

## Creative Destruction in Organizational Capital: Evidence from the Online Platform Economy in Japan and the United States

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Paper prepared for the 35th IARIW General Conference

Copenhagen, Denmark, August 20-25, 2018

Session 6C-2: New Types of Capital

FRIDAY, AUGUST 24 11:00-12:30

## Creative Destruction in Organizational Capital: Evidence from the Online Platform Economy in Japan and the United States

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Date: August 18, 2018

#### Abstract

Because of improved programming capabilities and the rapid price decline of information technology hardware, new business models have arisen and many of them embodied into different types of online platforms. For example, online sharing platforms, such as Uber and Airbnb, increase the efficiency of underutilized assets and lower the consumption prices of the services. Online retail platforms, such as Amazon Marketplace, have greatly reduced transaction costs for many small and medium sized enterprises to sell products across states and across borders. Online platforms, mostly created and run by young companies, are asset-light but have grown fast and deeply disrupted many industries. A prominent example is Airbnb, a company that has only 600 employees but the number of its listed properties has surpassed that of the world's largest hotel chain. Moreover, according to the European Commission (2015), between 2001 and 2011, online platforms accounted for 55% of U.S. GDP growth and 30% of GDP growth in the European Union.

In this paper, we develop a model where, in a service industry, a firm uses two types of inputs, labor and organizational capital to produce outputs. In this model, we examine how the introduction of an online platform affects a firm's value, investment behavior in organizational capital, and performance. The key hypothesis is that: when an online platform is introduced in the industry, non-platform participating incumbents cannot adjust their operational size and employment level in the short run, causing the deprecation of the incumbent's organizational capital. That is, the existing non-platform participating incumbent will see its organizational capital depreciate faster, which reduces its stock of organizational capital, and hence, its stock price. Based on sources from Compustat, Nikkei Financial Quest, NYSE, NASDAQ, and the Tokyo Stock Exchange, the initial data cover the hotel and transportation industries in both Japan and the U.S. for the period of 2002 to 2017.

Several preliminary findings are as follows: First, we measure the intangible assets of online platform participating companies and their non-participating counterparts in both Japanese and U.S. hotel and transportation industries. Second, platform participating firms have a higher degree of organizational capital intensity and accumulate a higher stock of organizational capital. Third, the creative destruction of the online platform technology has

<sup>&</sup>lt;sup>1</sup> The views expressed are those of the author and do not necessarily reflect those of the U.S. Bureau of Economic Analysis.

been shown in the comparison of the estimated depreciation rates of organizational capital between the two groups. In general, the higher depreciation rate of organizational capital for existing non-platform participating incumbents implies that the value of their organizational capital is declining faster. Fourth, by using a machine learning technique on a sample of 42,573 daily stock price observations, we show that the shock of the online platform technology caused a negative impact on the stock prices of existing non-platform participating incumbents but a positive impact on their platform participating counterparts. Moreover, we find that when there is a new online platform technology shock, while we will not observe an immediate impact on output or employment, rather than total factor productivity, the effect of the introduction of the new technology operates through the depreciation of organizational capital. As a result, we will observe an immediate effect in a firm's value and investment rate. This important finding supports Brynjolfsson et al.'s (2017) conclusion that there is a significant lag between the rapid advances in technologies due to the rise of new general purpose technologies and their impacts on an economy's productivity growth. Lastly, based on our ridesharing service study, we propose a new way to indirectly measure the welfare impacts of online platforms.

#### 1. Introduction

Because of improved programming capabilities and the rapid price decline of information technology hardware, new business models have arisen and many of them embodied into different types of online platforms. For example, online sharing platforms, such as Uber and Airbnb, increase the efficiency of underutilized assets and lower the consumption prices of the services. Online retail platforms, such as Amazon Marketplace, have greatly reduced transaction costs for many small and medium sized enterprises to sell products across states and across borders. Online platforms, mostly created and run by young companies, are assetlight but have grown fast and deeply disrupted many industries. A prominent example is Airbnb, a company that has only 600 employees but the number of its listed properties has surpassed that of the world's largest hotel chain. Moreover, the size and the scale of online platforms have been growing rapidly. For example, a recent Brookings' study based on Census data shows that the U.S. ridesharing service has been experiencing a hyper-growth rate and is predicted to take over the taxi services in the near future (Hathaway and Muro, 2017). The trend exhibits a fast growth of the online platform economy in service industries across the globe. For example, PricewaterhouseCoopers has estimated that the main sectors of the online sharing economy could represent US \$335 billion in revenue worldwide by 2025 (Matzler et al., 2015). Lastly, according to the European Commission (2015), between 2001 and 2011, online platforms accounted for 55% of U.S. GDP growth and 30% of GDP growth in the European Union.

The rapid rise of the online platform economy also motivates technology firms to aggressively invest in enabling technologies. For example, Google's investment in the platform

of Google Map which allows Google to collect abundant user data, an asset that not only produces tremendous economic benefits to Google but also helps Google develop driverless cars. Note that it is reported that Google's driverless car project is to eventually rid the need for households to own cars by using rental services. Google's goal is similar to the concept of Zipcar. A survey on Zipcar members finds that nearly 50% of its members, mostly in urban areas and college campuses, can avoid purchasing a car (Eha, 2013). An OECD study on the use of selfdriving cars in Lisbon finds that sharing driverless cars could reduce the number of cars needed by 80-90% (The Economist, 2016). That is, the sharing platform not only can increase the efficiency of underutilized assets but can also accelerate technological progress in the economy. Moreover, lower consumption costs offered by online platform companies also allow consumers to have more resources spent on other goods and services.

Because online platform companies are creating new business models that are challenging the existing ones in established industries, negatively affected firms in those industries are requesting more regulations as shown in the cases of Uber ridesharing service ban in some East Asian and European countries. To provide important policy implications, we need to better measure the activities related to the online platform economy and examine its impacts on platform companies, platform participating firms and the consumers. For example, how does the rise of the online platform economy negatively affect the incumbents? How does the rise of the online platform economy affect the consumers? How does the rise of the online platform economy affect the growth of platform participating firms? Because the rise of the online platform economy lowers transaction costs and average service costs, how does the cost saving

affect the consumption of other economic activities? How does the enabling nature of the online platform economy affect the economic growth within a nation?

Economists have been trying to explain the fast growth of various online platforms based on different business models and estimate their impacts on different economic players and the economy. However, due to data constraints, the current literature is limited to conceptual studies, regional studies, and case studies (Nadler, 2014, Zervas et al., 2014, Wallsten, 2015, Cohen et al., 2016), and the issues are focused on impacts on the revenues and quality of affected firms and the impacts on consumer welfare. Methodologies are needed to measure the various related activities, capital involved, corporate profits, consumer welfare, and economic growth.

To contribute to the understanding of the online platform economy, we focus on examining the impacts of the rise of the online platform economy on the market valuation of firms, their investment behaviors in intangibles, and their performances, proposing a new way to indirectly measure the impacts on social welfare, and discussing the implied measurement issues. Specifically, after the introduction of a new online platform technology, a new business model, except the negative impacts on the revenues of some existing incumbents, what happens to the values of their intangibles and their investment behaviors in intangibles? Does the new online platform technology act as creative destruction that makes the old business model of existing incumbents outdated or deteriorate faster? That is, the resource based theory indicates that the depreciation of their intangibles is expected to be higher than those of their new counterparts. How do the incumbents react to cope with the entrants with new business

model? Unlike their traditional counterparts, platform companies are in general low physical asset intensive but have superior business models to generate rapid growth. A prominent example is Airbnb, where the company has only 600 employees but the number of listed properties has surpassed that of the world's largest hotel chain, Marriot International, Inc. Another example is Uber, with a latest estimated market valuation of US \$68 billion and around 11% of Apple's market valuation on September 16, 2016, and does not have its own fleet. To explain the high market valuation, intangible assets are the key candidate to examine. That is, we need to examine whether those new platform companies have a much higher intensity of intangible assets. Eisfeldt and Papanikolaou (2013) find that firms with a higher degree of organizational capital intensity are also more productive and their average market returns are 4.6% higher. So, we examine how the entry of platform companies affects the stock performances of existing incumbents. Lastly, what happens to the consumers?

Before conducting the analysis to answer those research questions, we need to measure the intangibles, mainly organizational capital, of interested companies in the hospitality and transportation industries. To measure intangibles, economists generally encounter the problems that there is no arms-length market for most intangibles and that the majority of them are developed for a firm's own use. Following earlier research, we use the sales, general, and administrative (SG&A) expense as a proxy for a firm's investment in organizational capital (Lev and Radhakrishnan, 2005; Eisfeldt and Papanikolaou, 2013). Firms report this expense in their annual income statements. It includes most of the expenditures that generate organizational capital, such as employee training costs, brand enhancement activities, consulting fees, and the installation and management costs of supply chains. Because SG&A

expenditures may include some items that are unrelated to improving a firm's organizational efficiency, people might question whether it is a valid measure of a firm's investment in organizational capital. Eisfeldt and Papanikolaou (2013) use five ways to validate their measure, and the results show that four out of five ways clearly support this approach. Moreover, the inefficiency of the investment in organizational capital by definition should show in the depreciation rate of organizational capital. That is, if a firm's investment in organizational capital has a lot of inefficiency, the value of its organizational capital cannot be maintained well, which implies that it will have a higher depreciation rate of organizational capital. As shown in Li (2015), across U.S. high-tech industries, market leaders in general have a smaller depreciation rate than their followers. In this research, we adopt the R&D depreciation model that Li and Hall (2018) developed to estimate the depreciation rates of the organizational capital for the hospitality and transportation industries of Japan and the U.S. separately. Following Hall (1998), we use the perpetual inventory method to construct the stock of organizational capital for key firms in those two industries in both Japan and the U.S.

Our data cover the key firms in the hospitality and transportation industries in both Japan and the U.S. The majority of the data cover the period of 2002 to 2017. The data sources include the Compustat dataset, Nikkei Financial Quest Database, New York Stock Exchange, NASDAQ, and Tokyo Stock Exchange. For the impacts on the market valuation, we also examine the fund raising history of firms that we study in this research to determine the event timings.

In this paper, we develop a model where, in a service industry, to produce goods, a firm uses two types of inputs, labor and organizational capital.<sup>2</sup> In this model, we examine how the introduction of a new online platform technology affects a firm's value, investment behavior in organizational capital, and performance. The key hypothesis is that: when a new online platform technology is introduced in the industry, the existing incumbents, not adopting the new technology, cannot adjust the operational size and employment level in the short run, the effect of the introduction of the new online platform technology will operate through the depreciation of organizational capital. That is, the existing incumbent will see its organizational capital depreciate faster, the increase in the depreciation rate of organizational capital leads to the reduction in the investment of organizational capital, and hence, its stock price. Several preliminary findings are as follows: First, we measure the intangible assets of platform participating companies and their non-participating counterparts in both Japanese and U.S. hotel and transportation industries. Second, platform participating firms have a higher degree of organizational capital intensity and accumulate a higher stock of organizational capital. Third, the creative destruction of online platforms has been shown in the comparison of the estimated depreciation rates of organizational capital between the two groups. In general, the higher depreciation rate of organizational capital for existing non-platform participating incumbents implies that the value of their organizational capital is declining faster. Fourth, by using a machine learning technique on a sample of 42,573 daily stock price observations, we show that the shock of online platforms cause a negative impact on the stock prices of existing

<sup>&</sup>lt;sup>2</sup> In the service industries that we study in Japan and the U.S., the majority of firms do not invest in R&D assets but do invest in organizational capital.

non-platform participating incumbents but a positive impact on their platform participating counterparts. Moreover, we find that when there is a new online platform technology shock, while we will not observe an immediate impact on output or employment, rather than total factor productivity, the effect of the introduction of the new technology operates through the depreciation of organizational capital. As a result, we will observe an immediate effect in a firm's value and investment rate. This important finding supports Brynjolfsson et al.'s (2017) conclusion that there is a significant lag between the rapid advances in technologies due to the rise of new general purpose technologies and their impacts on an economy's productivity growth. Lastly, based on our ridesharing service study, we propose a new way to indirectly measure the welfare impacts of online platforms.

The rest of paper proceeds as follows. Section 2 describes the analytical framework. Section 3 describes the methodology. Section 4 describes the data. Section 5 shows the empirical analysis results for online platform participating firms and non-participating incumbents. Section 6 concludes.

#### 2. Model

In this section, we develop a model that presents our basic hypotheses. Consider a firm that produces goods or services using organizational capital as an input. Suppose now that the depreciation rate of the organizational capital is increased.<sup>3</sup> According to resource based theory, this can happen when its competitor introduces a new type of organizational capital, such as a new business model embodied in a new type of online platforms, which renders the old type of organizational capital obsolete at a faster rate (Barney, 1991). We are interested in how the increase in depreciation rate affects the firm's value, investment behavior and operational profits.

Let  $k_t$  denote organizational capital and  $l_t$  labor input. Let  $f(k_t, l_t)$  denote the production function of this firm. The price of the product (relative to the numeraire good) p and real wage w are taken as given by the firm. The organizational capital is accumulated as  $k_{t+1} =$  $(1 - \delta)k_t + x_t$ , where  $\delta$  is the depreciation rate of organizational capital and  $x_t$  is the firm's investment in organizational capital in period t. The investment is done by purchasing the numeraire goods. The firm's profit in t is written as  $\pi_t = pf(k_t, l_t) - wl_t - x_t$ .

We specify the production function to be Cobb-Douglas:  $f(k_t, l_t) = ak_t^{\gamma} l_t^{\alpha}$ . Solving for the optimal labor input, we obtain  $l_t = (\alpha a p k_t^{\gamma} / w)^{1/(1-\alpha)}$ . Substituting into the profit function, we obtain  $\pi_t = Ak_t^{\theta} - x_t$ , where  $A \equiv (1 - \alpha)(w/\alpha)^{\alpha/(\alpha-1)}(pa)^{1/(1-\alpha)}$  and  $\theta \equiv$ 

<sup>&</sup>lt;sup>3</sup> In the service industries that we study in this research, the majority of firms do not invest in R&D. However, they do invest in organizational capital.

 $\gamma/(1-\alpha)$  are exogenous to the firm's choice. The firm's objective is to maximize its value:  $q_t = \sum_{\tau=0}^{\infty} (1+r)^{-\tau} \pi_{\tau}$  where r denotes the discount rate instructed by the firm's owners.

Under this setup, the optimal capital choice is determined by  $A\theta k_{t+1}^{\theta-1} = MPK = r + \delta$ . The long-run optimal capital level is  $k^* = \left(\frac{r+\delta}{\theta A}\right)^{\frac{1}{\theta-1}}$ . At this steady state capital, the firm's value achieves  $(Ak^{*\theta} - \delta k^*)/r$ , that is:

$$q^* = \frac{1}{r} \left( A \left( \frac{r+\delta}{\theta A} \right)^{\frac{\theta}{\theta-1}} - \delta \left( \frac{r+\delta}{\theta A} \right)^{\frac{1}{\theta-1}} \right) = \frac{1}{r} \left( \frac{r+\delta}{\theta A} \right)^{\frac{1}{\theta-1}} \left( \frac{r+\delta}{\theta} - \delta \right).$$

Now suppose that the depreciation rate  $\delta$  of organization capital is increased exogenously. We also assume that the production function exhibits decreasing returns to scale:

 $\alpha + \gamma < 1$ , which implies  $\theta < 1$ . The long-run capital level  $k^* = \left(\frac{r+\delta}{\theta A}\right)^{\frac{1}{\theta-1}}$  is decreased by the increase in  $\delta$ , and corresponding employment level  $l^* = \left(\frac{\alpha a p k^{*\gamma}}{w}\right)^{1/(1-\alpha)}$  is also decreased. The value of the firm also decreases as  $\delta$  increases. This can be seen by taking a derivative

$$\frac{dq^*}{d\delta} = -k^* \left[ \frac{1}{1-\theta} \frac{r}{r+\delta} + 1 \right] < 0$$

where the last inequality holds because  $\theta < 1$ .

The previous analysis shows that an increase in the depreciation rate of organizational capital causes the firm's operation size and value to decline in the long run. Thus, the long-run response of firms by the increase in depreciation rate is parallel to the response to a decrease in productivity. However, the firm's transition path may differ between the two scenarios.

We now consider the case where capital adjustment incurs convex adjustment costs. Following Hayashi (1982), we assume a quadratic adjustment cost function and constant returns to scale  $\alpha + \gamma = 1$  for production. Our profit function is now written as

$$\pi_t = Ak_t - x_t - \frac{\phi}{2} \left(\frac{x_t}{k_t}\right)^2 k_t$$

where  $\phi > 0$  is a parameter that determines the scale of adjustment costs.

The maximization problem of a firm can be solved as follows. The value of the firm q is expressed by a value function that satisfies the following Bellman equation:

$$q(k) = \max_{k'} Ak - (k' - (1 - \delta)k) - \frac{\phi}{2} \left(\frac{k' - (1 - \delta)k}{k}\right)^2 k + (1 + r)^{-1} q(k').$$

This Bellman equation allows a closed-form solution, as explained in Appendix A. The optimal investment rate  $i^* = (k' - (1 - \delta)k)/k$  is constant in capital as

$$i^* = r + \delta - \sqrt{(r+\delta)^2 - \frac{2}{\phi}(A-r-\delta)}.$$

By taking derivative of  $i^*$ , we obtain that an increase in depreciation rate affects negatively on the investment rate:

$$\frac{\partial i^*}{\partial \delta} = 1 - \frac{r + \delta + \frac{1}{\phi}}{r + \delta - i^*} < 0.$$

Moreover, the firm's value v(k) is linear in the optimal investment rate, as

$$v(k) = (1+r)(\phi i + 1)k$$

This implies that the immediate impact of the increase in the depreciation rate of organizational capital on the stock price is captured by a reduction in i multiplied by  $(1 + r)\phi$ . Because the optimal investment rate responds negatively to the depreciation rate, we conclude that an increase in depreciation rate reduces the investment rate, and hence, reduces the stock price.

Even though the stock price and investment rate drop immediately upon the increase of the depreciation rate, we note that the employment and output levels do not change immediately, because productivity and capital do not change immediately. This contrasts with the response to a decrease in productivity, which will lead to an immediate drop in employment and output. This observation leads us to our basic hypothesis: If the effect of an introduction of a new online platform technology operates through the depreciation of organizational capital, rather than total factor productivity, we will observe an immediate decrease in a firm's value and investment rate if there is an increase in the depreciation rate of organizational capital, while we will not observe an immediate decrease in output, employment or sales, and vice versa. In the following sections, we empirically investigate these variables of the firms that are affected by the online platform technology.

## 3. Methodology for Identifying the Causality Effect of A New Online Platform Technology on the Market Valuations of Firms

#### **3.1 Extended Difference-in-Differences**

In this section, we use the stock prices of existing incumbents to estimate the causal effect of the introduction of a new online platform technology on their future profitability. To conduct the causal inference, econometricians have developed tools such as randomized controlled trial (RCT), difference-in-differences (DiD), and structural estimation. Because we cannot perform laboratory experiments in the study of the online platform economy, RCT, though the best approach, is infeasible. In addition, because most platform companies are currently private and their financial data are not publicly available, the approach of structural estimation is also infeasible. As a result, the DiD approach is the only feasible and most promising one to infer the causal impact of the online platform technology. Based on the DiD approach, one can infer the causal impact by estimating the difference between the pre-post difference of the treatment group, T, and that of the controlled group, C. Since the pre-post difference C can be used as a proxy for the pre-post difference T without intervention, the difference between the two groups allows us to estimate the causal treatment effect.<sup>4</sup>

Because the DiD approach is the best approach, we adopt this approach in this paper and apply an extended procedure of DiD by using state-space models (Varian, 2014; Scott and Varian, 2014; Brodersen et al., 2015). The method overcomes two major limitations of DiD. The first limitation is that DiD generally assumes a static regression model. If data are serially

<sup>&</sup>lt;sup>4</sup> See Angrist and Krueger (1999) for general discussion on difference-in-differences.

correlated in practice, the specification error deteriorates the estimation outcome. And, the second one is that analyses based on the DiD approach study the difference between two time points, before and after the intervention. However, in general, it is uncertain when the intervention is over. Moreover, we may want to know the temporal causal impact of an ongoing event or phenomenon, such as the introduction of a new online platform technology. These effects usually evolve over time; hence, it is not preferable to solely use the difference between two time points to identify the causality.

In the extended DiD procedure, we first separate the time-series data into a preintervention period and a post-intervention period. Second, we specify the state space model, also called Bayesian structural time-series model, and use pre-intervention data to estimate the reduced-form parameters. Third, from the posterior predictive distribution, we simulate the counter-factual post-intervention time series. Finally, we compute the pointwise impact by taking the difference between the real post-intervention time series, the treatment group, and the simulated post-intervention time series, the control group. Since the simulated time series can be considered as a proxy for the real time series without intervention, we can use the difference between the two time series to estimate the causal treatment effect.

#### 3.2 State Space Model

A state space model for time-series data is generally defined as an observation equation and a state equation:

$$y_t = Z_t^T \alpha_t + \epsilon_t, \ \epsilon_t \sim N(0, H_t)$$
$$\alpha_{t+1} = T_t \alpha_t + R_t \eta_t, \ \eta_t \sim N(0, Q_t),$$

where  $Z_t$  is a vector of independent variables and  $\alpha_t$  represents a state vector. This study uses the following specification of the state space model:

$$y_t = x_t^T \beta_t + \mu_t + \epsilon_t, \qquad \epsilon_t \sim N(0, \sigma^2)$$
$$x_t^T \beta_t = \sum_{j=1}^J x_{j,t} \beta_{j,t}$$
$$\beta_{j,t+1} = \rho_j \beta_{j,t} + \eta_{j,t}, \qquad \eta_{j,t} \sim N(0, \sigma_j^2)$$
$$\mu_{t+1} = \mu_t + \delta_t + u_t, \qquad u_t \sim N(0, \sigma_\mu^2)$$
$$\delta_{t+1} = D + \phi(\delta_t - D) + \eta_{\delta,t}, \qquad \eta_{\delta,t} \sim N(0, \sigma_\delta^2)$$

where  $y_t$  denotes the dependent variable and  $x_t$  denotes the contemporaneous independent variable with time-varying coefficients  $\beta_{j,t}$ , which follows an AR(1) process. Let  $\mu_t$  denote a linear stochastic trend following a random-walk process with a slope of  $\delta_t$ , which follows an AR(1) process and fluctuates around a nonzero value *D*. The dependent variable is the stock price of a firm affected by a new online platform technology. For independent variables, we use an aggregate stock price index and an aggregate bond price. Both individual and aggregate stock prices are unit-root processes. For the individual stocks that we investigated, we found no co-integration structure between individual and aggregate stock prices. Therefore, to avoid a spurious regression, we include the stochastic trend term in the observation equation. Additionally, we use Gibbs sampling method to estimate the model parameters (See Appendix B).

#### 4. Data

#### 4.1 Data for the Investment in Organizational Capital

To measure intangibles, economists generally encounter the problems that there is no arms-length market for most intangibles and that the majority of them are developed for a firm's own use. Following earlier research, we use the sales, general, and administrative (SG&A) expense as a proxy for a firm's investment in organizational capital (Lev and Radhakrishnan, 2005; Eisfeldt and Papanikolaou, 2013). Firms report this expense in their annual income statements. It includes most of the expenditures that generate organizational capital, such as employee training costs, brand enhancement activities, consulting fees, and the installation and management costs of supply chains. Because SG&A expenditures may include some items that are unrelated to improving a firm's organizational efficiency, people might question whether it is a valid measure of a firm's investment in organizational capital. Eisfeldt and Papanikolaou (2013) use five ways to validate their measure, and the results show that four out of five ways clearly support this approach.

Moreover, the inefficiency of the investment in organizational capital by definition should show in the depreciation rate of organizational capital. That is, if a firm's investment in organizational capital has a lot of inefficiency, the value of its organizational capital cannot be maintained well, which implies that it will have a higher depreciation rate of organizational capital. As shown in Li (2015), across U.S. high-tech industries, market leaders in general have a smaller depreciation rate than their followers. In this research, we adopt the R&D depreciation model that Li and Hall (2018) developed to estimate the depreciation rates of the

organizational capital for the hospitality and transportation industries of Japan and the U.S. separately. Following Hall (1998), we use the perpetual inventory method to construct the stock of organizational capital for key firms in those two industries in both Japan and the U.S.

#### **4.2 Data for Firm-level Stock Prices**

We use the time series of daily firm-level stock prices for dependent and independent variables. In addition, we investigate the funding history of online platform companies and the history of their market entries to determine the event timing of the introduction of a new online platform technology.

Our data cover 10 Japanese and U.S. companies as shown in Table 1. For the U.S. transportation industry, we study three public companies, Medallion Financial Corporation, Hertz, and Avis, which acquired ZipCar in 2013. For Japan's transportation industry, we study Park24 and DaiwaMT. For the U.S. hospitality industry, we study discount sellers, Expedia, Priceline, and TripAdvisor, and existing incumbents, including Hyatt and Starwood. The choice of the companies is based on the data availability.

In the U.S. transportation industry, we cover two groups of companies of interest. First, Medallion Financial Corp (NASDAQ: MFIN) is a specialty finance company and a leader in originating, acquiring and servicing loans that finance taxicab medallions. Because the values of taxicab medallions have been negatively affected by the entry of Uber services, Medallion Financial Corp's stock price is expected to decrease.<sup>5</sup> The stock price data is a daily data from

<sup>&</sup>lt;sup>5</sup> These expectations are expressed in the following media articles: <u>https://biz.yahoo.com/e/160809/mfin10-q.html</u> <u>https://www.cbinsights.com/blog/public-stock-driven-uber/</u> <u>http://www.crainsnewyork.com/article/20141201/BLOGS04/141209994/as-uber-rises-yellow-taxi-medallion-stock-plunges</u>

May 24, 1996 to July 31, 2018. The time after August 22, 2013 is referred as the postintervention (Uber) period.<sup>6</sup> In addition to Medallion Financial Corporation, we also analyze the time series of Chicago's Medallion price from January 16, 2011 to June 28, 2018 with the same research scheme.<sup>7</sup>

The second group of companies of interest is providers of rental car services. We choose two large providers, Avis Budget Group Inc. (NASDAQ:CAR) and Hertz Global Holdings, Inc. (NYSE:HTZ). Avis acquired Zipcar in 2013, which is a company providing short-term rental services but the term is shorter than that regular rental car service provides but longer than that provided by a taxi and Uber. Thus, Avis operates a car sharing service through Zipcar. Hertz also offered a car-sharing service in 2008 to compete with Zipcar but closed most sites in the U.S. in 2015. Although rental car companies and Uber belong to the same transportation industry using passenger cars, it is not obvious whether they are substitutes for each other. Uber mainly caters to the short- and medium-term transportation demand, whereas the rental cars mainly serve the medium- to long-term demand.

For the impacts of the online sharing platform on the rental-car industry, we organize our study in two experiments. First, we study the difference in the stock price responses between Avis and Hertz against the Uber's intervention. Avis announced to buy Zipcar on January 2, 2013.<sup>8</sup> Hertz launched a car-sharing service in 2008 to compete with Zipcar but ended the service in the U.S. and some European cities in 2015. However, it did not exit all the

<sup>&</sup>lt;sup>6</sup> On August 23, 2013, Uber raised its breakout US \$258 million Series C at US \$3.5 billion valuation, which overwhelms its previous fund raising of US \$11 million, US \$60 million valuation at Series A, and US \$37 million at Series B. <u>https://www.crunchbase.com/organization/uber#/entity</u>
<sup>7</sup> The medallion price data is publicly available at:

https://www.cityofchicago.org/city/en/depts/bacp/supp\_info/medallion\_owner\_information.html http://www.wsj.com/articles/SB10001424127887324374004578217121433322386

international markets completely.<sup>9</sup> In 2010, Zipcar had 94 US locations, 128 in 2011, and 151 in 2012. Hertz has the most U.S. locations among all rental car firms. So, in terms of convenience, it might be able to compete with Zipcar but may not be cost competitive. Both firms' entry into the car-sharing business would potentially benefit from the advancement of the online sharing platform technology.

Second, Hertz signed deals with both Uber and Lyft to supply cars for the drivers of both platforms on June 30, 2016.<sup>10</sup> This announcement suggested that the ridesharing industry and the rental-car industry might become complementary, and implied that Hertz would also benefit from the online sharing platform economy. Thus, the stock price is expected to increase after the announcement. The daily stock price data for Avis is from December 31, 2010 to July 31, 2018, for Hertz is from November 17, 2006 to July 31, 2018. For Hertz, the intervention date for the Uber-Lyft deal is October 17, 2016.

In the Japanese transportation industry, we study Park 24 Co., Ltd (Tokyo: 4666) and Daiwa Motor Transportation Co., Ltd (Tokyo: 9082). Park 24 operates numerous small-size parking lots in large cities. Its business grew fast on the backdrop of large supply of small-lot land which were left idle partly due to low rates of realty tax in Japanese municipals. On the rise of the online sharing platform technology, Park 24 started offering a car-sharing service called "Times Car Plus." Times Car Plus provides 13,149 cars at 7,311 locations (as of October 2015) for use in increments of 15 minutes. Park 24 can profit by a sharing economy and the stock price is

<sup>&</sup>lt;sup>9</sup> http://www.businesstravelnews.com/Business-Travel/Hertz-To-Cease-Car-Sharing-Services-In-U-S-Next-Month

<sup>&</sup>lt;sup>10</sup> <u>https://www.bloomberg.com/news/articles/2016-06-30/hertz-signs-deals-with-uber-lyft-to-supply-cars-to-drivers</u>

expected to increase.<sup>11</sup> We set the time after March 24, 2009, the date that Park 24 started the car-sharing service, as the post intervention (car-sharing) period. Their daily stock price data cover the period of April 30, 1999 to July 31, 2018. The other Japanese firm we study is DaiwaMT, which mainly focuses on the passenger automobile transportation business in the Kanto region which includes Tokyo. DaiwaMT is one of the incumbents in the taxi industry and the stock price is expected to decrease when the ridesharing business gets popular. Uber started its service in Japan on August 5, 2014.<sup>12</sup> However, due to Japan's regulation constraints, instead of ridesharing services, Uber only offers limousine-hiring services. Thus, DaiwaMT's stock price is expected to be unaffected. The daily stock price data of DaiwaMT cover the period of December 25, 1997 to July 31, 2018, and the intervention (car sharing) timing is set on August 5<sup>th</sup>, 2014, which is Uber's starting service date in Japan.

In the hospitality industry, we study the U.S. mid-range and high-end hotel chains, and Japan's Hotel REIT Investment Corporation.<sup>13</sup> The data of U.S. high-end hotel chains cover Mariott International, Inc. (NASDAQ: MAR), Starwood Hotels & Resorts Worldwide Inc. (NYSE: HOT), Intercontinental Hotels Group plc (NYSE: IHG), and Hyatt Hotels Corp. (NYSE: H). The data of U.S. mid-range hotel chains are also considered: Choice Hotels International, Inc. (NYSE: CHH) and Wyndham worldwide corp. (NYSE: WYN) which competes with Holiday Inn and Best Western.<sup>14</sup> In addition, we study Japan Hotel REIT Investment Corp. which invests in mid-range

<sup>&</sup>lt;sup>11</sup> <u>http://www.park24.co.jp/en/keywords.html</u>

<sup>&</sup>lt;sup>12</sup> <u>http://toyokeizai.net/articles/-/44594</u>

<sup>&</sup>lt;sup>13</sup> We do not study Hilton (NYSE: HLT), because Hilton put on market at 2013/12/12 and we do not have sufficiently long training data to generate the reliable estimate.

<sup>&</sup>lt;sup>14</sup> For example, CHH includes Comfort Inn, Econo Lodge, and Rodeway Inn. WYN includes Days Inn, Ramada, and Super 8. We note that, on June 1, 2018, Wyndham worldwide corp. split into Wyndham destinations corp. (NYSE: WYND) and Wyndham hotels and resorts Inc. (NYSE: WH).

hotels in Japan (Tokyo: 8985).<sup>15</sup> For the U.S. analysis, because Airbnb raised its breakout US \$475 million series D at US \$10 billion market valuation on May 21<sup>st</sup>, 2014, we use the time after May 22<sup>nd</sup>, 2014 as the post-intervention (Airbnb) period.<sup>16</sup> As for Japan's analysis, we use Airbnb's business starting date as the same intervention date.

 <sup>&</sup>lt;sup>15</sup> The stock price data cover the period of October 13th, 1993 to July 31, 2018 for MAR, May 11, 2001 to August 29, 2016 for HOT, April 10, 2003 to July 31, 2018 for IHG, November 15, 2009 to July 31, 2018 for H, April 10, 2003 to July 31, 2018 for CHH, July 19, 2006 to May 31, 2018 for WYND, and June 14, 2006 to July 31, 2018 for JHRIC.
 <sup>16</sup> <u>http://www.wsj.com/articles/SB10001424052702303802104579451022670668410</u>

### 5. Empirical Analysis

#### 5.1 Organizational Capital: Depreciation and Stock

In this research, we construct the firm-level stock of organizational capital from 2002 to 2017. We apply the Li and Hall (2018) model to estimate the firm-level depreciation rates of organizational capital for the key Japanese and U.S. firms in the hospitality and transportation industries (See Appendix C). The choice of firms are based on the availability of the firm-level data. Table 1 shows the depreciation rates of organizational capital for the studied.

Firms	δ_ΟC [%]	Degree of Digitization	
U.S. Hospitality Firms			
Expedia	8%	Higher	
Priceline	19%	Higher	
Hyatt	36%	Lower	
Starwood	33%	Lower	
TripAdvisor	17%	Higher	
Japanese Transportation Firms			
Park24	21%	Higher	
DaiwaMT	26%	Lower	
US Rental Car Companies			
Hertz	14%		
Avis	36%		
US Taxi Related Company			
Medallion financial	No SG&A data		

# Table 1: Depreciation Rates of Organizational Capitalfor Key Japanese and U.S. Firms in the Hospitality and Transportation Industries

Table 1 shows that in general, in both Japan's transportation industry and U.S. hospitality industry, the existing asset-heavy and less-digitized incumbents have higher depreciation rates of organizational capital. For example, U.S. hospitality firms offering a complementary service to the incumbents' products at a discount price have smaller depreciation rates of organizational capital than those of incumbents. Expedia Inc., a spin-off company from Microsoft in 1999, has a new business model that provides an online sharing platform, which offers hotel rooms from different hotel chains at the same time and thus reduces the transaction costs, for travelers to purchase hotel rooms. Moreover, the Priceline Group provides an additional discount service on its online platform, which allows travelers to bid hotel rooms at a higher discount price. Compared with Hyatt and Starwood, both Expedia and Priceline have smaller deprecation rates of organizational capital. Lastly, in the Japanese transportation industry, Park24, a parking and car-sharing company, has a smaller depreciation rate of organizational capital than its counterpart, DaiwaMT, a taxi fleet firm, does.<sup>17</sup>

Depreciation rates of organizational capital can indicate the level of the appropriateness of a firm's organizational capital (Li and Hall, 2018; Li, 2015). If the rate is higher, it indicates that the firm can less appropriate the return from its investment in organizational capital. As shown in Li (2015), in the U.S. high-tech industries, market leaders in general have a smaller depreciation rate of organizational capital than their followers do. This is consistent with the argument in resource-based theory: the sustained competitive advantage of a firm lies primarily in the application of valuable tangible or intangible resources that are neither perfectly imitable nor substitutable without great effort (Barney, 1991). In the new era of the online platform economy, online platform companies are applying the new online platform technology to creatively destruct the existing business model in their industries. As a result, we

http://www.businesstravelnews.com/Business-Travel/Hertz-To-Cease-Car-Sharing-Services-In-U-S-Next-Month

<sup>&</sup>lt;sup>17</sup> In the U.S. rental car industry, Hertz, the market leader with the best recognizable brand name, does have a smaller depreciation rate of organizational capital. Note that both companies offer car sharing services, but car sharing services only account for small portions of the businesses for both firms.

expect to see that the organizational capital of existing incumbents, such as business models and marketing strategies, will lose its value faster than those of online platform participating firms. This argument is consistent with the results shown in Table 1. That is, in the new era of the online platform economy, the existing business models and marketing strategies of the incumbents may be outdated and needed to be revised.

Before conducting further analysis, we first construct the stocks of organizational capital for all firms.<sup>18</sup> To construct the firm-level stock of organizational capital, we follow the method of constructing the annual stock of R&D assets for U.S. manufacturing industries in Hall (1998). First, for the U.S. firms, we deflate each firm's annual SG&A expenditures by using the U.S. GDP deflator with 2005 as the base year. Then, we apply our estimated depreciation rates and the perpetual inventory method to construct each firm's annual stock of organizational capital. Lastly, we use the U.S. GDP deflator again to bring back the real number to the correspondent nominal value in that year. We set the initial capital stock at the beginning to be zero and conduct the analysis without the first three years of data that were more influenced by the initial value. The time series of the stocks of organizational capital cover the period of 2002 to 2015. We also apply the same procedure for Japanese firms.

Firms with a higher degree of organizational capital are more productive and have a higher average market return rate (Eisfeldt and Papanikolaou, 2013). In this section, we examine the impacts of the new online sharing platform technology on firms' organizational capital. We conduct the analysis on the intangible capital of several firms in the U.S. hospitality

<sup>&</sup>lt;sup>18</sup> All firms in this study have no data on R&D investments.

industry, U.S. transportation industry, and Japanese transportation industry. Figures 1 to 6 show the annual organizational capital stock, the growth rates of investment in organizational capital and the growth rates of organizational capital of key firms with data available in this study.<sup>19</sup>



Figure 1: Annual Organizational Capital Stock for Selected U.S. Hospitality Firms

<sup>&</sup>lt;sup>19</sup> Note that: in the transportation and hospitality industries, among all case studies, these firms do not report R&D investments in their financial statements. Therefore, it is reasonable to conclude that the only type of intangible capital in those companies is organizational capital.



Figure 2: Growth Rates of Organizational Capital Investment and Stock for Selected

U.S. Hospitality Firms

In the U.S. hospitality industry, we see that after 2004, Expedia Inc., a spun-off company from Microsoft in 1999, has a larger stock of organizational capital than Starwood does. The new business model of providing an online platform that reduces the transaction costs for travelers to purchase hotel rooms from different hotel chains. Moreover, the Priceline Group provides an additional discount service, which allows travelers to bid hotel rooms at higher discount prices, and we see that the organizational capital of Priceline overtook Starwood during the period of financial crisis and has been catching up with Expedia fast. In contrast, Starwood had a negative growth rate of investments in organizational capital during the period of financial crisis and around a zero growth rate of investments in organizational capital in recent years, and later got purchased by Marriot International Corporation in 2016.

In the U.S. car rental industry, Avis has a smaller stock of organizational capital than its larger competitor, Hertz, does except during the period of 1998 to the period of financial crisis. Hertz, the best recognized brand in the industry, has a more stabilized growth rate of organizational capital. But, as we can see from Figure 4, after 2010, in terms of the growth rate of organizational capital stock, Avis has caught up with Hertz fast and note that it also acquired Zipcar in 2013.

As for the Japanese transportation industry, in general, Park 24, an online platform participating company, has a higher stock of organizational capital than DaiwaMT does during the sample period. In addition, in terms of the growth rates of investments in organizational capital and stock of organizational capital, Park 24 also has higher rates than DaiwaMT does.







Figure 4: Growth Rates of Organizational Capital Investment and Stocks for Selected

**U.S. Rental Car Firms** 



Figure 5: Annual Organizational Capital Stock for Selected Japanese Transportation

Firms



Figure 6: Growth Rates of Organizational Capital Investment and Stock for Selected

**Japanese Transportation Firms** 

After taking out the firms with a very short length of data in the U.S. hospitality industry, we find that in general, in both Japan's transportation industry and the U.S.'s hospitality industries, the existing asset-heavy and less-digitized incumbents have higher depreciation rates of organizational capital. It implies that their existing business model and brand equity, etc. are losing value faster, a result that is consistent with people's expectations and our analysis on the impacts of the shock of the online sharing platform technology on incumbents' stock prices. That is, in the new era of digital economy, their existing business model and marketing strategies, etc. may be outdated and need to be revised. In contrast, companies, such as Expedia and Priceline, are accumulating a larger stock of organizational capital by investing in tangible and intangible capital like Uber, an asset light model<sup>20</sup> to build strong brand recognition and accumulate deep knowledge of demand patterns and consumer behavior. That is, compared with existing incumbents, those firms are highly organizational capital intensive.

In Japan's transportation industry, there is a sign that the Daiwa Motor Transportation has increased its investment in organizational capital after 2011; however, due to the higher depreciation rate of organizational capital, its growth rate of the stock of organizational capital is smaller. In contrast, in the U.S. hospitality industry, Starwood did not increase the investment in organizational capital in recent years and later was sold to Marriot in 2015.

In the U.S. rental car industry, we study Hertz and Avis. Hertz entered the car sharing services in 2008 to compete with Zipcar but the sharing business did not run successfully in the U.S. and closed operations in the U.S. and some cities in Europe, despite the fact that car

<sup>&</sup>lt;sup>20</sup> Here, the asset light model refers to the low investments in physical assets.

sharing service is popular in Europe. However, Zipcar later was purchased by Avis in 2013 and continues operating nowadays and we see Avis has higher growth rate of the stock of organizational capital after 2010 and catches up with Hertz fast since then.

#### 5.2 Stock Performance – the Effects of the Introduction of the Online Platform Technology

#### 5.2.1 Transportation Industry

#### U.S. Medallion Financial Corporation and Medallion in Chicago

For the transportation industry, we first use the price of U.S. Medallion Financial Corporation (NASDAQ:MFIN) as a proxy for the price of Medallion and study the impact of the entry of the online sharing platform technology on the stock price of Medallion Financial Corporation. Additionally, we also study the impact on the price of Medallion in Chicago.



#### Figure 7: U.S. Medallion Financial Corporation (left) and Medallion in Chicago (right)

The solid line shows an actual stock price data and the dotted line shows a predicted counterfactual time series with a 90% confidence interval. Over the post-intervention period,

the actual price level was \$6.49 on average. For the same period, the time-average of the counterfactual estimate of U.S. Medallion Financial Corporation is \$14.59 with 90% confidence interval [\$6.69, \$31.82]. Thus, when we consider the intervention period as a whole, the intervention has exerted a negative effect, but the magnitude of the effect is not statistically significant. This result may be due to that Medallion Financial is an imperfect proxy for the taxi industry, because nearly half of its business is commercial and consumer lending rather than medallion loans. As a lender, it is not as exposed to risks from falling medallion prices as the actual equity holders in taxi medallions are. Note that although the company does directly own some Chicago medallions, but that is a small part of its business.<sup>21</sup> Even though the effect is insignificant on average for the intervention periods, we do find the time point where the causal effect is statistically significant toward the end of the observation period.

Similarly, the estimation outcome of Chicago Medallion (the right panel of Figure 7) indicates some time point toward the end of the observation period where the causal effect is statistically significant, even though the estimated average effect over the entire postintervention period is not statistically significant (counterfactual prediction at \$4,744,923, with 90% confidence interval [\$221,904, \$882,046], while actual observation is \$81,634). Therefore, we conclude that we find a statistically significant decrease in stock price in some particular

<sup>&</sup>lt;sup>21</sup> <u>https://www.washingtonpost.com/news/wonk/wp/2014/06/20/taxi-medallions-have-been-the-best-investment-in-america-for-years-now-uber-may-be-changing-that/</u> <u>http://www.nytimes.com/2014/12/04/upshot/how-our-taxi-article-happened-to-undercut-the-efficient-markethypothesis.html?rref=collection%2Ftimestopic%2FMedallion%20Financial%20Corporation&action=click&contentCollection=business&region=stream&module=stream\_unit&version=latest&contentPlacement=1&pgtype=collection& r=0</u>

time horizon, even though we do not find a negative causal effect on average for the entire post-intervention period.

#### U.S. Rental Car Companies: Avis and Hertz

Second, we study the two key U.S. rental car companies with available data: Avis Budget Group Inc. (NASDAQ:CAR) and Hertz Global Holdings, Inc. (NYSE:HTZ). The first estimation result for Avis (Figure 8) suggests that there is a time point at which a causal positive effect is statistically significant, although the average effect over the post-intervention period is insignificantly positive (the observation is \$40.04, while the prediction is \$51.94 with 90% confidence interval [\$14.59, \$179.47]). We note the fact that Avis bought Zipcar seven months before the Uber intervention. Thus, Avis could benefit from the online sharing platform economy. Our estimate indicates that there is a significant positive stock price impact in the short run, while the impact was blurred by random shocks in the long run.



Avis

**Figure 8: Avis** 

Figure 9 shows the estimate for Hertz. Overall, the intervention has exerted a negative effect on stock price when considering the intervention period as a whole, but this effect is not statistically significant (observed \$23.81, prediction \$26.58, 90% CI [\$11.13,\$64.07 ]). Hertz did launch a car-sharing service in 2008 to compete with Zipcar but ended the service in the U.S. and some European cities in 2015. It did not exit from all the markets completely, however. This may explain why the negative impact of the entry of Uber is not statistically significant. Additionally, the non-significant effect may be explained by market segmentation. Because Hertz has the highest brand recognition and is considered a high-end rental firm, consumers that need cars to use for a few hours or for a ride will tend to choose cheaper solutions rather than renting a car from the regular car rental service of Hertz. In the bottom panel of Figure 9, we observe that the pullback from the car-sharing market had negative effects on Hertz's stock price, although we do not find the average effect statistically significant. As reported on a recent *Wall Street Journal* article, the car sharing business did not grow much in the U.S. in the past few years, but it is still popular in European markets.



Figure 9: Hertz: Entry and Exit of Its Car-Sharing Service in the U.S.



#### Figure 10: Hertz's Alliance with Uber and Lyft

As mentioned in the introduction, some studies have predicted that in the U.S., the ridesharing business is expected to take over taxi services in the future. Figure 10 shows the estimate of the impact of Hertz's alliance with Uber and Lyft on its stock price and the result shows a statistically significant positive effect during the intervention period. The average observed price is \$21.54, while the counterfactual average price is \$11.59with a 90% confidence interval [\$4.62, \$31.50]. Therefore, the average positive effect observed in the entire intervention period is unlikely due to random fluctuations. This result implies that market participants expected Hertz to benefit from the sharing economy through collaboration with Uber and Lyft. **Japan Taxi Company, Daiwa Motor Transportation, and Car-sharing Service Provider, Park24** Finally, we study the impact of Uber's entry on the stock price of Daiwa Motor Transportation (Tokyo: 9082), a Japanese taxi and limousine company. Figure 11 shows a statistically non-

significant impact of the entry of Uber.<sup>22</sup> The result is expected, especially given the situation that Uber is currently banned from providing the UberX ridesharing service in Japan by the Road Transport Vehicle Act.



Figure 11: DaiwaMT

Contrary to Daiwa Motor Transportation, Park 24 (Tokyo: 4666) provides carsharing services in Japan. Figure 12 indicates that the launch of the car-sharing business seems to exert a positive effect, though not statistically significant on average, throughout the postintervention period.<sup>23</sup> However, we do find the time point where the causal effect is statistically significant. This result is consistent with the development of Park24's car-sharing business. Five years after the launch, Park24's car-sharing business finally became profitable in October 2014,<sup>24</sup> and continues to strengthen its presence in the short- and medium-term transportation market.

<sup>&</sup>lt;sup>22</sup> The average observed price is at 6.2, while the counterfactual is 5.9 with 90% CI [5.3, 6.6].

<sup>&</sup>lt;sup>23</sup> The observation is 7.9 and the counterfactual is 7.5 with 90% CI [7.0, 8.0].

<sup>&</sup>lt;sup>24</sup> Nikkei Shinbun, December 10, 2014.



Figure 12: Park24

#### 5.2.2 Hospitality Industry

For the hospitality industry, we study the U.S. mid-range and high-end hotel chains and Japan Hotel REIT Investment Corp (Tokyo: 8985), investing in Japan's mid-range hotels. The data cover the U.S. high-end hotel chains including Marriott International, Inc. (NASDAQ: MAR), Starwood Hotels & Resorts Worldwide Inc. (NYSE: HOT), Intercontinental Hotels Group plc (NYSE: IHG), and Hyatt Hotels Corp. (NYSE: H)), and mid-range hotel chains, including Choice Hotels International, Inc. (NYSE: CHH) and Wyndham worldwide corp. (NYSE: WYN), which compete with Holiday Inn and Best Western. Given the fact that Airbnb competes with hotels in the low and/or lower mid-end markets, we reasonably expect no Airbnb entry effect for both the U.S. high-end and mid-range hotels, and Japan Hotel REIT Investment Corporation (JHIRC). From Figures 13 to 19, we can see that as expected, the analysis results indicate no price impacts of Airbnb's entry on the U.S. high-end hotels and mid-range hotels, and Japanese mid-range hotels.<sup>25</sup> These results are consistent with Zervas et al. (2016), where they empirically confirmed that the causal impact of Airbnb is non-uniformly distributed and low-end hotels are most negatively affected.



Figure 13: Marriot International (MAR)

<sup>&</sup>lt;sup>25</sup> The estimates are as follows: MAR (Observed (\$83.10), Counterfactual (\$68.03), 90% CI [\$32.79, \$145.47]); HOT (Observed (\$76.71), Counterfactual (\$79.04), CI [\$52.98, \$119.10]); IHG (Observed (\$45.15), Counterfactual (\$48.91), CI [\$32.45, \$75.19]); H (Observed (\$57.97), Counterfactual (\$39.65), CI [\$15.33, \$90.02]); CHH (Observed (\$56.26), Counterfactual (\$55.15), CI [\$29.37, \$109.95]); WYN, WYND (Observed (\$35.23), Counterfactual (\$30.57), CI [\$9.58, \$76.71]); JHRIC (Observed (\$768.80), Counterfactual (\$480.50), CI [\$178.54, \$1332.52]).



Figure 14: Starwood Hotels & Resorts Worldwide Inc. (HOT)



Figure 15: Intercontinental Hotels Group Inc. (IHG)



Figure 16: Hyatt Hotels International, Inc. (H)







Figure 18: Wyndham Worldwide Corporation (WYN, WYND (- 2018-5-31))



Figure 19: Japan Hotel REIT Investment Corporation (JHRIC)

#### **5.3 Depreciation and Market Valuation**

In Section 2, our theoretical hypothesis indicates that if the effect of an introduction of a new online platform technology operates through the depreciation of organizational capital, rather than total factor productivity, we will observe an immediate decrease in a firm's value and investment rate if there is an increase in the depreciation rate of organizational capital, and vice versa, while we will not observe an immediate decrease in output, employment or sales, and vice versa. In this section, we summarize our empirical investigation in these variables of the firms that are affected by the online platform technology.

Table 2 summarizes the changes of firms' depreciation rates of organizational capital after the entry of Airbnb and Uber, and the causality effect on their stock prices. From Table 2, we can see that: First, in the Japanese and U.S. transportation industries, when there is a statistically significant causality effect on the stock price of a firm, we also find a consistent directional movement in the depreciation rate of organizational capital. Second, after the entry of Airbnb in 2014, all U.S. hotels, no matter high-end or low-end, have higher depreciation rates of organization capital. Although we did not find negative stock price effects on those U.S. hotels, this is not inconsistent with our theoretical prediction. In that, there may be a lag between the increase in a firm's depreciation rate of organizational capital and the drop of its stock price. Also note that Airbnb and other online platform companies are increasingly offering luxury lodging options in the past two years. Therefore, we plan to expand the current analysis to a longer length of data when it is available.

Lastly, for the three online travel platform companies, the impacts of Airbnb, are not definite. The reasons are that they are more diversified in terms of the coverage of services,

including airline tickets, rental cars, and lodging. As mentioned before, in the lodging service,

they can offer complementary services to traditional hotels; however, like hotels, they compete

with Airbnb directly.

#### Table 2: Changes in Depreciation Rates of Organizational Capital

Industry/Firms	Entry Data	Entry-event	Expectation	δ_ΟC	<b>Causality Effect on Stock Price</b>	Statistically Significance ?
US Transportation			_	_	-	
Avis	1/2/2013	Purchasing Zipcar	No/Positive	decrease	Positive	Yes
Hertz 1	8/22/2013	Series C, Uber	No	decrease		No
Hertz 2	9/1/2015	Pull-back	Negative	decrease		No
Hertz 3	6/30/2016	Deal with Uber/Lyft	Positive	decrease	Positive	Yes
Japanese Transportat	ion					
Park 24	3/24/2009	Onset of car-sharing	Positive	decrease	Positive	Yes
DaiwaMT	8/5/2014	Uber's entry in Japan	No	increase		No
US Hotels						
Marriot	5/22/2014	Series D, Airbnb	No	increase		No
Starwood	5/22/2014	Series D, Airbnb	No	increase		No
Intercontinental	5/22/2014	Series D, Airbnb	No	increase		No
Hyatt	5/22/2014	Series D, Airbnb	No	increase		No
Choice	5/22/2014	Series D, Airbnb	No	increase		No
<b>US Online Travel Plat</b>	form Compan	ies: cover airline ticke	ts, rental car,	and hotel	rooms	
Expedia	5/22/2014	Series D, Airbnb	Indefinite	increase		No
Priceline	5/22/2014	Series D, Airbnb	Indefinite	decrease		No
Tripadvisor	5/22/2014	Series D, Airbnb	Indefinite	decrease	Negative	Yes

and Causality	/ Effect on	Stock	Price
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#### 5.4 Implied Welfare Effects: An Experimental Measurement of Consumer Surplus

In this study, we propose a new way to measure consumer surplus for the online platform economy in the transportation and hospitality industries. The declined share prices of an incumbent could signal the value created by a new firm that is not necessarily listed yet. As shown in the Airbnb case, Airbnb is a technological shock to the hotel industry. Because Airbnb provides a platform to allow low marginal cost (MC) firms to supply rooms, this technology shock shifts the supply curve to the right. The profits of the low MC firms are unobservable. While the hotel industry is loosely segregated by quality: low-, middle-, and high-end, studies have shown that the Airbnb shock hits the low-end hotels most (Zervas et al., 2014). However, the degree of the business-stealing effect is determined by the elasticity of substitution between Airbnb and a hotel category. In this study, we observe the declines in profit and stock values of low-end hotels. We propose that this decline in the stock values of existing incumbents can be used to indirectly measure the consumer surplus that Airbnb generates.

The impacts on welfare can be divided into three areas. First, the profit margin, revenue minus cost, generated by Airbnb suppliers is a new value-added. Second, Airbnb renters gain consumer surplus, which is the triangular below the demand curve in the price range between the Airbnb price and the low-end hotel price. Third, competing with low-cost Airbnb suppliers, the low end hotels face the reduced mark-up, which causes revenue loss. This revenue loss represents a transfer from the low-end hotels to the consumers of low end hotels. Therefore, even though the value added by the low end hotel is reduced, the consumer gains it in the form of surplus.





Similarly, for the simple scheme for the case of the taxi industry and Uber, Figure 20 shows the demand and supply curves for the automobile transportation service. The taxi industry was under the regulated quantity  $q_0$ , and the rent was received, the rectangle area,

 $p_0p_1BA$ . The introduction of Uber shifts the supply curve downward with low marginal costs, and potentially with higher elasticity (from *S* to *S'*).

The impacts of the Uber shock on the taxi industry are divided into two areas.

- 1. The impacts on consumer surplus:
  - a. With the downward shift of the supply curve, the rent of the taxi industry is transferred from producers to consumers. This impact is partly captured by the declined capitalization of Medallion Financial Corporation and the reduced Medallion price.
  - b. Additional consumer surplus, shown by a triangle ACE below the demand curve D, can be potentially large, if the impact on quantity  $q_E$  is large. As mentioned earlier, the recent Wall Street Journal article report shows the hyper growth of the U.S. ridesharing service, which is expected to take over the taxi service in the future.
- 2. Impacts on income (GDP)
  - a. The rent was counted as a part of GDP: the factor incomes of drivers or taxi companies are counted as a rent and is a part of GDP. Thus, the rent reduction may lead to an underestimate of GDP, if the price index of the transportation service is not properly adjusted. If the decline in transportation service price is properly measured, it will increase real GDP and compensate for the effect of the rent.<sup>26</sup>

<sup>&</sup>lt;sup>26</sup> Ahmad and Schreyer (2016) also raise a similar point.

- b. Online sharing platforms, provided by firms such as Uber or Lyft, generate corporate income that is equal to the narrow triangle beneath the new price  $p_{E}$  and above the new supply curve *S'*. The stock price analyses of Park24, Avis (through the purchase of Zipcar), and Hertz (after its alliance with Uber and Lyft) indicate that the discounted sum of this future cash flow is expected to be large by market participants. This might suggest that the future impact of this new transportation service innovation on *q* can be large. If so, it suggests that the consumer surplus (1b) can be large. However, if firms can use big data to have finer price discrimination, the future cash flow can be really large.<sup>27</sup> In that case, the large capitalization implies a large rent above the supply curve and thus relatively small consumer surplus.
- c. Suppliers through the online sharing platform generate income that is equal to the area ODEq<sub>E</sub> beneath the new supply curve. In principle, the drivers' incomes are taxable and should appear in the tax records. However, there may be underreported income for those "occasional self-employed workers." As reported in a recent Wall Street Journal article, currently, IRS only request income above US \$20,000 and with transaction times more than 20 to file Form 1099. But, it is reported that some Airbnb suppliers can earn more than US \$100,000 per year and not reported tax because their annual transaction

<sup>&</sup>lt;sup>27</sup> Kaplan (2015) suggests such possibility in the context of the use of artificial intelligence.

number is less than 200. This article points out that the unreported ratio can be very large.

#### 6. Conclusion

Because of the increasing programming capabilities, the modularity and rapid price falling of IT hardware and a growing number of things have gone digitized, those powerful forces have enabled the rapid creation of new business models embodied into various online platforms across industries and caused the creative destruction of existing business models in the affected industries, which cover not only service industries but also manufacturing industries. Moreover, people have been concerned about how the online platform economy will shape the future industry structure, job creation and destruction, and how it affects consumer welfare.

In this research, we focus on the study of the online platform economy in the transportation and hospitality industries in both Japan and the U.S. We find that in general, the shock of the new online platform technology has caused negative impacts on existing incumbents' stock prices but positive impacts on firms adopting the new technology. In addition, studies have found that firms with a higher degree of organizational capital intensity also are more productive, IT intensities, and have a higher average return. And, in this study, we find that compared with existing incumbents, firms adopting the new online platform technology also are more organizational capital intensive and have accumulated a larger stock of organizational capital. These findings are consistent with the key results from other studies related to organizational capital. A growing body of studies have find the importance of organizational capital in the production process (Prescott and Visscher, 1980; Hall, 2000; Atkeson and Kehoe, 2005; Carlin, Chowdhry, and Garmaise, 2011; Lustig, Syverson, and Van Nieuwerburgh, 2011) and have empirically confirmed the positive relationship between

organizational capital and the TFPs of the U.S. industries (Corrado et al., 2009; Li, 2016). Moreover, Eisfeldt and Papanikolaou (2013) find that firms with a higher degree of organizational capital intensity also are more productive and have higher managerial quality scores based on the measure of Bloom and Van Reenen (2007), more information technology (IT) intensive, and have average returns that are 4.6% higher than firms with less organizational capital.<sup>28</sup>

Moreover, to resolve the redux of the Solow (1987) Productivity Paradox, Brynjolfsson et al. (2017) conclude that because of the required adjustment costs, related organizational changes and new skills, there is a significant lag between the rapid advances in technologies due to the rise of new general purpose technologies and their impacts on an economy's productivity growth. In this research, our theoretical and empirical works support their conclusion. We find that when there is a new online platform technology shock, while we will not observe an immediate impact on output or employment, rather than total factor productivity, the effect of the introduction of the new technology operates through the depreciation of organizational capital. As a result, we will observe an immediate effect in a firm's value and investment rate.

Last but not least, we find a new way to indirectly measure the welfare impacts of the online platform economy, which can be huge potentially. For example, the analysis also points out that given the rapid growth of the adoption of the online sharing platform technology in the

<sup>&</sup>lt;sup>28</sup> Note that Brynjolfsson and Hitt (2002) find the complementary relationship between organizational capital and IT investment.

transportation industry, lacking correct adjustment in the price index of the transportation service could cause the underestimation of GDP and hence, the productivity growth.

Due to data limitations, we are unable to study the impacts of the online platform technology on all the firms in the U.S. and Japan's hospitality and transportation industries and other industries. We plan to explore more data to study the full impact of the new online platform technology. Lastly, because the online platform economy has grown rapidly across industries and around the world, future research should also work on the correct measurement of related price indexes to avoid the underestimation of GDP and resulting GDP and productivity growth.

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#### **Appendix A. Derivation of Optimal Investment Policy**

In this section, we derive the optimal investment policy shown in Section 2. The first-order condition of the Bellman equation determines the optimal investment rate  $i \equiv x/k$  as

$$\phi i + 1 = \frac{q_k(k')}{1+r},$$

while the derivative of the value function satisfies an envelope condition

$$q_k(k) = A + 1 - \delta - \frac{\phi}{2}i^2 + \phi i(1 - \delta + i),$$

where we used

$$\frac{\partial}{\partial k} \left( \frac{k' - (1 - \delta)k}{k} \right)^2 = 2 \left( \frac{k' - (1 - \delta)k}{k} \right) \left( -\frac{k'}{k^2} \right) = 2i(1 - \delta + i)/k.$$

We make a guess that the investment rate i is constant and independent of k. Then, the envelope condition indicates that the derivative of the value function is constant. Therefore, the value function is linear in capital as q(k) = Bk + C. Substituting the guess  $k' = (1 - \delta + i)k$  into the Bellman equation, we obtain

$$Bk + C = q(k) = \left(A - i - \frac{\phi}{2}i^2\right)k + (1 + r)^{-1}(B(1 - \delta + i)k + C).$$

Since the above equation holds for any k, we obtain C = 0 and

$$B = \frac{1+r}{r+\delta-i} \left( A - i - \frac{\phi}{2} i^2 \right).$$

Note that *B* is positive only for  $i < r + \delta$ . Since the firm's value must be positive, *i* must be smaller than  $r + \delta$ . The first-order condition and the envelope condition require

$$\phi i + 1 = B/(1+r)$$

and

$$B = A + 1 - \delta - \frac{\phi}{2}i^{2} + \phi i(1 - \delta + i).$$

Combining these two equations, we can determine the investment rate by

$$(\phi i + 1)(1 + r) = A + 1 - \delta - \frac{\phi}{2}i^2 + \phi i(1 - \delta + i).$$

This is rewritten as

$$i^{2} - 2(r+\delta)i + \frac{2}{\phi}(A-r-\delta) = 0.$$

Thus, i is a root of the quadratic equation, which is

$$i = r + \delta \pm \sqrt{(r+\delta)^2 - \frac{2}{\phi}(A - r - \delta)}.$$

This condition is violated by the larger root of *i*. Hence,

$$i^* = r + \delta - \sqrt{(r+\delta)^2 - \frac{2}{\phi}(A-r-\delta)}.$$

#### **Appendix B. Gibbs Sampling Method**

Gibbs sampling is one of MCMC technique, and is to generate posterior samples by iterative resampling from its conditional distribution with the remaining variables constant. For instance, consider the random variables  $\theta_1$  and  $\theta_2$ . We start by setting  $\theta_1^0$ ,  $\theta_2^0$  to their initial values, sampling from a prior distribution. Then, we sample  $\theta_1^i \sim p(\theta_1 | \theta_2^{i-1})$  and  $\theta_2^i \sim p(\theta_2 | \theta_1^i)$ iteratively until convergence. Let  $\theta$  denote the set of all parameters except for  $\beta$ ,  $\rho$ , and  $\sigma_j$  in the model. The Gibbs sampling procedure is stipulated as below.

$$y_{t} = x_{t}^{T}\beta_{t} + \mu_{t} + \epsilon_{t}, \qquad \epsilon_{t} \sim N(0, \sigma^{2})$$

$$x_{t}^{T}\beta_{t} = \sum_{j=1}^{J} x_{j,t}\beta_{j,t}$$

$$\beta_{j,t+1} = \rho_{j}\beta_{j,t} + \eta_{j,t}, \qquad \eta_{j,t} \sim N(0, \sigma_{j}^{2})$$

$$\mu_{t+1} = \mu_{t} + \delta_{t} + u_{t}, \qquad u_{t} \sim N(0, \sigma_{\mu}^{2})$$

$$\delta_{t+1} = D + \phi(\delta_{t} - D) + \eta_{\delta,t}, \qquad \eta_{\delta,t} \sim N(0, \sigma_{\delta}^{2})$$

1. Initialize  $\Theta^0$ ,  $\beta^0$ , and  $\mu^0$  by sampling from prior distributions.

For 
$$i = 0, ...,$$

- 2. For j = 1, ..., J, execute as follows.
  - 1. Sample  $\beta_j^i | \Theta^{i-1}, \mu^{i-1}$ .
  - 2. Sample  $\rho_j^i | \beta_j^i$ .
  - 3. Sample  $\sigma_j^i | \beta_j^i, \rho_j^i$ .
- 3. Sample  $\mu^i | \Theta^i, \beta^i$ .
- 4. Sample  $\delta^i \mid \mu^i$ .

- 5. Sample  $\varphi^i|\,\delta^i$  .
- 6. Sample  $D^i | \delta^i, \varphi^i$ .
- 7. Sample  $\sigma^i_{\delta} | \, \delta^i, \varphi^i, D^i$ .
- 8. Sample  $\sigma_u^i | \mu^i, \delta^i, \varphi^i, D^i$ .
- 9. Sample  $\sigma^i | \beta^i, \mu^i$ .
- 10. Go back to 2 until convergence.

#### Appendix C: Depreciation Model of Business R&D Capital

Li and Hall (2018) develop a depreciation model to estimate U.S. business R&D capital. The premise of the model is that R&D capital depreciates because its contribution to a firm's profit declines over time and the main driving forces for the decline are the pace of technological progress and the degree of industry competition. The model can apply to other intangible capitals as long as the data on investments and sales are available. Below is the brief summary of the model.

A profit-maximizing firm will invest in R&D such that the expected marginal benefit equals the marginal cost. That is, in each period *t*, a firm will choose an R&D investment amount to maximize the net present value of the expected returns to R&D investment:

$$\max_{R_t} E_t[\pi_t] = -R_t + E_t \left[ \sum_{j=0}^{\infty} \frac{q_{t+j+d} I(R_t) (1-\delta)^j}{(1+r)^{j+d}} \right]$$
(1)

where  $R_t$  is the R&D investment amount in period t,  $q_t$  is the sales in period t,  $l(R_t)$  is the profit rate due to R&D investment,  $\delta$  is the R&D depreciation rate, and r is the cost of capital. The parameter d is the gestation lag and is assumed to be an integer which is no less than 0. R&D investment in period t will contribute to the profits in later periods but at a geometrically declining rate. They assume that the sales q for periods later than t grows at a constant growth rate, g. That is,  $q_{t+j} = q_t (1+g)^j$ . This assumption is consistent with the fact that the U.S. output of most R&D intensive industries grows fairly smoothly over time.

To resolve the issue that the prices of most R&D assets are generally unobservable, the study defines I(R) as a concave function:

$$I(R) = I_{\Omega} \left( 1 - \exp\left[\frac{-R}{\theta}\right] \right)$$
(2)

with  $I''(R) < 0., I'(R) = \frac{I_{\Omega}}{\theta} \exp(\frac{-R}{\theta}) > 0, I'(0) = \frac{I_{\Omega}}{\theta}$ , and  $\lim_{R\to\infty} I(R) = I_{\Omega}$ . This functional form has few parameters but nevertheless shows the desired concavity with respect to *R*. In this, the approach is similar to that adopted by Cohen and Klepper (1996), who show that when there are fixed costs to an R&D program and firms have multiple projects, the resulting R&D productivity will be heterogeneous across firms and self-selection will ensure that the observed productivity of R&D will vary negatively with firm size. The model incorporates the assumption of diminishing marginal returns to R&D investment implied by their assumptions, which is more realistic than the traditional assumption of constant returns to scale (Griliches, 1996). In addition, the model implicitly assumes that innovation is incremental, which is appropriate for industry aggregate R&D, most of which is performed by large established firms.

The function *I* includes a parameter  $\theta$  that defines the investment scale for increases in R&D and acts as a deflator to capture the increasing time trend of R&D investment as a component of investment in many industries. The value of  $\theta$  can vary from industry to industry, allowing different R&D investment scales for different industries.

Using this function for the profitability of R&D, the R&D investment model becomes the following:

$$E_{t}[\pi_{t}] = -R_{t} + E_{t}\left[\sum_{j=0}^{\infty} \frac{q_{t+j+d}I(R_{t})(1-\delta)^{j}}{(1+r)^{j+d}}\right]$$

$$= -R_{t} + I_{\Omega}\left[1 - \exp\left(-\frac{R_{t}}{\theta_{t}}\right)\right]\sum_{j=0}^{\infty} \frac{E_{t}[q_{t+j+d}](1-\delta)^{j}}{(1+r)^{j+d}}$$
(3)

Note that they have assumed that d, r, and  $\delta$  are known to the firm at time t. Because  $\theta$  varies over time, they model the time-dependent feature of  $\theta$  by  $\theta_t \equiv \theta_0 (1+G)^t$ , where G is the growth rate of  $\theta_t$ . To estimate G, they assume that the growth pattern of industry's R&D investment and its R&D investment scale are similar and they estimate G by fitting the data for R&D investment to the equation,  $R_t = R_0 (1+G)^t$ . Using this assumption, Equation (3) becomes:

$$\pi_{t} = -R_{t} + I_{\Omega} \left[ 1 - \exp\left(-\frac{R_{t}}{\theta_{0}(1+G)^{t}}\right) \right] \frac{q_{t}(1+g)^{d}}{\left(1+r\right)^{d-1}\left(r+\delta-g+g\delta\right)}$$
(4)

Note that because of their assumptions of constant growth in sales and R&D, there is no longer any role for uncertainty in this equation, and therefore no error term. Assuming profit maximization, the optimal choice of  $R_t$  implies the following first order condition:

$$\frac{\partial \pi_t}{\partial R_t} = \frac{(1+G)^t}{I_\Omega} \theta_0 exp \left[ \frac{R_t}{\theta_0 (1+G)^t} \right] + \frac{q_t (1+g)^d}{(1+r)^{d-1} (r+\delta-g+g\delta)} = 0 \quad (5)$$

For estimation, they add a disturbance to this equation (reflecting the fact that it will not hold identically for all industries in all years) and then estimate  $\theta_0$  and the depreciation rate  $\delta$ .