Hedonic valuation of country of origin in the Chinese dairy market

RESEARCH ARTICLE

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Abstract

The implicit value to Chinese consumers of the country-of-origin (COO) characteristic of dairy products is of great importance to estimate. This study adopted the hedonic price model to evaluate the shadow price of the COO attribute of both UHT fluid milk and infant formula collected from the five leading e-commerce platforms (Alibaba's Tmall Supermarket, Jingdong, Suning Purchase, COFCO I buy nets, and Yihaodian) in China. The target countries were Germany, France, the Netherlands, and Spain from the EU, and Australia and New Zealand from Oceania. The results show that the implicit values of the COO of UHT fluid milk and infant formula are reversed. Having a COO of Spain and Germany decreased the price of UHT fluid milk compared with China, while Germany, New Zealand, France, the Netherlands, and Spain all earned a price premium on infant formula. The B2C platforms Yihaodian, Jingdong, Alibaba's Tmall Supermarket and Suning Purchase all earned a price premium above COFCO I buy nets. These findings have important implications for dairy industry of EU countries, Australia, New Zealand, and China in terms of the promotion of domestic dairy products. Moreover, this study contributes to the existing body of literature by innovating in employing sales data from e-commerce scanners to study the implicit value of food attributes.

Keywords: country-of-origin, B2C platform, implicit value, hedonic price analysis, dairy product

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1. Introduction

Urban China has witnessed a rapid growth of dairy consumption from the 1990s to 2008 as a result of income growth, expansion of modern food retailers or marketing channels, the trend of higher education levels, and changes in urban lifestyles (Bai *et al.*, 2008; Cheng *et al.*, 2014; Fuller *et al.*, 2006; Wu *et al.*, 2014). According to the China Dairy Yearbook (1996–2018), the average annual dairy consumption of urban residents was 7.33 kg in 1995, which increased to 24.87 kg in 2007. However, this growth trend for the Chinese domestic dairy market was negatively impacted by the melamine scandal in 2008 (Dong and Li, 2016). Thus, consumption of dairy products declined to 16.5 kg in 2017 – much lower than the consumption in 2007.

Although the average annual consumption was decreasing, the import of both milk powder and fluid milk in China accelerated rapidly during 2008 to 2017. The average annual growth rates were 24.4 and 63.9%, respectively (Figure 1). This is in line with the prediction from Fuller *et al.* (2006) that imported products would likely play an increasing role in China's dairy market. Two major factors led to the sharp increase in dairy imports in China. Firstly, the loss of confidence by Chinese consumers in domestic dairy products due to the melamine scandal in 2008, this incident has made Chinese consumers overwhelmingly concerned about China's food safety situation (Bai *et al.*, 2013), and the safety of dairy products has become one of the top food safety concerns in China (Jia *et al.*, 2012, 2014; Qiao *et al.*, 2010; Tao *et al.*, 2016; Xiu and Klein, 2010; Yu, 2012). Consumers tend to take measures to reduce food risk (Baron *et al.*, 2000), thus imported products are a desirable substitute for domestic products. Secondly, the online market is growing rapidly in China and it is expected to be the biggest online market in 2019 (Jiang *et al.*, 2019), therefore e-commerce is becoming increasingly important for Chinese consumers, which is making it easier for Chinese consumers to access imported dairy products.

Country of origin labelling (COOL) serves as an extrinsic cue to indicate quality and safety, and it influences consumers' preferences and food choices (Agrawal and Kamakura, 1999; Bonroy and Constantatos, 2015; Deselnicu *et al.*, 2013; Hussein and Fraser, 2018). Herrmann and Teuber (2012) claimed that the use of COOL has increased due to the growing concern and awareness about food quality and safety, since many consumers place extra value on the traceability of the food they eat. Wang *et al.* (2019) found that COO is the most important attribute of milk power for Chinese consumers. China imports the vast majority of its

Figure 1. The import of fluid milk and milk powder into China (unit: 10⁴ tons). Data from 1995 to 2010 is adapted from the China Dairy Yearbook (CMYEB, 2012), and the data from 2011 to 2017 comes from the China Dairy Trade Monthly (DAC, 2018).

dairy products from the European Union, Australia, and New Zealand. The EU cancelled its dairy production quota in 2015 and the Chinese government signed a free trade agreement with New Zealand and Australia, as the international dairy market is increasingly competitive. Thus, it is imperative to clarify the shadow price or implicit price of the different COOL of the major trading countries, which may have marketing implications for the Chinese dairy sector.

Several studies have investigated the impact of COOL of food products on consumers. According to Newman *et al.* (2014), COO information was found to often have strong effects on consumer attitudes, evaluations, perceptions, preferences, willingness-to-pay (WTP), purchase intentions, and purchase behavior. Prior studies have claimed that in developed countries consumer attitudes seem more positive to domestic food than imported, and domestic food is perceived to be of higher quality and safer, thus it is preferred over imported options. The relationship between quality and COOL is strong, particularly for fresh and perishable products (Tsiros and Heilman, 2005). However, the preference is the opposite in emerging or less-developed countries (Ortega *et al.*, 2016; Zhang *et al.*, 2018).

In terms of the WTP for food COOL information, US consumers are willing to pay more for domestic food such as steak and aquatic products (Lim *et al.*, 2013; Ortega *et al.*, 2014; Umberger *et al.*, 2002). Loureiro and Umberger (2003) claimed that US households were willing to offer about \$184 more for COO information annually; they would pay a \$0.31/lb price premium for domestic organic broccoli over Canadian-grown organic broccoli, and this premium would be more than \$1 when compared with organic broccoli from China and Mexico (Xie *et al.*, 2016). They also reported being willing to pay a \$6.94/lb and \$6.53/lb price premium for domestic shrimp, with enhanced perceived food safety, than for the same shrimp from China and Thailand, respectively (Ortega *et al.*, 2014). Similarly, Norwegian consumers would offer an NOK 20 per kilogram price premium for domestic beef in comparison to US beef (Ortega *et al.*, 2014), and consumers from France, Denmark, Sweden, and the UK would pay approximately 5% more for domestic pork (Dransfield *et al.*, 2005). Consumer ethnocentrism, safety concerns, taste and flavor, among other considerations, are the main factors influencing the higher WTP for domestic foods in developed countries (Lewis and Grebitus, 2016; Peterson and Yoshida, 2004; Umberger *et al.*, 2002). These factors are from the perspective of consumers' subjective attitudes or perceptions.

The previous studies based on Chinese dairy consumption have made a notable contribution to the literature around Chinese consumer preferences and valuation of food safety attributes (Bai *et al.*, 2007, 2013; Cheng *et al.*, 2014; Gao *et al.*, 2016; Luo, 2011; Ortega *et al.*, 2012; Quan *et al.*, 2018; Wang *et al.*, 2019; Zhang *et al.*, 2012, 2018). These studies found that Chinese consumers are willing to pay for sustainable milk (Gao *et al.*, 2016) and green certified milk (Cheng *et al.*, 2014). They also are willing to pay a price premium for milk with government certification over products with a brand or private certification, but they have a negative WTP for UHT fluid milk with a shelflife longer than three months (Ortega *et al.*, 2012). Chinese consumers also had a strong desire and higher price premium for traceable milk (Bai *et al.*, 2013; Zhang *et al.*, 2012), and this was related to the certificate issuers (Bai *et al.*, 2013). Quan *et al.* (2018) found that Chinese consumers have an 11.6 to 47.0% higher WTP for imported baby milk formula, and they would like to buy branded fresh milk or milk with quality certifications (Ding and Michele, 2019). In terms of research methods, these researchers mainly adopted the stated preference methods such as CVM (Cheng *et al.*, 2014; Gao *et al.*, 2016; Wang *et al.*, 2008; Zhang *et al.*, 2012), choice experiments (Ortega *et al.*, 2012; Quan *et al.*, 2018) or choice-based conjoint (CBC) experiments (Bai *et al.*, 2007, 2013), and auction experiments (Zhang *et al.*, 2018), and the study areas were often localized or confined to urban areas. Little attention has been given to estimating the economic value that consumers place on dairy product safety attributes by employing nationwide sales data.

The primary objective of this study is to estimate the implicit value Chinese consumers place on COOL, and the effect of other attributes of UHT fluid milk and infant formula on market price from different countries and different e-commerce platforms. To accomplish this, the hedonic model of prices as a function of product attributes is adopted. This study is based on the sale prices and attributes of both UHT fluid milk and infant

formula collected from the five leading e-commerce platforms in China: Alibaba's Tmall Supermarket, Jingdong, Suning Purchase, COFCO I buy nets, and Yihaodian. This study contributes to the existing body of literature as it, contrary to most studies, uses real sales data in the form of nationwide e-commerce scanner data, and the revealed preference methods with real purchase data more truthfully reflect consumer preference and choice in the real market than do stated preference methods (Gao *et al.*, 2016). Furthermore, it includes two categories of dairy products, UHT fluid milk and infant formula, thereby contributing a better understanding of consumer behavior in dairy product purchasing decisions in a retail environment characterized by a vast number of alternative options from different countries.

2. Model and data

2.1 Model

Lancaster proposed a theory that a product is regarded as a combination of multiple characteristics. Products can be distinguished simply and uniquely by their characteristics, and that utility is derived from the properties or characteristics of goods (Lancaster, 1966). This theory is the basic conceptual framework of hedonic price analysis (Huang and Lin, 2007). Hedonic price analysis is usually adopted to estimate the implicit values of food and beverage attributes (Hussein and Fraser, 2018; Ladd and Martin, 1976; Ladd and Suvannunt, 1976), based on the premise that the bundled product attributes are not marketed individually (Costanigro *et al.*, 2010). Consumers and producers, in a market with perfect information and product differentiation, recognize product attributes in approximately the same ways (Huang and Lin, 2007), and equilibrium prices will depend on differences in product attributes, but the individual actors cannot affect the prices (Costanigro *et al.*, 2010).

From the perspective of the consumer, the utility of a product with the attributes $z = (z_1, \dots, z_k)$ can be functioned as:

$$U = U(x, z_1, \dots, z_n; \alpha) \quad (1)$$

where x is a composite good with the normalized unit price and α denotes preference.

The budget constraint is:

$$y = x + P(z) \quad (2)$$

where y is income, and the hedonic price function $P(z)$ describes the competitive equilibrium price relationship reached simultaneously by both the supply and demand of a collection of attributes.

$$P(z) = P(z_1, \dots, z_n) \quad (3)$$

Mathematically, maximization of the utility function is subject to the budget constraint, and must satisfy the first order conditions:

$$\frac{(\delta U / \delta z_k)}{(\delta U / \delta x)} = \frac{\delta P(z)}{\delta z_k} = P_{z_k}, i = 1, \dots, n \quad (4)$$

P_{z_k} is the marginal implicit value for attribute z_k . The price paid by the consumer for each product consumed equals the sum of the marginal monetary values of the product's characteristics (Ladd and Suvannunt, 1976).

With regard to the functional form of the dependent variable, previous literature provides no theoretical guidance (Carew and Florkowski, 2010; Edenbrandt *et al.*, 2018). The most basic specification the estimated hedonic function takes is the following linear form:

$$P_i = a_0 + \sum_{k=1}^K \beta_k z_{ki} + \varepsilon_i \quad (5)$$

where z_k is the attribute vector of product i . However, the chosen functional forms vary widely and often include non-linear transformations of the dependent variable, the independent variables, or their interaction, so hedonic and implicit price functions can be expected to be non-linear (Costanigro and McCluskey, 2011; Ekeland *et al.*, 2002, 2004). Regarding the non-negativity and right-skewness features of parametric distribution of product prices is consistent with the log-normal distribution. Then, the logarithmic transformation of the dependent variable can be depicted as:

$$\ln P_i = a_0 + \sum_{k=1}^K \beta_k z_{ki} + \varepsilon_i \quad (6)$$

2.2 Data and statistics

The data were collected from emerging modern food marketing channels: the e-commerce platforms in China, between late February and early March 2017. For all the self-operated UHT fluid milk and infant formula sales of the five platforms, the price and other characteristics or attributes were carefully recorded. Each observation represents a product. The attributes are recorded and their definitions are exhibited in Table 1.

Table 1. Description of variables.

Variables	Type	Description
Dependent variable		
Price	Continuous	Yuan per 200 ml for UHT fluid milk and 200 g for infant formula
Independent variables		
Country-of-origin	Categorical	CHN=1, GER=2, NZL=3, FRA=4, AU=5, NED=6, ESP=7
B2C Platforms	Categorical	COFCO I buy nets=1, Yihaodian=2, Jingdong=3, Alibaba's Tmall Supermarket=4, Suning Purchase=5
Brand	Categorical	For UHT fluid milk: Yili (CHN)=1, Sanyuan (CHN)=2, SUNSIDES (GER)=3; Satine of Yili (CHN)=4; Shengmu (CHN)=5, Anchor (NZL)=6; Devondale (AU)=7; Weidendorf (GER)=8; Oldenburger (GER)=9; Muh-Metro (GER)=10; Muh-Gump's ranch (GER)=11; MeadowFresh (NZL)=12; ATO (ESP)=13; Mengniu (CHN)=14; Deluxe of Mengniu=15; Others=16; for infant formula: Biostime (CHN)=1; Junlebao (CHN)=2; Wandashan (CHN)=3; Wyeth=4; Aptamil (GER)=5; Friso (NED)=6; MeadJohnson (USA)=7; Nutrilon (NED)=8; Beingmate (CHN)=9; Nestlé (Switzerland)=10; Similac (USA)=11; Others=12
Discount	Dummy	Discount=1, otherwise=0
Salesize	Continuous	Sales unit, UHT fluid milk in ml; infant formula in grams
Shelflife	Continuous	Quality guarantee period marked in the package (month)
Organic	Dummy	Organic=1, otherwise=0
Traceability	Dummy	Traceability=1, otherwise=0
Introduction_source	Dummy	Introduction of the source of raw milk=1, otherwise=0
Other_credentials	Dummy	Other credentials=1, otherwise=0
Protein	Continuous	For UHT fluid milk, the mass of protein per 100 ml; for infant formula, the mass of protein per 100 g
Milk_fat	Continuous	For UHT fluid milk, the mass of milk fat per 100 ml; for infant formula, the mass of milk fat per 100 g
Calcium	Continuous	For UHT fluid milk, the mass of Calcium per 100 ml; for infant formula, the mass of Calcium per 100 g
Reconstituted_milk	Dummy	Reconstituted milk=1, otherwise=0
Stage	Categorical	Stage of infant formula, the first stage=1; the second stage=2; the third stage=3, the fourth stage=4

According to Jiang *et al.* (2019), Alibaba's Tmall is the biggest e-commerce B2C platform in China, with a market share of 65.2%, followed by Jingdong and Suning Purchase with shares of 23.2 and 5.3%, respectively. The other online platform was COFCO I buy nets, which is also an important and professional online food retailer established by China Oil & Foodstuffs Corporation (COFCO for short). Moreover, another platform used was Yihaodian, which is also an important online food retailer, accounting for 37.2% of the market share of imported dairy products sold in China in 2013. All consumers have access to these platforms theoretically, so the data can be regarded as representative. The initial sample sizes for UHT fluid milk and infant formula were 927 and 776, respectively. In this study, we focused on the top six original countries (Germany, New Zealand, France, Australia, the Netherlands, and Spain), alongside China. After excluding outliers, the final samples of UHT fluid milk and infant formula were 797 and 636, respectively. The summary statistics of the sample are shown in Table 2.

The average price of UHT fluid milk from the Netherlands and China are 3.32 CNY¹/200 ml and 3.49 CNY/200 ml, respectively, far exceeding that of Australia, Germany, and especially Spain. In the case of infant formula, the price for the Chinese brand is the lowest, 27.3% less than the formula from New Zealand, and 49.1% less than formula from France.

3. Results and discussion

To emphasize the importance of COO and other characteristics with regard to dairy prices, UHT fluid milk and infant formula were both included in the analysis. First, we specified the models for both UHT fluid milk and infant formula. Second, the implicit price of COO was examined and the results of UHT fluid milk and infant formula are reported.

3.1 Model specification

Though the log-linear hedonic model is the most commonly used, model specification should be implemented by estimating several alternative forms. According to Costanigro *et al.* (2007) and Costanigro and Mccluskey (2011), this paper specified several transformations of the dependent variable in terms of heteroscedasticity, misspecification, and normality of the residuals². Then, the adequate or 'best' models were chosen. We found that the natural log form was the best performing transformation for UHT fluid milk, and the simple linear was adequate for infant formula.

The price function for the UHT fluid milk takes the following form:

$$\begin{aligned} \ln(\text{Price}_i) = & \beta_0 + \beta_1 \text{COO}_i + \beta_2 \text{Brand}_i + \beta_3 \text{Platform}_i + \beta_4 \text{Salesize}_i + \beta_5 \text{Shelflife}_i \\ & + \beta_6 \text{Organic}_i + \beta_7 \text{Traceability}_i + \beta_8 \text{Introduction_source}_i \\ & + \beta_9 \text{Other_credentials}_i + \beta_{10} \text{Protein}_i + \beta_{11} \text{Discount}_i + \beta_{12} \text{Calcium}_i \\ & + \beta_{13} \text{Milk_fat}_i + \beta_{14} \text{Reconstituted_milk}_i + \varepsilon_i \end{aligned} \quad (7)$$

The price function for the infant formula is the following:

$$\begin{aligned} \ln(\text{Price}_i) = & \beta_0 + \beta_1 \text{COO}_i + \beta_2 \text{Brand}_i + \beta_3 \text{Platform}_i + \beta_4 \text{Salesize}_i + \beta_5 \text{Shelflife}_i \\ & + \beta_6 \text{Organic}_i + \beta_7 \text{Traceability}_i + \beta_8 \text{Introduction_source}_i \\ & + \beta_9 \text{Other_credentials}_i + \beta_{10} \text{Protein}_i + \beta_{11} \text{Discount}_i + \beta_{12} \text{Calcium}_i \\ & + \beta_{13} \text{Milk_fat}_i + \beta_{14} \text{Stage}_i + \varepsilon_i \end{aligned} \quad (8)$$

¹ In February and March 2017, the average exchange rate was 1 US\$ = 6.8823 CNY.

² The RESET test was used to test model misspecification; the Breusch-Pagan test was used for heteroscedasticity; and the Kurtosis test, Shapiro-Wilk test, and Shapiro-Francia test were used to test for normality of residuals.

Table 2. Sample summary statistics.

Attributes	UHT fluid milk							Infant formula						
	CHN n=308	GER n=229	NZL n=70	FRA n=40	AU n=107	NED n=17	ESP n=26	CHN n=367	GER n=38	NZL n=43	FRA n=30	AU n=14	NED n=130	ESP n=14
Average price ¹	3.32	2.59	3.13	3.18	2.72	3.49	1.89	40.5	65.19	55.66	79.64	57.94	60.65	81.49
No. brand	8	6	3	2	3	1	2	9	2	3	2	1	4	1
No. platforms	5	5	5	5	5	3	4	5	5	5	3	4	5	4
Sale size ²	4,122.6	6,479.8	5,939.3	2,727.5	5,736.5	4,600	6,000	877	755.26	840.7	870	892.86	832.69	688.57
Shelflife / month	6	11.6	11.2	10.4	9.7	12	10	22.3	21.3	24.1	31.2	32.3	23.0	27.6
Discount / %	0.33	6.02	7.69	2.56	3.88	0	4	13.62	15.15	10.26	7.14	0	14.04	16.67
Organic / %	11.07	1.31	5.71	12.5	3.74	5.88	0	0	13.16	0	6.67	64.29	0	0
Traceability / %	4.89	0	2.86	0	0	0	0	17.71	13.16	39.53	16.67	7.14	36.15	0
Introduction_source / %	49.84	70.74	82.86	55	78.5	47.06	84.62	14.71	21.05	37.21	53.33	50	56.92	0
Other_credentials / %	16.29	12.22	41.43	25	17.76	41.18	65.38	27.79	21.05	13.95	50	42.86	35.38	14.29
Protein ³	3.26	3.4	3.49	3.26	3.32	3.57	3.17	15.02	14.12	16.08	13.46	17.20	14.98	12.68
Milk_fat ³	3.41	2.11	3.03	2.76	2.18	1.77	1.71	24.33	22.38	23.39	23.20	25.51	22.36	26.19
Calcium ³	110.2	120.9	123.4	118.2	116.2	120.0	120.0	527.2	600.4	589.7	421.8	568.2	562.2	451.9
Reconstituted_milk / %	2.64	5.58	0	5.88	8.86	0	0	—	—	—	—	—	—	—
Stage ⁴	—	—	—	—	—	—	—	1-4	1-4	1-4	1-3	1-4	1-3	1-3

¹ The price sold in e-commerce, measured by CNY, to be comparable, for UHT fluid milk: the unit price was for 200 ml and for infant formula the unit price was for 200 g.

² Sale size: one sale unit sold on the e-commerce platforms, the unit of UHT fluid milk is milliliters (ml), the unit of infant formula is grams (g).

³ The mass (g) of protein/milk fat/calcium in every 100 ml UHT fluid milk or in 100 g infant formula.

⁴ There are four stages of infant formula: 1-3 means the first, second and third stage of formula from a specific country sold on the e-commerce platforms.

Since UHT fluid milk is liquid and infant formula is a milk power, different attributes are included. Reconstituted milk is a special type of UHT fluid milk, and for each 'stage' it is specific to infant formula for babies of different ages, for whom different stages of milk power should be selected. Separate models were estimated for UHT fluid milk and infant formula.

3.2 UHT fluid milk

The results of UHT fluid milk model estimates are reported in Table 3 (Model 1), and the model with the simple linear form of the dependent variable was also conducted as a robust test (Model 2). Model 1 and Model 2 have R^2 values of 0.466 and 0.432, respectively, which suggests that the independent variables of these two models can explain more than 45% of the variation of the dependent variable, and indicates that both the models have a good fit.

Table 3. Results of the hedonic model for UHT fluid milk.¹

Variables	Model 1 Coefficient	Model 2 Coefficient
Dependent variable	Ln (price)	price
Brand ²	controlled	controlled
Country-of-origin		
CHN	—	—
GER	-0.206*** (-2.71)	-0.395* (-1.67)
NZL	0.069 (0.71)	0.222 (0.73)
FRA	-0.098 (-1.28)	-0.146 (-0.62)
AU	-0.098 (-1.52)	-0.066 (-0.33)
NED	0.093 (0.87)	0.404 (1.21)
ESP	-0.409*** (-2.76)	-1.020** (-2.22)
B2C Platforms		
COFCO I buy nets	—	—
Yihaodian	0.143*** (2.86)	0.394** (2.55)
Jingdong	0.157*** (3.22)	0.521*** (3.43)
Alibaba'sTmall Supermarket	0.245*** (5.06)	0.764*** (5.07)
Suning Purchase	0.194*** (3.61)	0.553*** (3.31)
Controlled variables		
Salesize	-0.00004*** (-12.95)	-0.00001*** (-11.50)
Shelflife	-0.022** (-2.04)	-0.098*** (-2.88)
Protein	0.195** (2.46)	0.732*** (2.96)
Organic	0.270*** (4.33)	0.823*** (4.25)
Traceability	0.087 (1.09)	0.283 (1.15)
Introduction_source	-0.027 (-1.02)	-0.047 (-0.57)
Other_credentials	-0.047 (-1.44)	-0.153 (-1.50)
Discount	-0.134** (-2.04)	-0.307 (-1.50)
Calcium	0.003 (1.17)	0.009 (1.14)
Milk_fat	0.008 (0.76)	0.025 (0.82)
Reconstituted milk	-0.039 (-0.62)	-0.172 (-0.87)
Constant	0.077 (0.26)	-0.276 (-0.31)
N	797	797
R-squared	0.466	0.432

¹ *t*-statistics are in parentheses; *, **, *** indicate statistical significance at the 10, 5 and 1% levels, respectively.

² The regression result of Brand has been withheld to protect privacy.

It is revealed from Model 1 and 2 that Spain and Germany have significantly negative coefficients, implying that, compared to China, the imported UHT fluid milk from Germany and Spain has lower prices, ranging from 20.6 to 40.9% less than that of China in a perfect competition market. That is to say, the COOL of imported milk, especially for milk from Germany, did not earn positive implicit value under fierce competition. However, this objective implicit price with negative significance (especially Germany) is inconsistent with the stated preference (subjective WTP) of Zhang *et al.* (2018), who adopted a BDM auction mechanism to elicit Chinese consumers' evaluations of UHT fluid milk from Australia, New Zealand, Germany and France compared with China. They found that Chinese consumers have a stated WTP premium of over 50% for UHT fluid milk imported from the studied four countries. This discrepancy may be triggered by the distrust in Chinese domestic dairy products; Chinese consumers in this study evaluated the image of German dairy industry as better than that of the Chinese industry, so were willing to pay a higher price for the imported milk (Zhang *et al.*, 2018). As the importation of UHT fluid milk in China is increasing and the international competition is fierce in the context of globalization and trade openness, the COOL of UHT fluid milk from the European Union, Australia and New Zealand will probably lead to a higher implicit value in future.

The regression results reveal that compared with COFCO I buy nets, Yihaodian, Jingdong, Alibaba's Tmall Supermarket and Suning Purchase all have significantly positive coefficients for the two models, implying a positive price premium (about 14 to 25%) for these four B2C platforms. Attributes like organic, protein and short shelflife also earned a price premium.

3.3 Infant formula

The results of the UHT fluid milk model estimates are reported in Table 4 (Model 3), and the model with a natural log form of the dependent variable was also conducted as a robust test (Model 4). Model 3 and 4 have R^2 values of 0.549 and 0.543, respectively, which suggests that the independent variables of these two models can explain about 55% of the variation of the dependent variable, and indicates that both the models have a good fit, and also that the results of Model 3 and 4 are consistent.

The results show that, compared with China, infant formula from Germany, New Zealand, France, the Netherlands and Spain all earn higher price premium, which suggests that Chinese consumers prefer imported infant formula. This finding is in accordance with Wang *et al.* (2019), who found that Chinese consumers perceived COO as the most important attribute. As Luo (2011) reported, most Chinese consumers purchase foreign milk powder brands rather than Chinese ones, and they perceive the price to be the least important cue in infant formula evaluations and were indifferent to paying higher prices for it. The probable reason for this is that infant formula has special targeted groups. When the 2008 melamine scandal first broke out in relation to Chinese Sanlu infant formula, it destroyed the confidence of Chinese consumers, leading to a sharp increase in imports of infant formula. The coefficient value also suggests that consumers give more value to European countries (Germany, France, the Netherlands and Spain) than Oceania countries (Australia and New Zealand). The probable reason for this is the free trade agreements between China and Australia (in 2015) and New Zealand (in 2018), and also due to *Clostridium botulinum* being discovered in the products of dairy giant Fonterra from New Zealand in 2013, which might have had an adverse impact on the company's reputation and consumers' valuation of dairy products from these countries.

In terms of the B2C platforms, the price of infant formula from Yihaodian, Jingdong, Alibaba's Tmall Supermarket and Suning Purchase all have a positive premium of about 20% more than COFCO I buy nets. The organic attribute endows infant formula with about a 20% price premium.

3.4 UHT fluid milk and infant formula

For both UHT fluid milk and infant formula, the price of products sold on Yihaodian, Jingdong, Alibaba's Tmall Supermarket and Suning Purchase platforms were typically higher than those sold on COFCO I buy nets. The probable reason for this is that COFCO I buy nets is a special website dedicated to shopping food

Table 4. Results of the hedonic model for infant formula.¹

Variables	Model 3 Coefficient	Model 4 Coefficient
Dependent variable	price	ln (price)
Brands ²	controlled	controlled
Country-of-origin		
CHN	—	—
GER	29.097*** (7.68)	0.534*** (7.08)
NZL	13.486*** (4.69)	0.232*** (4.05)
FRA	39.964*** (6.73)	0.697*** (5.89)
AU	1.378 (0.25)	-0.036 (-0.32)
NED	23.270*** (8.68)	0.404*** (7.55)
ESP	34.431*** (7.38)	0.546*** (5.87)
B2C Platforms		
COFCO I buy nets	—	—
Yihaodian	11.901*** (4.00)	0.247*** (4.17)
Jingdong	12.138*** (4.23)	0.250*** (4.37)
Alibaba's Tmall Supermarket	9.612*** (3.04)	0.194*** (3.08)
Suning Purchase	8.587*** (2.83)	0.196*** (3.24)
Controlled variables		
Salesize	-0.006*** (-3.29)	-0.000*** (-4.21)
Shelflife	0.595*** (2.66)	0.018*** (4.13)
Protein	0.52 (-1.36)	0.017** (-2.22)
Organic	15.831*** (3.06)	0.226** (2.19)
Traceability	0.237 (0.13)	0.005 (0.14)
Introduction_source	1.44 (0.81)	0.017 (0.49)
Other_credentials	-1.466 (-0.91)	-0.033 (-1.03)
Discount	-5.064** (-2.37)	-0.118*** (-2.76)
Calcium	-0.018** (-2.07)	-0.000** (-2.56)
Milk_fat	0.009 (-0.28)	0.000 (-0.43)
Stage	-5.169*** (-5.18)	-0.120*** (-6.04)
Constant	39.009*** (5.42)	3.435*** (23.91)
N	636	636
R-squared	0.549	0.543

¹ *t*-statistics in parentheses; *, **, *** indicate statistical significance at the 10, 5 and 1% levels, respectively.

² The regression result of Brand has been withheld to protect privacy.

products; it is not a comprehensive e-commerce platform, so its market awareness is not as high as that of the other four comprehensive platforms. Moreover, COFCO I buy nets has no self-support logistics outside Beijing, while the other four platforms all have self-logistics with better timeliness. Dairy prices vary by package size and shelflife; a larger package size decreases the price per unit for both categories. However, long shelflife leads to a higher price for infant formula but a lower price for UHT fluid milk.

The difference or opposite effect of COO on the prices of UHT fluid milk and infant formula might be due to two main reasons. Firstly, COO is a proxy of quality, and according to Zhang *et al.* (2018), Chinese consumers have better perceptions of the micro-image (or dairy industry image) of Germany compared with the Chinese dairy sector. The WTP for imported fluid milk (UHT, 200 ml) is more than 6 CNY, considerably more than the sale price. The difference between subjective WTP and objective selling price, or consumer surplus, will further boost the increase in fluid milk importation. Secondly, in terms of infant formula, due to the vulnerability of infants, strict quality and safety standards are needed. The melamine scandal first

out broke in domestic infant formula, therefore the negative spillover effect on consumers' confidence has been long-lasting and still exists today. Moreover, the purchase of imported infant formula is also a matter of 'face/prestige'; many Chinese parents still hold the belief 'do not let the child lose at the starting line'. Therefore, the distrust in the domestic product, the special consumer group, the good reputation of imported dairy products, and conspicuous consumption will keep the price of imported infant formula high for a long period of time. It is also the main reason for the increase in infant formula purchasing through cross-border online shopping.

4. Concluding discussion

Dairy product prices vary substantially across product characteristics and categories. Dairy firms and dairy sectors, both at home and abroad, are constantly seeking to attract new consumers and increase their market share. This study investigated the price-COO relationships of dairy products and the implicit value of dairy product attributes in the online market, for both UHT fluid milk and infant formula.

The overall results suggest that the implicit value of COO for UHT fluid milk and infant formula have opposite outcomes. For UHT fluid milk, the imported milk from Germany and Spain has a negative implicit value; however, infant formula has a significant positive implicit value. The lack of popularity of imported UHT fluid milk leads to a negative or insignificant positive implicit price of imported UHT fluid milk, and the vulnerable target group and distrust in domestic infant formula contribute additional value to consumers for the imported infant formula.

This study has several implications. Firstly, as UHT fluid milk is a fast-growing product in China, but the COOL of the EU countries, Australia and New Zealand do not earn positive implicit value, to better satisfy Chinese consumers' diversified demand, it is feasible for these countries to adopt promotion strategies to improve the popularity and brand awareness of UHT fluid milk among Chinese consumers. For the Chinese dairy industry, awareness that the fluid UHT market will become more and more competitive in the context of free and open international trade and the rapid development of e-commerce is important, so they can consider shifting their marketing focus from UHT fluid milk to pasteurized milk and taking effective measures to advertise the benefits of pasteurized milk, to induce Chinese consumers to change their purchasing habits from UHT fluid milk to pasteurized milk with a short shelf life (15 days or 7 days). As refrigerator penetration is high and cold-chain transportation is well developed, it is plausible to foster the pasteurized milk consumption market. Secondly, compared with the EU countries, the COOL of infant formula from Australia and New Zealand does not earn a positive price premium. Though Chinese infant formula has price advantage, the market share is still low after the 2008 melamine issue in infant formula. Therefore, the Chinese dairy industry should make concerted efforts to develop brand equity and rejuvenate consumers' confidence in domestic infant formula.

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Conflicts of interest

The authors declare no conflicts of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

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