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Dog Eat Dog: Balancing Network Effects and Differentiation in a Digital Platform Merger

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Abstract. Network effects are often used to justify platform strategies such as acquisitions and subsidies that aggregate users to a single dominant platform. However, when users have heterogeneous preferences, a single platform may not be as effective as multiple platforms from both a strategic perspective and an antitrust perspective. We study the role of network effects and platform differentiation in the context of a merger between the two largest platforms for pet-sitting services. To obtain causal estimates of network effects, we leverage geographic variation in premerger market shares and employ a difference-in-differences approach. Our results reveal that although users of the acquiring platform benefit from the merger thanks to network effects, those of the acquired platform are comparatively worse off because their preferred option is removed. Network effects and differentiation offset each other such that at the market level, users are not substantially better off with a combined platform than with two separate platforms. These findings have strategic and regulatory implications as well as highlight the importance of platform differentiation even in the presence of network effects.

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1. Introduction

Companies must make a multitude of strategic decisions when pursuing growth, including how to innovate and attract new customers, whether to acquire competitors, and if so, how to integrate their processes into the merged enterprise. These choices become more complex with network effects, which occur when the value per user from a product or service increases with the number of other users (Katz and Shapiro 1985). Network effects are often considered a defining characteristic of platforms (Rochet and Tirole 2003) and a main driver of their growth (Dubé et al. 2010). They are also used to justify first-mover advantages or equilibria where a single winner eventually dominates the market (Lieberman and Montgomery 1988). In practice, however, the mere presence of network effects does not suffice to draw such conclusions given that other countervailing forces may be at play.

Here, we consider the role of platform differentiation in countervailing network effects in the context of digital transaction platforms (Cusumano et al. 2019) (*platforms* henceforth). Such platforms help buyers and sellers find each other and safely transact. Examples include Airbnb, Amazon Marketplace, and Uber. Sometimes, these platforms are designed to cater to subsets of users with specific preferences, for instance by emphasizing original and unique items (e.g., Etsy) or delivery speed and convenience (e.g., Amazon). Even platforms that offer very similar services can attract different types of users because of subtle differences in design (Jia et al. 2021). When platforms are differentiated and network effects are not too large, the adoption of strategies meant to drive all users onto a single platform may not be justified for platform managers and regulators alike (Farrell and Shapiro 2000).

To examine this issue, we investigate the relative importance of network effects and platform differentiation in a merger between two competing platforms in the local services industry, where the biggest platform acquired and then shut down its largest competitor. We find that buyers on the acquiring platform engaged in more transactions after users of the acquired platform joined. This first result confirms that some buyers benefited from the merger thanks to network effects. However, many buyers on the acquired platform chose not to switch to the acquiring platform, suggesting that others were negatively impacted by the removal of their preferred platform. Network effect benefits and the loss of platform differentiation thus offset each other, such that buyers are not, on average, significantly better off with a single platform than with two competitors. Although our focus is on buyer outcomes, we find similar results for platform and seller revenues, which remain constant after the merger compared with the sum of revenues from the two competing platforms before the merger.

These findings provide insights on two key decisions that managers face when considering acquisitions. First, the net result that users are not better off with one compared with two platforms makes it more difficult for regulators and managers to justify platform acquisitions solely on the basis of network effects. Second, even if an acquisition is approved, it may be beneficial for a company to operate multiple platforms rather than merge them. More generally, our findings call into question growth strategies based on first-mover advantage and winner-takes-all equilibria.

Measuring network effects on platforms is challenging because changes in the number of users are typically endogenous. Our identification strategy relies on the sudden increase in the number of buyers and sellers induced by a platform merger. Specifically, in March 2017, Rover, the biggest U.S. platform for pet-sitting services, acquired DogVacay, their closest and largest competitor. A single platform emerged from this acquisition, as DogVacay was shut down within four months and no other platform gained a sizable market share in the period following the merger. Crucially, our setting offers the unique possibility of observing data from *both* platforms.

This acquisition provides an excellent natural experiment to not only measure network effects but also, evaluate whether network effects are large enough to offset the loss of platform differentiation. First, the local nature of the services exchanged means that we can treat each geography as a separate market. Second, the two platforms seem to have been close substitutes and were active in the same places, making it more likely that combining users would lead to more and better matches. Third, prior to the acquisition, the platforms varied in their market shares across geographies, meaning that some locations experienced bigger increases in the number of users interacting with one another compared with others. Finally, the acquiring platform did not increase its nominal or actual commission fees, a potential confound that might offset the benefits of the merger for platform users.

Our first question is whether network effects exist in platforms like ours. Answering this query is important because platform businesses such as those studied here have taken network effect benefits for granted, despite doubts raised by recent evidence (Fradkin 2018, Cullen and Farronato 2021, Fong 2022). Specifically, we assess the *effect of the merger for the buyers on the acquiring platform*, exploiting variation in premerger market shares that are at least in part explained by differences in early-stage growth efforts. In our setting, network effects arise because more sellers improve buyer outcomes by providing more and higher-quality matches, and the same holds true for sellers when there are more buyers. The combination of the network effect benefits that each user group creates for the other group implies that increasing both buyers and sellers *at the same rate* benefits both types of users. We can test this implication in our context; the buyers on the acquiring platform should benefit more in geographies receiving a bigger influx of buyers and sellers from the acquired platform. In practice, the influx of buyers and sellers is not guaranteed to increase both user groups at the same rate, although our results are not driven by changes in the number of buyers *relative to* sellers.

Our second question is whether network effects are large enough to offset the reduction in platform variety and thus, justify a single platform. This is both a managerial and policy-relevant query. From a managerial perspective, the acquiring firm could decide to continue operating the two platforms separately or instead, to shut down one platform and invite its users to join the other. From a policy perspective, the antitrust regulator has the authority to allow or block a merger altogether or even to stipulate that the acquiring firm continues operating both platforms separately. These strategic and policy decisions are made based on expectations regarding the effects of the merger on platform revenues and consumer welfare, respectively, which are proxied for by the outcomes we analyze.

To evaluate whether the network effects are large enough to justify a single platform, we study the *effects of the merger on the market*, aggregating data from both platforms.[1] With large-enough network effects, combining the two platforms would lead to greater user benefits in geographies where both platforms were equally large before the merger compared with those where one platform was already dominant. This is because in split geographies, the merger effectively doubles the number of users who can interact.

We adopt a difference-in-differences approach, comparing outcomes before and after the acquisition and across zip codes with different market shares. Selection into market shares is explicitly addressed with matching. Our findings reveal that after the merger, the platform usage of existing Rover buyers increased more in geographies where Rover received a bigger influx of users from DogVacay. Although existing DogVacay buyers similarly benefited from network effects, they decreased their platform usage *relative to* existing Rover buyers after the merger. Indeed, many of these buyers chose not to switch to Rover, and those who did switch transacted less frequently and matched at lower rates than comparable Rover buyers. Two related mechanisms help to explain these effects: coordination failure and disintermediation, whereby DogVacay buyers had a harder time finding their previous providers on Rover, perhaps leading them to transact with these same providers off the platform.

Attrition by DogVacay buyers almost perfectly offsets the increased usage of Rover buyers, such that at the *market* level, we find no evidence that the combined platform substantially improves market outcomes compared with the sum of the two separate platforms. This applies to both the extensive margins, such as user adoption, retention, or total transactions, and the intensive margins, such as match rates or ratings. Although we predominantly focus on buyer outcomes, we check that our results are not simply due to a redistribution of value across buyers, sellers, and the platform.

Our findings imply that even if network effects are strong in online platforms, preference heterogeneity can offset the benefits of a single platform compared with multiple competing platforms, even when competitors appear to be close substitutes. This result holds across different types of geographies: places with a small versus large baseline number of users and places where users have lower versus higher propensity to multihome.

The rest of the paper is structured as follows. Section 2 reviews the relevant literature. Section 3 introduces a stylized model motivating our empirical analysis. Section 4 describes the context and relevant data, and Section 5 presents our empirical specification. We discuss our results in Section 6 and then conclude in Section 7 with a reflection on the implications of our findings for platform strategy and antitrust regulation.

2. Literature Review

In this section, we present the mostly theoretical literature on platforms and network effects and explain why our setting is ideal for studying network effects empirically.

Early work focuses on competition and product compatibility in the presence of network externalities (Farrell and Saloner 1985, Katz and Shapiro 1985), with pioneering models of multisided platforms later introduced by Caillaud and Jullien (2003), Rochet and Tirole (2003), Parker and Van Alstyne (2005), and Armstrong (2006). In their models, platform businesses are characterized by multiple user groups and the presence of positive cross-side network effects, where each user benefits from having more users in other groups. The earlier papers focus on platform pricing strategies (Weyl 2010), whereas other strategic choices, such as entry, vertical integration, and degree of openness, are explored by Boudreau (2010), Eisenmann et al. (2011), Zhu and Iansiti (2012), Hagiu and Wright (2014), and Suarez et al. (2015) among others. More recently, Bakos and Halaburda (2020), Jeitschko and Tremblay (2020), and Park et al. (2021) investigate how platform strategies change as a function of multihoming (i.e., the propensity of users to join multiple platforms).

In the theoretical literature on platforms, the presence of network effects has led scholars to highlight several strategic implications: platforms entering first have an advantage (Lieberman and Montgomery 1988), markets with multiple competitors tend to tip toward a single platform (Dubé et al. 2010), and a single platform will eventually control the entire market (Cennamo and Santalo 2013). In such cases where a dominant platform emerges, Nikzad (2020) and Tan and Zhou (2020) predict that the interaction of network effects, product variety, and pricing power leads to theoretically ambiguous effects of platform dominance on consumer surplus. Argenziano (2008) even theorizes that the competitive outcome is inefficient when platforms are differentiated. Our work adds empirical evidence to this literature by emphasizing the importance of platform variety in counterbalancing network effect benefits. Our insights challenge unconditional tipping by estimating network effects that are too weak to naturally lead to winner-takes-all equilibria. We furthermore provide novel empirical evidence on the extent of multihoming, which although limited, is predominantly concentrated on the supply side among the largest sellers.

The empirical literature on network effects dates back to Greenstein (1993), Gandal (1994), and Saloner and Shepard (1995) and more recently, to Gowrisankaran and Stavins (2004) and Tucker (2008), who show that network effects are present in the adoption of a broad range of technologies, from bank automatic teller machines to video-messaging software. Rysman (2004), in looking at the Yellow Pages market, was among the first to empirically study and find evidence of positive cross-side network externalities. Chu and Manchanda (2016) obtain similar results for e-commerce platforms. Unlike our work, these papers often focus on the extensive margins of user participation, ignoring usage intensity and match quality.

Recent more granular data on how users interact with each other on digital platforms have facilitated the estimation of a particular manifestation of network effects, namely how the number of matches between the two user sides changes as a function of aggregate user participation. With the exception of Kabra et al. (2016), most work on digital markets has not found evidence of increasing returns to scale in matching (Fradkin 2018, Li and Netessine 2020, Cullen and Farronato 2021, Fong 2022), possibly because of a lack of exogenous shocks to the number of users or an inability to control for user selection. We address these limitations by observing users on two competing platforms before and after they merge. This degree of visibility means that we can evaluate the effects not only at the level of the acquiring platform but also at the market level, accounting for differences in user composition. The latter analysis allows us to derive implications for platform managers and regulators that weigh network effect benefits against the costs of reducing platform differentiation.

In addition to measuring network effects, our study relates to existing empirical research on platform competition. Many papers have explored platform competition, predominantly in nondigital settings or focusing on competition between digital platforms and more traditional service providers (Seamans and Zhu 2014, Lam et al. 2021, Farronato and Fradkin 2022). When comparing platform monopoly versus competition, the literature traditionally looks at the trade-off between pricing power and network effect benefits (Rysman 2004, Chandra and Collard-Wexler 2009, Filistrucchi et al. 2012, Filistrucchi and Klein 2013, Song 2021). A handful of studies investigate the interactions between quality and network effects (Berry and Waldfogel 1999, Sweeting 2010, Zhu and Iansiti 2012, Fan 2013, Jeziorski 2014). We confirm that the trade-off between quality and network effects is empirically important by showing that rather than higher prices, market dominance leads to a reduction in platform differentiation, which hurts a subset of users.

Given that concentration in the industry under study occurs through acquisitions (Gautier and Lamesch 2021, Pérez-Pérez et al. 2021, Yan et al. 2021), we contribute to the broad literature exploring strategic acquisitions variously aimed at reconfiguring businesses (Karim and Mitchell 2000), acquiring new assets (Kaul and Wu 2016), removing competitive threats (Cunningham et al. 2021), or vertically integrating (Li and Agarwal 2017, He et al. 2021). Our results shed light on how to effectively integrate the activities of acquired competitors, a topic begging further research as the drivers of acquisition outcomes remain poorly understood (Zaheer et al. 2013, Graebner et al. 2017).

3. Theoretical Framework

This section presents a model that highlights the key trade-off between network effects and platform differentiation. It provides us with expressions for buyers' utilities before and after a merger of two competitors, which in turn, guide our empirical analysis.

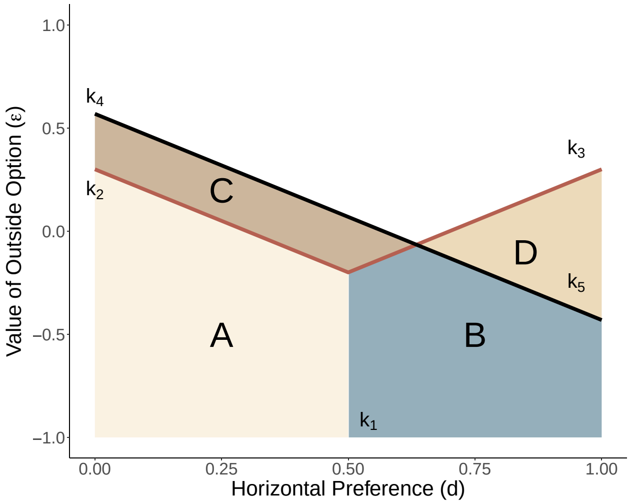
Like our later analysis, our model focuses on buyers, implicitly assuming away any redistribution of merger gains between buyers, sellers, and the platform. In practice, this means that if buyers captured say 20% of value before the merger, they still capture 20% after the merger.[2] This simplification, which is supported by the data, makes the model more tractable and intuitive. In addition, our model does not capture the separate effect of increasing the number of buyers versus sellers. In a two-sided platform, doubling buyers hurts each individual buyer because of a crowding out effect, whereas doubling sellers benefits them thanks to cross-side network effects. However, the combination of cross-side network effects from each user group to the other implies that doubling both buyers and sellers should benefit each individual buyer. As we are interested in this combination of cross-side network effects, we assume that the number of buyers relative to sellers is fixed, equal to one for simplicity, so that doubling the number of users means increasing the number of buyers and sellers at the same rate.

In our model, there are two platforms—platform α, the acquiring platform, and platform β, the acquired platform—and a unit mass of buyers that are located on a Hotelling line. Platform α is located at zero, and platform β is located at one. Each buyer also has a value for the outside option. Buyer types are identified by their location on the Hotelling line, $d_i \sim U(0,1)$, and their value for the outside option, $\epsilon_i \sim U(-1,1)$. A buyer i located at point d_i on the Hotelling line has utility for platform α equal to $u_{i\alpha}(n_\alpha) = v(n_\alpha) - d_i$, where n_α is the mass of buyers using platform α. Horizontal preferences are given by the parameter d_i. Network effects exist whenever $v()$ is increasing in its argument. We assume that $v()$ is neither too small nor too large, so that the share of buyers located at d_i who choose the outside option is strictly between zero and one along the entire Hotelling line.

We have two periods, the premerger period in which both platforms α and β are available but each user is only aware of one of them, and the postmerger period in which only platform α is available and everyone is aware of platform α. Buyers do not expect the merger to occur. Premerger, when both platforms are available, we assume that advertising and customer acquisition efforts effectively split buyers in two groups, each of which is only aware of a single platform. We posit that there is an exogenous cutoff, k_1, such that buyers to the left of the cutoff ($d_i \leq k_1$) consider only platform α and the outside option, whereas to the right of k_1, buyers only consider platform β and the outside option. Buyers have rational expectations over the equilibrium number of buyers choosing the various options. They select, among the options of which they are aware, that which gives them the highest utility given their type (d_i, ϵ_i). In particular, buyer i for whom $d_i \leq k_1$ joins platform α if and only if $u_{i\alpha}(n_\alpha) \geq \epsilon_i$. Similarly, buyer i for whom $d_i > k_1$ joins platform β if and only if $u_{i\beta}(n_\beta) \geq \epsilon_i$.

Buyer choices result in two indifference conditions, depicted in Figure 1. The first condition is the point

Figure 1. (Color online) Buyer Types



Notes. This figure divides the space of buyer types according to an exogenous cutoff, k_1, and their optimal choices conditional on that cutoff. A denotes buyers who choose platform α both before and after the merger. B denotes buyers who switch from platform β to α. C denotes buyers who switch from the outside option to platform α. D denotes buyers who switch from platform β to the outside option.

along the vertical axis, k_2, where buyers are indifferent between the outside option and platform α: $v(n_\alpha) = k_2$. Similarly, the second condition determines the point of indifference, k_3, between platform β and the outside option: $v(n_\beta) = k_3$. The two indifference conditions and the exogenous cutoff, k_1, allow us to find an equilibrium in (k_1, k_2, k_3). The two market shares n_α and n_β can be derived from k_1, k_2, and k_3. They are graphically depicted as the A area (for n_α) and the B + D area (for n_β) in Figure 1. Note that this model could, in principle, have multiple equilibria, although for our purposes, equilibrium selection is not important.

At the realized equilibrium, the average per-buyer utility on platform α is equal to

$$\overline{u}_\alpha = v(n_\alpha) - \int_0^{k_1} d_i g(d_i) \partial d_i, \tag{1}$$

where $g(d_i) = 1/2n_\alpha[v(n_\alpha) + 1 - d_i]$ is the distribution of buyers' types along the Hotelling line (determined by the left trapezoid in Figure 1). Note that the utility has two components. The first, $v(n_\alpha)$, is the network effect component; the second, $\int_0^{k_1} d_i g(d_i)\partial d_i$, is the average distance from platform α among the buyers who choose to join platform α. The average per-buyer utility from platform β is similarly determined:

$$v(n_\beta) - \int_{k_1}^{1} (1 - d_i) h(d_i) \partial d_i, \tag{2}$$

where $h(d_i) = 1/2n_\beta\left[v(n_\beta) + d_i\right]$.

After the merger, platform β is removed, and every buyer becomes aware of platform α. The new equilibrium is determined by a single indifference condition: $v(n^*) = k_4$, where n^* denotes platform α's market share postmerger and k_4 is the utility for the outside option of the buyer located at $d_i = 0$ who is indifferent between platform α and the outside option. In Figure 1, the slope of the line between k_4 and k_5 is determined by the distribution of ϵ_i. Even if k_5 could be along the vertical line at $d_i = 1$ (where the share of buyers choosing platform α postmerger is strictly positive for all $d_i \in (0, 1)$) or along the horizontal line before $d_i = 1$, this line is parallel to that separating platform α and the outside option premerger. It is also worth noting that, regardless of the initial premerger market shares induced by the exogenously given k_1, the equilibrium postmerger always leads to the same split of buyers between platform α and the outside option and thus, the same n^*. The model assumptions imply that $n^* > n_\alpha$ (i.e., the number of buyers on platform α increases postmerger) and similarly, $n^* > n_\beta$.

There are four groups of buyers whose utility changes, as displayed in Figure 1. Buyers in the A area (stayers) are those who remain on platform α. Buyers in the B area (switchers) are those who migrate from platform β to α. Buyers in C (joiners) are those who join platform α from the outside option. Finally, buyers in D (leavers) are those who switch from platform β to the outside option.

To compare how utilities change after the merger, we start with buyers who remain on platform α. Their horizontal preferences remain constant (Equation (1)), whereas the value from a larger platform changes, so their per-buyer utility changes by

$$v(n^*) - v(n_\alpha). \tag{3}$$

If network effects exist, this difference is positive, and platform α's buyers are better off. Furthermore, the smaller the n_α, the larger the influx of users postmerger, and the larger the benefit to existing platform α's buyers. This is a testable hypothesis.

Hypothesis 1. *The benefits of the merger to existing buyers on platform α are decreasing in n_α (or equivalently, increasing in n_β).*

The hypothesis states that with network effects, the increase in average value for existing buyers on platform α is bigger in geographies where platform α was smaller before the merger.

To evaluate the role of horizontal preferences, we compare the post- and premerger utility of buyers who switch from platform β to platform α (switchers). The change in utility is equal to

$$\left[v(n^*) - v(n_\beta)\right] - \left[\int_{k_1}^{1} (d_i + k_1 - 1) f(d_i) \partial d_i\right], \tag{4}$$

where $f(d_i)$ is the distribution of switchers along the Hotelling line (area B in Figure 1). Switchers benefit from network effects because $n^* > n_\beta$ but are also on average farther from their platform of choice.

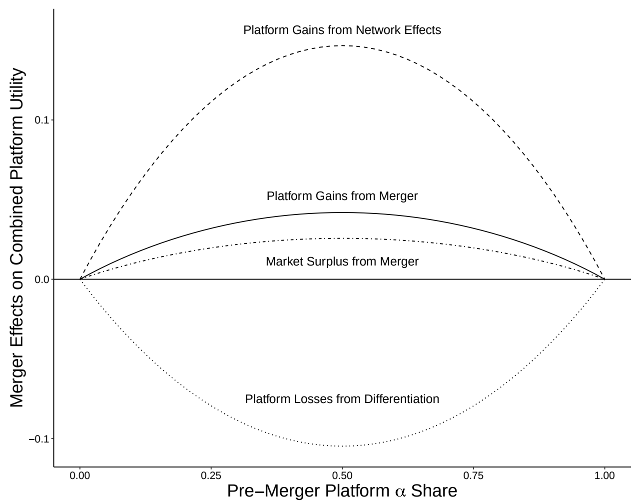
Our model does not yield a sharp prediction about how utility changes after the merger for switchers. Depending on whether network effects dominate over horizontal preferences, switchers may be better or worse off after the merger. Note, however, that there is a close relationship between the gains of buyers from platform α and platform β. In particular, suppose we compare the benefits to platform α's buyers from a merger in a geography where platform α had $\overline{n}$ buyers premerger and the benefits to platform β's buyers in a geography where platform β had $\overline{n}$ buyers. The benefits to platform α's buyers from the merger are greater than the benefits to platform β's buyers from the symmetric merger, and the difference is solely because of the role of platform differentiation. This is because in both Equations (3) and (4), the network effect benefits are $v(n^*) - v(\overline{n})$, whereas the reduction in platform differentiation only negatively impacts switchers (the integral in Equation (4)). If users have horizontal preferences over different platforms, the difference between Equations (3) and (4) when $n_\alpha = n_\beta = \overline{n}$ is negative. This is another testable implication.

Hypothesis 2. *Consider two geographies, one where platform α has $\overline{n}$ number of buyers and the other where platform β has $\overline{n}$ buyers. If buyers have horizontal preferences over platforms, switchers in the second geography benefit less from the merger than stayers in the first geography.*

Are network effects large enough for a single platform to create more value for buyers than two separate platforms? For this to be true, network effects need to dominate horizontal preferences. We have already argued that stayers should benefit and that switchers may or may not benefit. Joiners (area C) are definitely better off by switching from the outside option to the now larger platform α. Leavers (area D in Figure 1) are definitely worse off in switching to the outside option, which was already available premerger.

Rather than providing the algebraically complicated equations determining the change in buyer values, in what follows we discuss graphical intuitions from Figure 1. Platform managers care about how the merger affects their users, regardless of the alternative choices those users have at their disposal. This implies that platform managers care about the changes in buyers' utilities in areas A and B, to which they add buyers' postmerger utility in C and subtract buyers' premerger utility in D. This comparison is displayed in Figure 2, which plots the change in aggregate utility created by the platform as a solid line. The figure also separates the net change into its two components: the gains from network effects (dashed) and the losses from the removal of platform β (dotted). To more closely map the model to our empirical strategy, we plot the change in buyer utility as a function of the

Figure 2. Change in Buyer Utility



Notes. The figure plots the change in aggregate utility experienced by platform buyers after the merger as a function of platform α's premerger market share. Market share is computed as $n_\alpha/(n_\alpha + n_\beta)$. The solid line represents the total gains from the merger for buyers of either platform. These total gains are the combined result of benefits because of network effects (top line) and costs from the loss of platform differentiation (bottom line). The dotted-dashed line just below the solid line represents the total change in utility for all buyers, including those who choose the outside option.

market shares that we can compute in our data, $n_\alpha/(n_\alpha + n_\beta)$. Network effect gains are maximized in geographies where platform α's premerger market share is 0.5. Similarly, the losses from platform differentiation are largest at the same point. If network effects dominate, as in Figure 2, the benefits from the merger are maximized in more competitive geographies, where the two platforms have similar market shares. This is our last testable hypothesis.

Hypothesis 3. *If network effect benefits dominate the losses from the reduction in platform differentiation, then buyers in geographies with intermediate market shares for the two platforms will benefit the most from the merger.*[3]

This latter hypothesis informs the strategic considerations of platform managers. Our theory highlights the tension between network effects and platform differentiation. Depending on the relative importance of these two forces, eliminating an acquired platform may or may not be beneficial to the acquirer. To make an effective decision about whether to combine platforms, managers need to understand the magnitude of these two forces.

We see in Figure 2 that the net gains from the merger are smallest where platform α's premerger market share approaches one, thus rationalizing our use of such geographies as a control group in the analysis. Finally, before turning to our setting and empirical results, note that this model also partially informs antitrust. Regulators care about the change in utility of all buyers, considering their alternative options with or without platform β. This means that, in addition to that focused on by platform managers, regulators also take into account the value from the outside option that joiners enjoyed before the merger and the value from the outside option that leavers enjoy after the merger. Our theory assumes that the value of the outside option is constant before and after the merger. Under this assumption, the value that a regulator considers when evaluating a platform merger (dotted-dashed line in Figure 2) will tend to be below the value that platform managers take into account when choosing whether to operate two platforms versus one platform (solid line in Figure 2). It is not possible, however, to measure this in our empirical analysis.

4. Setting and Data

Our study relies on proprietary data from A Place for Rover, Inc. (Rover). Founded in 2012 in Seattle, Rover was the largest online platform for pet care services in the United States as of 2018, with a valuation of $970 million.[4] At the time, the company was processing roughly 1 million bookings per month. DogVacay was a nearly identical platform, founded in 2012 in Santa Monica.

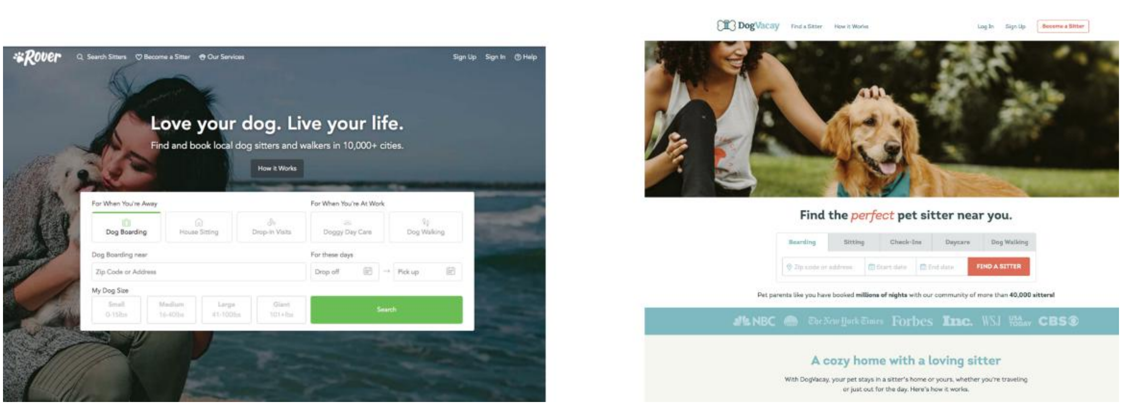
The pet industry market is large and growing. According to the American Pet Products Association,[5] in 2019 pet owners in the United States spent $95.7 billion on their pets, including $10.7 billion in services like boarding, grooming, training, pet sitting, and walking, constituting a 5.5% increase over the previous year. In the United States, 84.9 million households, or 68% of all households, own a pet. Of them, 75% own a dog.

Dog owners (buyers) use Rover—and DogVacay before the acquisition—to obtain pet care services offered by sitters (sellers).[6] The services range from dog walking to in-home pet grooming, with dog boarding being the biggest category on both platforms. Indeed, before the acquisition, Rover and DogVacay were the largest players in the online dog boarding market. The next largest competitor was Wag Labs (Wag), which mainly offered dog-walking services. Wag only began to offer overnight boarding in 2016,[7] and this never became their most important service category. In 2017, Rover's revenues were five times higher than those of Wag.[8] Offline competitors include more traditional businesses, like kennels and dog hotels, and informal solutions, such as friends and family. Although we do not have data on these alternatives, our theoretical model is based on the assumption that kennels do not change the prices or quality of their offerings in response to the acquisition.

At first glance, Rover and DogVacay seem to be close substitutes, especially compared with competing platforms in other industries. They have similar interfaces (Figure 3) and transaction flows, which remain constant through the end of our study. When buyers need pet care services, they initiate a search for sellers available in their preferred category[9] for a given location and dates. As is typical in online platforms for local services, buyers then see a list of search results consisting of available sellers along with their name, picture, location, online ratings, and nightly price, ranked by the companies' proprietary algorithms. Buyers can then choose to contact a given seller to discuss their needs and confirm availability. An exchange is not finalized until both users accept the transaction. Transactions come with reservation protection, trust and safety support, and a secure payment system provided by the platform.

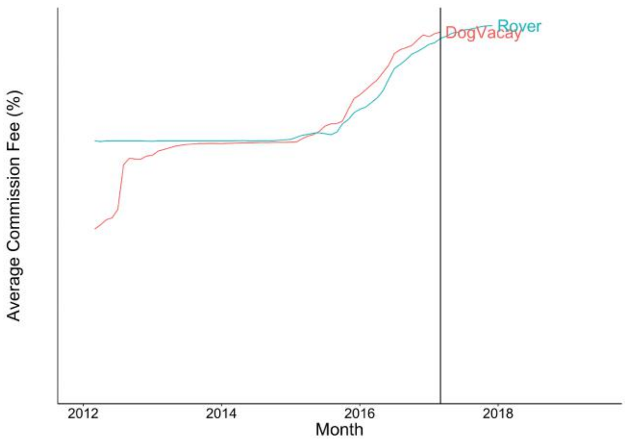
Figure 3. (Color online) Landing Pages of Rover and DogVacay

(a) (b)



Notes. (a) Rover.com, March 2017. (b) Dogvacay.com, March 2017. The figures show the landing pages of Rover and DogVacay before the acquisition. The screenshots are accessible on Wayback Machine (https://web.archive.org/web/20170307101746/https://www.rover.com/ and https://web.archive.org/web/20170228165616/https://dogvacay.com/).

Figure 4. (Color online) Average Fees



Notes. The figure plots the average commission fee as a percentage of the total amount that buyers pay in a given month. The vertical line indicates March 2017, when the acquisition was publicly announced. Levels on the *y* axis are hidden to protect company information.

A deeper comparison reveals, however, a number of differences between Rover and DogVacay. For one, the platforms' respective proprietary algorithms, used to rank sitters in the search results, weigh sitter characteristics differently.[10] DogVacay furthermore offered a "meet and greet" option before finalizing a match, whereas Rover did not. Lastly, user sorting across the platforms could create differences in user experiences, either because of path dependence or because of strategic decisions on the part of the platforms regarding which types of users to attract (Halaburda et al. 2018).

Just prior to the acquisition, both Rover and DogVacay took about 20% of gross transaction volume (GTV) in commission fees, up from 15% when they first started. Sellers would set the prices for their services.[11] By the end of our data, in early 2018, fees on Rover were divided into a provider (seller) fee and an owner (buyer) fee. The provider fee was 15% for those who joined before March 2016 and 20% for those who joined after this date. The owner fee was zero if the owner joined before September 2015, whereas it varied but was never more than $50 per booking for those who joined afterward.[12] DogVacay had a very similar fee structure, and its commissions were comparable with those of Rover throughout the period between 2012 and 2017 (Figure 4).

4.1. The Acquisition

On March 29, 2017, Rover announced it would buy DogVacay[13] and managed to do so in an all-stock deal.[14] Indeed, DogVacay had reportedly been struggling to keep up with the recent cash injections that Rover had received from venture capitalists.[15] Although additional terms of the acquisition were not disclosed, it is unlikely that the merger was subject to review by the Federal Trade Commission or the Department of Justice because the Hart–Scott–Rodino threshold for mandatory reporting was $80.8 million in 2017. Neither the Federal Trade Commission nor the Department of Justice have a publicly available case involving Rover.[16]

Three features provide a unique opportunity to study network effects from this acquisition: the purchasing of DogVacay led to a single aggregate platform, users migrated to the surviving platform within three months, and we can identify the same users across the two platforms.

It is, in fact, rare to see an acquired platform merged with the acquiring platform. For example, even though Zillow acquired Trulia in 2015, the two platforms are both still active. The same holds for Google Maps' purchase of Waze, as well as many online travel booking sites jointly owned by Booking Holdings. As Aaron Easterly, the Chief Executive Officer of Rover, explained in a public interview,[17] the decision to fully absorb DogVacay was made in light of the rapid growth that Rover was experiencing during the acquisition, as opposed to a direct consequence of network effects or the differentiation between Rover and DogVacay.

Second, the transfer of DogVacay's users to Rover happened quickly. In February 2017, Rover agreed to buy DogVacay. The acquisition was publicly announced at the end of March. In early May, Rover announced that DogVacay would be shut down. By early July, DogVacay ceased operations.

Third, Rover allowed the migrating DogVacay users to link their previous account to their new Rover account, thus transferring all their transactions and online rating history to the Rover platform. Multihoming users who did not actively link their accounts could meanwhile be identified from their email address. Although matching users based on email address can sometimes be inaccurate, the similarity of the services exchanged on the two platforms would suggest that individuals seriously interested in utilizing both platforms would use the same email address.[18]

4.2. Data

We observe all service requests, buyer-seller booking inquiries, matches, and reviews from *both* platforms before and after the acquisition. A *request* refers to a buyer's need for a sitter (e.g., dog boarding in Seattle from August 16th to August 18th) and is created when a buyer initiates a search or contacts a sitter directly. Contacts for the same request with different sellers are recorded as *booking inquiries*. A search leads to a recorded request only if a buyer sends at least one booking inquiry to a sitter. If a booking inquiry leads to a transaction, it is matched to a *stay*. Although both DogVacay and Rover have multiple service categories, we focus here on dog overnight boarding, which constitutes 70% of the gross transaction volume on Rover and 91% on DogVacay before the acquisition.

We consider all buyer-seller booking inquiries initiated between June 2011 and January 2018 for requests between January 2012 and January 2018. Of all booking inquiries, we remove those whose duration (i.e., number of nights requested) is recorded as negative or greater than one month (0.6% of requests) and those with lead times (i.e., time between start date and request date) recorded as negative or greater than one year (1.1%). We also remove outliers in terms of total price or commission fee percentage (2.3%). Specifically, we exclude prices below $1 or higher than $200 per night and commission fees greater than 30%. In total, this results in the exclusion of 4.2% of the requests and 3.8% of the transactions.

We now turn to competition between Rover and DogVacay before the acquisition, several aspects of which suggest that the merger would likely generate network effects if these exist in digital platforms such as ours. First, the two platforms were of similar size in the dog overnight boarding category before the acquisition, with Rover transacting at a 25% higher volume compared with DogVacay in the quarter before the acquisition.[19] Second, the local nature of the services exchanged implies that buyers are typically interested in transacting with sellers within the same city. Indeed, 79% of booking inquiries and 81% of stays occur within a buyer's core-based statistical area (CBSA).[20] This means that we can measure competition between Rover and DogVacay at the local rather than aggregate level. Third, we investigate multihoming. Few users, and fewer buyers than sellers, use both platforms. We define a user as multihoming if they transact at least once on both platforms over the five years before the acquisition. Only 3.3% of buyers and 7.6% of sellers multihome. Not surprisingly, multihoming users tend to transact more frequently than single-homing users. Indeed, 27% of the transactions are made by multihoming sellers, and 8% are made by multihoming buyers.[21]

During the period before the acquisition, DogVacay sellers received about $3.50 more per night (13% more) than sellers on Rover.[22] After controlling for geographic and time observables, this price difference decreases to about 6%, although it completely disappears once we compare the prices of multihoming sellers transacting on both Rover and DogVacay within the same month (Online Appendix C, Table C.1). This suggests that although sellers may have different qualities across platforms, which also may induce demand sorting, multihoming sellers consider the two platforms to be close substitutes.

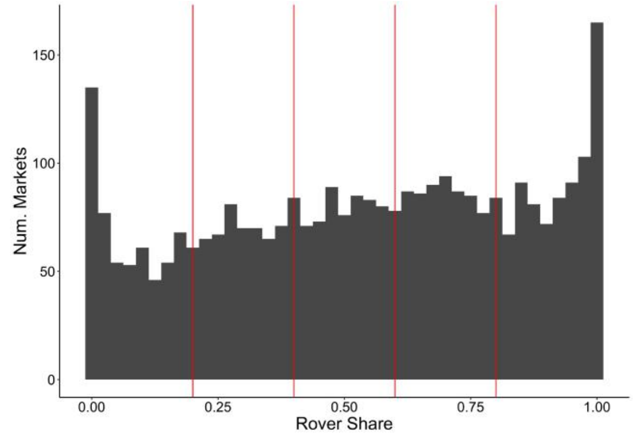
Figure 4 plots the average commission fee on the two platforms, computed as the ratio of platform fees over the total amount paid by buyers. We observe that commission fees were very similar across platforms and continued their preacquisition upward trend after Rover acquired DogVacay, largely because of the higher fee schedule for buyers and sellers who joined after September 2015 and March 2016, respectively, whose shares increased steadily over time. As is clear from the figure, commission fees did not increase discontinuously after the acquisition, suggesting that Rover did not take advantage of its increased market power to increase prices.

5. Empirical Strategy and Identification

In this section, we describe how we test our theory. Our hypotheses in Section 3 rely on premerger variation in the number of platform users across geographies. As there is a direct mapping from users to market shares, we focus on empirical variation in market shares measured in terms of gross transaction volume (GTV, or the total amount paid by buyers for platform and seller revenues). Figure 5 shows the distribution of Rover's market shares (equal to Rover GTV divided by the sum of Rover and DogVacay GTV) in 2016 across zip codes with at least 50 stays in that year. Because buyers' and sellers' zip codes may differ, we use sellers' zip codes for our market definition. In the average zip code in 2016, Rover had a 53.6% market share, although there is substantial variation across zip codes. At least part of this variation can be explained by the different expansion strategies adopted by Rover and DogVacay when they were just starting out.[23]

We separate zip codes into five groups: those where in 2016, Rover had a market share below 20%, between 20% and 40%, between 40% and 60%, between 60% and 80%, and above 80%. Merging the two platforms after the acquisition was effective in terms of shifting DogVacay users to Rover. Zip codes with a Rover market share smaller than 10% experienced a median increase in users on Rover of 550%, whereas markets above 90% had a median increase of 14% (Online Appendix C, Figure C.4).

Figure 5. (Color online) Rover Market Shares Preacquisition



Notes. The figure plots the histogram of Rover market shares in 2016, the year prior to the acquisition. Each observation is a zip code with at least 50 transactions in 2016. The Rover market share in a zip code is defined using gross transaction volume (GTV).

To test our hypotheses, we cannot simply compare zip codes before and after the merger because aggregate shocks (e.g., seasonality or changes in business operations following the acquisition) may confound the results. We accordingly create a control group—which we expect to be relatively unaffected by network effects and platform differentiation—using the zip codes where Rover was already dominant premerger (i.e., had more than 80% of the market share). We divide the remaining markets into four treatment groups, corresponding to the other market share groups displayed in Figure 5. Importantly, we allow for the treatment effects to vary across markets with differing market shares because our theory predicts nonmonotonic effects across these markets.

Zip codes where either Rover or DogVacay was dominant before the acquisition tend to be more rural, have fewer residents, have lower population densities, and have lower shares of college graduates. Areas where Rover is particularly successful also tend to have higher pet ownership rates.[24] These differences raise the concern that the main assumption behind our difference-in-differences approach—namely, that zip codes with different market shares have the same latent trends in platform performance—does not hold.

To ensure that zip codes in treated market share groups are as similar as possible to zip codes in the control group, we employ a matching estimator that accounts for covariate imbalance across groups (Imai et al. 2019). Specifically, we match one zip code from the control group to each "treated" zip code using covariate balancing propensity score matching, introduced by Imai and Ratkovic (2014). Distances are calculated on the total number of active sellers in each month up to a year before the acquisition, where an active seller is defined as having been involved in at least one booking inquiry in the given month. We hold the matched control group constant as we measure the effects of combining the two platforms across different outcomes of interest. Matching on number of sellers ensures that the treated and control groups have similar numbers of participants across the two platforms combined, but our results do not depend on whether we match on the number of buyers, the number of sellers, or a combination of both (Online Appendix A.2).

Online Appendix C, Table C.4 provides descriptive statistics for the matched samples and shows that we are able to improve matching on a number of covariates that are not explicitly used in the matching procedure.[25] However, the platform performance metrics that are not explicitly considered in the matching (e.g., prices, match rates, and share of repeat transactions) fail to balance across the treatment and control groups. Some of this imbalance is expected. For example, we know that prices are higher on DogVacay, and thus, average prices will be higher in markets with a greater DogVacay share. Other differences reflect the fact that platform performance metrics tend to positively correlate with a platform's market share. In any case, our empirical strategy (described here) does not require identical levels of pretreatment outcomes but rather, parallel trends. The figures in Section 6 provide support for this assumption.

Given matched zip codes, let y_{zt} be the outcome in treated zip code z and year-month t. Separately for each treated market share group $[0-20\%)$, $[20\%-40\%)$, $[40\%-60\%)$, and $[60\%-80\%)$, we estimate the following regression:

$$y_{zt} - y_{z't} = \beta + \alpha_{t,t\neq Feb'17} + \epsilon_{zz't}, \tag{5}$$

where z is the treated zip code, z' is the matched control zip code, and t is the year-month. The coefficients $\alpha_{t,t\neq Feb'17}$ should be interpreted as changes in the outcome variable relative to the control group and relative to February 2017, the month before the acquisition announcement. Cluster-robust standard errors are calculated using the method from Aronow et al. (2015).[26]

Equation (5) allows us to test Hypotheses 1 and 3. Hypothesis 1 posits that, because of network effects, the coefficients $\alpha_{t,t\neq Feb'17}$ after the merger should be positive and increasing as Rover market share decreases. With regard to Hypothesis 3, if network effects are large enough to justify a single combined platform, we would expect the largest benefits from network effects to arise in the zip codes with intermediate market shares.

A different approach is needed to test Hypothesis 2. Recall that in order to evaluate the role of platform differentiation, we must estimate the extent to which DogVacay buyers are worse off *relative to* Rover buyers who experienced the same change in platform size. Rover buyers in markets with Rover's premerger market share of $\overline{n}$ experience a change in platform size similar to DogVacay buyers in markets with Rover's premerger market share of $1-\overline{n}$. We attribute any difference in outcomes between Rover and DogVacay buyers in these symmetric markets to a reduction in platform differentiation.

Let $s \in \{0, 20\%, 40\%, 60\%, 80\%\}$ denote the lowest Rover's market share in each of our market share groups. For each of the five s, we consider the outcomes of Rover buyers in zip codes with market shares within $[s, s+20\%)$ and the outcomes of DogVacay buyers in zip codes with market shares within $[80\%-s, 100\%-s)$. With these outcomes, we estimate the following regression:

$$y_{zt} = \delta_t + \gamma_{t,t\neq Feb'17}\mathbb{1}\{z \text{ has market share in } [80\%-s, 100\%-s)\} + \nu_z + \epsilon_{zt}, \tag{6}$$

where y_{zt} is the outcome of Rover buyers in zip code z and year-month t if $z \in [s, s+20\%)$ or the outcome of DogVacay buyers in zip code z and year-month t if $z \in [80\%-s, 100\%-s)$. The coefficients γ_t measure the difference in outcomes between DogVacay and Rover buyers in markets where both users experienced the same change in market size and in month t relative to February 2017. We expect the γ_t to be negative because of the loss of platform differentiation.

In estimating Equations (5) and (6), we first use outcomes that proxy for a buyer's utility: match rates, computed as the number of successful transactions in a given month and zip code divided by the number of posted requests, and total number of transactions in a month and zip code. To ensure that results for buyers are not driven by a reallocation of value to the platform or sellers, we also use GTV and commission revenues as additional outcomes.

To test Hypotheses 1 and 2, we categorize buyers as Rover or DogVacay buyers premerger. Rover buyers are those whose booking inquiries in a given calendar year were all done on Rover. We define DogVacay buyers similarly. We then measure their outcomes—match rates and transactions—in any given month of the following calendar year. The small share of multihomers (those with inquiries on both platforms in a given year) are analyzed separately in Online Appendix A, Figure A.6.

To test Hypothesis 3 (i.e., are network effects large enough to justify a combined platform?), we compute market-level outcomes by aggregating Rover and DogVacay outcomes (or simply Rover outcomes after DogVacay was shut down). We also measure outcomes for buyers who had never posted requests prior to the given month and observe that the results hold for those new buyers.

Online Appendix A presents additional outcomes proxying for other components of buyers' utility as well as assesses robustness to alternative matching strategies and synthetic difference in differences (Arkhangelsky et al. 2021, Orchinik and Remer 2021). Finally, we obtain similar results for more aggregated market definitions based on zip code clusters, which are less prone to potential violations of the stable unit treatment value assumption but produce noisier estimates.

6. Results

This section presents our results,[27] starting with tests of platform-level network effects (Hypothesis 1). In this case, y_{zt} is the outcome of buyers in zip code z and year-month t for buyers who had posted their booking inquiries only on Rover in the calendar year preceding t. Figure 6(a) plots the estimates of Equation (5) with log number of transactions and request match rates as the outcomes. As our theory predicts, the upper row shows that Rover buyers benefit more from the merger when the influx of users from DogVacay is larger. The effects on the upper row imply a 26% increase in transactions for the markets with 0–20% market shares (first plot from the left) and around a 17% increase in transactions for markets with 20%–40% or 40%–60% market shares (second and third plots). This rise in transactions is consistent with the increased variety of sellers on the platform because of the migration of sitters from DogVacay, as opposed to other explanations such as relatively less competition from other buyers.[28] The increase in Rover buyer activity comes from the extensive margins—more users posting requests—rather than match quality or match rates. Indeed, the lower row of Figure 6(a) shows that Rover buyers did not experience an improvement in match rates, and Online Appendix A, Figure A.1 confirms that our proxies for match quality remain unchanged.

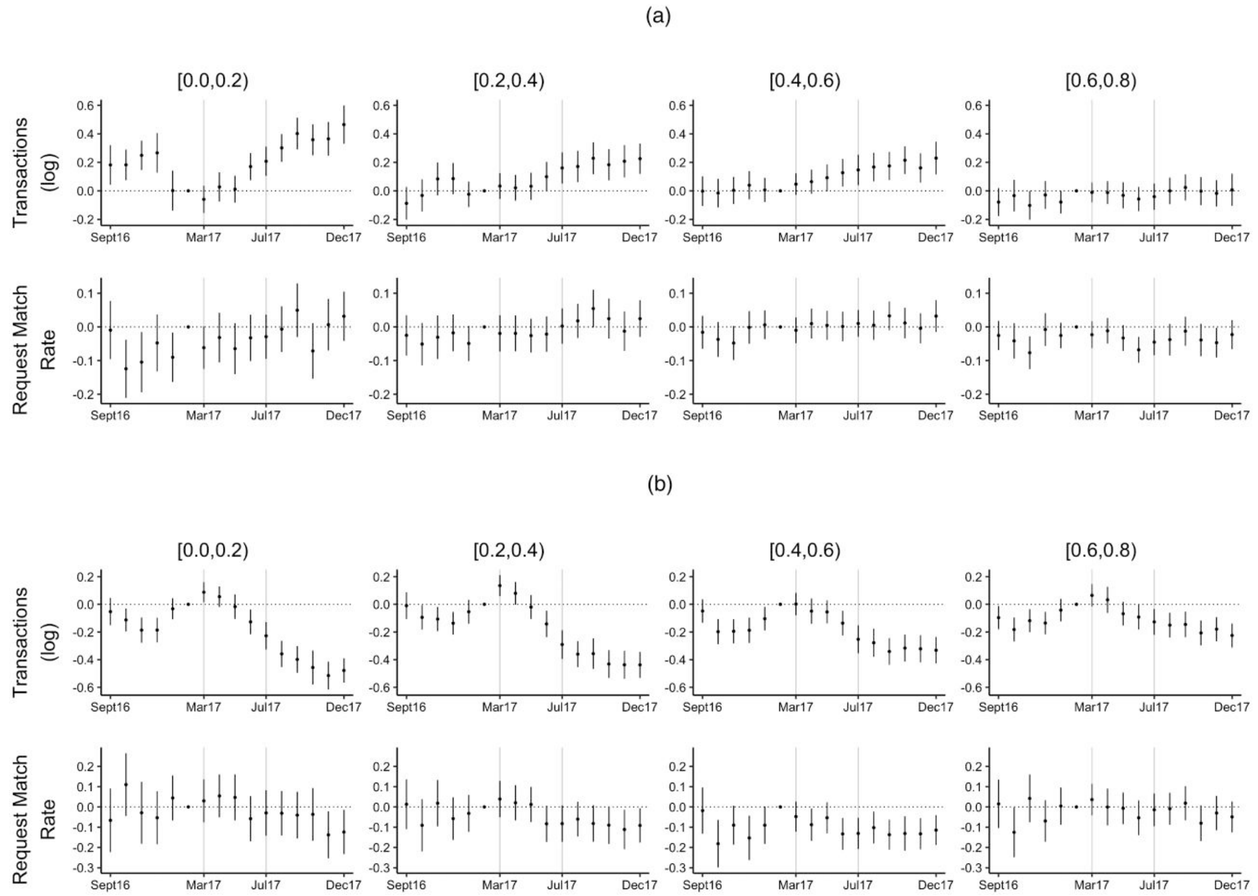
We see in the upper row of Figure 6(a) that network effects do indeed exist, potentially justifying the company's decision to integrate an acquired competitor into its existing platform. However, as we shall see, the presence of network effects is not sufficient to justify a dominant platform.

Next, we evaluate the effects of the merger on DogVacay users. We start with Figure 6(b), which mirrors the previous analysis. Here, y_{zt} is the outcome in zip code z and year-month t for buyers who had posted booking inquiries only on DogVacay in the calendar year preceding t. The upper row of Figure 6(b) shows that DogVacay buyers experience higher attrition and lower match rates compared with before the acquisition and compared with DogVacay buyers in the control zip codes.[29]

Although the negative coefficients in Figure 6(b) seem to suggest that DogVacay buyers are worse off after the merger, this figure actually shows something more subtle; the merger benefits are lower for DogVacay buyers in higher DogVacay-share markets versus control markets. This pattern simply confirms that the network effect benefits of the merger for DogVacay buyers are largest in the control markets where DogVacay was smaller.

To evaluate the role of platform differentiation, we estimate Equation (6), where the γ_t coefficients represent the extent to which DogVacay buyers are worse off *relative to* Rover buyers who experienced the same change in platform size. Figure 7 plots the estimated γ_t coefficients for each month leading up to and after the acquisition. Across all market share groups, DogVacay buyers clearly experienced a reduction in the number of transactions (upper row) and request match rate (lower row) relative to Rover buyers in symmetric markets. In fact, the decline in outcomes started in January and February 2017, before the merger was announced but presumably during merger talks. This decline continued during the March to July 2017 period as DogVacay users started migrating to Rover. Outcomes then drop drastically after DogVacay was shut down before stabilizing. Overall, the reduction in DogVacay buyer transactions relative to those of Rover buyers is at least 10% across all market share groups, and the reduction in match rates is at least four percentage points (Online Appendix A, Table A.3).

Figure 6. Estimates of Merger Effects at the Platform Level

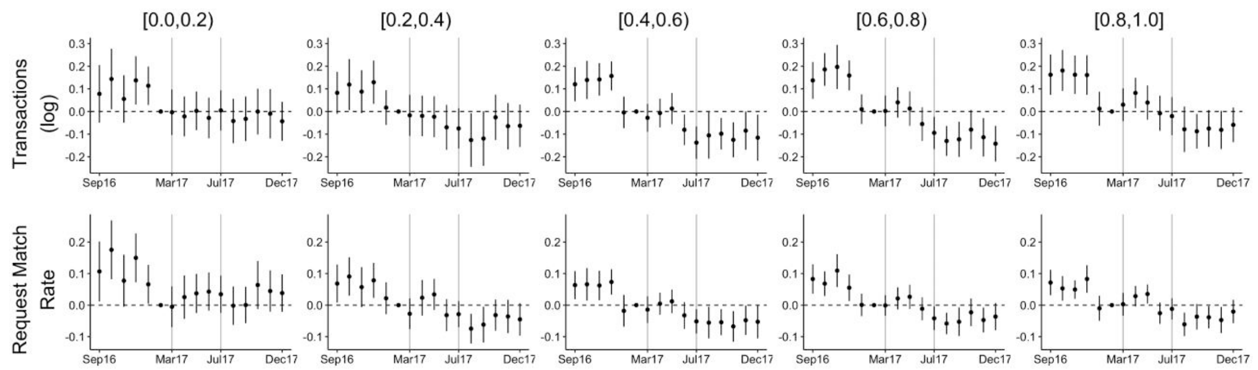


Notes. (a) Rover users. (b) DogVacay users. Regression estimates of Equation (5). In panel (a), we test Hypothesis 1. The upper row displays results where the outcome is the (log) number of transactions of buyers whose booking inquiries had all been made on Rover in the prior calendar year. The lower row displays results for the match rate of those same Rover buyers (i.e., the number of stays divided by the number of posted requests). Panel (b) displays analogous outcomes for buyers who, in the prior year, had only engaged in booking inquiries on DogVacay. An observation is a matched zip code-month. In each panel, the regressions come from two different outcomes (transactions and match rates) and four treatment groups (zip codes with Rover market shares in the following bins: 0–20%, 20%–40%, 40%–60%, and 60%–80%). The control group from which matched zip codes are selected includes zip codes with Rover market shares greater than 80%. Grey vertical lines denote March and July 2017, the months when the acquisition was announced and DogVacay was effectively shut down, respectively. Extensions, including other outcomes, results for multihoming users, and estimates with clusters of zip codes as markets, can be found in Online Appendix A.

The final step in our analysis consists of testing whether network effects are large enough to more than offset harm from the loss of platform differentiation (Hypothesis 3). Figure 8(a) plots the results where the outcome in the first row is the (log) total number of transactions in a given zip code-month, regardless of whether these were intermediated by DogVacay or Rover. As before, each column corresponds to a different treatment group. This time, however, if network effects dominate the reduction in platform differentiation, we would expect the largest increase in the number of transactions to occur in zip codes with intermediate market shares (i.e., 40%–60%).

The upper row of Figure 8(a) shows that indeed, an uptick in the number of transactions seems to occur postmerger in zip codes with 40%–60% market shares. Yet, the estimated effect is noisy and often indistinguishable from a null effect. Pooling together the months after DogVacay's shutdown to estimate a single difference-in-differences coefficient for each treatment group (Online Appendix A, Table A.4) confirms that the effect is not statistically significant. Zip codes with market shares farther from 40%–60% are indistinguishable from the control group, and if anything, the difference-in-differences coefficient for the 0%–20% and 20%–40% market share groups implies a marginally significant 7.5% decrease in the number of transactions. Similarly, we do not find any positive effect of the merger across market share groups for the request match rate (lower row of Figure 8(a)). For zip codes where Rover had less than a 20% market share, we even observe a considerable reduction in match rates of 3.5 percentage points. These findings and those presented in Online Appendix C, Figure A.4 suggest that buyers do not find matches of higher quality or at

Figure 7. Estimates of Merger Effects for DogVacay Users Relative to Rover Users



Notes. Regression estimates of Equation (6) testing Hypothesis 2. The upper row displays results where the outcome is the (log) number of transactions of buyers whose booking inquiries had all been made on Rover or DogVacay in the prior calendar year. The lower row displays results for the match rate of these same buyers. Each column corresponds to a market share group $(s, s+20\%)$. Given $(s, s+20\%)$, the figure plots the estimated difference in outcomes between DogVacay users in markets with Rover market shares in (80%–s, 100%–s) and Rover users in markets with Rover market shares in $(s, s+20\%)$. For example, the first plot in the upper row compares the (log) number of transactions that DogVacay users exchanged in markets where Rover had premerger market shares above 80% and the number of transactions that Rover users exchanged in markets where Rover had premerger market shares below 20%.

higher rates with the single merged platform compared with when there were two competing platforms. These market-level results are not driven by differences in the mix of buyers and sellers across market shares; indeed, postmerger, the number of buyers for each seller is similar in magnitude across market share groups (Online Appendix C, Figure C.8(b)).

When considering new buyers only, we again reject the hypothesis that a single platform is better for buyers than are two competitors. Specifically, Figure 8(b) displays regression estimates of Equation (5) using transactions and match rates of new buyers, defined as those who had never posted a request prior to the current month. The plots show surprisingly stable transaction volumes and match rates after the merger across all treatment groups relative to the control group. This is an interesting result in that it suggests that horizontal preferences for platforms are not something that users develop *after* joining a particular platform. Indeed, if this was the case, we would find a single dominant platform to be on average preferred by new buyers.

Lastly, we measure the effects of the merger on platform revenue as measured by GTV and commission fees. The results are presented in Figure 9 and show that both GTV and commission fees postmerger are comparable with the sum of GTV and commission fees from the two competitors premerger. This confirms that our findings for buyers are not due to a redistribution of value to the platform or its sellers.

6.1. Predictors of User Attrition Postmerger

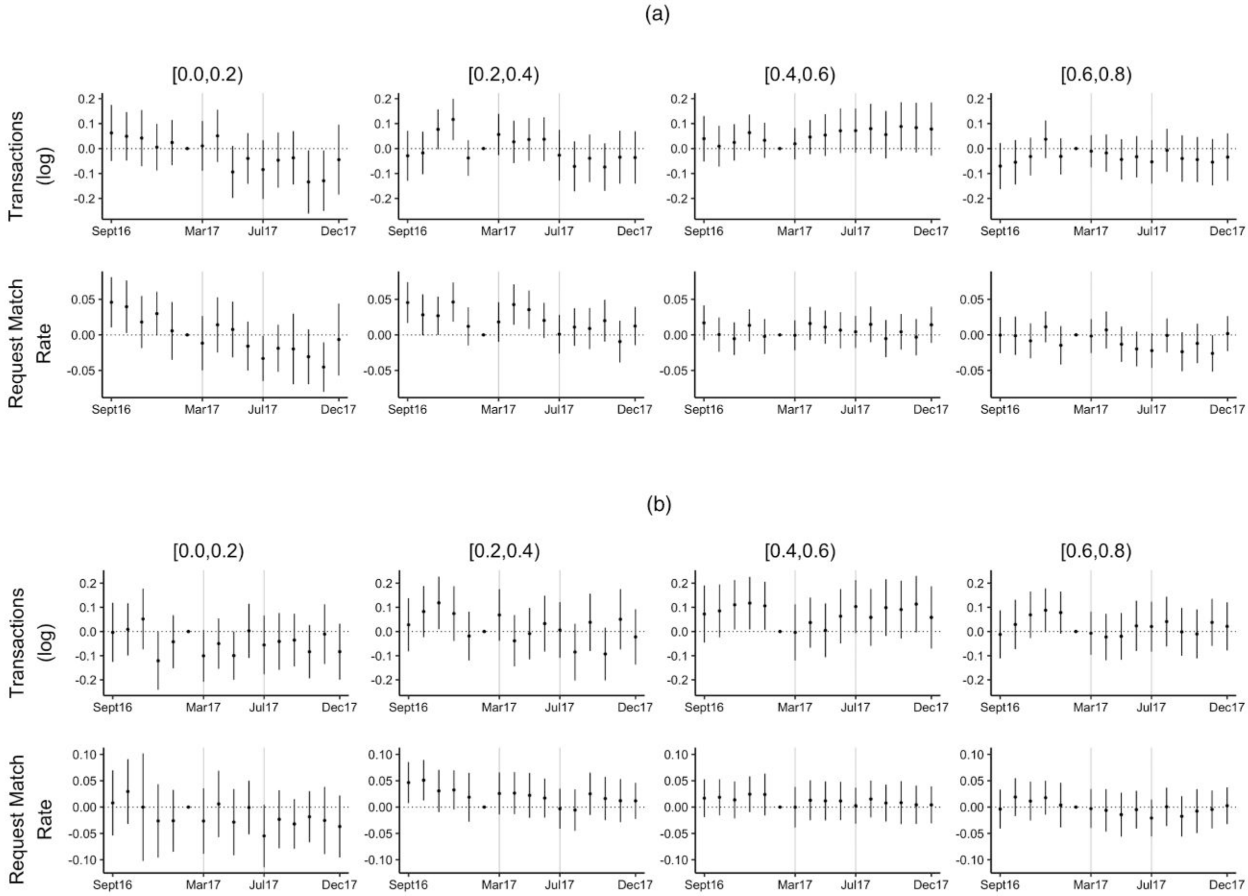
In this subsection, we set forth evidence helping to explain why DogVacay buyers, despite benefiting from the increase in platform size, are worse off relative to Rover buyers. The same analysis for sellers provides similar results (Online Appendix C, Table C.5).

We match DogVacay buyers to similar Rover buyers and explore their activity after DogVacay was shut down. Specifically, we consider buyers who made at least one transaction in 2016 and match them based on their activity throughout 2016. Each buyer is associated to a unique market corresponding to the modal zip code of the sellers with whom they communicated in 2016. We use coarsened exact matching on the number of transactions and booking inquiries, the month of the last transaction, whether they had at least two transactions in 2016 with the same seller, the average nightly price of all their 2016 transactions, and Rover's premerger market share in their market. For the latter, we match DogVacay buyers from market share group $[80\% - s, 100\% - s)$ with Rover users from market share group $[s, s+20\%)$. We then conduct regression analyses using the matching weights we obtain and excluding users for whom there was no match (Hong 2010). Our outcome of interest is a buyer's total number of transactions between August and December 2017, after DogVacay was shut down.

Our first result, displayed in Table 1, column (1), shows that DogVacay buyers are less likely to transact after the closure of their platform. The average number of transactions is 0.74, with DogVacay buyers engaging in 0.22 fewer transactions compared with Rover buyers. This effect is economically important, representing an almost 30% decline in transactions. The subsequent columns in the same table explore several potential reasons for this drop.

A first possible explanation is that dog owners prefer to engage in repeat transactions with prior sellers.

Figure 8. Net Effects at the Market Level



Notes. (a) Market outcomes. (b) New users. Regression estimates of Equation (5) testing Hypothesis 3. Panel (a) presents market-level outcomes (log transactions and request match rate), whereas panel (b) focuses on the same outcomes for new users, defined as those who had never made a booking inquiry before the given month. Otherwise, the plots are identical to Figure 6. Extensions and robustness checks are provided in Online Appendix A.

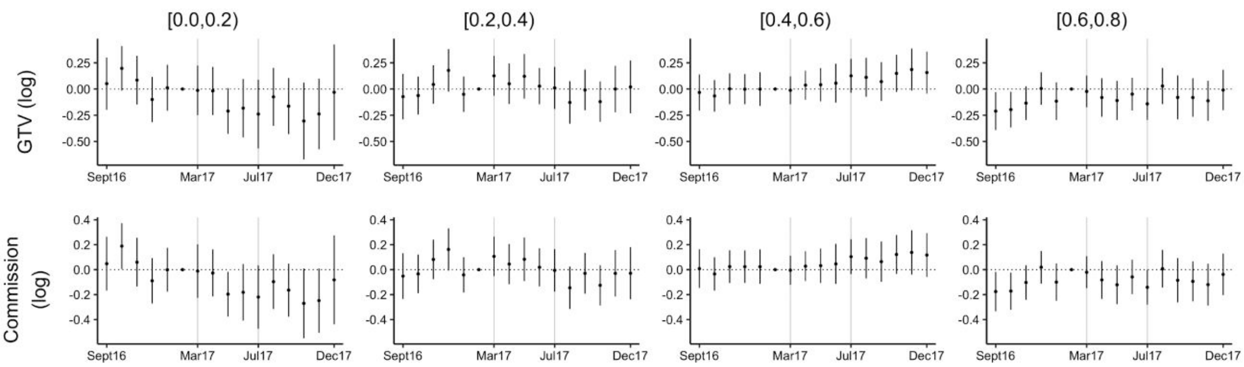
On average, 50.8% of 2016 transactions were between a buyer and a seller who had already worked together. If buyers and sellers come to trust each other, they may be willing to transact off the platform on future occasions. The shutdown of DogVacay could thus have led some users to disintermediate rather than migrate to Rover.

If disintermediation occurs, then we would expect DogVacay buyers with repeat transactions in 2016 to have fewer postmerger transactions relative to similar Rover buyers. We see in column (2) of Table 1 that this seems to be the case because the interaction term between DogVacay user and having repeat transactions has a statistically significant coefficient equal to −0.24. In fact, we find that DogVacay buyers with a prior repeat stay have 0.17 (0.24–0.07) fewer transactions postmerger relative to those without repeat stays, whereas Rover buyers have 0.07 more transactions, consistent with disintermediation.

Another explanation for why DogVacay buyers are worse off relative to Rover buyers is that they may not have been able to find their seller on Rover. Indeed, not all DogVacay sellers migrated to Rover. Buyers who did not find their prior sitter may have decided to either stop searching or send a request to a less preferred sitter. If this were true, then sellers' decisions to join Rover would help predict the postmerger transactions of the buyers with whom they interacted before the merger.

To study this coordination failure, we measure whether a DogVacay buyer's last seller in 2016 migrated their account to Rover postmerger. We add this dummy variable in column (3) of Table 1. We see that DogVacay buyers have 0.06 more transactions on Rover if their most

Figure 9. Net Effects on Platform and Seller Revenue



Notes. Regression estimates of Equation (5), where the outcomes are the logged GTV and logged commission fees (for Rover postmerger and as the sum of Rover and DogVacay premerger). Otherwise, the plots are identical to Figure 6.

recent DogVacay seller migrated and that having a prior repeat stay and a seller who migrated, are associated with an additional 0.17 increase in the number of transactions. This result provides support for the presence of coordination failures.

Finally, we show that the attrition patterns are consistent with switching costs. In column (4) of Table 1, we add a predictor by interacting an indicator for whether a buyer was on DogVacay in 2016 with their number of transactions in 2016. We find a negative coefficient of 0.09, implying that the more active DogVacay buyers had fewer transactions after their platform was shut down relative to similar Rover users. However, this coefficient is not large enough to imply that more frequent DogVacay buyers transact less postmerger compared with less frequent DogVacay buyers. This result suggests that switching costs at least partially explain attrition, given that high-value DogVacay buyers have the greatest incentive to switch platforms.

To summarize, we document that DogVacay buyers made 30% fewer transactions relative to similar Rover buyers after DogVacay was shut down. Although we

Table 1. Transactions of Buyers After DogVacay Is Shut Down

	Number of Transactions Post-DogVacay Shutdown			
	(1)	(2)	(3)	(4)
DogVacay User	−0.2234***	−0.0978***	−0.1504***	−0.0346**
	(0.0065)	(0.0057)	(0.0101)	(0.0152)
# 2016 Stays	0.0750***	0.0802***	0.0804***	0.1370***
	(0.0033)	(0.0044)	(0.0044)	(0.0083)
Avg. Nightly Price (2016)	0.0016***	0.0016***	0.0016***	0.0016***
	(0.0002)	(0.0002)	(0.0002)	(0.0002)
Has Repeat Stay		0.0727***	0.0729***	−0.0846***
		(0.0129)	(0.0129)	(0.0199)
DogVacay User × Has Repeat Stay		−0.2381***	−0.3899***	−0.1071***
		(0.0126)	(0.0204)	(0.0286)
DogVacay Seller Migrated			0.0634***	0.0622***
			(0.0103)	(0.0102)
Has Repeat Stay × DogVacay Seller Migrated			0.1712***	0.1716***
			(0.0200)	(0.0185)
DogVacay User × # 2016 Stays				−0.0937***
				(0.0093)
Mean of *Y*	0.74	0.74	0.74	0.74
R^2	0.02732	0.02928	0.03022	0.03509
Observations	212,817	212,817	212,817	212,817
Month of last stay FE	✓	✓	✓	✓
Platform share FE	✓	✓	✓	✓

Notes. This table displays coefficients of regressions where the outcome is the number of transactions of a buyer postmerger. Each observation is a single-homing buyer who made at least one transaction in 2016. The control variables include whether the user was on DogVacay in 2016, the number of stays in 2016, the average nightly price, whether a stay in 2016 was a repeat stay with a sitter from a prior transaction, and whether the seller migrated their profile to Rover postmerger (only applies to DogVacay users). A similar analysis for sellers is presented in Online Appendix C, Table C.5. FE, fixed effect.
***$p < 0.001$; **$p < 0.01$; *$p < 0.05$.

observe that switching costs partially explain this difference, we also find support for two alternative explanations. The first is that DogVacay buyers may continue transacting with prior providers outside the platform (disintermediation). The second is that there may be coordination failures, where DogVacay buyers are unable to find their previous providers on Rover, in part because these sellers did not migrate to the new platform.

7. Discussion

Network effects are often assumed to be large enough to warrant growth strategies that progressively concentrate activity on a single dominant digital platform. Even antitrust authorities have historically been hesitant to limit the acquisition efforts of platforms characterized by network effects. However, we find that the simple presence of network effects is not sufficient to justify the dominance of a single platform, especially when consumers have differentiated preferences over competitors.

We show that platform differentiation is in practice an important factor in offsetting network effects, even in industries where competing platforms appear to be very close substitutes. In analyzing the merger of the two largest platforms for pet-sitting services, we observe that the acquiring platform did experience sizable network effect benefits. Its existing buyers increased their platform activity, particularly in locations that saw a bigger influx of users from the acquired platform. Although network effects are often assumed to exist in digital platforms, we provide one of the few empirical confirmations to this regard.

In addition, we find that although existing buyers on both platforms benefit from aggregating user participation on a single platform, buyers from the acquired platform are worse off. Specifically, they match at lower rates and complete fewer transactions compared with buyers on the acquiring platform. Some of these differences are likely driven by the importance of repeat transactions, which may lead to disintermediation. However, we also document that new users do not prefer a single platform over two competitors, suggesting that horizontal preferences do not simply originate from experience gained while using a particular platform.

These two distinct results—network benefits and attrition because of horizontal preferences—offset each other, such that on average at the market level, users are equally well off with one or two platforms as evidenced by the constant number of transactions, match rates, and proxies for match quality. Combined with the fact that platform prices did not increase postmerger, our findings suggest that, on average, a single platform does not provide larger consumer surplus than the sum of two competing platforms.

Our study has important implications for the strategy and regulation of platforms. We begin with those specific to merger strategy, particularly two decisions that managers face when considering whether to acquire competitors and how to integrate them. The first is whether to shut down the acquired platforms and merge their users into a single platform. We show that it may be beneficial for a company to operate multiple platforms rather than combining them, offering a rationale for the many instances of acquisitions where the acquired platforms remain operative (e.g., Zillow and Trulia or the many online travel sites within the Booking Holdings group).

In situations in which platform differentiation is as valuable to consumers as the benefits of a larger network, managers can pursue several integration strategies. Where the decision is to shut down an acquired platform, the focus should be on increasing users' incentives to switch to the surviving platform. For example, algorithms and notifications could be temporarily adjusted to rank prior service providers higher when displaced buyers request services. In addition, users of the acquired platform might be offered discounts on platform fees to encourage them to migrate existing relationships to the new platform. Where, instead, the decision is to operate multiple platforms while facilitating multihoming, consenting users could automatically be crosslisted across platforms. This would allow users with strong preferences for one platform to remain with their preferred option without preventing exchanges with users who are indifferent between multiple platforms.

The second managerial decision is whether to acquire competitors in the first place. It should be mentioned that our focus on buyer outcomes ignores many other benefits, such as cost savings or a reduction in competition, which may drive platforms like Rover to pursue acquisition strategies even when managers anticipate limited network effect benefits. That said, platforms considering acquisitions are facing increased antitrust scrutiny (*The Economist* 2017).[30] Our results hint at reasons why antitrust regulators may be unlikely to allow mergers solely on the basis of network effects. Platform managers must, therefore, carefully consider the efficacy of engaging in acquisitions in the first place and be prepared to defend their acquisitions as beneficial for the market. In our context of pet-sitting services, we find that a merged platform does not impose higher prices or fewer and lower-quality matches on its users, and thus, it may effectively compete with a large fringe of nonplatform incumbents (kennels and dog hotels) by reducing fixed and variable costs. These considerations would, of course, be different in a setting where the acquiring platform was the only option for accessing pet-sitting services or where offline and online options were considered nonsubstitutable.[31]

Beyond mergers, our findings have implications for platforms' growth strategies more broadly. In particular, our study calls into question the importance of a first-mover advantage and the likelihood of a winner-takes-all equilibrium, which have historically pushed platforms to invest heavily to achieve scale fast and deter competitive entry. Our results also imply that despite network effects, entry and competition are likely in equilibrium, where multiple platforms can coexist and new platforms can successfully enter by identifying niche consumer preferences.

We focus on platforms that intermediate local and time-sensitive services. Other platforms with similar features include ride-sharing (Lyft), food delivery (Doordash), home improvement (HomeAdvisor), and childcare (Care.com). Because they are composed of geographically separate markets, these platforms are well suited for a similar causal analysis of network effects. Our assessment of user attrition postmerger shows that repeat transactions play an important role in counterbalancing network effects. Platform differentiation may thus be even more important on platforms offering childcare, where repeat transactions are more frequent, and comparably less important on ride-sharing platforms, where repeat transactions are rarer.

Our finding that network effects are not large enough to justify a single platform is particularly informative for the many other contexts where platforms tend to be more differentiated. Indeed, the two platforms in our study are almost identical in the way they intermediate services. Often, however, mergers occur between platforms that are not such close substitutes, meaning that horizontal preferences and user attrition are likely to play an even bigger role when it comes to a single dominant platform versus multiple competitors. In such cases, preferences for platform differentiation are likely to more than offset network effect benefits, making it particularly important to consider the advantages of retaining separate platforms.

Our paper has a number of limitations, the first and most important being that our results come from a single merger in a specific industry. Further research might evaluate the generalizability of our findings by extending the empirical approach here to other mergers in different industries where platforms intermediate local services.

In addition, we look specifically at differentiation among platforms rather than differentiated offerings within a platform. Although we find that some users prefer the acquired platform over the other, we cannot distinguish whether such preferences are because of the type of users that the platform attracts, platform-specific characteristics—such as user interfaces, customer support, or brand image—or a combination of both. If the differentiation among platforms is purely because of the type of users that platforms attract, it would be possible for the remaining platform to differentiate, over the long run, its offerings enough to eliminate consumers' strong preferences for the acquired platform.

The remaining platform might also increase or decrease the speed of innovation, a key driver of consumer value (Cabral 2021), although the effects on innovation are likely to take longer to materialize than the few months of data available to us. Given the difficulty of causally linking a merger in 2017 to events occurring many months later, we focus on the short run. However, extending theories and empirical approaches to estimate the long-term effects of mergers is fundamental for gaining a better understanding of the costs and benefits of acquisitions of early-stage competitors by incumbent platforms (Athey et al. 2019).

The merger we study here was not investigated by antitrust authorities, such that our results—based on a retrospective merger analysis—might not generalize to larger mergers (Carlton 2009). Nonetheless, the findings may apply to the 95% of mergers deemed too small to impact competition.[32] Although their size falls below the threshold triggering an investigation by antitrust authorities, these mergers may nonetheless result in significant consolidation of an entire industry (Wollmann 2019).

Finally, we look here at local as opposed to global effects. Yet, many important platforms also enjoy global network effects across geographies. Take, for example, the context of virtual work, like Upwork, or mobile applications, like iOS and Android. Our study does not speak to whether it is better for consumers to have two platforms with nonoverlapping geographic presence or a single platform active in all geographies (Zhu et al. 2019), nor are we able to measure cost efficiencies from the acquisition. These are areas ripe for future research.

Endnotes

[1] Note that we can actually only measure the effects on buyers who used one of these two platforms, which represent the vast majority of online pet sitting. Our assumptions on the value of the outside option (Section 3) imply that the value enjoyed by consumers who choose the outside option after the merger is either constant or lower compared with before the merger.

[2] This assumption ignores cost efficiencies that the platform may enjoy as a result of the merger or changes to sellers' service costs.

[3] The benefits are maximized exactly where platforms α and β each have a 50% market share under two additional conditions that must jointly hold. The first is the uniform distribution of buyer types d_i and ϵ_i, which leads to balancing joiners and switchers such that network effect benefits and losses from platform differentiation are both maximized at 50% market shares. The second condition is that the absolute values of the two first derivatives for the platform gains from network effects and the losses from differentiation (dashed and dotted lines in Figure 2) cannot cross. If the marginal benefit from network effects is always higher than the marginal loss from differentiation, the change in market-level average utility reaches a maximum at 0.5. If the marginal benefit from network

effects is always lower, there is a minimum at 0.5. In the intermediate cases (where the order of the first derivatives flips), there can be maxima and minima away from 0.5. Our empirical analysis in Section 5 does not constrain the net benefits to be maximized at 0.5.

[4] See https://www.wsj.com/articles/rover-raises-125-million-as-dog-sitting-war-heats-up-1527166801 (accessed June 2022).

[5] See https://www.americanpetproducts.org (accessed June 2022).

[6] It is fairly easy to join the platform as a pet sitter. One of us signed up on Rover by creating a sitter profile. Platform approval was quickly granted after a general background check. Additional background checks can be performed at the sitter's will (https://www.rover.com/background-checks/, accessed June 2022).

[7] See https://www.vox.com/the-goods/2018/9/12/17831948/rover-wag-dog-walking-app (accessed June 2022).

[8] See https://secondmeasure.com/datapoints/wag-rover-dog-walking-sales/ (accessed June 2022). Note that this figure includes total sales, not just from dog boarding.

[9] At the time of our study, the service categories included pet overnight boarding, sitting, drop-ins, daycare, and walking.

[10] Details on how the search algorithm works on Rover can be found at https://www.rover.com/blog/sitter-resources/how-rover-search-works/ (accessed June 2022).

[11] At the time of our study, the only price suggestion available was Rover's "holiday rate" feature, which advised sellers to increase their prices during holidays.

[12] Before July 2019, the maximum owner fee was $25 per booking, according to screenshots on Wayback Machine. These screenshots can be accessed at https://web.archive.org/web/20190705174452/https:/support.rover.com/hc/en-us/articles/205385304-What-are-the-service-fees-. Information on current policies is available at https://support.rover.com/hc/en-us/articles/205385304-What-are-the-service-fees- (accessed June 2022).

[13] See https://techcrunch.com/2017/03/29/rover-dogvacay-merge/ (accessed June 2022).

[14] See https://techcrunch.com/2017/03/29/rover-dogvacay-merge/ (accessed June 2022).

[15] See https://www.latimes.com/business/technology/la-fi-tn-dogvacay-rover-20170329-story.html (accessed June 2022).

[16] See https://www.ftc.gov/news-events/media-resources/mergers-and-competition/merger-review and https://www.justice.gov/atr/merger-enforcement (accessed June 2022).

[17] See https://soundcloud.com/acquiredfm/season-2-episode-10-the-rover and https://www.geekwire.com/2018/inside-rovers-dogvacay-deal-former-rivals-went-one-brand-not-two-acquisition/ (accessed June 2022). At the time, Rover preferred not to slow its growth with the challenges that would necessarily arise in having to navigate internal lobbying from two separate brands and the complexities of integrating the back ends while keeping two separate front ends.

[18] Survey evidence suggests that people have on average just under 2 email accounts, 2.5 when including a work account. Of these two accounts, one is often considered primary, and evidence suggests that there is considerable inertia when it comes to changing the latter. Finally, consumers are willing to share their primary address with businesses they trust. See https://www.zettasphere.com/how-many-email-addresses-people-typically-use/, which discusses results from the Data and Marketing Association (accessed June 2022).

[19] Across all service categories, Rover was 62% larger than DogVacay. Online Appendix C, Figure C.2 plots the number of monthly stays on DogVacay since January 2012 in log scale. Despite being founded after Rover, DogVacay immediately outgrew Rover in overnight boarding services before being surpassed again around March 2015.

[20] CBSAs roughly coincide with metropolitan and micropolitan areas.

[21] Online Appendix C, Figure C.3 plots the share of a user's transactions occurring on DogVacay prior to the acquisition separately for buyers and sellers. On average, only 4.2% of users are both buyers and sellers of services in any given year. Buyers rarely act as service providers on the platforms. In the years before the acquisition, on average 4.8% of buyers also transacted as sellers in any given year. A nontrivial share of sellers (25.8%) also acted as buyers on the platforms.

[22] The payment that a seller receives is equal to that paid by the buyer minus the platform commission fees. Tipping is not required and is not recorded on the platform, although nothing prevents dog owners from doing so outside the platform (https://support.rover.com/hc/en-us/articles/206199686-Should-I-tip-my-sitter-, accessed June 2022).

[23] We find that part of the variation in 2016 market shares can be explained by which platform was the first mover in the market. Online Appendix C, Table C.2 shows that, on average, Rover tends to have a 7% higher market share in zip codes where the first stay was booked on Rover rather than DogVacay. For confidentiality reasons, we cannot disclose how the expansion strategies differed between Rover and DogVacay beyond the fact that the two varied substantially in the ways they targeted growth by either expanding across geographies or growing their user base within particular geographies.

[24] Online Appendix C, Figures C.5 and C.6 provide comparisons for a large set of observable demographics and platform performance metrics.

[25] Online Appendix C, Table C.3 presents descriptives for the unmatched zip codes.

[26] Each matched pair, or dyad, is no longer independently informative, as a single control market can impact the estimates of multiple dyads. The method proposed in Aronow et al. (2015) accounts for the correlation in error terms between each matched pair.

[27] Specifically, we provide event study plots. Online Appendix A, Tables A.1–A.5 instead share the results of difference-in-differences regressions, aggregating the months in the preacquisition announcement period, those between the announcement and closure of DogVacay, and those after DogVacay was shut down.

[28] Premerger, the larger platform in a given geography tends to have more buyers for each seller relative to the smaller platform, as shown in Online Appendix C, Figure C.8(a). As a result, Rover buyers in 0–20% markets receive a higher influx of buyers relative to sellers compared with the control group. This should make it relatively harder for Rover buyers to find sitters in these markets. Instead, we find that Rover buyers benefit most in these markets, meaning that our results may be an underestimate of network effects when the shares of buyers and sellers are held constant.

[29] Online Appendix A, Figure A.2 documents that the reduction in transactions is largely because of a decline in the number of buyers rather than the frequency of transactions per transacting buyer.

[30] The appointment of Lina Khan as the Chair of the U.S. Federal Trade Commission represents one of the recent steps toward more regulatory oversight (https://www.ftc.gov/about-ftc/biographies/lina-m-khan, accessed June 2022).

[31] For example, H&R Block was stopped from acquiring rival TaxAct because the government argued that it would have monopolized the digital tax preparation market, despite the availability of many offline alternatives (https://www.wsj.com/articles/SB10001424052970203707504577010512495467038, accessed June 2022).

[32] See https://www.ftc.gov/tips-advice/competition-guidance/guide-antitrust-laws/mergers (accessed June 2022).

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