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Abstract

I used a continuous-time framework to model the effects of fixed costs, such as those associated with the coronavirus disease 2019 (COVID-19) pandemic and the phenomenon whereby one type of storable product can have two different prices, on the phenomenon “inbound-outbound tourism demand.” Using closed-form solutions, I showed that travel frequency, fixed costs, lifetime consumption behavior, and inventory costs are simultaneously determined. Although the optimal path of consumption shows a smooth curve in the absence of inventory costs, it demonstrates a “saw-toothed” shape when time-dependent inventory costs and repeated “explosive purchasing” behavior are considered. The COVID-19 pandemic is the most important influence on the recovery of the global tourism industry, and is likely to also be important for the domestic market.

JEL classification: D11, E21

Keywords: Inbound, outbound, price difference, inventory, saw-toothed consumption, storable goods, pandemic, COVID-19

1 Introduction

A reduction of approximately 4% in global gross domestic product in 2020, compared to 2019, was estimated by the International Monetary Fund (IMF, 2020) and Word Bank (2021). On December 17, 2020, the United Nations World Tourism Organization (UNWTO) declared, “Tourism is back to 1990 levels as arrivals fall by more than 7%.” A loss of approximately 2 trillion US dollars (approximately 2% of global gross domestic product) was attributed to this massive drop in tourism, due to the coronavirus disease 2019 (COVID-19) pandemic. Thus, recovery of the global tourism industry is essential for full recovery of the global economy. To stimulate tourism, the concept of “inbound-outbound tourism demand” must first be understood at both micro and macro levels.

In recent years, China has provided the largest number of outbound tourists worldwide (UNWTO, 2020). Chinese tourists also tend to spend more money than those from other countries. “Bakugai,” which roughly translates to “explosive purchasing,” was voted as one of the most popular Japanese words in 2015 in reference to Chinese tourists. As shown in Table 1, it was reported that the mostly expected item of China tourist was the shopping at Japan before arriving Japan (Japan Tourism Agency, 2014). However, the total expenditure of Chinese tourists visiting Japan in 2020 decreased by

43% relative to 2019, because of the COVID-19 pandemic (UNWTO 2020). This drop has been the subject of considerable debate in the literature.

[Insert Table 1 here.]

To my knowledge, there has been minimal research concerning the explosive purchasing behavior of Chinese tourists. In this study, I regard this type of consumer behavior as rational, and analyze the impact of the COVID-19 pandemic on inbound-outbound tourism demand. I use a continuous-time framework to model the effects of the COVID-19 pandemic, as well as the effect of international differences in the price of sortable goods on consumer purchasing behavior. I show that fixed costs, consumption trends, and the frequency and quantity of purchases are simultaneously determined. Moreover, the optimal path of consumption has a “saw-toothed” shape. The results indicate that the COVID-19 pandemic is the most important influence on the recovery of the global tourism industry, and presumably on domestic markets.

The rest of the paper is organized as follows. Section 2 presents the theoretical framework. Section 3 presents the results of analyses of inbound-outbound tourism demand at the macro level, and discusses the policy implications of the pandemic, such as increased taxation to recoup costs. Section 4 discusses the applicability of the results to purchasing behavior in convenience stores and shopping malls. Section 5 presents the conclusions.

2 The Model

2.1 Consumption Inventories

[Insert Figure 1 here.]

Let us assume that a consumer (tourist) will pay a higher price, p_1, in their home country for storable goods (e.g., due to safety issues or market conditions), and a lower price, p_0, in a foreign country (e.g., due to a lack of taxes) (Fig. 1). For simplicity, p_0 is assumed to be 1. Domestically, the consumer can buy goods at p_1 without any fixed or inventory costs, but in foreign markets must pay a fixed cost, υ, because of health risks posed by the COVID-19 pandemic, as well as a fee for traveling abroad. There is also an inventory cost (i.e., the opportunity cost associated with buying at p_0). According to Wan (2014), the consumer chooses the inventory period, τ, based on the price difference for a given product. The marginal cost of storable goods at time *0*, p_0, will increase with the interest rate, r, and thus becomes

$$p_0 e^{r\tau} \tag{1}$$

at time τ. This cost should be lower than p_1:

$$p_0 e^{r\tau} \leq p_1. \tag{2}$$

By assuming that $p_0 = 1$, I now consider a consumer facing the problem articulated by Ramsey (1928) and Wan (2014), where

$$\max_{c_t} \sum_{n=0}^{\infty} \int_{n\tau}^{(n+1)\tau} \ln c_t e^{-rt} dt \tag{3}$$

s.t.

$$\sum_{n=0}^{\infty} e^{-n\tau} \left(\int_{n\tau}^{(n+1)\tau} c_t dt + \upsilon \right) = \int_0^{\infty} e^{-rt} y dt + A^0 . \tag{4}$$

Under a constant discount rate of $r\ (>0)$, according to Wan (2021), a consumer chooses consumption behavior c_t based on their budget constraints, namely initial wealth A^0, when there is a constant wage income, $y(\geq 0)$, and the discount rate is $r(>0)$ at time t. In this case, the Lagrangian function becomes

$$L_{\{c_t,\lambda\}} = \sum_{n=0}^{\infty} \int_{n\tau}^{(n+1)\tau} \ln c_t e^{-rt} dt + \lambda \left(\int_0^{\infty} e^{-rt} y dt + A^0 - \sum_{n=0}^{\infty} e^{-n\tau} \left(\int_{n\tau}^{(n+1)\tau} c_t dt + \upsilon \right) \right). \tag{5}$$

I then find the optimal solution for λ and c_t:

$$\lambda^*(\tau) = \left[r(A^0 + y/r - \upsilon(1 - e^{-r\tau})^{-1}) \right]^{-1}, \tag{6}$$

$$c_t^*(\tau) = r(A^0 + y/r - \upsilon(1-e^{-r\tau})e^{-rt+n\tau} \quad , \text{ for } n = 0,1,2,\ldots\infty . \tag{7}$$

The optimal quantity, I_0, of goods purchased is

$$I_0^*(\tau) = \int_0^\tau c_t^*(\tau)dt \quad , \tag{8}$$

$$= (A^0 + y/r)(1-e^{-r\tau}) - \upsilon \quad . \tag{9}$$

The optimal inventory at time *t* is

$$I_t^*(\tau) = \int_{n\tau+t}^{(n+1)\tau} c_t^*(\tau)dt \quad , \text{ for } n = 0,1,2,\ldots\infty \tag{10}$$

$$= (A^0 + y/r - \upsilon(1-e^{-r\tau}))(e^{-r(t+n\tau)} - e^{-r(n+1)\tau})e^{n\tau} \quad ,$$

$$\text{for } n = 0,1,2,\ldots\infty . \tag{11}$$

The optimal closed-form solutions for purchases, consumption behavior, and inventories are shown in Figure 1. Their paths demonstrate a saw-toothed shape, rather than a smooth shape.

2.2 Maximum and Optimal Inventory Periods

2.2.1 Maximum Inventory Period

Based on Eq. (2), the maximum (but not optimal) inventory period, τ^{max}, is

$$\tau^{\max} = r^{-1}(\ln p_1 - \ln p_0) = r^{-1}\ln p_1 . \qquad (12)$$

2.2 Optimal Inventory Period

The consumer's consumption behavior is transformed to yield

$$U(\tau) = \max_{\tau} \sum_{n=0}^{\infty} \int_{n\tau}^{(n+1)\tau} \ln c_t^*(\tau) e^{-rt} dt , \qquad (13)$$

$$= r^{-1}\begin{bmatrix} \ln(r(A^0 + y/r - \upsilon(1-e^{-r\tau})^{-1})) \\ -1 + \tau(e^{r\tau} - 1)^{-1} \end{bmatrix} . \qquad (14)$$

I can then obtain,

Theorem 1:

The optimal inventory period (τ^*) is unique, and $0 < \tau^* < \tau^{max}$.

The appendix provides a proof.

For example, it can be set that $\tau^* = \theta\, \tau^{max}$ where $0 < \theta < 1$. When $p_0=1$, $A^0=200$,

υ=5, $\theta \approx$0.6 for p_1=1.5, $\theta \approx$0.2 for p_1=3, and $\theta \approx$0.1 for p_1=10.

2.3 Necessary and Sufficient Conditions

The fixed cost, υ, of a product should be positive according to Arrow et al. (1951). Without this cost, the consumer could buy the goods at price p_0 at any time, and there would be no inventory cost. To determine the sufficient conditions, I compare the consumer's total utility with and without inventory:

$$\int_0^{\tau^*} e^{-rt} \ln(r(A^0 + y/r - \upsilon(1-e^{-r\tau^*})^{-1})/p_0)dt \geq \int_0^{\tau^*} e^{-rt} \ln(r(A^0 + y/r)/p_1)dt\,, \tag{15}$$

The right and left sides of Eq. (15) are the utility with and without inventory, respectively. From this, I obtain

Theorem 2:

Inbound (outbound) tourism occurs if and only if the following sufficient condition is satisfied (see appendix for proof):

$$(p_1 - 1)p_1^{-2}(p_1 - e^{-r})(A^0 + y/r) \geq \upsilon > 0\,. \tag{16}$$

The necessary condition is $p_1 - e^{-r} > 0$.

3 Calculation of Inbound-Outbound Tourism Demand

3.1 Demand at a Given Point in Time

Let us also assume that there are *n* persons in the economy differing with respect to income *y*. The income is distributed from *0* to y_{max}. The first and *nth* person earn zero and have the highest possible income, respectively. Thus, I obtain the gross domestic product (GDP) using $0.5ny_{max}$. For simplicity, wealth is also assumed to be zero.

[Insert Figure 2 here.]

At some point in time, as shown in Figure 2, the *mth* person's income is assumed to satisfy the necessary condition (Eq. (16)), and I obtain the aggregate number of inbound-outbound tourists as

$$m\text{-}n \tag{17}$$

The aggregate purchase amount for *m-n* persons is

$$I_{0(m\text{-}n)} = \sum_{i=n}^{m} (I_{0i}). \tag{18}$$

3.2 Demand During a Fixed Period

Purchase frequency ($1/\tau^*_i$) differs between people due to income differences (see ***Theorem 1***), such that for a fixed period T (e.g., 1 year), the *ith* person should have T/τ^*_i or $1/\tau^*_i$ (for T=1) times of outbound demands. I then obtain

Theorem 3:

Outbound (or inbound) tourism demand in a fixed period can be expressed as

$$I_{(m-n)} = \sum_{i=n}^{m} (I_{0i}) \cdot \left(\frac{1}{\tau*_i}\right). \tag{19}$$

3.3 Policy Analysis

I assume that the government raises the money to develop a new vaccine or medicine for COVID-19 by collecting taxes. Within the framework presented here, the effectiveness of the new vaccine or medicine is assumed to reduce fixed cost υ, and the production function for the new vaccine or medicine is assumed to be $\upsilon = \upsilon$ (income tax). This decreases with income tax ($\upsilon' < 0$, $\upsilon'' > 0$, υ (maximum income tax) > 0). To maximize the utility of all households in the economy, the government could use the above model to find the optimal income tax rate with an endogenous fixed cost υ (although this fixed cost is exogenous at the individual household level).

4 Purchasing Behavior at Convenience Stores and Shopping Malls

Domestic sales occur frequently, and consumers will often make large purchases during sales. Hendel and Navo (2006) analyzed supermarket sales and consumer inventories, and tested their model using data concerning soft drink purchases. Feenstra and Shapiro (2001) posited that the consumer price index cannot be calculated precisely if inventory behavior is not considered. They tested this supposition using data regarding canned tuna purchases.

Generally, a consumer is likely to encounter two prices for the same product. For example, a beverage will likely be more expensive at a convenience store than a (less convenient) shopping mall. The theory laid out in this paper could be used to maximize the utility of the consumer in this context.

5 Conclusions

I constructed a model to explain inbound-outbound tourism demand, and used it to explain the large and sudden decline in tourism in 2020 associated with the COVID-19 pandemic. According to the theory presented herein, the COVID-19 pandemic is the most important influence on the recovery of the global tourism industry.

The model presented here can also explain purchase and consumption behavior in the context of a dichotomous choice between a convenience store and shopping mall. Under conditions of a price difference for storable goods between such outlets, purchasing and consumption behavior were modelled. I have shown that inbound-outbound tourism demand, fixed costs, and lifetime consumption behavior are determined simultaneously. The optimal path of consumption is saw-toothed in shape because of both repeat purchases and time-dependent inventory costs. According to the theory presented herein, effective treatments for COVID-19, visa exemptions, tax-free products, and general growth of income and assets would likely stimulate tourism demand while also promoting tourist welfare.

In future research, modeling multiple goods would be useful for understanding consumption and inventory behavior. Furthermore, the general influence of the supply sector and pricing behavior should be considered.

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Appendix

Proof of ***Theorem 1***:

The first order condition of Eq. (4) is as follows,

$$\tau = \frac{\upsilon}{\mathrm{r}}[A^0 - (1 - e^{-r\tau})^{-1}] + \frac{1}{\mathrm{r}}[1 - e^{-r\tau}]. \quad \text{(A.1)}$$

To differentiate the right hand side of Eq. (A.1) with respect to τ, I obtain,

$$\upsilon(1 - e^{-r\tau})^2 e^{-r\tau} + e^{-r\tau} > 0. \quad \text{(A.2)}$$

For the right hand side of Eq. (A.1),

$$\frac{\upsilon}{\mathrm{r}}[A^0 - (1 - e^{-r\tau})^{-1}] + \frac{1}{\mathrm{r}}[1 - e^{-r\tau}] \to -\infty \quad \text{for } \tau \to 0^+, \quad \text{(A.3)}$$

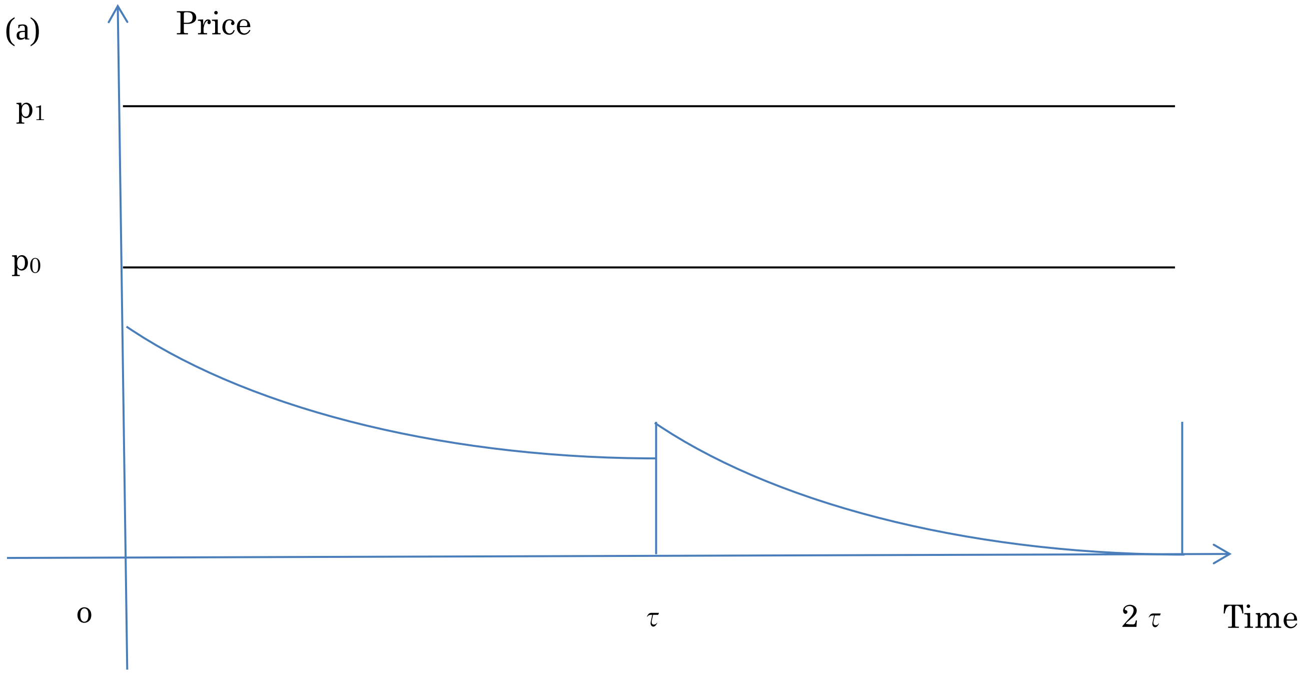
and

$$\frac{\upsilon}{\mathrm{r}}[A^0 - (1 - e^{-r\tau})^{-1}] + \frac{1}{\mathrm{r}}[1 - e^{-r\tau}] > \tau^{max} = r^{-1}\ln p_1 \quad \text{for } \tau = \tau^{max}, \quad \text{(A.4)}$$

then the unique τ^*, $0 < \tau^* < \tau^{\max}$ can be found via fixed point theorem.

Q.E.D.

Figure 1: (a) Consumption behavior according to product price, and (b) purchase and inventory data over time.



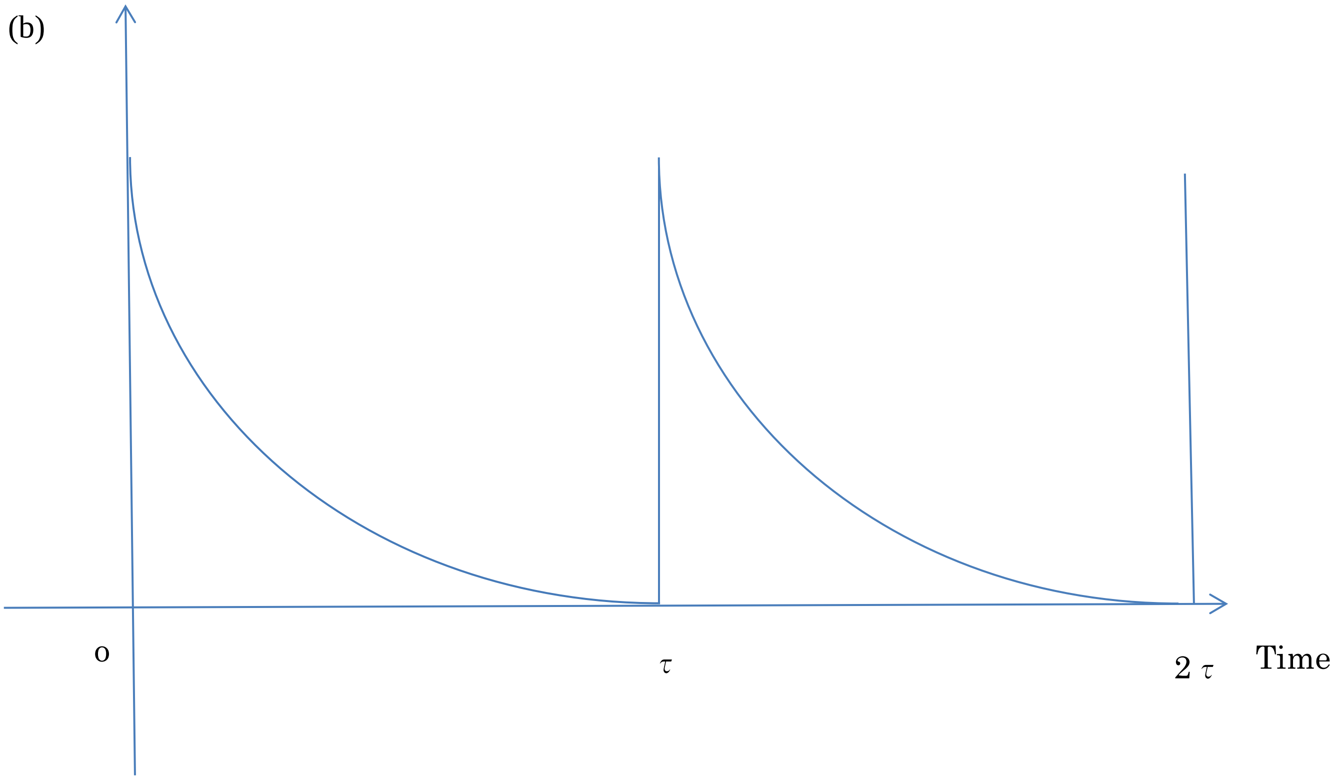


Figure 2: Income distribution and impact of changes in fixed costs associated with the COVID-19 pandemic.

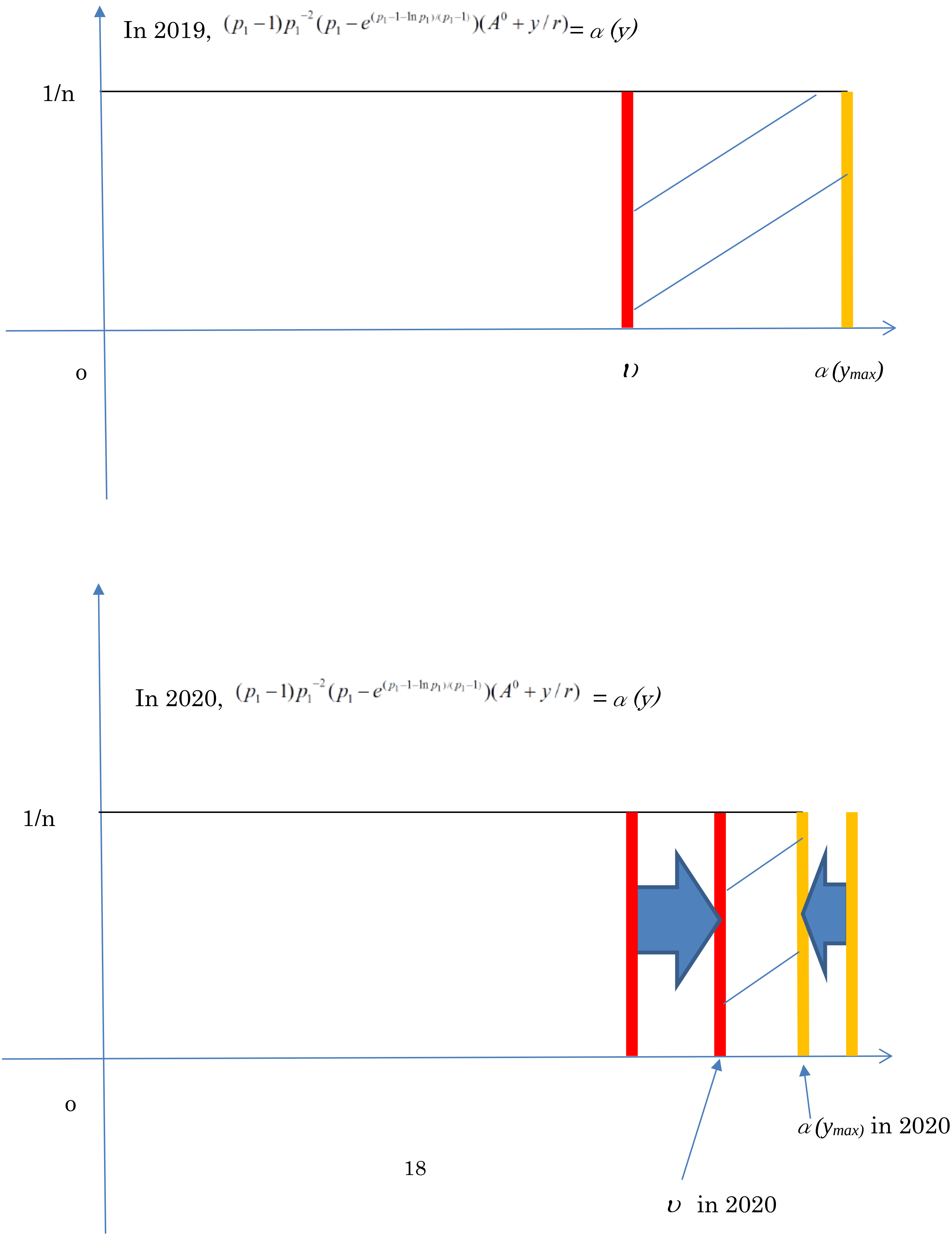


Table 1: Expected vs. practiced items of China tourists to Japan before and after arriving in Japan

Items	Expected items before arriving in Japan (Single choice, %)	Expected items before arriving in Japan (Multiple choices, %)	Practiced items after arriving in Japan (Multiple choices, %)
Shopping	24.3	76.9	87.9
Eating Japanese foods	20.4	78.2	94.1
Visiting	21.5	66.3	76.4
Walking at street	3.6	52.4	71.7
Enjoying spring water	8.9	53.4	60.4
Staying at hotel	0.9	36.3	65.0
Drinking Japanese wine	0.5	18.6	28.2
Japanese history and culture	3.3	16.1	15.7
Theme park	6.0	20.7	22.9
Enjoying seasonal beauty (Cherry-blossom viewing, Autumn leaves, snow, etc.)	2.6	14.6	11.1
Museum	0.9	10.9	12.4
Morden culture (fashion, anime, etc.)	1.8	8.7	7.8
Visiting film or anime locations	1.4	7.2	4.2
Tour on natural, agriculture and fishing villages	0.4	5.4	4.9
Ski and snowboat	1.6	5.1	3.5
Stage appreciation (Kabuki, theater, music, etc.)	0.9	4.3	3.3
Treatment or health examination	0.2	1.3	0.3
Watching sports (Sumo, football, etc.)	0.1	0.9	0.3
Golf	0.1	0.8	0.7
Others	0.5	2.0	0.1
Total	100.0	480.1	570.8

Source: Consumption Trend Survey on Foreign Vistors in Japan in 2014 (calendar year) by Japan Tourism Agency.