Lost in Transaction:
Individual-Level Welfare Loss in Quickly-Circulating Durable Goods Markets with Planned Temporary Ownership

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Abstract

A new style of durable goods consumption through a large scale online redistribution marketplace (e.g. eBay and Yahoo! Auction), characterized by a relatively small degree of usage and a short-term ownership, is becoming increasingly popular these days. Yet, the welfare structures of such emerging markets have not been investigated. By using a unique dataset of quickly-circulating multi-use train ticket resale markets, and by investigating perfectly-substitutable goods, this short article models, estimates, and analyzes individual-level welfare loss in such rapidly-growing market sectors. Our analysis shows that individual-level welfare losses caused by resale market friction costs is non-negligibly large, ranging from 3% to 15% of the new good price. We also find that such individual-level welfare losses, which could be considered as hidden charges, are largely heterogeneous across buyers with differing degrees of intended use. These losses are described as disadvantageous to users who demand light degrees of usage.

Keywords: Durable Goods Markets, Planned Temporary Ownership, Resale-Aiming Purchase

JEL codes: L12 - Monopoly, L68 - Consumer Durables, L81 -Retail and Wholesale Trade·E-Commerce

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1 Introduction

A new style of durable good consumption through a large-scale online redistribution marketplace, characterized by a relatively small degree of usage and a short-term ownership compared to a traditional one, is becoming increasingly popular these days. In such a consumption style, new durable goods buyers have solid plans to resale these goods after a short period to buyers.

Traditionally, resale market disfunctionalities, such as asymmetric information that creates the market-extinguishing lemon problem, hindered the opportunities of a durable goods consumption with temporary ownership. Now, with the emergence of secured, reputable, and convenient online websites that mitigate resale market disfunctionalities, online market places such as eBay and Yahoo! Auction enable us to pursue more and more temporal consumption of durable goods. As a consequence, it is now common to see an individual seller (including a non-professional) on eBay who auctions off a textbook after an academic semester, current year models of PRADA shoes and clothes after a few times of usage, a functional (yet expensive) childseat or stroller for an infant after a certain stage of development, a carpentry tool (e.g. power drill) after light use, video game software a few months after purchase, or any other high-tech gadgets (e.g. smart phones and tablets) after a short but specific period usage such as until the appearance of a next generation model. Moreover, author of the the business book "*Futureshop*" predicts the future of the durable goods markets as follows:

"*This [online-market-based temporary ownership] shift will redefine socially accepted norms of consumer buying and selling behavior. We will soon live in a world where the norm is to sell our iPods after using them a year. Or to sell our $800 Jimmy Choo shoes after wearing them twice...*"[1]

However, while the volume of such brief and resale-aiming purchases is increasing with unprecedented numbers of online durable goods sellers and buyers, the structure of such fast turn-around markets has not yet been much investigated. As a result, we thus far have limited understanding of the market structure and individual-level welfare nature of this newly emerging durable consumption style, such as welfare damage caused by resale transaction costs.

[1]See Nissanoff (2006) for details.

This short article contributes to the empirical durable goods literature by modeling quickly-circulating resale markets with planned temporary ownership and resale-aimed-purchasing buyers. It also theoretically and empirically assesses the individual-level welfare loss caused by resale-market friction costs. Although the markets for temporal ownership are rapidly growing and expected to expand further and faster in the future, to the best of our knowledge, no empirical research has been reported on welfare loss in such quickly-circulating durable goods markets.

For the sake of empirically deriving individual-level welfare implications, we use a unique dataset from a durable goods market in which perfectly-substitutable goods are traded with high volume. Specifically, the durable goods we analyze here are multi-use train tickets which are indivisible yet partially usable and resalable. Notably, as the buyers (train travelers) who purchase these tickets do so purely for the purpose of train riding, market participants treat new and used goods equally based on their demand and degree of usage.

Particularly, this resale market has the following advantages for empirical and structural analysis. First, there is a monopoly new durable good seller that sells new durable goods with a fixed price. Second, the durable goods are reasonably considered perfectly substitutable across any vintage, especially between new and resold durable goods, which in turn enable us to construct indifference conditions and estimate the closed-form solutions of resale market prices. Third, the degree of depreciation is objectively measured and clearly categorized by the recorded usage. Fourth, as the characteristic of durable goods is publicly well-known, there is little concern of asymmetric information between sellers and buyers in a resale market. Fifth, except the channel of monetary gain from resale, there does not exist the method of dynamic utility transfer, a factor that largely simplifies our empirical model. Sixth and most importantly, although this product is a specific good, it actually shares many common characteristics of general durable and resalable goods. Thus, we are able to derive profound insights on costs and welfare structures for other commonly-traded durable good markets.

1.1 Research Method

Our research methods are twofold. First, for the structural model analysis, we construct our model based on the assumption that a durable goods user knows her demand (how many degrees of depreciation she wants to consume) for modeling the essence of the recent trend of online durable goods trades (i.e. buying with planned temporary ownership). Also, by following the precedented literature, we use competitive price-taking rational expectation equilibria with no arbitrage condition in both primary new good and secondary resale good markets. We choose the price-taking assumption as there are numerous buyers and sellers observed (and recorded in the dataset) in our empirically-analyzed markets. In addition, anecdotal evidence supports that each market participant hardly has market power, and any arbitrage opportunities are immediately exploited by them. With the nature of perfect substitutability and the simplification of a committed search process in resale markets (in other words, once a potential buyer decides to buy a used good rather than new, she commits to hear search of used goods), the no arbitrage condition enables us to construct an indifference condition system from which analytic solutions of competitive resale market prices are derived. In addition, insightful analytic solutions for resale market prices and individual-level welfare loss among durable goods users are obtained. Such discerning observations clarify the direction of resale-market price distortions and the heterogeneous effects of individual-level welfare loss caused by resale market friction costs.

Second, for the empirical analysis, following the precedent of the empirical search model estimation method set by the seminal work of Hong and Shum (2006), we primarily use *price data* for our main estimation framework. Specifically, we estimate the closed-form solutions of competitive resale market prices with observed prices. Furthermore, we apply the rational expectation equilibrium framework, in which market participants have expectations on resale prices that agree with empirically observed prices, for applying Generalized Method of Moments (henceforth GMM) estimations. Our structural estimation results show that resale market friction costs are large (around $10 U.S. Dollars, approximately 8% of the new good price) and individual-level welfare losses are substantially heterogeneous and different across the types of durable goods users. We also consider these individual-level welfare losses to be "hidden charges" among durable goods market participants. Consequently, some users are excluded from markets as they cannot afford such hidden charges.

1.2 Literature Review

This research is related to the empirical and structural durable goods literature in which, despite the high real-world importance and practicality, only several structural estimations have been reported.

Suslow (1986) structurally investigated and estimated the classical case of Alcoa's aluminum primary and secondary (aluminum scrap) markets. Porter and Sattler (1999) propose a model of imperfectly substitutable durable goods and conduct the reduced-form investigations of U.S. automobile markets for testing their model predictions. Stolyarov (2002) proposes a durable goods market model that allows multi-period goods holding and calibrated the model to match U.S. autobmobile markets. Chevalier and Goolsbee (2005) study academic textbook markets and support that buyers (i.e. college students) are forward looking and expect durable goods renewals (i.e. textbook edition changes). The seminal structural-estimation work of Esteban and Shum (2007) enable the literature move forward by inventing an empirical dynamic model of oligopolistic primary and competitive secondary car markets with consumer heterogeneities by simplifying there is no resale market search and transaction costs. Chen et al. (2013) extend the framework of Esteban and Shum (2007) through calibration analyses and numerically investigate the welfare consequence of secondary market openings with transaction costs. Ishihara and Ching (2012) investigate the durable goods markets for non-depreciating goods (i.e. digital products) with Bayesian approaches. Gavazza et al. (2014) construct the model of heterogenous durable goods buyers and report the calibration result to match the data from the U.S. automobile market. Most recently, Leslie and Sorensen (2014) construct a structural model of concert ticket markets with limited supply quantities due to concert venue capacity constraints. In their model, concert goers and scalpers (who have rent-seeking motives) have to incur costly lining-up time (in a primary concert-ticket market) and resale market transaction costs.

The main conclusion from the literature is simple: durable goods market outcomes, such as welfare improvements and deterioration, ultimately depend on the magnitude of resale market friction costs.[2] This research extends these preceding works by focusing on temporal ownership trades with frequent turn-around in a large online platform. Notably, our research investigates primary and secondary market interactions without supply quantity restrictions so that we separately estimate both buyer-side search and seller-side resale costs. Given the rapid increases in online durable goods trades with resale-aimed purchases, we extend the literature as it is now more important than ever to understand the structure of such newly developing markets based on structurally estimated friction costs.

[2] In their influential calibration-based research, Chen et al. (2013) denoted that "In our analysis, transaction costs play a key role by letting us to assess the effects."

1.3 Limitations

Before proceeding, we end this introduction section by stating the limitations of this short article. We recognize that one of the ultimate purposes of empirical durable goods market research is aimed at an entire industry-level welfare analysis. Rather than looking at such an industry-level welfare structures, we here focus on the resale market structure and individual-level welfare loss analyses. For this reason, we simplify our analyses by fixing tge new good price.[3] Although our research focuses not on industry-level welfare but on individual-level welfare loss, the obtained analytic welfare-loss functions have straightforward interpretations. Accordingly, derived market properties in this article will provide clear insights for further research development. Such development includes calibration-based analyses in durable goods markets with resale opportunities, especially regarding temporary ownership markets that are rapidly growing with large redistribution systems (e.g. eBay and Yahoo! Auctions). In the conclusion section, we will provide the discussions of generalizability and applicability of our results to general durable goods markets.

1.4 Paper Organization

The rest of this article is organized as follows: Section 2 describes the durable goods markets from which we obtained our dataset and where perfectly substitutable goods are traded; Section 3 first illustrates a simple model of durable good users then reports several key observations, including welfare loss structures; Section 4 reports the estimation results and heterogenous welfare loss among durable goods users; lastly, Section 5 concludes with potential extensions.

2 Market Background and Data Description

This section describes our empirically analyzing durable goods, train coupon tickets, that are commonly traded in Japan. The primary market for these goods is monopolized by a national-wide semi-privatized railway operator that sets a fixed price for new goods, while decentralized secondary (used goods) markets are highly synchronized with each other due to the commoditized nature of ticket coupons. Although we have limited data extracted from an online auction platform, this specific market environment is still suitable for empirical and structural research.

[3] In our empirically analyzing dataset, the monopolist kept having a fixed new good price.

2.1 Durable Goods Sold by a Monopolist

We use the online transaction data of coupon tickets, called "*Seishun-18-Kippu*,"[4] issued by Japan Railways, the succeeding body (after the deregulation and semi-privatization) of the former national railway in Japan. This coupon ticket enables holders to have unlimited rides (within a day) throughout nationwide rail-transportation routes operated by Japan Railways, illustrated in Figure 1, yet it allows users to ride only slow/stopping train services (and users cannot ride express, overnight sleeper, or bullet trains). The coupon tickets are issued and used each year for limited periods, including the summer break period (from July 20th to August 31st), and we are emprically analyzing the data extracted from summer 2013 for this research.[5] According to Japan Railways, approximately 670,000 coupon tickets were issued throughout the calendar year of 2013[6] (including all spring, summer, and winter breaks), and the amount of (new goods) sales is approximately 77 million dollars.

The characteristics of this coupon ticket are unique, yet the coupon has many commonalities with other general durable goods. First, as shown in Figure 2, Japan Railways bundles a set of five rides[7] and sells the bundled coupon ticket at \$115 (or 11,500 yen = € 95 =£75)[8], and Japan Railways neither allows nor sells any other denominations of this coupon. Thus, there is no unbundled *Seishun-18-Kippu* coupon traded in either primary and resale markets. However, as similar to other general durable goods, it can be partially used. Therefore, the good is indivisible yet partially usable. The pictures of such partially used coupon tickets are listed in Figure 2 (b) to (e). We categorize such partially used tickets as Vintage IV, III, II, and I according to their remaining usages. For instance, the Vintage III ticket is still valid for three all-day rides. We also refer to the new ticket (listed in Figure 2 (a)) as a new or Vintage V ticket. Note that as Japan Railways is the only seller of the new tickets, it is considered to be a monopolistic

[4] The direct translation of "*Seishun*" is "youth" and "*Kippu*" is "ticket," yet the literal meaning here is a ticket for college-aged (approximately age *18*) students. There is, however, no age restriction on purchasing this ticket and a student card is not required. See http://www.jreast.co.jp/e/pass/seishun18.html for the details of this coupon.

[5] Other periods for which *Seishun-18-Kippu* coupon tickets are issued and used are the spring break period (from March 1st to March 31st) and winter break period (December 10th to December 31st). We choose the summer period for our empirical investigation as it has the longest issuing (and resale trading) duration and is most suitable for durable goods research with resale opportunities. As the name of *Seishun-18-Kippu* indicates, Japan Railways designed to sell these coupon tickets for selling to students who have sufficient time to afford slow/stopping train travels during their school break periods.

[6] Data Source: *Asahi-Shinbun* newspaper, 2014 July 26th Evening Edition

[7] Throughout this research, we use the term "ride" to refer to one all-day (and within-day-unlimited) use of the ticket. So, a ticket with two remaining rides means it is still valid for two all-day uses.

[8] Throughout this research, we use the U.S. dollar notations with the fixed exchange rate of 1 U.S. dollar = 100 Japanese yen (= 0.826 Euro = 0.652 British Pound)for the simplicity of discussion.

seller[9] of new (or Vintage V) tickets. Also, Japan Railways does not engage in any means of resale business.

Regarding the time framework of this empirical research, we restrict our analyses to summer breaks, and a time period index $t \in \{0, 1, \cdots, T\}$ is defined as follows. At the beginning of a summer break season, Japan Railways begins to provide *Seishun-18-Kippu* related services. We set two days after such a service starting date[10] as $t = 0$ and chronologically define time periods (i.e. a day) based on dates. On the other hand, at the end of a summer, Japan Railways stops selling new tickets. We set one week before such a sell-stoppage date[11] as time T. Based on this time period framework, we have $T = 32$ in our empirical analyses.

2.2 Secondary Markets

Due to their partial-usability nature, the used *Seishun-18-Kippu* coupon tickets are widely traded in secondary markets in Japan, such as a large-size online auction site and second-hand ticket scalping shops. Among them, "*Yahoo! Auction*" is the most well-known trading place, and we focus on the data from this online auction market.[12] In fact, the number of partially-used *Seishun-18-Kippu* coupon tickets traded on the Yahoo! Auction site per day by far exceeds an average of one hundred during a summer break season. Specifically, in summer 2013, about 8,000 *Seishun-18-Kippu* coupon tickets were transacted on Yahoo! Auction. Accordingly, in our structural model, we exploit the large-size nature of this online trading place.

Regarding resale market prices, averaged daily transacted prices for each vintage category in summer

[9]The primary and secondary markets of *Seishun-18-Kippu* are reasonably considered to be separated from other travel service markets in Japan for the following reasons. First, due to its (cheap but) time-consuming nature, *Seishun-18-Kippu* is different from other types of train services (i.e. rapid express, overnight sleeper, and bullet trains) offered by Japan Railways. In fact, the coupon is well-known among young people as an extremely cheap (yet extremely time-consuming) mean of transportation during break seasons. Second, all other private railways in Japan are localized and regionally operate. Thus, given the nature of nation-wide usability, the coupon is reasonably considered to have negligibly low substitutability with other train tickets offered by other private railways as buyers of the *Seishun-18-Kippu* tickets are different from buyers of tickets issued by regional railways. Lastly, due to the slow/stopping train service nature, it is more time-consuming to travel with *Seishun-18-Kippu* compared to bus travel. In fact, bus traveling is a relatively more expensive mean of transportation in Japan due to high expressway toll charges and, for the reason of daytime congestion, attracts overnight travelers (which would require to consume two all-day rides of a *Seishun-18-Kippu* coupon ticket and thus would not be attractive to those coupon holders).

[10]We exclude the first two days for securing a high volume of used tickets sold on Yahoo! Auction.

[11]We exclude the last seven days in order to define expected resale prices based on rational expectations. Detailed explanations are provided in the estimation section.

[12]Yahoo! Auction is the dominant online-auction site in Japan, and its share of online trades was 76 percent as of June 2014. Note that eBay, the dominant online auction platform in North America, Europe, and Australia, was introduced in Japan in 1999, yet it exited in 2002 due to the low number of users.

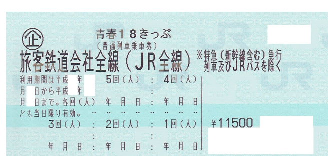
2013 are plotted in Figures 3 and 4. The solid (and perfectly horizontal) lines are added for depicting the fixed new (Vintage V) price of $115 that is set by Japan Railways. In Figure 3, we observe that within-a-day-averaged transacted prices of Vintage IV and III tickets are slightly and gradually decreasing over the sampled period, while those of Vintage II and I tickets are relatively flatter. Figure 4 reports the percentage of the new goods price (i.e. $115 is equal to 100%). We also add the horizontal lines of 80%, 60%, 40%, and 20% of the new goods prices, called theoretical percentages (or theoretical prices), that have theoretical foundations to be explained in the modeling section. Interestingly, we discover that observed within-a-day-averaged prices are both above and below theoretical percentages, a phenomena that will be structurally explained by our structural model.

Lastly, it should be noted that Yahoo! Auction is not the only place where train travelers trade their durable coupon tickets, and we only observe a portion of resale transactions regarding *Seishin-18-Kippu* during the summer of 2013. In fact, out of the 670,000 new (Vintage V) coupon tickets issued by Japan Railways in the calendar year of 2013, we only observe approximately 8,000 resale transaction records collected from Yahoo! Auction during the summer of 2013. Moreover, over-the-counter scalping shops for tickets are legally allowed and quite popular in Japan, and there are a couple of chain stores that engage in such ticket scalping business. Thus, our dataset is limited and missing resale market transaction data that happened outside of Yahoo! Auction.

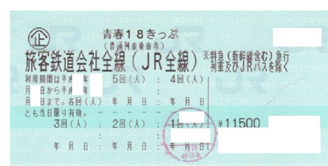
These difficulties notwithstanding we construct our structural model based on the observed and averaged price data collected from Yahoo! Auction. The economic logic that justifies the usage of such limited resale market data (and non-usage of other resale market transactions) is that the *Seishun-18-Kippu* tickets are highly commodified and easily resalable with publicly-known characteristics and little asymmetric information. Thanks to many online forums disseminating price information (both buying and selling prices) and the fact that scalping shops post *Seishun-18-Kippu* daily buying and selling prices on their websites, resale market prices are common knowledge and known to be synchronized. Thus, there is no difficulty in finding trading opportunities to resell in various (both online and over-the-counter) resale markets. As a result, although our dataset is limited, the recorded prices in our dataset are generated from resale markets that are closely linked and synchronized with other resale markets. In fact, discussions on online forums indicate that any price gap in resale markets is immediately exploited by market participants, including scalping shop managers. Thus, the observed prices in our dataset intrinsically contain the price information of other resale markets. We will provide detailed explanations regarding this point in the modeling section of this research.

Figure 1: Available Nation-Wide Railroads Valid for a *Seishun-18-Kippu* Train Ticket

Figure 2: *Seishun-18-Kippu*



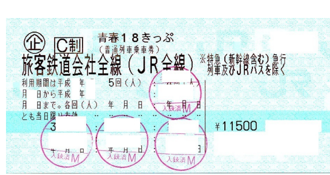
(a) Vintage V (New) Ticket: Valid for Five Train Rides, sold at $115 (the fixed new good price)



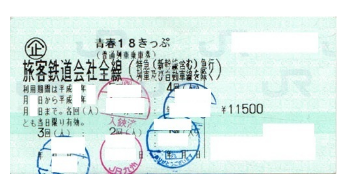
(b) Vintage IV (Slightly Used/ Used Once Already) Ticket

(c) Vintage III (Moderately Used / Used Twice Already) Ticket

(d) Vintage II (Slightly Heavily Used / Used Three Times Already) Ticket



(e) Vintage I (Heavily Used / Used Four Times Already) Ticket



(f) Invalid (Used Five Times Already) Ticket: No Longer Valid

Figure 3: Observed Nominal Prices

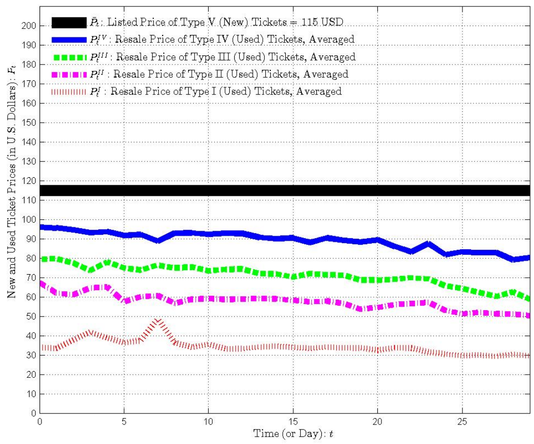
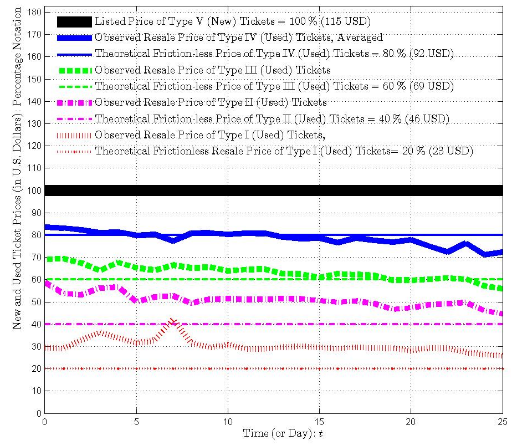


Figure 4: Observed vs. Theoretical Prices: Percentages



3 A Model of Resale Goods Markets and Welfare Implications

In this section, we first describe an empirical model of resale markets with perfectly substitutable durable goods. Then, we illustrate the key assumptions and their economic interpretations, including individual-level welfare implications. Next, we discuss the influence of sales taxes and derive the conclusion that individual-level welfare loss caused by resale market friction costs is invariant to sales tax rates. Lastly, we connect individual and market-level welfare implications. The primary goal here is constructing a minimalistic model that enables us to interpret and estimate resale market friction costs for understanding individual-level welfare loss.

3.1 A Model of Competitive Resale Goods Markets

A new good seller (i.e. Japan Railways) supplies new durable (and partially usable yet indivisible) goods in a primary market without the restriction of a supply capacity, at least within a relevant range of supply. The seller is committed to the new goods price $\overline{P}^{\text{New}}$ (or $\overline{P}^{\text{V,New}}$) for an exogenous reason, and it does not engage in resale trade. Used goods buyers and sellers are trading in resale markets. As similar to most durable goods resale markets (e.g. used iPhone and car sold on eBay), a buyer is able to substitute between a new good and a used good. For exploiting the nature of our empirically analyzing goods, in the rest of this research, we focus on the case of perfectly substitutable new and used goods.[13] We assume the arrival of buyers and sellers are exogenous, and all market participants know the process of such arrivals. We construct a model in which a buyer knows a plan for her durable goods usage (i.e. how many train rides she will use) in advance and her private-value-based willingness to pay (denoted as V) before she purchases a new or used good. Accordingly, we use the notation d for a buyer who has a demand for four train rides, c for a buyer who has a demand for three, and b and a are defined in the same fashion.[14]

We define the following three types of secondary market friction costs. The first friction cost is *search-and-bidding cost* ($Search$) for capturing a buyer-side opportunity cost for searching a desired good in an online resale market, investigating the details (e.g. shipping method after winning), making a bid (or bids), awaiting a result, and potentially re-participating in other auctions if she fails to obtain a currently bid-on good. We assume this search-and-bidding cost to be constant over time and across buyers as all resale good buyers have the same option of substituting to a new good regardless of their demand types and timings. The second type of resale market friction cost is *expected resale transaction cost* ($Resale$) that captures secondary market seller-side opportunity costs such as preparing photos and textural explanations on an auction website, answering inquiries from potential buyers, awaiting an auction outcome, shipping an auctioned good to a winner, and potentially having to resubmit a good in the case of an unsuccessful sale. We use the term "expected" for this friction cost as this is a perceived cost when a buyer (who will later be a used good seller) makes her purchasing decision, yet the cost is realized later when she become a seller. The third friction cost is a *scrap cost* ($Scrap$) that captures a disposal cost that a user has to incur when she uses up a durable good.[15] We normalize the cost of buying a new good to be zero.[16] Moreover, we use the notation of $\mathbb{EP}_t$ for an expected resale price at time t, and several empirical constructions are examined regarding expected resale prices as robustness checks later.

[13]We will discuss the implications to imperfectly substitutable good markets in the conclusion section.

[14]This framework could be translated into car buyers in new and used car markets based on intended usage of mileage. For example, a type e buyer intends to use a car for 200,000 miles, a type d buyer intends 160,000 miles, ..., and so on.

[15]We include this scrap cost for the generalizablility and economic interpretations of our model. In our empirical analysis, we set $Scrap = 0$ (or negligibly small), which is validated as scrap cost simply means the cost of discarding a *Seishun 18* paper ticket into a trash box after using it up. In addition, as we will discuss later, $Resale$ and $Scrap$ cannot be separately identified.

[16]One can alternatively interpret that the cost of buying a new good (ticket) is included in a willingness to pay (V_d, V_c, V_b, or V_a) as a normalization. This normalization is justified as a ticket buyer (a train traveler) has to go to a train station when she travels, and a new ticket is sold only at Japan Railways train stations.

Given these notations, a type d buyer (who has a demand of four train rides) has purchasing options of

$$
\begin{aligned}
U_d^{\mathrm{V,New}} &= V_d - \overline{P}^{\mathrm{V,New}} \quad + \mathbb{EP}_t^{\mathrm{I}} - \mathit{Resale}_t^{\mathrm{I}} && (d\text{-V})\\
U_d^{\mathrm{IV}} &= V_d - P_t^{\mathrm{IV}} - \mathit{Search} \quad - \mathit{Scrap}. && (d\text{-IV})
\end{aligned}
$$

One could view the above utility specifications as a two-period model in which a buyer purchases a (new or used) good today and potentially resales the remaining usage later. Equation (d-V) describes the utility gain from purchasing a new ticket from a primary market (i.e. from Japan Railways) for a buyer who later will resale the remaining one train ride in the resale market with the sacrifice of the resale transaction cost. On the other hand, equation (d-IV) illustrates the gains from purchasing a slightly used vintage-IV ticket in a secondary market with the sacrifice of search-and-bidding cost (and consumes four train rides) and the scrap cost upon using up. As the new and used goods are perfectly substitutable, a buyer obtains the same utility V_d in both equations (d-V) and (d-IV). Note that buyers could be heterogeneous in V_d, yet the heterogeneities in willingness to pay does not affect theoretical results and empirical estimation methods we explain later. Next, a type c buyer (who has a demand of three train rides) has options of

$$
\begin{aligned}
U_c^{\mathrm{V,New}} &= V_c - \overline{P}^{\mathrm{V,New}} \quad + \mathbb{EP}_t^{\mathrm{II}} - \mathit{Resale}_t^{\mathrm{II}} && (c\text{-V})\\
U_c^{\mathrm{IV}} &= V_c - P_t^{\mathrm{IV}} - \mathit{Search} + \mathbb{EP}_t^{\mathrm{I}} - \mathit{Resale}_t^{\mathrm{I}} && (c\text{-IV})\\
U_c^{\mathrm{III}} &= V_c - P_t^{\mathrm{III}} - \mathit{Search} \quad - \mathit{Scrap}. && (c\text{-III})
\end{aligned}
$$

Furthermore, a type b buyer (who has a demand of two train rides) has options of

$$
\begin{aligned}
U_b^{\mathrm{V,New}} &= V_b - \overline{P}^{\mathrm{V,New}} \quad + \mathbb{EP}_t^{\mathrm{III}} - \mathit{Resale}_t^{\mathrm{III}} && (b\text{-V})\\
U_b^{\mathrm{IV}} &= V_b - P_t^{\mathrm{IV}} - \mathit{Search} + \mathbb{EP}_t^{\mathrm{II}} - \mathit{Resale}_t^{\mathrm{II}} && (b\text{-IV})\\
U_b^{\mathrm{III}} &= V_b - P_t^{\mathrm{III}} - \mathit{Search} + \mathbb{EP}_t^{\mathrm{I}} - \mathit{Resale}_t^{\mathrm{I}} && (b\text{-III})\\
U_b^{\mathrm{II}} &= V_b - P_t^{\mathrm{II}} - \mathit{Search} \quad - \mathit{Scrap}. && (b\text{-II})
\end{aligned}
$$

Lastly, a type a buyer (who has a demand of one train ride) has options of

$$
\begin{aligned}
U_a^{\mathrm{V,New}} &= V_a - \overline{P}^{\mathrm{V,New}} && + \mathbb{E}\mathbb{P}_t^{\mathrm{IV}} - Resale_t^{\mathrm{IV}} && \text{(a-V)}\\
U_a^{\mathrm{IV}} &= V_a - P_t^{\mathrm{IV}} - Search && + \mathbb{E}\mathbb{P}_t^{\mathrm{III}} - Resale_t^{\mathrm{III}} && \text{(a-IV)}\\
U_a^{\mathrm{III}} &= V_a - P_t^{\mathrm{III}} - Search && + \mathbb{E}\mathbb{P}_t^{\mathrm{II}} - Resale_t^{\mathrm{II}} && \text{(a-III)}\\
U_a^{\mathrm{II}} &= V_a - P_t^{\mathrm{II}} - Search && + \mathbb{E}\mathbb{P}_t^{\mathrm{I}} - Resale_t^{\mathrm{I}} && \text{(a-II)}\\
U_a^{\mathrm{I}} &= V_a - P_t^{\mathrm{I}} - Search && - Scrap. && \text{(a-I)}
\end{aligned}
$$

We now propose the following assumption for the sake of simplifying individual-level welfare analyses and empirical investigations.

Assumption 1 - *Competitive Price-Taking Rational Expectation Equilibrium with no Arbitrage Condition:*

Resale markets are competitive in the sense that market participants are price takers. In addition, they form rational expectations, and their expectations on resale prices agree with observed prices. Furthermore, there is no arbitrage (no free lunch) opportunity, and a buyer gets the same utility regardless of her new- or used-good purchasing choice.

The above price-taking assumption fits with to resale markets in which numerous buyers and sellers are participating and price information is publicly known, as there is little chance to exploit arbitrage opportunities in such resale markets through asymmetric information and market power.[17] In our empirical application, we investigate the auction markets for resale goods in which numerous buyers and sellers make transactions for the same goods within a day, and transaction prices are publicly displayed. In such large-size resale good markets, it is not likely that a single participant has a significant market power to change the price. Furthermore, Yahoo! Auction employs an eBay-like proxy-bid format in which a winner of auction pays a second-highest proxy bid. In other words, conditional on winning, the winner's own bid does not change a market price. One indifference-condition is based on type d buyer's utility functions; three are based on type c; six are based on type b; and ten are based on type a. The exact form of such an indifference condition system is written as

[17]The modeling framework of a competitive resale market is also used in Esteban and Shum (2007) and Chen et al. (2013). Furthermore, regarding our empirically analyzing resale markets, anecdotal evidence left on internet forums shows that arbitrage opportunities were immediately exploited by market participants.

$$
\begin{array}{rcll}
-P_t^{\mathrm{IV}} - \mathbb{EP}_t^{\mathrm{I}} & = & -\overline{P}^{\mathrm{V,New}} + \mathit{Search} - \mathit{Resale}^{\mathrm{I}} + \mathit{Scrap} & (d\text{-IV}) = (d\text{-V}) \\
\hdashline
-P_t^{\mathrm{IV}} - \mathbb{EP}_t^{\mathrm{II}} + \mathbb{EP}_t^{\mathrm{I}} & = & -\overline{P}^{\mathrm{V,New}} + \mathit{Search} - \mathit{Resale}^{\mathrm{II}} + \mathit{Resale}^{\mathrm{I}} & (c\text{-IV}) = (c\text{-V}) \\
-P_t^{\mathrm{III}} - \mathbb{EP}_t^{\mathrm{II}} & = & -\overline{P}^{\mathrm{V,New}} + \mathit{Search} - \mathit{Resale}^{\mathrm{II}} + \mathit{Scrap} & (c\text{-III}) = (c\text{-V}) \\
P_t^{\mathrm{IV}} - P_t^{\mathrm{III}} - \mathbb{EP}_t^{\mathrm{I}} & = & - \mathit{Resale}^{\mathrm{I}} + \mathit{Scrap} & (c\text{-III}) = (c\text{-IV}) \\
\hdashline
-P_t^{\mathrm{IV}} - \mathbb{EP}_t^{\mathrm{III}} + \mathbb{EP}_t^{\mathrm{II}} & = & -\overline{P}^{\mathrm{V,New}} + \mathit{Search} - \mathit{Resale}^{\mathrm{III}} + \mathit{Resale}^{\mathrm{II}} & (b\text{-IV}) = (b\text{-V}) \\
-P_t^{\mathrm{III}} - \mathbb{EP}_t^{\mathrm{III}} + \mathbb{EP}_t^{\mathrm{I}} & = & -\overline{P}^{\mathrm{V,New}} + \mathit{Search} - \mathit{Resale}^{\mathrm{III}} + \mathit{Resale}^{\mathrm{I}} & (b\text{-III}) = (b\text{-V}) \\
-P_t^{\mathrm{II}} - \mathbb{EP}_t^{\mathrm{III}} & = & -\overline{P}^{\mathrm{V,New}} + \mathit{Search} - \mathit{Resale}^{\mathrm{III}} + \mathit{Scrap} & (b\text{-II}) = (b\text{-V}) \\
P_t^{\mathrm{IV}} - P_t^{\mathrm{III}} - \mathbb{EP}_t^{\mathrm{II}} + \mathbb{EP}_t^{\mathrm{I}} & = & - \mathit{Resale}^{\mathrm{II}} + \mathit{Resale}^{\mathrm{I}} & (b\text{-III}) = (b\text{-IV}) \\
P_t^{\mathrm{IV}} - P_t^{\mathrm{II}} - \mathbb{EP}_t^{\mathrm{II}} & = & - \mathit{Resale}^{\mathrm{II}} + \mathit{Scrap} & (b\text{-II}) = (b\text{-IV}) \\
P_t^{\mathrm{III}} - P_t^{\mathrm{II}} - \mathbb{EP}_t^{\mathrm{I}} & = & - \mathit{Resale}^{\mathrm{I}} + \mathit{Scrap} & (b\text{-II}) = (b\text{-III}) \\
\hdashline
-P_t^{\mathrm{IV}} - \mathbb{EP}_t^{\mathrm{IV}} + \mathbb{EP}_t^{\mathrm{III}} & = & -\overline{P}^{\mathrm{V,New}} + \mathit{Search} - \mathit{Resale}^{\mathrm{IV}} + \mathit{Resale}^{\mathrm{III}} & (a\text{-IV}) = (a\text{-V}) \\
-P_t^{\mathrm{III}} - \mathbb{EP}_t^{\mathrm{IV}} + \mathbb{EP}_t^{\mathrm{II}} & = & -\overline{P}^{\mathrm{V,New}} + \mathit{Search} - \mathit{Resale}^{\mathrm{IV}} + \mathit{Resale}^{\mathrm{II}} & (a\text{-III}) = (a\text{-V}) \\
-P_t^{\mathrm{II}} - \mathbb{EP}_t^{\mathrm{IV}} + \mathbb{EP}_t^{\mathrm{I}} & = & -\overline{P}^{\mathrm{V,New}} + \mathit{Search} - \mathit{Resale}^{\mathrm{IV}} + \mathit{Resale}^{\mathrm{I}} & (a\text{-II}) = (a\text{-V}) \\
-P_t^{\mathrm{I}} - \mathbb{EP}_t^{\mathrm{IV}} & = & -\overline{P}^{\mathrm{V,New}} + \mathit{Search} - \mathit{Resale}^{\mathrm{IV}} + \mathit{Scrap} & (a\text{-I}) = (a\text{-V}) \\
P_t^{\mathrm{IV}} - P_t^{\mathrm{III}} - \mathbb{EP}_t^{\mathrm{III}} + \mathbb{EP}_t^{\mathrm{II}} & = & - \mathit{Resale}^{\mathrm{III}} + \mathit{Resale}^{\mathrm{II}} & (a\text{-III}) = (a\text{-IV}) \\
P_t^{\mathrm{IV}} - P_t^{\mathrm{II}} - \mathbb{EP}_t^{\mathrm{III}} + \mathbb{EP}_t^{\mathrm{I}} & = & - \mathit{Resale}^{\mathrm{III}} + \mathit{Resale}^{\mathrm{I}} & (a\text{-II}) = (a\text{-IV}) \\
P_t^{\mathrm{IV}} - P_t^{\mathrm{I}} - \mathbb{EP}_t^{\mathrm{III}} & = & - \mathit{Resale}^{\mathrm{III}} + \mathit{Scrap} & (a\text{-I}) = (a\text{-IV}) \\
P_t^{\mathrm{III}} - P_t^{\mathrm{II}} - \mathbb{EP}_t^{\mathrm{II}} + \mathbb{EP}_t^{\mathrm{I}} & = & - \mathit{Resale}^{\mathrm{II}} + \mathit{Resale}^{\mathrm{I}} & (a\text{-II}) = (a\text{-III}) \\
P_t^{\mathrm{III}} - P_t^{\mathrm{I}} - \mathbb{EP}_t^{\mathrm{II}} & = & - \mathit{Resale}^{\mathrm{II}} + \mathit{Scrap} & (a\text{-I}) = (a\text{-III}) \\
P_t^{\mathrm{II}} - P_t^{\mathrm{I}} - \mathbb{EP}_t^{\mathrm{I}} & = & - \mathit{Resale}^{\mathrm{I}} + \mathit{Scrap}. & (a\text{-I}) = (a\text{-II})
\end{array}
$$

Note that valuation terms (V_d, V_c, V_b, and V_a) are canceled out as we are analyzing perfectly substitutable goods.[18]

3.2 Observations and Individual-Level Welfare Implications

The indifference condition system provides the following insightful observations. We first restrict our attention to the case of *stationary equilibrium* (i.e. $P_t^k = \mathbb{EP}_t^k$ for $k \in \{\text{I, II, III, IV}\}$, the price you see today will be the same one you will see upon your resale transaction) with which the indifference condition system has a unique solution. Stationary equilibrium indicates a direction of price distortions caused by each of the three resale-market friction costs. Then, we investigate the case of *non-stationary equilibria* in which a current price could be different from an expected price (i.e P_t^k could differ from $\mathbb{EP}_t^k$) for discussing individual-level welfare implications. For the simplicity of notations, we here omit the time subscript t. Furthermore, we slightly abuse the ticket-vintage index in the way of $k \in \{1, 2, 3, 4, 5\} = \{\text{I, II, III, IV,V}\}$ for simplifying mathematical notations. The linear-algebra-based proofs of the following observations are found in Appendix. Note that in our analyses, the new good (fixed) price and resale market friction costs are exogenous, while resale market prices are endogenously determined.

Observation 2 - *Stationary Equilibrium ($P^k = \mathbb{EP}^k$) - Theoretical Frictionless Resale Prices:*

[18] The left hand side of the system equations are endogenous variables, while the right hand side parameters are exogenous. Under the stationary ($P^k = \mathbb{EP}^k$) assumption, the rank and unknown variables in the left hand side matrix are both four, indicating a unique solution. On the other hand, under the non-stationary (P^k could differ from $\mathbb{EP}^k$) assumption, the rank of left hand side matrix is seven with eight unknown variables, indicating a general solution has one undetermined parameter. See Observation 4 for such a general solution.

If resale market friction costs are all zero (i.e. $Search = Resale^{\text{IV}} = Resale^{\text{III}} = Resale^{\text{II}} = Resale^{\text{I}} = Scrap = 0$), there is a unique solution of the indifference condition system, $P^k = \mathbb{E}\mathbb{P}^k = \frac{k}{5}\overline{P}^{\text{V,New}}$ for $k \in \{\text{I, II, III, IV}\}$.

Observation 2 provides us with the basis of individual-level welfare loss analyses. In our empirical investigation, the listed price is $\overline{P}^{\text{V,New}} = \$115$ (= €95 = £75). Consequently, we denote theoretical frictionless prices of each type of ticket as $P^{\text{IV,Theo}} = \$92$ (= €76 = £60), $P^{\text{III,Theo}} = \$69$ (= €57 = £45), $P^{\text{II,Theo}} = \$46$ (= €38 = £30), and $P^{\text{I,Theo}} = \$23$ (= €19 = £15).

Next, we investigate resale market price distortions caused by friction costs. The following observation summarizes the implications of resale price distortions in a stationary equilibrium.

Observation 3 - *Unique Stationary Equilibrium ($P^k = \mathbb{E}\mathbb{P}^k$) - Mixed Directions of Resale Price Distortions:*

If $Search > 0$, $Resale = Resale^{\text{IV}} = Resale^{\text{III}} = Resale^{\text{II}} = Resale^{\text{I}} > 0$, and $Scrap > 0$, there is a unique solution of the indifference condition system,

$$P^k = \mathbb{E}\mathbb{P}^k = \frac{k}{5}(\overline{P}^{\text{V,New}} - Search) + \frac{5-k}{5}Resale - \frac{5-k}{5}Scrap,$$

for $k \in \{\text{I, II, III, IV}\}$.

Observation 3 indicates that, even in a unique stationary equilibrium, the directions of price distortions depend on the size of friction costs. Thus, an empirical estimation is required for understanding the causes of such price distortions and investigating welfare implications. The comparisons between theoretical prices (based on Observation 2) and distorted resale prices (based on Observation 3) are summarized in Table 1. In Table 1, the row of a vintage V (brand new) ticket that has the exogenous and fixed price of $\overline{P}^{\text{V,New}}$ is supplementarily added for a comparison purpose. Notably and interestingly, in Table 1, there is a discontinuity in coefficients of search-and-bidding cost ($Search$) between vintage V (brand new good) and IV (slightly used good).

Now we move to a class of non-stationary (i.e. P^k could differ from $\mathbb{E}\mathbb{P}^k$) equilibria.

Observation 4 - *Non-Stationary Equilibrium (P^k could differ from $\mathbb{E}\mathbb{P}^k$) - General Solutions:*

If $Search > 0$, $Resale = Resale^{\text{IV}} = Resale^{\text{III}} = Resale^{\text{II}} = Resale^{\text{I}} > 0$, and $Scrap > 0$, solutions of

Table 1: Resale Price Distortions in Stationary Equilibrium ($P^k = \mathbb{EP}^k$)

Vintage category	Price in Frictionless Resale Markets	Price in Frictional Markets ($Search > 0$, $Resale > 0$, and $Scrap > 0$)	Price Distortion Caused by Resale Market Frictions
V: valid for five rides (brand new good)	$\frac{5}{5} P^{\mathrm{V,New}}$	$\frac{5}{5}\overline{P}^{\mathrm{V,New}} - \frac{0}{5} Search + \frac{0}{5} Resale - \frac{0}{5} Scrap$	$-\frac{0}{5} Search + \frac{0}{5} Resale - \frac{0}{5} Scrap$
IV: ...... four rides (slightly used good)	$\frac{4}{5} P^{\mathrm{V,New}}$	$\frac{4}{5}\overline{P}^{\mathrm{V,New}} - \frac{4}{5} Search + \frac{1}{5} Resale - \frac{1}{5} Scrap$	$-\frac{4}{5} Search + \frac{1}{5} Resale - \frac{1}{5} Scrap$
III: ...... three rides (moderately used good)	$\frac{3}{5} P^{\mathrm{V,New}}$	$\frac{3}{5}\overline{P}^{\mathrm{V,New}} - \frac{3}{5} Search + \frac{2}{5} Resale - \frac{2}{5} Scrap$	$-\frac{3}{5} Search + \frac{2}{5} Resale - \frac{2}{5} Scrap$
II: ...... two rides (slightly heavily used good)	$\frac{2}{5} P^{\mathrm{V,New}}$	$\frac{2}{5}\overline{P}^{\mathrm{V,New}} - \frac{2}{5} Search + \frac{3}{5} Resale - \frac{3}{5} Scrap$	$-\frac{2}{5} Search + \frac{3}{5} Resale - \frac{3}{5} Scrap$
I: ...... one ride (heavily used good)	$\frac{1}{5} P^{\mathrm{V,New}}$	$\frac{1}{5}\overline{P}^{\mathrm{V,New}} - \frac{1}{5} Search + \frac{4}{5} Resale - \frac{4}{5} Scrap$	$-\frac{1}{5} Search + \frac{4}{5} Resale - \frac{4}{5} Scrap$

The row of a vintage V ticket, which has the exogenous and fixed price of $\overline{P}^{\mathrm{V,New}}$, is added for comparison.
There is a discontinuity in coefficients of search-and-bidding cost (*Search*) between vintage V (brand new good) and IV (slightly used good).

the indifference condition system can be written as,

$$\begin{bmatrix} P^{\mathrm{IV}} \\ P^{\mathrm{III}} \\ P^{\mathrm{II}} \\ P^{\mathrm{I}} \\ \mathbb{EP}^{\mathrm{IV}} \\ \mathbb{EP}^{\mathrm{III}} \\ \mathbb{EP}^{\mathrm{II}} \\ \mathbb{EP}^{\mathrm{I}} \end{bmatrix} = \begin{bmatrix} 4/5 \\ 3/5 \\ 2/5 \\ 1/5 \\ 4/5 \\ 3/5 \\ 2/5 \\ 1/5 \end{bmatrix} (\overline{P}^{V,New} - Search) + \begin{bmatrix} 1/5 \\ 2/5 \\ 3/5 \\ 4/5 \\ 1/5 \\ 2/5 \\ 3/5 \\ 4/5 \end{bmatrix} Resale + \begin{bmatrix} -1/5 \\ -2/5 \\ -3/5 \\ -4/5 \\ -1/5 \\ -2/5 \\ -3/5 \\ -4/5 \end{bmatrix} Scrap + \begin{bmatrix} 1/5 \\ 2/5 \\ 3/5 \\ 4/5 \\ -4/5 \\ -3/5 \\ -2/5 \\ -1/5 \end{bmatrix} s, \quad (1)$$

where $s \in \mathbb{R}$ is a scalar parameter.

The above observation indicates infinite number of equilibrium solutions, as a solution with an arbitrary parameter $s \in \mathbb{R}$ satisfies the indifference condition system. Note that if $s \neq 0$, the system solutions are non-stationary (and asymmetric) in the sense that $P^k \neq \mathbb{EP}^k$ for $k \in \{\mathrm{I, II, III, IV}\}$. In equation (1), the last term (the term that contains an arbitrary parameter s) has the positive vector elements for P^k_ts and the negative ones for $\mathbb{EP}^k_t$s, indicating the possibility of a bubbling (i.e. $P^k < \mathbb{EP}^k$ with $s < 0$) or a busting ($P^k > \mathbb{EP}^k$ with $s > 0$) equilibrium.[19]

Next, by assigning the equilibrium prices in Observation 4 to the utility functions [(d-V) to (a-I)], we can derive the individual buyer level utility losses caused by resale market friction costs. By counterfactually positing that the resale market with and without friction costs share the same parameter

[19] In the case of non-stationary equilibrium, the other conditions, such as $P^{\mathrm{IV}} < \overline{P}^{\mathrm{V,New}}$, $\mathbb{EP}^{\mathrm{IV}} < \overline{P}^{\mathrm{V,New}}$, $P^{\mathrm{I}} > 0$, and $\mathbb{EP}^{\mathrm{I}} > 0$ (i.e. resale prices are between zero and a new good price), have to be satisfied.

Table 2: Utility Loss in Non-Stationary (P^k may not be equal to $\mathbb{EP}^k$) Equilibria

User Type	Utility in Frictionless Resale Markets	Utility in Frictional Markets ($Search > 0$, $Resale > 0$, and $Scrap > 0$)	Utility Loss Caused by Resale Market Frictions
e: demanding five train rides	$V_e - \frac{5}{5}P^{\mathrm{V,New}} - \frac{0}{5}s$	$V_e - \frac{5}{5}P^{\mathrm{V,New}} - \frac{0}{5}Search - \frac{0}{5}Resale - \frac{5}{5}Scrap - \frac{0}{5}s$	$-\frac{0}{5}Search - \frac{0}{5}Resale - \frac{5}{5}Scrap$
d: ...... four	$V_d - \frac{4}{5}P^{\mathrm{V,New}} - \frac{1}{5}s$	$V_d - \frac{4}{5}P^{\mathrm{V,New}} - \frac{1}{5}Search - \frac{1}{5}Resale - \frac{4}{5}Scrap - \frac{1}{5}s$	$-\frac{1}{5}Search - \frac{1}{5}Resale - \frac{4}{5}Scrap$
c: ...... three	$V_c - \frac{3}{5}P^{\mathrm{V,New}} - \frac{2}{5}s$	$V_c - \frac{3}{5}P^{\mathrm{V,New}} - \frac{2}{5}Search - \frac{2}{5}Resale - \frac{3}{5}Scrap - \frac{2}{5}s$	$-\frac{2}{5}Search - \frac{2}{5}Resale - \frac{3}{5}Scrap$
b: ...... two	$V_b - \frac{2}{5}P^{\mathrm{V,New}} - \frac{3}{5}s$	$V_b - \frac{2}{5}P^{\mathrm{V,New}} - \frac{3}{5}Search - \frac{3}{5}Resale - \frac{2}{5}Scrap - \frac{3}{5}s$	$-\frac{3}{5}Search - \frac{3}{5}Resale - \frac{2}{5}Scrap$
a: ...... one	$V_a - \frac{1}{5}P^{\mathrm{V,New}} - \frac{4}{5}s$	$V_a - \frac{1}{5}P^{\mathrm{V,New}} - \frac{4}{5}Search - \frac{4}{5}Resale - \frac{1}{5}Scrap - \frac{4}{5}s$	$-\frac{4}{5}Search - \frac{4}{5}Resale - \frac{1}{5}Scrap$

The row of type e buyer who has a demand of five train rides is added for comparison.

value of s, we get the following proposition that will be the basis of our welfare analyses.[20] Note that the proposition below holds for any values of s.

Proposition 5 - *Non-Stationary Equilibria (P^k could differ from $\mathbb{EP}^k$) - Individual-Level Welfare Loss:*

The individual level utility loss caused by the resale market friction costs to a durable goods buyer who demands the degree of D usage (train rides) is

$$WelfareLoss(D) = -\underbrace{\frac{5-D}{5}}_{\text{reversely-proportional}} Search \; - \underbrace{\frac{5-D}{5}}_{\text{reversely-proportional}} Resale \; - \underbrace{\frac{D}{5}}_{\text{proportional}} Scrap, \tag{2}$$

where $D \in \{1,2,3,4,5\}$ is a demanded durable good usage index.

Table 2 summarizes the findings of welfare distortions created by the resale market friction costs. The second column reports utilities achieved with hypothetical frictionless resale market prices, while the third column addresses utilities attained with frictional resale market prices. The last column states the gaps between unitilies obtained from frictionless and frictional resale markets. In addition, Figure 5, under the assumption of no search cost ($Seach = 0$), visually illustrates the individual-level welfare losses categorized by the intended degree of usage. The height dimension is an individual-level welfare loss ($WelfareLoss(D)$), the width dimension is a search cost ($Search$), and the depth dimension is a resale cost ($Resale$). There are three immediate individual-level welfare implications in this proposition. First, welfare loss is *heterogeneous* across buyers who demand a different degree of durable good usage. Furthermore, the degree of heterogeneities increases as search and resale costs become large, as depicted in Figure 5. Second, the coefficients of a search cost ($Search$) and a resale cost ($Resale$) are *reversely-*

[20] This counterfactual argument is legitimate since it is pragmatically not feasible to obtain data of frictionless resale markets (that do not exist in a real world setting) and estimate the parameter s of such fictionless marekts.

proportional to the intended usage. This means the utility loss caused by an additional increase in search or resale costs is relatively large among buyers who demand a smaller degree of usage. Third, contrary to the second finding, the coefficient of a scrap cost ($Scrap$) is *proportional* to the usage.

Proposition 5 distills the fundamental role of competitive resale markets; competitive resale good markets proportionally or reverse-proportionally split negative externalities caused in resale transactions, based on buyers' intended degrees of durable goods usage. Note that any resale market transaction intrinsically creates negative externalities. If Alice wants to resell her durable good, that means she is implicitly asking a buyer in a durable good market to sacrifice a search cost to find Alice's good. Oppositely, if Ben wants buy a used good, he is essentially requesting a seller in a resale market to endure a resale cost to transfer a good to Ben. Furthermore, if Chris attempts to sell his currently own good rather than scrapping it, he is fundamentally appealing to a next (or subsequent) owner to forgo a scrap cost. Durable good resale markets, in a nutshell, are tools to transfer and split such durable goods related negative externalities.[21]

3.3 Effect of Sales Taxes

Next, we investigate the effect of sales taxes. We here analyze the three taxes that are proportionally charged on transacted prices: a buyer-side sales tax on a new good with the rate of τ_B^{New}, a buyer-side sales tax on a resale good with the rate of τ_B, and a seller-side sales tax on a resale good with the rate of τ_S.[22] Note that if a market organizer (e.g. eBay, Yahoo! Auction, etc.) charges a seller a fee that is proportional to a transacted price, one can include such a proportional fee in τ_S. Accordingly, utility functions can be modified with these taxes. For example, type d buyer's utility functions become

$$\begin{aligned}
U_d^{\mathrm{V,New}} &= V_d - (1+\tau_B^{\mathrm{New}})\overline{P}^{\mathrm{V,New}} + (1-\tau_S)\,\mathbb{EP}^{\mathrm{I}} - \mathit{Resale} && (d\text{-V})' \\
U_d^{\mathrm{IV}} &= V_d - (1+\tau_B)P^{\mathrm{IV}} - \mathit{Search} - \mathit{Scrap}. && (d\text{-IV})'
\end{aligned}$$

[21]Note that proportional or reversely proportional coefficients in (2) could be interpreted in a Vickrey-Clarke-Groves (VCG) mechanism fashion.

[22]Note that some countries, including Japan, apply a value-added-based taxation system of $\tau_B^{\mathrm{New}} > 0$ and $\tau_B = 0$ since a treasury of such a country legislatively interpret that a used good transaction in a resale market does not add a value to a good. In other words, they hold that resale goods do not add value and, thus, not taxable.

As described in the above utility functions, the existence of sales taxes does not change the structure and rank of indifference condition system,[23] and the solutions of indifference condition system equations are characterized as

$$\begin{bmatrix} P^{\mathrm{IV}} \\ P^{\mathrm{III}} \\ P^{\mathrm{II}} \\ P^{\mathrm{I}} \\ \mathbb{EP}^{\mathrm{IV}} \\ \mathbb{EP}^{\mathrm{III}} \\ \mathbb{EP}^{\mathrm{II}} \\ \mathbb{EP}^{\mathrm{I}} \end{bmatrix} = \begin{bmatrix} (1+\tau_B)^{-1} \\ (1+\tau_B)^{-1} \\ (1+\tau_B)^{-1} \\ (1+\tau_B)^{-1} \\ (1-\tau_S)^{-1} \\ (1-\tau_S)^{-1} \\ (1-\tau_S)^{-1} \\ (1-\tau_S)^{-1} \end{bmatrix} .\times \left\{ \begin{bmatrix} 4/5 \\ 3/5 \\ 2/5 \\ 1/5 \\ 4/5 \\ 3/5 \\ 2/5 \\ 1/5 \end{bmatrix} \Big((1+\tau_B^{\mathrm{New}})\overline{P}^{\mathrm{V,New}} - \mathit{Search} \Big) + \begin{bmatrix} 1/5 \\ 2/5 \\ 3/5 \\ 4/5 \\ 1/5 \\ 2/5 \\ 3/5 \\ 4/5 \end{bmatrix} \mathit{Resale} + \begin{bmatrix} -1/5 \\ -2/5 \\ -3/5 \\ -4/5 \\ -1/5 \\ -2/5 \\ -3/5 \\ -4/5 \end{bmatrix} \mathit{Scrap} + \begin{bmatrix} 1/5 \\ 2/5 \\ 3/5 \\ 4/5 \\ -4/5 \\ -3/5 \\ -2/5 \\ -1/5 \end{bmatrix} s \right\}, \quad (3)$$

where $s \in \mathbb{R}$ is a scalar parameter and $.\times$ is an element-by-element multiplication operator. Then, by substituting these equilibrium prices, we get the following observation.

Observation 6 - *Non-Stationary Equilibria ($(1+\tau_B)P^k$ could differ from $(1-\tau_S)\mathbb{EP}^k$) - Sales Tax Rate Invariance:*

The individual-level welfare loss caused by resale-market friction costs are invariant to buyer- and seller-side sales tax rates.

Note that, with these sales taxes, the contents of Table 2 that describe individual-level utilities remain the same, except the minor change that $\overline{P}^{\mathrm{V,New}}$ is replace by $(1+\tau_B^{\mathrm{New}})\overline{P}^{\mathrm{V,New}}$.

3.4 Heterogeneous Welfare Effects of Resale Market Friction Costs

The findings in individual-level welfare loss can be easily connected to the market-level welfare analysis as depicted in Figures 6 to 9. In each of these figures, the demand of type e buyer (who demands five train rides) is drawn at the left-most position, that of type d (who demands four train rides) is second from the left, and other types of buyers' demands are illustrated in the same way. Note that these figures are for describing welfare of durable good buyers and not for describing markets for each vintages of durable goods. For this reason, the horizontal axises are for describing the demanded quantities of each type of buyers, and we use the notation of Q_e, Q_d, Q_c, Q_b, and Q_a for conceptually representing them. Figure 6 illustrates the welfare gain if resale opportunities were prohibited.[24] Figure 7 describes the welfare

[23] Precisely describing, if we redefine after-tax new good prices as $\overline{\rho}^{\mathrm{V,New}} = (1+\tau_B^{\mathrm{New}})\overline{P}^{\mathrm{V,New}}$, resale market prices as $\rho^k = (1+\tau_B)P^k$, and expected resale market prices as $\mathbb{E}\rho^k = (1-\tau_S)\mathbb{EP}^k$, the mathematical structure of indifference condition system equations preserves.

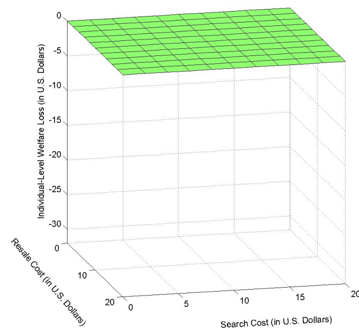
[24] Prohibition of resale opportunities is not unrealistic as in the cases of airline, some sports events (e.g. Olympic games), and music concert tickets. For example, in the U.K., it is a legal offense to resale football/soccer match tickets under the Parliament

that could be generated when resale opportunities are allowed in frictionless (i.e. no resale related costs) resale markets. As described in Observation 2, the resale prices are proportional to the remaining usage of durable goods, and a welfare gain is generated though the legalization of resale markets. However, as characterized in Proposition 5, the existence of resale market friction costs dwarfs such welfare gain, as represented in Figure 8. The structure of welfare loss is two-fold. The first and direct loss is caused by disutility resulting from resale market friction costs in a buyer's utility function. The second loss is caused by the changes in resale market prices that also appear in utility functions. Note that this second loss could be positive or negative as described by the mixed price distortions directions in Observation 3. Lastly, the dead-weight loss is illustrated in Figure 9, and the height of loss within each type of demand is characterized in Proposition 5.[25]

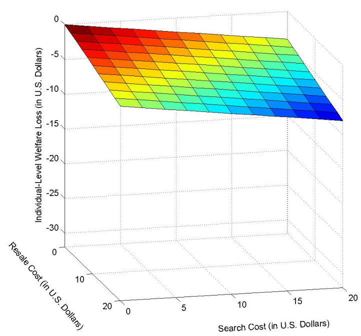
Act in 1994.

[25]A numerical evaluation of dead-weight loss caused by resale market friction costs requires entire-market-level transaction data, and it is beyond the scope of this research. We leave such an assessment as an open agenda for future researchers who are able to obtain detailed transaction data from both primary and secondary markets. It should be credited that, in the case of limited supply in a primary market, Leslie and Sorensen (2014) (who analyze rock concert ticket markets) assess the dead-weight loss through counterfactual simulations.

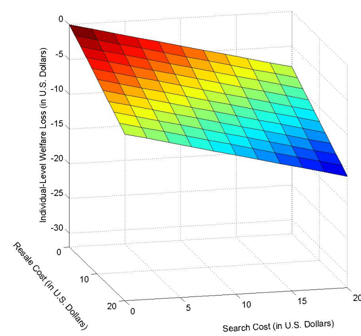
Figure 5: Individual-Level Welfare Losses (with $Scrap = 0$)



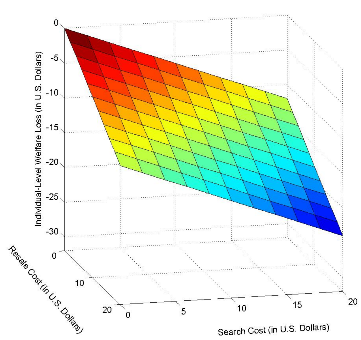
(a) Type e User (Who has the demand of five rides) - No Welfare Loss



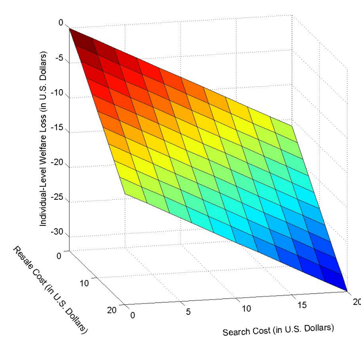
(b) Type d User (Who has the demand of four rides)



(c) Type c User (Who has the demand of three rides)



(d) Type b User (Who has the demand of two rides)



(e) Type a User (Who has the demand of one ride)

Figure 6: Welfare among Users without Resale Markets

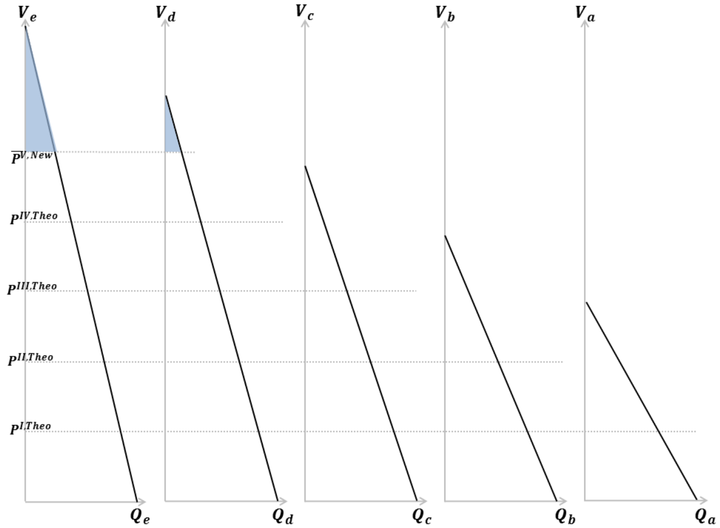


Figure 7: Welfare among Users with Frictionless Markets

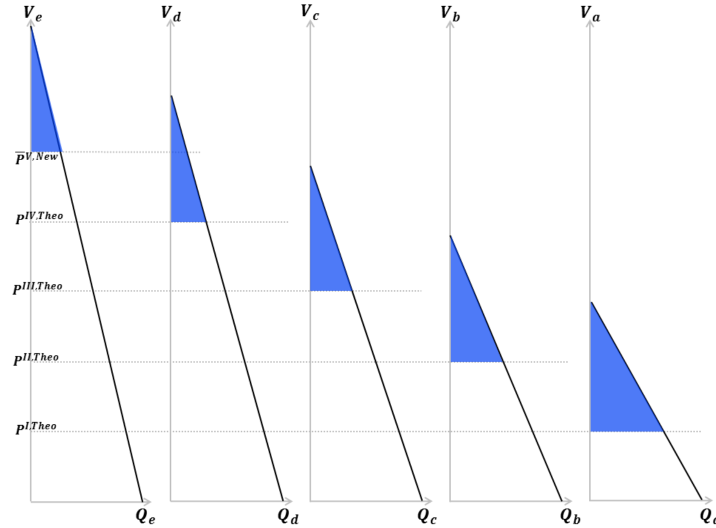


Figure 8: Welfare among Users with Resale Market Friction Costs

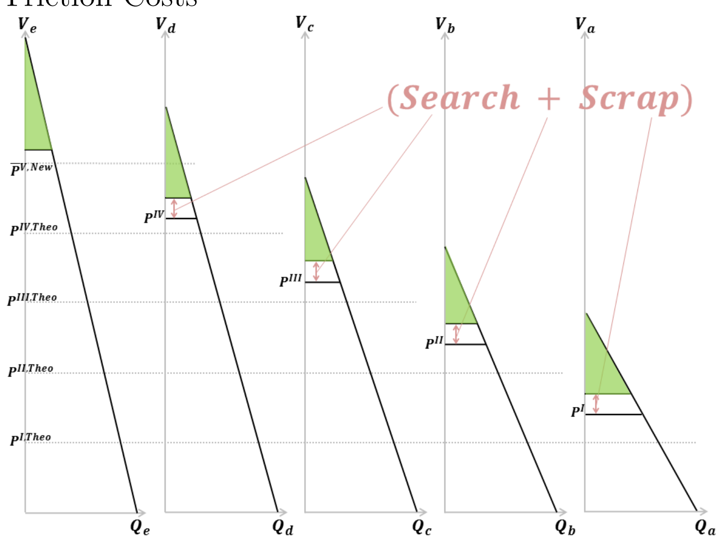
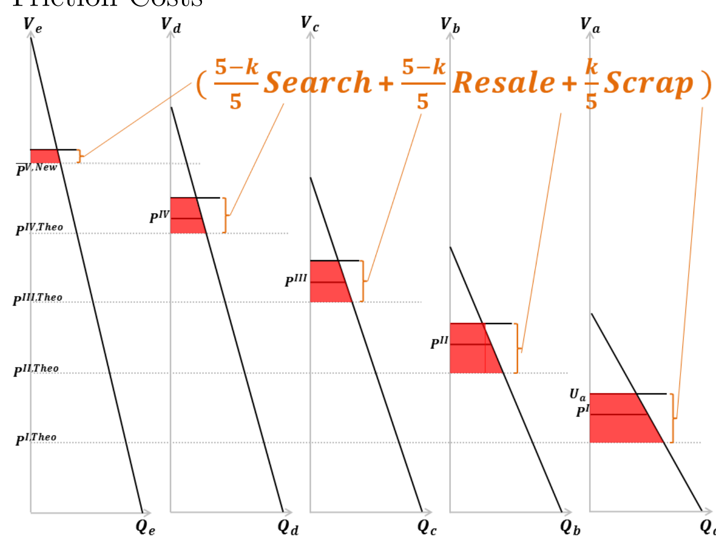


Figure 9: Welfare Losses Caused by Resale Market Friction Costs



4 Estimation Methods and Results

This section first explains the three types of expected price constructions that will be used for the GMM estimations. Then, we report the GMM estimation results based on the closed-form resale market price solution equations of (3). We also calculate Heteroskedasticity Autocorrelation Consistent (HAC) standard errors and report the results of over-identification tests.

4.1 Empirical Constructions of Expected Resale Prices

The construction of the expected resale prices at time t, denoted as $\mathbb{EP}_t^k$ where $k \in \{\mathrm{I}, \mathrm{II}, \mathrm{III}, \mathrm{IV}\}$ is a used ticket vintage index, plays a crucial role in our empirical investigations. Here, for the robustness checks, we investigate the three different constructions of expected resale prices: (1) averaged subsequent transaction price, (2) present-price-biased stationary price, and (3) ten-day-later later price construction methods.

(1) Averaged Subsequent Transaction Price Construction:

The next construction uses the auction market transaction-level data for calculating the expected resale prices. We here denote n_t^k as a number of transacted sales of vintage k tickets at time t. Then, we calculate an expected resale price in the following simple fashion of

$$\mathbb{EP}_t^k = \frac{1}{N_{t,\mathrm{After}}^k} \sum_{a=t+1}^{T} \sum_{j=1}^{n_a^k} p_{a,j}, \tag{4}$$

where $N_{t,\mathrm{After}}^k = \sum_{a=t+1}^{T} n_a^k$ is a number of observed transacted sales of vintage k tickets recorded after time t, $a \in \{t+1, \cdots, T\}$ is an index for periods after the period t, $p_{a,j}$ is a recorded transacted price, and $j \in \{1, \cdots, n_a^k\}$ is a transaction index. Intuitively, this definition of expected price assumes that a bidder who buys a ticket today with the intention of reselling (the unused proportion of the ticket) later has a likelihood to resale based on the empirically observed resale transaction frequency in the online auction market. In other words, a buyer (who buys a resalable ticket today) stochastically chooses her timing of the resale day with the probability that agrees with empirically observed subsequent resale good transaction frequency.

(2) Stationary (Present-Price-Biased) Price Construction:

The natural starting point of examination is

$$\mathbb{E}\mathbb{P}_t^k = P_t^k, \tag{5}$$

as suggested by the Observations 2 to 3. This construction empirically assumes that buyers in our empirically analyzing market believe that, after a train ride (or train rides) they will be able to resale the used ticket at a currently (on a purchasing date) observed price.

(3) One-Week-Later Ad Hoc Price Construction:
The last construction assumes that a reseller returns to a market in approximately one week after she purchased it.

$$\mathbb{E}\mathbb{P}_t^k = P_{t+7,\text{Moving Average}}^K, \tag{6}$$

Although this construction is *ad hock* in terms of the resale date, it has the advantage of capturing the traveling periods after the purchase date.

4.2 Estimation Method and Results

Given the above constructions of expected prices, we here apply the two-step GMM estimation method. As observed prices within each ticket vintage are time series data, serial correlations are naturally expected to emerge. For this reason, we apply the Heteroskedasticity Autocorrelation Consistent (HAC) method for calculating weight matrices and standard errors. Specifically, we apply the Bartlett Kernel for computing covariance matrices. Note that this GMM estimation has eight moments (of closed form solutions of resale market prices) and three estimating parameters (*Search*, *Resale*, and s). Thus, overidentification and model validity test can be examined.

The estimation results are listed in Table 3 (excluding the term of *Scrap*, which set to be zero in our empirical investigation). We estimated resale market friction costs (*Search* and *Resale*) and market condition (s) parameters under the three types of expected price constructions discussed previously. It turns out that the estimates of *Search* are stable across different constructions, while *Resale* and s both change under the different specifications. Especially, the stationary (present-price-biased) model provides

Table 3: Estimation Results⋆ (2013, Summer)

Resale market parameter	(1) Averaged-subsequent transaction price construction	(2) Stationary (present-price-biased) price construction	(3) One-week-later ad hoc price construction
$Search^{\dagger}$	\$6.752***	\$6.374***	\$6.622***
	(0.296)	(0.689)	(0.352)
$Resale^{\ddagger}$	\$10.03***	\$14.88***	\$12.83***
	(0.021)	(0.581)	(0.210)
s	8.745***	N.A.	5.853***
	(0.195)	(N.A.)	(0.235)
Number of periods	33	33	33
J-statistic	4.659	4.487	4.561
(p-value)	(0.459)	(0.482)	(0.472)

⋆: Inside of brackets are HAC standard errors, **** indicates the significance with 1%
†: Used good buyer-side search-and-bidding cost
‡: Used good seller-side reselling cost
Note: Scrap cost ($Scrap$) fixed at zero.

the highest resale cost and lowest market condition parameter.

In Table 3, all parameters have significance at 1% level. Additionally, calculated p-values indicate that the model moments conditions are not rejected. Thus, our structual motel is not rejected by the observed data. Furthermore, all estimated cost parameters are reasonably large (ranging from approximately \$6 to \$14), indicating the importance of empirically investigating resale market friction costs. Given these empirical findings, we now proceed to the welfare loss analyses.

5 Individual-Level Welfare Loss Implications

In this section, we discuss individual-level welfare loss analyses caused by the resale market friction costs. The effects are largely heterogeneous and described as disadvantages for durable goods users who purchase them with the intention of a relatively short degree of usage.

Table 4: Individual-Level Welfare Loss: with $\widehat{Search} > 0$, $\widehat{Resale} > 0$, and $Scrap = 0$, Summer 2013

User Type	(1) Averaged-subsequent transaction price construction	(2) Stationary (present-price-biased) price construction	(3) One-week-later ad hoc price construction
e: demanding five train rides	-$ 0.000 (- 0.0%)	-$ 0.000 (- 0.0%)	-$ 0.000 (- 0.0%)
d: ...... four	-$ 3.356 (- 2.9%)	-$ 4.251 (- 3.7%)	-$ 3.890 (- 3.4%)
c: ...... three	-$ 6.713 (- 5.8%)	-$ 8.502 (- 7.4%)	-$ 7.781 (- 6.8%)
b: ...... two	-$10.069 (- 8.8%)	-$12.752 (-11.1%)	-$11.671 (-10.1%)
a: ...... one	-$13.426 (-11.7%)	-$17.003 (-14.8%)	-$15.562 (-13.5%)

Inside of parentheses are percentages of the new goods price ($115).
The row of type e buyer who has a demand of five train rides is added for comparison.

5.1 Empirical Individual-Level Welfare Loss: Heterogeneous Effects

Based on the estimation results reported in Table 3, the heterogeneous and individual-user-level welfare-loss effects are calculated based on equation (2) with estimated search and resale cost parameters under three different constructions of expected resale prices, listed as (1), (2), and (3) in Table 4. For our empirical analyses, that we assume $Scrap = 0$. Note that individual-level welfare deteriorates thorough two channels. The first channel is resale-market friction costs ($Search$ and $Resale$) that directly appear in the utility functions. The second channel is resale market prices. Under the competitive resale market condition, resale market prices (that users have to accept) are affected by resale market friction costs, as expressed by the closed form solution in equation (1) (or equation (3)).

There are two major findings in Table 4. First, if durable goods users do not intend to use up goods, the size of welfare-loss is non-negligibly large. The only user type who is free from welfare loss is a type e user (who has the demand of five rides) and who intends to use up the train rides. Second, although the degree of welfare losses slightly vary across different expected resale price constructions (i.e. across (1) to (3)), we empirically find that they significantly differ across user types (i.e across user type e to a). For example, under the construction of (1), individual-level welfare losses differ from -2.9% (for a type d user who intends to use four times) to -11.7% (for a type a user who intends to use only one time) of the new good price.

Descriptively speaking, these individual-level welfare losses could be considered as "hidden charges" levied on the resale market participants, and some potential durable goods users are excluded from the markets as their willingness-to-pays are not large enough to justify these hidden changes. Lastly, as $Search \to 0$ and $Resale \to 0$ (and in our general model, $Scrap \to 0$), these individual-level welfare losses converge to zero, enabling frictionless resale markets without any welfare loss and enabling more potential users (who have relatively low willingness-to-pays) to purchase durable goods.

6 Conclusion

By proposing the structural model of competitive resale markets with no arbitrage conditions and by using the unique dataset of perfectly substitutable durable goods, this research empirically assesses the individual-level welfare losses caused by resale market friction costs. Traditionally, resale market friction costs are not included in empirical durable goods market investigations due to model tractability concerns, yet our estimation results newly show that such individual-level welfare losses are non-negligibly large and largely heterogeneous across users with differing degrees of intended durable goods usage. Such individual-level welfare losses could be considered as "hidden charges" on participants of durable goods resale markets. Such hidden charges make some buyers excluded from both new and used goods markets. As the markets of quickly-circulating durable goods are rapidly growing and expanding in scope, these new findings will be the basis of further investigations of a broader categorization of online-traded durable goods.

Lastly, the scope of external validities and limitations of these results should be clearly mentioned. The goods investigated in this research differ from general durable goods (mobile phones, electric devices, cars, houses, etc.) in at least two dimensions: imperfect substitutability and perfect planning on durable goods usage. First, if durable goods are imperfectly substitutable, a buyer has less utility (or disutility) when she fails to obtain her most desired good. In this case, such disutility is considered as another friction cost, and it straight-forwardly transmits through competitive resale market prices. As a result, imperfect substitutability negatively contributes to an individual-level welfare loss.[26] Thus, an individual-level welfare loss in imperfectly-substitutable durable good markets is expected to be larger than the one with perfectly-substitutable markets expressed in Equation (2). Second, if there are imperfectly-planning durable good users, the individual-level welfare analyses have unclear implications. Note that our em-

[26] Provide a simple example of this disutility and further welfare loss in Appendix.

pirical analyses can reasonably assume a train traveler knows her intended usage as they have to decide their travel plans in advance (to coordinate with their other travel arrangements, such as hotel bookings and schedule coordination with other people). In addition, this assumption of perfectly-planning durable good users agrees with the recent trend of resale-aimed purchases with planned temporary ownership, described in the introduction. However, in many durable goods markets, users have vague plans for the timing of their reselling. The inclusion of such imperfectly-planning users inevitably requires dynamic programmings and is computationally challenging. Yet, given the importance of durable goods markets and associated welfare implications in the real world, empirical and structural investigations with imperfectly-planning users are an essential direction of future research.

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