0194 | 0.0766** | 0.0234 | -0.0831** | 0.0001 |
| $D_{\text{year}2006}$ | 0.3445*** | 0.0331 | 0.1107*** | 0.0242 | -0.0942** | 0.0001 |
| $D_{\text{year}2007}$ | -0.0766*** | 0.0084 | 0.0724** | 0.0258 | -0.1244*** | 0.0001 |
| $D_{\text{year}2008}$ | -0.1117*** | 0.0089 | 0.0443 | 0.0279 | -0.1015** | 0.0001 |
| $D_{\text{year}2009}$ | -0.0816* | 0.0396 | 0.0915** | 0.0344 | -0.1347*** | 0.0001 |
| $D_{\text{year}2010}$ | -0.0107 | 0.0582 | -0.0128 | 0.0326 | -0.1671*** | 0.0001 |

**Note:** *p*-value = .05 for rejecting the null hypothesis; ***, ** and * indicate significance at 0.001, 0.01, 0.05 levels, respectively.
|                | 2% milk |                | 1% milk |                | Whole milk |                | Fat-free milk |                |
|----------------|---------|----------------|---------|----------------|------------|----------------|---------------|----------------|
|                | Estimate| SE             |         | Estimate       | SE         |                | Estimate       | SE             |
| 2% milk        | 0.7680  | 0.0196         | 1.1903  | 0.0657         | 0.5959     | 0.0210         | 1.0430         | 0.1401         |
| 1% milk        | 1.0305  | 0.0206         | 0.9907  | 0.0242         | 0.8492     | 0.0098         | 1.3589         | 0.0136         |
| Whole milk     | 1.4012  | 0.0584         | 0.6274  | 0.0044         | 0.7191     | 0.0112         | 1.2257         | 0.0414         |
| Fat-free milk  | 1.2354  | 0.0095         | 0.2850  | 0.0287         | 0.5987     | 0.0037         | 1.0189         | 0.0079         |
|                | 1.1369  | 0.0158         | 0.3515  | 0.0025         | 0.6012     | 0.0224         | 0.6308         | 0.0031         |
|                | 1.0067  | 0.0037         | 0.3448  | 0.1272         | 0.5192     | 0.0656         | 0.2804         | 0.0680         |
|                | 0.8408  | 0.0346         | 0.8206  | 0.0182         | 0.3694     | 0.0027         | 0.9848         | 0.0573         |
|                | 1.4743  | 0.0789         | 0.2792  | 0.0225         | 0.4528     | 0.0308         | 0.9327         | 0.0749         |
|                | 0.6081  | 0.0024         | -1.1616 | 0.0473         | 0.4081     | 0.0683         | -0.3710        | 0.1160         |
|                | 0.2989  | 0.0302         | 0.3606  | 0.0247         | -0.0816    | 0.0255         | 0.1107         | 0.0242         |
|                | 0.8566  | 0.0653         | 0.2053  | 0.0020         | 0.2470     | 0.0113         | 0.3430         | 0.0702         |
|                | 0.1550  | 0.0204         | 0.4186  | 0.1072         | 0.1976     | 0.0281         | 0.5997         | 0.0120         |
|                | 0.8351  | 0.0698         | -2.7819 | 0.0568         |            |                | 0.2843         | 0.0250         |
|                | 0.3689  | 0.0017         |            |                |            |                | 0.3371         | 0.0653         |
|                | 0.3371  | 0.0017         |            |                |            |                | 0.5269         | 0.0115         |
|                | 0.2012  | 0.0216         |            |                |            |                |                |                |
|                | -0.0964 | 0.0052         | -0.2333  | 0.0142         | -0.1081    | 0.0055         | -0.1043        | 0.0058         |
|                | -0.3122 | 0.0081         | 0.3389   | 0.0161         | -0.2169    | 0.0122         | -0.2792        | 0.0103         |
|                | 0.1550  | 0.0204         | 0.4186   | 0.1072         | 0.1976     | 0.0281         |                |                |
|                | 0.0700  | 0.0255         | 0.4233   | 0.0732         | -0.7621    | 0.1369         |                |                |
|                | -0.4437 | 0.2611         | -0.0833  | 0.0034         | -0.1700    | 0.0900         |                |                |
|                | -0.0566 | 0.0026         | 0.0894   | 0.0072         | -0.0577    | 0.0026         | -0.0687        | 0.0030         |
|                | 0.0098  | 0.0040         | 0.0027   | 0.0072         | 0.0509     | 0.0038         | 0.0807         | 0.0045         |
|                | -0.0273 | 0.0039         | -0.0146  | 0.0071         | -0.0089    | 0.0038         | 0.0463         | 0.0044         |
|                | -0.0319 | 0.0039         | -0.1124  | 0.0068         | -0.0201    | 0.0034         | -0.0142        | 0.0043         |
|                | -0.1253 | 0.0039         | -0.2117  | 0.0274         | -0.1134    | 0.0038         | -0.1055        | 0.0046         |
|                | -0.1783 | 0.0039         | 0.0335   | 0.0060         | -0.1768    | 0.0039         | -0.1523        | 0.0066         |
|                | -0.0367 | 0.0038         | -0.0412  | 0.0066         | -0.0273    | 0.0036         | -0.0020        | 0.0042         |
|                | -0.1104 | 0.0038         | -0.1872  | 0.0058         | -0.1053    | 0.0068         | -0.0744        | 0.0050         |
|                | -0.2384 | 0.0040         | -0.1680  | 0.0061         | -0.2053    | 0.0039         | -0.2251        | 0.0044         |
|                | -0.2233 | 0.0040         | -0.1787  | 0.0061         | -0.1815    | 0.0039         | -0.2100        | 0.0045         |
|                | -0.2427 | 0.0040         | 0.0894   | 0.0072         | -0.2000    | 0.0039         | -0.2316        | 0.0044         |
|                | 117,536 | 49,422         | 100,390  | 88,259         | 749,46     | 112,48         | 4,543.94       | 2,773.87       |
|                | <0.0001 | <0.0001        | <0.0001  | <0.0001        | 0.1923     | 0.2002         | 0.2609         | 0.2801         |
|                | .7400   | .6849          | .6243    | .5376          |
model indicates the contribution of unit increase in the nutrient to the change of unit price on average while the estimated coefficient $D_k$ captures the change of log unit price caused by unit increase in each attribute.

In terms of the effect of fat content, Gulseven and Wohlgenant (2015) found that lipid fat contributes 0.861 to prices of milk products considered in their study. Comparatively, in linear hedonic pricing models, fat content contributes negatively to unit price (monthly average price per 8 oz.) in our study with estimated coefficient $-0.1080$ for rice milk and $-0.0025$ for soy milk, reflecting that if fat content is raised by one unit, consumers' willingness to pay for unit price decrease of rice milk and soy milk are on an average 10.8 percent and 0.25 percent respectively. However, fat contributes positively to prices of almond milk in semi-log hedonic pricing model. The contrasting result is possibly caused by model specifications and product categories taken into account. The research results of Gulseven and Wohlgenant (2015) are based on a composite viewpoint by which they aggregate several milk products and soy milk in to one product type, while our work examines different product separately. In addition, one likely reason for consumers' willingness to pay for fat content is that fat contributes to the texture, flavor, and aroma of a wide variety of foods (Drewnowski & Almiron-Roig, 2010), the consumers who have a strong preference for flavor and taste of food might be willing to pay more for fat.

Instead of considering calorie content, Gulseven and Wohlgenant (2015) include carbohydrate content in their model and the estimation results show that carb content exerts positive effect on prices. Similarly, calorie has significant positive effect (0.03%) on unit prices of soy milk but has negative effect on unit prices of rice milk ($-0.01\%$) in linear hedonic model. It is commonly known that food provides energy to the body in the form of calories and the energy in dairy alternative beverages comes from protein, carbohydrate and fat content. As suggested by Drewnowski (2015), Americans were advised to get the most nutrition out of their calories and to make smart, nutrient-dense choices from every food group. Taubes (2008) argued that there are good and bad calories; the key to good health is the kind of calories we take in, not the number. As shown in Table 3, vitamin A contributes positively to prices of soy milk and almond milk, with coefficient being 0.0029 and 0.073 respectively, but it contributes negatively to rice milk. It is interesting to find that vitamin D, however, has the mirror effect on these three beverage types. These results can be possibly explained by consumers different attitudes toward these two vitamins. By analogy with Bonanno (2016)'s study which shows that fiber, a health-related attribute in food products, is perceive unfavorably by yogurt consumers if the yogurt is enriched and fortified with fiber, even though vitamin A and vitamin D are considered as a beneficial nutrient, consumers might have negative attitude toward them when they are artificially enriched in dairy alternative beverages. Also, Willett (2013) indicates that when it comes to vitamins and minerals, the notion of "the more, the better" is incorrect since nutrients can be harmful when taken in amounts above what is considered beneficial and multivitamin is one of them. The positive and significant effect of protein and calcium on prices manifest consumers' favorable acceptance of these nutritional attributes. Comparing different weights of nutritional variable from Tables 3 and 4, we can witness that among all the nutritional variables considered, protein has highest weight meaning it is regarded by consumers as the most preferred qualitative characteristics for soy milk and almond milk and calorie is least valued by consumers.

The dummy variable "Brands" has negative sign and is significant as expected, indicating that prices of private label products are lower than that of national brand products. Packaging size and shape are also significant factors in designing the package and a decision-making instrument (Ksenia, 2013). We can witness that in our study almost all package-size dummy variables have positive and significant contribution to prices and this offers essential information for the companies about the consumer attraction and importance of designing attributes. In general, people prefer smaller sizes at least not bigger than 64 oz. per package. Coupons and deals have negative and significant effects on unit price. Similar results can be found in Gulseven and Wohlgenant (2015)'s study in which the estimated coefficient of marketing promotion dummy is $-1.583$. The effects of multi-pack dummies have little inconsistency. Regarding to soy milk, pack of 4 and 6 have positive influences meaning that these two package units are preferred than pack of 1, but for almond milk and rice milk, consumers are inclined to purchase pack of 2 rather than other multi packages. This result is in line with works of Bonanno, Bimbo, Costanigro, Lansink, and Viscecchia (2019) and Bimbo, Bonanno, and Viscecchia (2016) showing that presence of a two-compartment package (Two Compartments) show positive implicit prices of Italian yogurt. The package preference should be taken seriously by manufacturers to make optimal production policy. Yearly dummies are significant for soy milk and rice milk, with year 2004 to year 2009 showing the greatest significance, but the same significant effects are not observed on almond milk except for year 2008 and 2009.

Comparatively, in semi-log model, all package sizes dummies have positive and significant effects on unit price. The impact of multi-pack dummies is almost the same as it in the linear hedonic form too. Also, the yearly dummies do not show much significance for almond milk except for year 2008 in which a great increase about 11% on unit price is observed. In term of 2% and 1% reduced fat milk, almost all the variables are significant at 0.1% level. One interesting result is that calcium has negative effect on prices of reduced fat milk but has positive effects on prices of other milk products. But in general, consumers treat the acquisition of calcium as important component of a healthy diet.

6 | CONCLUSIONS, LIMITATIONS AND FUTURE RESEARCH

In terms of rate of growth, dairy alternative beverage market in the United States has surpassed the growth of conventional milk
market in recent years. The ongoing competition between dairy alternative beverages and conventional milk is expected to intensify over the next several years as consumers become more comfortable with milk alternative beverages and criticism of dairy foods continues to grow. This work focuses on analyzing the relationship between the qualitative characteristics embedded in the differentiated dairy alternative beverages and their market prices. We take product characteristics approach, specifically hedonic pricing model to study consumers' preference and their willingness to pay for the qualitative characteristics. By investigating the existing research about hedonic pricing model in different agricultural area and comprehensively taking into consideration of factors that might affect prices of dairy alternative beverages and conventional milk, we constructed a valid model to explain and estimate prices of these products. The price composition of these products is directly related to multiple factors which include not only the qualitative attributes, such as nutritional content, brand, package size and multi packages but also such common factors as supply and demand. This work focuses mainly on how the nutritional attributes and other qualitative characteristics affect the formation of price mechanism. The estimation results indicate that both linear and semi-log hedonic pricing models fit the data of seven products very well. Regardless of the functional forms of hedonic pricing models, almost all the nutritional variables have significant effects on prices implying that nutritional contents are seriously considered when consumers make purchasing decisions. Health-related nutritional attributes such as protein and calcium are widely recognized by consumers and certain amount of good fat and calories are also accepted. Protein is the most valued attribute by consumers. The multivitamins, Vitamin A and D, should be cautiously considered by manufactures since consumers feel more encouraged to purchase dairy alternative beverages contained with natural nutritional attributes. The estimation results also suggest that selecting appropriate qualitative attributes to tap into the demand of dairy alternative beverages can result in successfully differentiated products.

This analysis does however show limitations. Due to data limitations, we can only use pooled UPC level information to estimate the hedonic pricing models. Because milk alternative beverages are starting to gain ground in the recent years, adequate purchase observations were not available at the beginning of the time period pertaining to this study. In addition, we need variations on the nutritional attributes, but household level data cannot guarantee enough variability. Therefore, we consider pooled data which can not only capture variability of the nutritional attributes but also enable us to expand the time period to be considered. Data limitations have also constrained our selection of related dairy alternative beverages from which we can only include soy milk, almond milk and rice milk. Besides, the information about nutritional data is very scarce and limited for dairy alternative beverages in the Nielsen Homescan database and also in the USDA nutritional database. Therefore, bulk of the nutritional data was collected from product labels. The estimated results of demand could possibly be more definitive and convincing if data after the year 2010 were used and more nutritional information about dairy alternative beverages is available. Another limitation is that the analysis performed cannot provide insights on the impacts of demographic variation across markets.

Studying consumer behavior cannot leave without consumer demand analysis. Traditionally, consumer demand is analyzed using demand system such as AIDS, Rotterdam and some modifications to these two models. The basic assumption for these conventional demand models is that consumers' utility is obtained from the quantity of goods they consumed which is also the assumption of hedonic pricing model as aforementioned. However, the conventional demand system estimation is complicated in that the number of parameters we need to estimate is large. Therefore, some innovative method to estimate demand which is based on hedonic pricing model estimation and then reparameterizing the estimators is developed such as Distance Matrix method and Hedonic Metric approach. The latter is based on hedonic pricing model estimates to estimate demand of milk products. This approach overcomes the shortages of Distance Matrix method but also greatly reduced the number of parameters to be estimated. It is expected that our future work will develop this method and apply it into the analysis of demand on dairy alternative beverages to explore their expenditure, own-price and cross-price elasticities.

ACKNOWLEDGEMENT
Thanks are due to Dr. Dharmasena for assistance with the accomplishment of this paper.

CONFLICT OF INTEREST
We declare that we do not have any conflict of interest.

ETHICAL REVIEW
This study does not involve any human or animal testing.

INFORMED CONSENT
Written informed consent was obtained from all study participants.

ORCID
Tingyi Yang https://orcid.org/0000-0001-8463-5342

ENDNOTES
1 These variable names used in this study are referenced to the original variable names in Neilson HomeScan dataset.

REFERENCES
Aggarwal, A., Rehm, C. D., Monsivais, P., & Drewnowski, A. (2016). Importance of taste, nutrition, cost and convenience in relation to diet quality: Evidence of nutrition resilience among US adults using
National Health and Nutrition Examination Survey (NHANES) 2007–2010. Preventive Medicine, 90, 184–192. https://doi.org/10.1016/j.ypmed.2016.06.030

Bimbo, F., Bonanno, A., & Viscecchia, R. (2016). Do health claims add value? The role of functionality, effectiveness and brand. European Review of Agricultural Economics, 43(5), 761–780. https://doi.org/10.1093/erae/jbw002

Bonanno, A. (2016). A hedonic valuation of health and nonhealth attributes in the U.S. yogurt market. Agribusiness, 32(3), 299–313. https://doi.org/10.1002/agr.21448

Bonanno, A., Bimbo, F., Costanigro, M., Lansink, A. O., & Viscecchia, R. (2019). Credence attributes and the quest for a higher price – A hedonic stochastic frontier approach. European Review of Agricultural Economics, 46(2), 163–192. https://doi.org/10.1093/erae/jby024

Claeys, W. L., Verraes, C., Cardoen, S., De Block, J., Huyghebaert, A., Raes, K., ... Herman, L. (2014). Consumption of raw or heated milk from different species: An evaluation of the nutritional and potential health benefits. Food Control, 42, 188–201. https://doi.org/10.1016/j.foodcont.2014.01.045

Copeland, A., & Dharmasena, S. (2016). Impact of Increasing Demand for Dairy Alternative Beverages on Dairy Farmer Welfare in the United States. 2016 Annual Meeting, February 6-9, 2016, San Antonio, Texas. https://doi.org/10.22004/ag.econ.230044

Davis, C. G., Dong, D., Blaney, D. P., & Owens, A. (2010). An Analysis of U.S. Household Dairy Demand, TB-1928, United States Department of Agriculture, Economic Research Service. https://doi.org/10.22004/ag.econ.184308

Decloedt, A. I., Landschoot, A. V., Watson, H., Vanderputten, D., & Vanhacene, L. (2017). Plant-based beverages as good sources of free and glycosidic plant sterols. Nutrients, 10(1), 21. https://doi.org/10.3390/nu10010021

Dharmasena, S., & Capps, O. (2014). Unraveling demand for dairy-alternative beverages in the united states: The case of soymilk. Agricultural and Resource Economics Review, 43(1), 140–157. https://doi.org/10.1017/S106828050000695X

Drewnowski, A. (2015). The carbohydrate-fat problem: Can we construct a healthy diet based on dietary guidelines? Advances in Nutrition, 6(3), 3185–3255. https://doi.org/10.3945/an.114.006973

Drewnowski, A., & Almiron-Roig, E. (2010). Human Perceptions and Preferences for Fat-Rich Foods. Retrieved from https://www.ncbi.nlm.nih.gov/books/NBK53528/

Epplen, J. (1987). Hedonic prices and implicit markets: Estimating demand and supply functions for differentiated products. Journal of Political Economy, 95(1), 59–80. https://doi.org/10.1086/261441

Ghalli, Z. Z. (2020). Effect of utilitarian and hedonic values on consumer willingness to buy and to pay for organic olive oil in Tunisia. British Food Journal, 122(4), 1013–1026. https://doi.org/10.1108/BFJ-06-2019-0414

Gulsev, O., & Wohlgemant, M. (2015). A quality-based approach to estimating quantitative elasticities for differentiated products: An application to retail milk demand. Quality & Quantity, 49(5), 2077–2096. https://doi.org/10.1007/s11135-014-0094-8

Ksenia, P. (2013). Packaging design as a Marketing tool and Desire to purchase (Master’s Thesis). Retrieved from: https://www.theseus.fi/bitstream/handle/10024/55293/Polyakov_Ksenia.pdf?sequence=1

Laassal, M., & Kallas, Z. (2019). Consumers preferences for dairy-alternative beverage using home-scan data in Catalonia. Beverages, 5(3), 55. https://doi.org/10.3390/beverages5030055

Ladd, G. W., & Suvannunt, V. (1976). A model of consumer goods characteristics. American Journal of Agricultural Economics, 58(3), 504–510. https://doi.org/10.2307/1239267

Lancaster, K. J. (1966). A new approach to consumer theory. Journal of Political Economy, 74(2), 132–157. https://doi.org/10.1086/255651_3_34

Mäkinen, O. E., Wanhalinna, V., Zannini, E., & Arendt, E. K. (2016). Foods for special dietary needs: non-dairy plant-based milk substitutes and fermented dairy-type products. Critical Reviews in Food Science and Nutrition, 56(3), 339–349. https://doi.org/10.1080/10404982.2012.761950

Muehlhoff, E., Bennet, A., McMahon, D., & Food and Agriculture Organisation of the United Nations (FAO). (2014). Milk and dairy products in human nutrition (2013). Dairy Technology, 67, 303–304. https://doi.org/10.1111/1471-0307.12124

Nepal, M., Rai, R. K., Khadayat, M. S., & Somananthan, E. (2020). Value of cleaner neighborhoods: Application of hedonic price model in low income context. World Development, 131, 104965. https://doi.org/10.1016/j.worlddev.2020.104965

Nimon, R. W., & Beghin, J. C. (1999). Are eco-labels valuable? Evidence from the apparel industry. American Journal of Agricultural Economics, 81(4), 801–811. https://doi.org/10.2307/1244325

Rosen, S. (1974). Hedonic prices and implicit markets: Product differentiation in pure competition. Journal of Political Economy, 82(1), 34–55. https://doi.org/10.1086/260169

Sethi, S., Tyagi, S. K., & Anurag, R. K. (2016). Plant-based milk alternatives: an emerging segment of functional beverages: A review. Journal of Food Science and Technology-Mysore, 53(9), 3408–3423. https://doi.org/10.1007/S13197-016-2328-3

Singhal, S., Baker, R. D., & Baker, S. S. (2017). A comparison of the nutritional value of cow’s milk and nondairy beverages. Journal of Pediatric Gastroenterology and Nutrition, 64(5), 799–805. https://doi.org/10.1097/MPG.0000000000001380

Taubes, G. (2008). Good Calories, Bad Calories: Fats, Carbs, and the Controversial Science of Diet and Health, New York, NY: Anchor Books.

Vanga, S. K., & Raghavan, V. (2018). How well do plant based alternatives fare nutritionally compared to cow’s milk? Journal of Food Science and Technology-Mysore, 55(1), 10–20. https://doi.org/10.1007/S13197-017-2915-Y

Verduci, E., D’Eliaos, S., Cerrato, L., Comberiati, P., Calvani, M., Palazzo, S., ... Peroni, D. G. (2019). Cow’s milk substitutes for children: Nutritional aspects of milk from different mammalian species. Special Formula and Plant-Based Beverages. Nutrients, 11(8), 1739. https://doi.org/10.3390/nu11081739

Waugh, (1928). Quality as a determinant of vegetable prices. New York, NY: Columbia University Press.

Willett, W., Sesso, H., ... Rimm, E. (2013). Re: Food and Vitamins and Supplements! Oh My! Demystifying nutrition: the value of food, vitamins and supplements [Online forum comment]. Retrieved from https://hms.harvard.edu/sites/default/files/assets/Sites/Longwood_Seminars/Nutrition_3_5_13.pdf

How to cite this article: Yang T, Dharmasena S. Consumers preferences on nutritional attributes of dairy-alternative beverages: hedonic pricing models. Food Sci Nutr. 2020;8:5362–5378. https://doi.org/10.1002/fsn3.1757