DOES WORKING FROM HOME WORK?
EVIDENCE FROM A CORPORATE EXPERIMENT

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Abstract:
The frequency of working from home has been rising rapidly in the US, with over 10% of the work-force now regularly home working. But there is skepticism over the effectiveness of this, highlighted by phrases like "shirking from home". We report the results of the first randomized experiment on home-working, run in a 13,000 employee NASDAQ listed Chinese firm. Employees that volunteered to work from home were randomized into 9-months of home-working by even/odd birth-date. We find a highly significant 12% increase in performance from home-working, of which 8.5% is from working more minutes of their shift period (fewer breaks and sick-days) and 3.5% from higher performance per minute (quieter working environment). We find no negative spillovers onto workers left in the office. Home workers also reported substantially higher work satisfaction and psychological attitude scores, and their job attrition rates fell by over 50%. Despite this ex post success, the impact of home-working was ex ante unclear to the firm, which is why it ran the experiment. Employees were also ex ante uncertain, with one quarter of employees switching practices after the end of the experiment. This highlights how the impact of modern management practices like home-working is unclear to both firms and employees, helping to explain their slow adoption over time.

Keywords: working from home, organization, productivity, field experiment and China

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I. INTRODUCTION

The trade-off between home-life and work-life has received increasing attention as the number of households in the US with all parents working has increased from 25% in 1968 to 48% by 2008 (Council of Economic Advisors, 2010). Not surprisingly, given these rising work pressures many Governments in the US and Europe are investigating ways to maintain a work-life balance. For example, the Council of Economic Advisers (CEA) published a report launched by Michelle and Barak Obama at the White House in Summer 2010 on policies to improve work-life balance. Strikingly one of the conclusions in the executive summary was the need for research to identify the trade-offs in work-life balance policies, stating:

> "*A factor hindering a deeper understanding of the benefits and costs of flexibility is a lack of data on the prevalence of workplace flexibility and arrangements, and more research is needed on the mechanisms through which flexibility influences workers' job satisfaction and firms' profits to help policy makers and managers alike*" (CEA, 2010)

Not surprisingly given this lack of rigorous empirical evidence firms are also uncertain about what policies on home working to adopt. As a result firms in very similar industries adopt extremely different practices – for example in airline industry Jet Blue allows all regular call-center employees to work from home, Delta and Southwestern have no home working, while United has experimented with a mix of practices. As such the adoption of working from home is an example of a type of modern management practice whose impact is uncertain and so the adoption is gradual process, much like Griliches (1957) classic paper on the adoption of hybrid seed-corn.

Given the uncertainty over the impact of working from home CTrip – China's largest travel agent with 13,000 employees and a $6bn valuation on NASDAQ – wanted to experiment with home working before deciding whether to roll it out across the firm. The motivation was both to reduce office costs, which were becoming an increasingly high share of total costs due to rising rental rates at their Shanghai base, and also to reduce their 50% annual rate of attrition. Their concern was that allowing employees to work at home away from the supervision of their managers would have an extremely negative impact on their performance.

This experiment is also unusual because one of the co-authors of this paper (James Liang) is also the co-founder and Chairman of CTrip. This has provided excellent access to both the experimental data and also the managements' views on working from home. As such the experiment provides an insight into the adoption of a modern management practice by a large publicly listed firm, helping to address some of the questions over the reasons for the non-adoption of other ex post beneficial management practices by firms.[1]

In summary, the firm decided to run a nine-month experiment on working from home. They took the Airfare and Hotel divisions of the firm in their Shanghai headquarters and offered all eligible employees the option to work from home for four days to a week.[2] Of the 508 employees offered

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[1] See, for example, the survey in Bloom and Van Reenen (2011).

[2] *Eligible* employees were those with 6+ months tenure, a broadband connection at home and access to a quiet room during their shift. 51% of the employees were eligible according to this criteria (see Table 1).

this option 255 wanted to work from home, and after a lottery draw those with even birthdays were selected to work at home while those with odd birthdates stayed in the office to act as the control group. Both home and office employees worked the same shift period, in their same teams under the same manager as before, using the same IT equipment and with the same work order flow, with the only difference being the location of work.

We found four main results. First, the performance of the home workers went up dramatically, increasing by 12% over the nine month experiment. This improvement came mainly from an 8.5% increase in the number of minutes they worked during their shift (they were logged in to the computer system) due to a reduction in breaks and sick-days for home workers. The remaining 3.5% improvement was because home workers were more productive per minute worked due to the quieter working conditions at home. Second, there were no spillovers on to the rest of the group – interestingly those remaining in the office had no change in performance. Third the rates of attrition fell sharply for the home workers, dropping by almost 50% versus the control group. Home workers also reported substantially higher work-satisfaction and attitude survey outcomes. Finally, at the end of the experiment the firm was so impressed by the impact of home-working they decided to roll the option out to the entire firm, allowing the treatment and control groups to re-choose their working arrangements. About one quarter of the treatment group changed their mind and returned to the office while three quarters of the control group (who initially all requested to work from home) have as yet decided to stay in the office. This highlights how the impact of these types of management practices are also ex ante unclear to employees. We are continuing to collect data on the current and ex-employees to evaluate longer-run impacts on recruitment, promotion and other work and non-work outcomes.

In terms of connections to the wider literature there is an extensive case-study literature on individual firms which adopt various home working programs. These tend to show large positive impacts, but are hard to evaluate because of the non-randomized nature of these programs. This is both true in terms of the selection of firms into working-from home programs, and also the selection of employees to work at home. For example, as we show in Table 7 when CTrip allowed a general roll-out of home-working we see high-performing employees choose to move home and low-performing employees choosing to return to the office, so that the non-experimental impact of working from home looks substantially larger than the experimental impact. Other related papers include Oettinger's (2010) piece on the incidence of home-working across the US, which has been rising rapidly since the 1980s due to increasing use of information-communication-technologies (ICT), and Bloom, Kretschmer and Van Reenen's (2010) piece showing a strong correlation between homeworking practices and productivity and management practices across firms and countries.

Section II describes the experiment in more detail, while section III presents the results and section IV provides a set of concluding comments.

II. THE EXPERIMENT

II.A. The Company

Our experiment takes place in Ctrip, a leading travel service provider for hotel accommodation, airline tickets and packaged tours in China. Ctrip aggregates information on hotels and flights,

and generates revenue through commissions from travel suppliers. The services provided by Ctrip are comparable to Expedia, Orbitz or Travelocity. Ctrip was established in 1999 and was quoted on NASDQ in 2003, and is currently worth about $6bn. It is the largest travel agent in China for number of room in terms of hotel nights and airline tickets booked. The co-founder of Ctrip and their current Chairman is James Liang, who is also currently a Stanford GSB graduate student and co-author on this paper. This has provided us with unparalleled access to the company, both in terms of data and experimental design, but also is terms of understanding the management decision making behind the experiment and roll-out.

To provide some background on the company Exhibition A displays photos of the Ctrip headquarters and call center in Shanghai. This is a modern multi-story building that houses the call center which is running the experiment, as well as several other CTrip divisions and its top management team. The firm also operates a second larger call center in Nan Tong, outside Shanghai. Call center employees are organized into small teams of around 10 to 15 people, grouped by department and the type of work. Teams sit together in one area of the floor, typically occupying an entire aisle. Each team member works in a cubical with equipment including a computer, a telephone and a headset. Team leaders patrol the aisles to monitor employees' performance as well as helping to resolve issues with reservations at the spot.

II.B. The Experimental Design

Ctrip employs about 13,000 employees, of which 7,500 work at two large call centers as customer service representatives in Shanghai and Nan Tong. Our experiment takes place in the airfare and hotel booking departments in the Shanghai call center. The representatives' main job is to answer phone calls, make reservations, and work to resolve issues on existing bookings. They typically work 5 shifts a week, scheduled by the firm ahead of time. Employees are organized by teams of between 10 and 20 members (with a mean of 14.3). A team works on the same schedule so individuals do not choose their shifts. The firm adjusts the length of the shift depending on volume of the bookings.

The treatment in our experiment is to work 4 shifts at home and to work on the 5th shift in the office on a fixed day of the week. Treatment employees still work on the same schedule as their teammates because they have to work under the supervision of the team leader (who is always office based), but operate from home for 4 of their five shifts. For example, in a team the treatment employees might work from home from 9am to 5pm on Monday, Tuesday, Wednesday and Friday and from the office from 9am to 5pm on Thursday. The control employees would work from the office from 9am to 5pm on all five days. Hence, the experiment only changes the location of work, not the type of work or the hours of work. Since all incoming phone-calls and work orders are distributed by central servers the work flow is also identical between work and home locations.

Importantly, individual employees are not allowed to work overtime outside their team shift as they require their team leader to supervise their work. Hence, entire teams can have their hours changed – for example all teams had their shifts increased during the week before Chinese New Year – but no individual is able to work overtime on their own. So the impact of eliminating commuting time (which is about 80 minutes a day for the average employee) on home-workers

ability to work overtime is not a factor directly driving the results.[3] Home workers also use the same equipment and software, face the same pay and promotions structure, and undertake the same training as office workers.

In early November 2010, employees in the airfare and hotel booking departments were informed of the working from home program. They all took an extensive survey on demographics, working conditions and their willingness to join the program. Employees who are both willing and qualified to join the program are recruited for the experiment. To qualify an employee needed to have tenure of at least 6 months, have broadband Internet at home to connect to the network, and to have an independent workspace at home. 51% of the 996 employees in the airfare and hotel booking departments qualify for the experiment. Of those 49% were interested in joining the experiment (full details in Table 1). In the end, 255 employees joined the experiment.

The treatment and control groups were then determined from this group of 255 employees through a public lottery. Employees with an even birthdate (a day ending 2, 4, 6, 8 etc) were selected into the treatment and those with an odd birthdate (a day ending 1, 3, 5 etc) were in the control group. This selection of even birthdates into the treatment group was randomly chosen by the Chairman, James Liang, by drawing a ping-pong ball from an urn in a public ceremony one week prior to the experiment start date (see Exhibit B).[4] Even birthdate employees who had chosen to be in the experiment group are notified and equipment is installed at each treatment participant's home the following week. Odd birthdate employees who had chosen to be in the experiment acted as the control group. The experiment commenced on December 6, 2010.

The experiment lasted 9 months. On August 31, 2011, employees were notified that the experiment had ended and Ctrip would roll out the experiment to those who are qualified and interested in working at home. Throughout the experiment employees were told the experiment would be evaluated to guide future company policies, but they did not learn the actual policy until August 31st. Because of the large scale of the experiment and the lack of dissemination of experimental results beyond the core management team, employees were uncertain as to the long-run decision of the firm on roll-out prior to the decision. Employees in the treatment group who wished to come back to work in the office full-time were allowed to come back at the beginning of September (but not before then). Other qualified employees who wished to work at home gradually after the practice was rolled out to the whole firm on August 31st moved home after equipment was installed from November onwards.

Figure 1 shows compliance with the experiment throughout the experimental period until the end of December 2011. The percentage of treatment group working at home shot up to 90% within two weeks of the commencement of the experiment. It hovered between 80% and 90% throughout the experimental period and dropped sharply after the experiment ended in late August. Then it stabilized at around 60% through the rest of the year. The compliance does not

[3] It could indirectly matter if, for example, employees at home can run household errands in the time saved by not commuting that employees working from the office have to take breaks to perform.

[4] It was important to have this draw in an open ceremony so that managers and employees could not complain of "favoritism" in the randomization process. The choice of odd/even birthdate was made deliberately to make the randomization process straightforward and transparent.

reach 100% during the experiment mainly due to technical reasons.[5] The control group worked in the office full-time during the experiment. No employees were allowed to change status until after the end of the experiment.

Since compliance was not perfect our estimators – that take even birthdate status as the treatment status – are intention to treat estimators rather than the actual impact of working from home. Given we are interested in evaluating the impact of a policy of allowing home-working this seemed appropriate.

II.C. The Experimental Motivation

Ctrip was interested in running the experiment to investigate the impact of allowing employees to work from home. They believed allowing employees to work from home would allow them to save on office space, cut down turnover, and reduce labor costs by tapping into a wider pool of workers, such as people living too far outside Shanghai to commute in on a daily basis but close enough to commute in on a weekly basis. But they were uncertain on the impact of allowing employees to work from home on their performance. Their workforce is primarily younger employees, many of which may struggle to remain focused working from home.

Since no other Chinese firm had moved to allowing home-working amongst its call center employees there was no local precedent. In the US the decision to allow employees in call centers to work from home varies across firms, even those within the same industry, suggesting a lack of any consensus on its impact. For example, in the airline industry while Jet Blue and American Airlines allow home-working, British Airways, Continental, Delta and Southwestern do not, and United is experimenting with a mixed model. The prior academic literature on call centers also offered limited guidance, being based on case-studies of individual firm-level interventions.

II.D. Data Collection

Ctrip has an extremely comprehensive central data collection system. Many of its founders, including James Liang, came from Oracle so had extensive database software experience. The majority of data we use in our paper are directly extracted by from the firms' central database, providing extremely high data accuracy. The data we collected can be categorized in 5 fields: performance, labor supply, attrition, reported employee work satisfaction, detailed demographic information and attitudes towards the program.

Performance measures vary by the type of workers, as detailed in Appendix 1. In summary, we have 4 types of workers and 6 different performance measures in our sample. We have 137 order takers, 71 order placers, 36 order correctors, and 11 night shift workers. Order takers main tasks are to answer phone calls and record orders in the Ctrip system. Their key performance measures are the number of phone calls answered and number of orders taken. Order placers process the orders by contacting the hotels and notify clients of confirmed reservations. Their key measures are numbers of different types of confirmation phone calls and notification phone calls

[5] Four installations were not successful therefore these employees remained working in the office. A few employees lost their lease and exited the experiment due to the loss of independent working space. Occasionally, employees had to work in the office full-time if Internet connection broke down at home. In all estimations since we use the even birthdate as the indicator for working-at-home these individuals are treated as home workers.

depending on the department. Order correctors resolve issues on existing reservations such as overbooking, etc. Their key measure is the number of orders corrected. Night shift workers cover responsibilities of both order placers and order correctors at night, typically from 11PM to 7AM.

For order takers, minutes on the phone is a direct and accurate measure of time spent working. We have logs of phone calls and call lengths from the central database of Ctrip. The firm also uses this measure to monitor work of their employees. We also calculate phone calls answered by minute on the phone as a measure of labor productivity for this type of workers.

We have daily key performance measures of all employees in the airfare and hotel booking departments from January 1st, 2010 to December 25th, 2011. We also have daily minutes on the phone for order takers during the same period. We have detailed daily records of hours of leave from the airfare department by types of leave from September 1st, 2010 to August 31st, 2011. We know the date and reason of employees in the experiment quitting the experiment or leaving the firm. We have data from weekly survey of the employees in the experiment on work exhaustion, positive and negative attitudes (See details in Appendix A2). Lastly, we designed and conducted two rounds of surveys in November 2010 and August 2011. From the surveys and the company database, we collect detailed information on all the employees in the two departments including basic demographics, income, attitudes toward the Program.

III. RESULTS

III.A. Performance Regressions

We start by estimating the intention to treat equation

$$OUTCOME_{i,t} = aTREAT_i \times EXPERIMENT_t + b_t + c_i + e_{i,t} \qquad (1)$$

We start by estimating the impact of work-from-home (WFH) Program via equation (1). TREAT is a dummy variable that equals 1 if an individual belongs to the treatment group defined by having an even-numbered birthday. EXPERIMENT is a dummy variable that equals 1 for weeks after the experiment started on December 6th. OUTCOME is one of the key measures of work performance including an overall performance z-score measure, log of weekly phone calls answered, log of phone calls answered per minute on the phone, and log of weekly sum of minutes on the phone. b_t incudes a series of week dummies to account for seasonal variation in traveling demand such as the World Expo in 2010 and the Chinese New Year. c_i is the individual fixed effect that includes non-time-varying individual idiosyncratic factors that affect work performance.

Overall performance z-score is a measure to make performance of different types of workers comparable. First we generate weekly sum of key measures of performance for each type of workers. For example, order takers have two key measures of performance—phone calls answered and orders placed. To obtain z scores of each key measure, we subtract the weekly sum by pre-experiment mean by department of the key measure, and divide it by pre-experiment

standard deviation. Then we average the key measure z-scores within each type to generate an overall performance z-score measure. Finally, we normalize this measure again by subtract the pre-experiment mean and divide by the pre-experiment standard deviation to create the final double z-scored overall performance measure. This measure has mean 0 and standard deviation 1 over the pre-experiment period.

From the top panel of column (1) of Table 2, overall performance of the treatment group is 0.2 standard deviations higher than the control group after the experiment started. The result is very significant at 1%. We can also see the results from Figure 2 where overall performance of the treatment group and the control group are plotted from Jan 1st 2010 to August 31st 2011. The red vertical line is when the experiment started. The black solid line represents the treatment group and the red solid line represents the control group. Before the experiment started, despite seasonal variations, the treatment group trends closely with the control group. After 6 weeks of the experiment, treatment group starts to differ from the control group, and the difference is quite consistent until the last few weeks of the experiment.

The largest type of workers we have in our sample are the 137 order takers. If we limit the sample to the order takers, we can use phone calls answered as the key performance measure for all the order takers. The z-scores of phone calls account for different volume and average length of phone calls in two departments. Column (2) shows that order takers in the treatment group answer 0.249 standard deviation more phone calls than the control group after the experiment started. We also use log of weekly phone calls as the outcome variable. We see that the treatment group answers 11.7% more phone calls than the control group, as shown in column (3).

We further decompose the difference in performance observed in column (3) into phone calls answered per minute on the phone, a measure of productivity, and minutes on the phone, a measure of labor supply. Column (4) and (5) suggest that out of the 11.7% difference in performance between the treatment group and the control group, 3.4% is accounted for by difference in productivity, and 8.4% is accounted for by difference in labor supply. One question is that whether quality of the service has been compromised as a tradeoff for the increase in productivity in the treatment group. We construct two quality measures: conversion rate and weekly recording scores. Conversion rate is calculated as the percentage of phone calls answered resulting in orders. The first two columns of Appendix A3 show that the treatment group does not differ in conversion rate from the control group during the experiment. Phone calls are all recorded and sampled for quality control by the company on a weekly basis. The last two columns of Appendix A3 show that treatment group maintains the same level of recording scores as the control group.

The impact of the experiment varied over time. We divide the experimental period into the first 6 months and the last 3 months. The results are shown in the middle and bottom panel of Table 2. The overall result in the top panel is mainly driven by the first 6 months of the experiment as during the last 3 months, treatment and control group does not differ in performance and efficiency. The reason for this variation appears to be differences in the weather as the summer months are hot and humid in Shanghai and many people do not have good air conditioning at home (or do not want to pay for this all day). As a result during the hotter summer months the performance gap between the office (with air-conditioning) and home shrinks substantially. This

highlights of course the importance of home working conditions for the performance of home-workers

III.B. Labor Supply Regressions

In Table 3, we investigate further factors that contribute to difference in labor supply. Order takers may adjust labor supply in three different ways. First, they may spend more minutes answering the phone for each hour of their shift. Second, they may take fewer hours off for each shift. Third, they may take fewer shifts off.

Because we have accurate records of hours of leave from the airfare booking department only, we limit the sample further to 89 order takers in the airfare department. Column (2) of Table 3 shows that these order takers are not different from those in the hotel booking department in labor supply (results are very similar to the full group in Column (1)). Column (3)-(5) suggest that out of 8.95% difference in labor supply between the treatment and the control group 6.7% is accounted for by taking fewer hours off each shift and 3.9% is accounted for by taking fewer shifts off.

Again we divide the sample period into first 6 months and last 3 months to investigate what contributes to the reduction in the minutes worked gap between treatment and control group during the last 3 months of the experiment. Looking at the bottom panel of Table 3 we find it is because the gap in hours per day worked equalizes between the treatment and control group over this period, because working the office relative to home becomes substantially more attractive due to the comfort value of having air-conditioning.[6]

III.C. Comparisons with two "quasi" control groups

Is the gap between treatment and control caused by the treatment group performing better or the control group performing worse? In Table 4, we collect data on two other "quasi" control groups to answer this question. The first group are the eligible employees in the Nan Tong call center. This is CTrips other large call center, located in Nan Tong, a city about 1 hour drive outside of Shanghai. This call center also has airfare and hotel departments, and calls are allocated across the Shanghai and Nan-Tong call centers randomly. The second group are the 253 eligible employees that did not volunteer to participate in the WFH experiment in the Shanghai call center. These are the individuals that were eligible for the experiment (own room, 6+ months of tenure and broadband) but did want to work from home (those in Table 1 column (2) but not in column (3)). We think these two groups are comparable to the treatment and control groups for two reasons. First, all four groups face the same demand for their service. Second, they all meet the requirements for eligibility to participate in the experiment.

Figure 3 shows that the performance of the eligible group in the Nan Tong call center tracks that of the treatment and control well before the experiment. After the experiment started, the performance of the Nan Tong group is similar to that of the control group. Results in the top panel of Table 4 confirm this finding. Differences in overall performance, efficiency and labor supply between the control group and the Nan Tong eligible group is statistically insignificant from zero. The bottom panel compares treatment and control group to the eligible non-

[6] The control group tend to arrive earlier and leave later from work because it is much cooler, while the treatment group apparently work fewer minutes at home because of the heat.

experimental group in Shanghai. Again we find no difference between the control group and the eligible non-experimental group. These results suggest that the gap between the treatment and control group mainly reflects an improvement in performance, efficiency and labor supply of the treatment group rather than any deterioration of the control group. That is, although the control group and the treatment group work in the same team we find little evidence of the control group being discouraged by not able to work at home.

III.D. Attrition

One of the reasons Ctrip is interested in running the experiment is to retain workers. Turnover rate in Ctrip call center representatives has been historically hovered around 50% per year, which is typical of the call center industry in China. Management estimates that hiring and training a representative costs on average $2000, about 6 months salary of an average employee. Figure 4 plots the cumulative attrition rate of treatment and control group separately over the experimental period. Shortly after the commencement of the experiment, cumulative attrition rates diverged between the two groups and the difference is statistically significant. By the end of the experiment, attrition rate in the treatment group (17%) is nearly half as that in the control group (35%).

We further test whether selective attrition exists by running probit regressions. The dependent variable is whether an employee quits the job during the experimental period between December 6th 2010 and August 31st 2011. Column (1) in Table 5 confirms the finding in Figure 4. Column (2) and (3) test whether employees with worse performance before the experiment are more likely to attrite in treatment group compared to control group. Pre-experiment performance is the average of individual weekly performance z-scores during the pre-experimental period from January 1st 2010 to December 5th 2010. We find no evidence that such is the case. We find that younger employees and those with higher cost of commute are more like to quit their job.

In column (4) and (5), we use the same specifications as in column (2) and (3) but replace the pre-experiment performance with post-experiment performance. Post-experiment performance is the average of individual weekly performance z-scores during the post-experimental period from December 6th 2010 to August 31st 2011. We find that in both groups employees with worse performance during the experiment are more likely to attrite, but they are more likely to attrite in control group compared to treatment group. The difference is statistically significant, but the impact of the performance gap between the treatment and control groups is quantitatively negligible as Appendix Figure 1 shows.

III.E. Employee Self-reported outcomes

Ctrip management is also interested to find out how employee self-reported well-beings are impacted by the Program. They ran two sets of surveys: the satisfaction survey and emotion survey. Details of survey questions and methodology are listed in Appendix A2, but in summary these are reasonably standard employee satisfaction tests developed by Christina Maslach and Susan Jackson in the 1970s (see for example Maslach and Jackson, 1981). The satisfaction survey was conducted five times throughout the experimental period. Once in early November before the randomization took place and four times after the experiment had started. Since the employees were unaware of the assignment at the initial survey, the first survey is a credible baseline. The first three columns of Table 6 show three different satisfaction measures. The

treatment group reports no different satisfaction level from the control group at the first survey, but the treatment group reports statistically significantly higher satisfaction level throughout the experiment.

The emotion survey is conducted every week. The first week was conducted in late-November 2010, before the experiment began but after the randomization so that individuals had been informed of their status in the treatment or control groups. Although not consistently statistically significant, the treatment group already reports higher positive attitude, less negative attitude and less exhaustion from work upon learning their assignment but before changing their location of work. After starting the experiment the gap between the treatment and control group rose further, so that treatment group reported statistically significantly higher positive attitude and less work exhaustion.

III.F. Employees' views toward the Program

We designed a survey to inquire employees' views toward the Program as well as collecting demographic information. We administered the same survey with the help of the Ctrip management in November 2010 and August 2011. Employees are asked specifically whether they are interested in participating in the Work-at-Home Program if they were eligible. They can choose from three answers: yes, no or undecided. For the November 2010 survey employees were not told the eligibility rules in advance of the survey (i.e.: own room, 6+ months tenure, internet connect etc). For the November 2011 survey they were told the experiment was being rolled out to the company, but again not what the criteria for this would be.

In Table 7 Panel A, we tabulate employees answers in November 2010 against August 2011. The sample includes 568 employees who answered both surveys. In November 2010, 51% of the employees are willing to work at home, compared to 40% in August 2011. More then 53% of the employees maintained their positions in both surveys, evidenced by the weights on the diagonals. About 20% of those who answers yes in the first survey decided they were not interested in the second survey where 12% of those who initially were not interested showed interest in the second survey.

III.G. Roll-out and Switch

On August 31, 2011, employees were notified that the experiment had ended and Ctrip would roll out the experiment to those who are qualified and interested in working at home. Employees in the treatment group who wished to come back to work in the office full-time were allowed to come back at the beginning of September. To understand the characteristics of the workers who choose to come back to the office, we run probit regressions using whether a worker returns to the office as the outcome. The sample for returning to the office includes the 103 treatment works still at CTrip at the end of the experiment in September 2011. Out of the 103 treatment workers, 22 opt to come back to work in the office full-time. As shown in column (3) of Table 7 Panel B, we find that employees who have better pre-experiment performance and worse post-experiment performance are more likely to return to the office. They are likely a group of employees who did not benefit as much from the Work-from-Home Program. We also find that married employees or those living with parents are less likely to return to the office. In-depth interviews with the employees as well as home visits suggest that these employees tend to

benefit more from the Program as they enjoy spending more time with their family and have won support from their family as well.

Other qualified employees who wish to work at home gradually went home after equipment was installed at the beginning of November. The sample for moving home includes the 41 employees in the Airfare group from the control group still in the experiment by September 2011. 18 out of the 41 employees choose to work at home. We do not find correlation between performance and switch to work at home (perhaps due to small sample size), but we do find that older employees are more likely to work at home.

IV. CONCLUSIONS

The frequency of working from home has been rising rapidly in the US, with over 10% of the work-force now reporting regular home working. But there is a uncertainty and skepticism over the effectiveness of this, highlighted by phrases like “shirking from home”. We report the results of the first randomized experiment on home-working, run in a 13,000 employee NASDAQ listed Chinese firm. Employees that volunteered to work from home were randomized into 9-months of home-working by even/odd birth-date. We find a highly significant 12% increase in performance from home-working, of which 8% is from working more minutes of their shift period (fewer breaks and sick-days) and 3% from higher performance per minute. We find no negative spillovers onto workers left in the office. Home workers also reported substantially higher work satisfaction and psychological attitude scores, and their job attrition rates fell by over 50%. Interestingly, the impact of home-working was ex ante unclear both to the firm and the employees. The firm ran to experiment to evaluate its impact, and after the experiment was so enthusiastic it decided to permanently roll out the practice. The employees’ response was much more heterogeneous, with about one third of employees switching practices after the end of the experiment. This highlights how the impact of management practices like home-working is unclear to firms and employees, helping to explain their slow adoption over time.

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DATA APPENDIX

Appendix A1: Table for different types of workers and their key performance measures

Types of Workers	Department	Key Performance Measures	Number of Workers
Order Takers	Airfare	Phone Calls Answered Orders Taken	89
	Hotel		48
Order Placers	Airfare	Notifications Sent	46
	Hotel	Reservation Phone Calls Made	25
Order Correctors	Hotel	Orders Corrected	36
Night Shift Workers	Hotel	Reservation Phone Calls Made Orders Corrected	11

Appendix A2: Explanations on the Work Satisfaction Survey

Work Exhaustion: Ctrip's in-house psychology counselors use an adapted excerpt from the Maslach Burnout Inventory Survey to measure the emotional exhaustion of the employees from work. The MBI survey was developed by Berkeley psychologist Christina Maslach and Susan Jackson in the 1970s (see Maslach and Jackson, 1981).

Each employee is asked to evaluate his or her "emotional exhaustion" at the end of the work week. The survey contains 6 questions. Each employee is asked to report how often he has felt the way described at work during the week: feel this way every day, almost all the time, most of the time, half of the time, a few times, rarely, never. The survey questions are listed below:

1. I feel emotionally drained from my work.
2. I feel used up at the end of the work day.
3. I dread getting up in the morning and having to face another day on the job.
4. I feel burned out from my work.
5. I feel frustrated by my job.
6. I feel I am working too hard on my job.

Positive and Negative Attitudes: Ctrip's in-house psychology counselors use an adapted 16-item Positive and Negative Affect Schedule (PANAS) developed by Clark and Tellegen in 1988 to measure the positive and negative attitudes of the employees.

The survey comprises two mood scales, one measuring positive affect and the other measuring negative affect. Each item is rated on a 5-point scale ranging from 1 = *very slightly or not at all* to 5 = *extremely* to indicate the extent to which the employee feels this way the day he takes the survey. To evaluate the positive affect, psychologists sum the odd items. In cases with internally missing data (items not answered), the sums were computed after imputation of the missing values: # items on scale / # actually answered, multiplied by the sum obtained from the answered items. A higher score indicates more positive affect, or the extent to which the individual feels enthusiastic, active, and alert. The negative affect is evaluated similarly by summing up the even items.

The 16 items are listed below.

1. Cheerful
2. Jittery
3. Happy
4. Ashamed
5. Excited
6. Nervous
7. Enthusiastic
8. Hostile
9. Content
10. Guilty
11. Relaxed
12. Angry
13. Proud
14. Dejected
15. Active
16. Sad

Appendix A3: Quality did not change in the experiment

	(1)	(2)	(3)	(4)
Dependent Variable	recording grade	recording grade	conversion (z score)	conversion (z score)
Individual FE	No	Yes	No	Yes
Week fixed-effects	Yes	Yes	Yes	Yes
Experiment*Treatment	-0.007	-0.006	-0.026	-0.026
	(0.008)	(0.008)	(0.071)	(0.065)
Treatment	0.000		-0.011	
	(0.005)		(0.091)	
Number of Employees	89	89	135	135
Number of Weeks	87	87	87	87
Observations	5689	5689	9815	9815

Notes: Sample in the first two columns includes 89 order takes in the airfare department (for which we can obtain recording grade information). The sample in the last two columns includes 135 order takers in airfare and hotels (the group for which conversion rate data exists). Clustered standard errors. *** denotes 1% significance, ** 5% significance and * 10% significance.

Table 1. Summary Statistics

Variable	**Total**	**Volunteered (to work from home)**	**Experiment (volunteered, own room and 6+ months tenure)**	**t-stat (experiment v total)**
Number of people	996	508	255	
Age	23.2	23.2	24.4	7.232
Male	0.32	0.34	0.46	5.607
Married	0.15	0.18	0.27	6.348
Education (omitted group is high school)				
tertiary technical school	0.39	0.35	0.34	-1.690
university	0.02	0.02	0.02	-0.270
Prior work experience (months)	10.8	12.8	17.9	6.691
Tenure (months)	24.9	23.1	26.8	1.607
Children (1=yes)	0.09	0.11	0.18	5.896
Rental	0.50	0.49	0.22	-11.01
Age of youngest child (years)	0.26	0.36	0.61	5.470
Live with child	0.06	0.07	0.12	4.380
Grandparents provide childcare	0.07	0.09	0.15	5.170
Commute (minute/daily)	80.6	86.5	112.2	10.82
Cost of commute (yuan/daily)	5.54	6.30	8.33	7.279
Internet	0.99	1.00	1.00	0.99
Independent bedroom	0.60	0.66	1.00	16.23
compensation (yuan/month)				
Basewage	1541	1529	1536	-0.608
Bonus	990	950	1015	0.676
Overtime	119	115	124	1.337
Benefit	222	234	265	4.152

Notes: The total sample covers all CTrip employees in their Shanghai Airfare and Hotel group. Willingness to participate is based on the initial survey in Nov 2010. Employees were not told the eligibility rules in advance of the survey (i.e.: own room, 6+ months tenure, internet connect etc). Compensation is calculated as a monthly average of salary from Jan 2010 to Sep 2010 (note that 1 Yuan is about 0.15 Dollars). The t-stat in the last column tests whether difference between all the employees in the airfare and hotel departments are significantly different from those in the final sample.

Table 2: The performance impact of working from home

	(1)	(2)	(3)	(4)	(5)
Dependent Variable	Overall Performance	Phonecalls	Phonecalls	Phonecalls Per Minute	Minutes on the Phone
Dependent Normalization	z-score	z-score	log	log	log
Period: All pre and 9 months post					
Experiment*Treatment	0.200***	0.249***	0.117***	0.034***	0.084***
	(0.063)	(0.063)	(0.026)	(0.013)	(0.028)
Number of Employees	255	137	137	137	137
Number of Weeks	87	87	87	87	87
Observations	17953	9716	9716	9716	9716
Period: All pre and first 6 months post					
Experiment*Treatment	0.230***	0.295***	0.138***	0.036***	0.103***
	(0.072)	(0.064)	(0.028)	(0.013)	(0.031)
Number of Employees	255	137	137	137	137
Number of Weeks	73	73	73	73	73
Observations	15767	8616	8515	8515	8515
Period: All pre and last 3 months post					
Experiment*Treatment	0.112	0.161	0.064	0.025	0.039
	(0.100)	(0.127)	(0.039)	(0.016)	(0.038)
Number of Employees	137	137	137	137	137
Number of Weeks	62	62	62	62	62
Observations	15153	8321	6969	6969	6969

Notes: The regressions are run at the individual by week level, with a full set of individual and week fixed effects. Experiment*treatment is the interaction of the period of the experimentation (December 6th 2010 until August 31st 2011) by an individual having an even birthdate (2nd, 4th, 6th, 8th etc day of the month). The pre period refers to January 1st 2010 until December 5th 2010. The first six months of the experiment refers to December 6th 2010 until June 6th. The last three months to June 7th until August 31st 2011. The z-scores are constructed by taking the average of normalized performance measures (normalizing each individual measure to a mean of zero and standard deviation of 1 across the sample). Since all employees have z-scores but not all employees have phonecall counts (because for example they do order booking) the z-scores covers a wider group of employees. Minutes on the phone is recorded from the call logs. Standard errors are clustered at the individual level. *** denotes 1% significance, ** 5% significance and * 10% significance.

Table 3: Decomposition of the change in labor supply

VARIABLES	(1) Minutes on the Phone	(2) Minutes on the Phone	(3) Minutes on the Phone/ Hours Worked	(4) Hours Worked/ Days Worked	(5) Days Worked
Sample	All	Airfare	Airfare	Airfare	Airfare
Period: All pre and 9 months post					
Experiment*Treatment	0.084***	0.0895**	-0.017	0.0677**	0.0388**
	(0.028)	(0.0441)	(0.0332)	(0.0276)	(0.0150)
Number of Employees	137	89	89	89	89
Number of Weeks	87	87	87	87	87
Observations	9,716	3531	3531	3531	3531
Period: All pre and first 6 months post					
Experiment*Treatment	0.103***	0.105**	-0.0136	0.0790**	0.0397**
	(0.031)	(0.0456)	(0.0341)	(0.0308)	(0.0154)
Number of Employees	137	89	89	89	89
Number of Weeks	73	73	73	73	73
Observations	8515	2792	2792	2792	2792
Period: All pre and last 3 months post					
Experiment*Treatment	0.039	0.0313	-0.0303	0.0189	0.0427*
	(0.038)	(0.0571)	(0.0432)	(0.0222)	(0.0236)
Number of Employees	137	89	89	89	89
Number of Weeks	62	62	62	62	62
Observations	6969	1786	1786	1786	1786

Notes: The regressions are run at the individual by week level, with a full set of individual and week fixed effects. Experiment*treatment is the interaction of the period of the experimentation (December 6th 2010 until August 31st 2011) by an individual having an even birthdate (2nd, 4th, 6th, 8th etc day of the month). The pre period refers to January 1st 2010 until December 5th 2010. The first six months of the experiment refers to December 6th 2010 until June 6th. The last three months to June 7th until August 31st 2011. Only employees in the Airfare group provides full holiday and leave data so the breakdown by hours and days in the office is only undertaken for this group. Standard errors are clustered at the individual level. *** denotes 1% significance, ** 5% significance and * 10% significance. Minutes on the phone is recorded from the call logs. Hours worked is measured by the phone system log-in and log-out data.

Table 4: The treatment performance also looked good benchmarked against non-experimental and Nantong employees

VARIABLES	(1) Overall Performance	(2) Overall Performance	(3) Phone calls	(4) Phone calls
Comparison to Nan Tong				
	Treatment Vs. Nan Tong	Control Vs. Nan Tong	Treatment Vs. Nan Tong	Control Vs. Nan Tong
Experiment*treatment	0.190***		0.235***	
	(0.047)		(0.049)	
Experiment*control		-0.014		-0.017
		(0.048)		(0.044)
Observations	99643	98342	83264	82484
Comparison to Eligible Non-experiment group				
	Treatment Vs. Non-experiment	Control Vs. Non-experiment	Treatment Vs. Non-experiment	Control Vs. Non-experiment
Experiment*treatment	0.279***		0.246***	
	(0.054)		(0.060)	
Experiment*control		0.070		-0.006
		(0.055)		(0.055)
Observations	23641	22306	14117	13321

Notes: Nan-Tong is CTrips other large call center, located in Nan-Tong, a city about 1 hour drive outside of Shanghai. This call center also has airfare and hotel departments, and calls are allocated across the Shanghai and Nan-Tong call centers randomly. The "Eligible non-experimental group" are the individuals that were eligible for the experiment (own room, 6+ months of tenure and broadband) but did not participate in the two departments in Shanghai. The regressions are run at the individual by week level, with a full set of individual and week fixed effects. Experiment*treatment is the interaction of the period of the experimentation (December 6th 2010 until August 31st 2011) by an individual having an even birthdate (2nd, 4th, 6th, 8th etc day of the month), while Experiment*control is the interaction of the period of the experimentation by an individual having an odd birthdate. All performance measures are z-scores (constructed by taking the average of normalized performance measures, where these are normalizing each individual measure to a mean of zero and standard deviation of 1 across the sample). Standard errors are clustered at the individual level. *** denotes 1% significance, ** 5% significance and * 10% significance.

Table 5. Attrition

	(1)	(2)	(3)	(4)	(5)
Dependent variable	quit	Quit	Quit	quit	quit
Performance Measure Period	Baseline	Pre-experiment	Pre-experiment	Post-experiment	Post-experiment
Performance		-0.394*	-0.338	-1.044***	-1.101***
		(0.204)	(0.223)	(0.226)	(0.229)
Performance*Treatment		0.257	0.277	0.617*	0.691**
		(0.279)	(0.296)	(0.327)	(0.336)
Treatment	-0.564***	-0.552***	-0.538***	-0.168	-0.0904
	(0.174)	(0.176)	(0.186)	(0.241)	(0.252)
Age			-0.108***		-0.0939***
			(0.0329)		(0.0353)
Men			0.0992		-0.0529
			(0.197)		(0.206)
Married			-0.157		-0.231
			(0.336)		(0.375)
Cost of Commute			0.0292***		0.0304***
			(0.0111)		(0.0112)
Children			0.624*		0.888**
			(0.375)		(0.418)
Constant	-0.379***	-0.401***	1.808**	-0.870***	0.993
	(0.117)	(0.119)	(0.755)	(0.186)	(0.811)
Observations	255	255	255	255	255

Notes: The regressions are all probits at the individual level. The dependent variable is whether the employee quit over the experimental period between December 6th 2010 and August 31st 2011. Pre-experiment performance is the average of individual weekly performance z-score during the pre-experimental period from January 1st 2010 to December 5th 2010. Post-experiment performance is the average of individual weekly performance z-score during the post-experimental period from December 6th 2010 to August 31st 2011. Performance*treatment is the interaction of the performance measure by an individual having an even birthdate (2nd, 4th, 6th, 8th etc day of the month). Cost of commute is measured at daily level in Chinese yuan (note that 1 Yuan is about 0.15 Dollars). Standard errors are clustered at the individual level. *** denotes 1% significance, ** 5% significance and * 10% significance.

Table 6: Employee self-reported work outcomes

	(1)	(2)	(3)	(4)	(5)	(6)
Variables:	Satisfaction	General Satisfaction	Life Satisfaction	Exhaustion	Positive Attitude	Negative Attitude
Data source:		Satisfaction survey			Emotion Survey	
Experiment *treatment	0.155***	0.072***	0.168***	-0.564***	0.160***	-0.183***
	(0.052)	(0.021)	(0.047)	(0.168)	(0.040)	(0.058)
Experiment*announcement				-0.102	0.080*	-0.095
				(0.167)	(0.042)	(0.058)
Experiment	-0.015	-0.012	-0.043			
	(0.048)	(0.020)	(0.066)			
Observations	855	855	855	5109	5109	5109

Notes: The satisfaction survey was conducted five times throughout the experimental period. See details of survey questions and methodology in Appendix A2. Once in early November before the randomization took place and four times after the experiment had started. The emotion survey is conducted every week. The first week was conducted in late-November 2010, before the experiment begun but after the randomization so that individuals had been informed of their status in the treatment or control groups. All the dependent variables are logged values. The regressions are run at the individual level with a full set of time-dummies. Experiment*treatment is the interaction of the treatment group with the period of the experimentation. Experiment*announcement is the interaction with the treatment group with the period of post-announcement but pre-experiment. Standard errors are clustered at the individual level. *** denotes 1% significance, ** 5% significance and * 10% significance.

Table 7 Panel A: Employee survey views before and after the experiment

Interested in in working from home: November 2011	Interested in working from home: August 2010			
	No	Yes	Undecided	Total
No	71	59	79	209
	12.5	10.39	13.91	36.8
Yes	12	181	55	236
	2.11	31.87	9.68	41.55
Undecided	17	43	51	123
	2.99	7.57	8.98	21.65
Total	100	295	173	568
	17.61	51.94	30.46	100

Notes: The total sample covers all CTrip employees in their Shanghai Airfare and Hotel group in November 2010 and August 2011. For the November 2010 survey employees were not told the eligibility rules in advance of the survey (i.e.: own room, 6+ months tenure, internet connect etc). For the November 2011 survey they were told the experiment was being rolled out to the company, but again not what the criteria for this would be.

Table 7 Panel B: Employee switches after the end of the experiment

	(1)	(2)	(3)	(4)	(5)	(6)
Switch	Home to Office	Home to Office	Home to Office	Office to Home	Office to Home	Office to Home
Performance during the experiment	-0.426**		-0.966***	0.189		0.659
	(0.214)		(0.313)	(0.26)		(0.51)
Performance before the experiment		-0.160	0.659*		0.271	-0.77
		(0.218)	(0.346)		(0.39)	(0.73)
Age			0.0279			0.260***
			(0.0462)			(0.09)
Married			-1.221**			-0.93
			(0.485)			(0.78)
Live with parents			-0.696**			-0.425
			(0.331)			(0.65)
Cost of commute			-0.000692			-0.027
			(0.0254)			(0.05)
Constant	-0.856***	-0.804***	-0.945	-0.187	-0.201	-5.659***
	(0.149)	(0.141)	(1.102)	(0.20)	(0.20)	(2.03)
Observations	103	103	103	41	41	41

Notes: Sample for returning to the office includes the 103 treatment works still at CTrip at the end of the experiment in September 2011. Out of the 103 treatment workers, 22 opt to come back to work in the office full-time. Pre-experiment performance is the average of individual weekly performance z-score during the pre-experimental period from January 1st 2010 to December 5th 2010. Post-experiment performance is the average of individual weekly performance z-score during the post-experimental period from December 6th 2010 to August 31st 2011. The sample for moving home includes the 41 employees in the Airfare group from the control group still in the experiment by September 2011. Robust standard errors. *** denotes 1% significance, ** 5% significance and * 10% significance.

Figure 1. Compliance

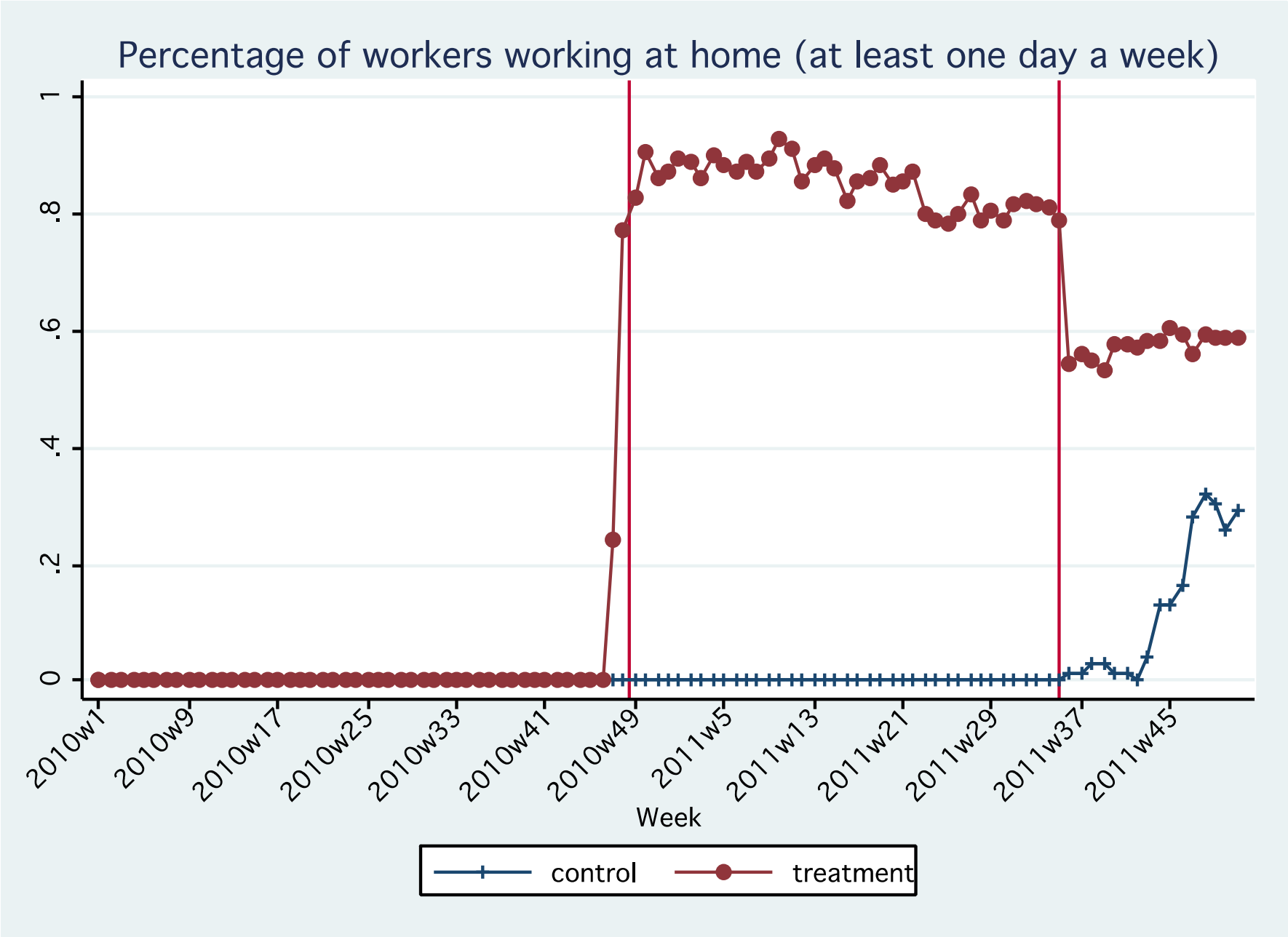


Figure 2. Treatment group consistently has higher performance than the control group.

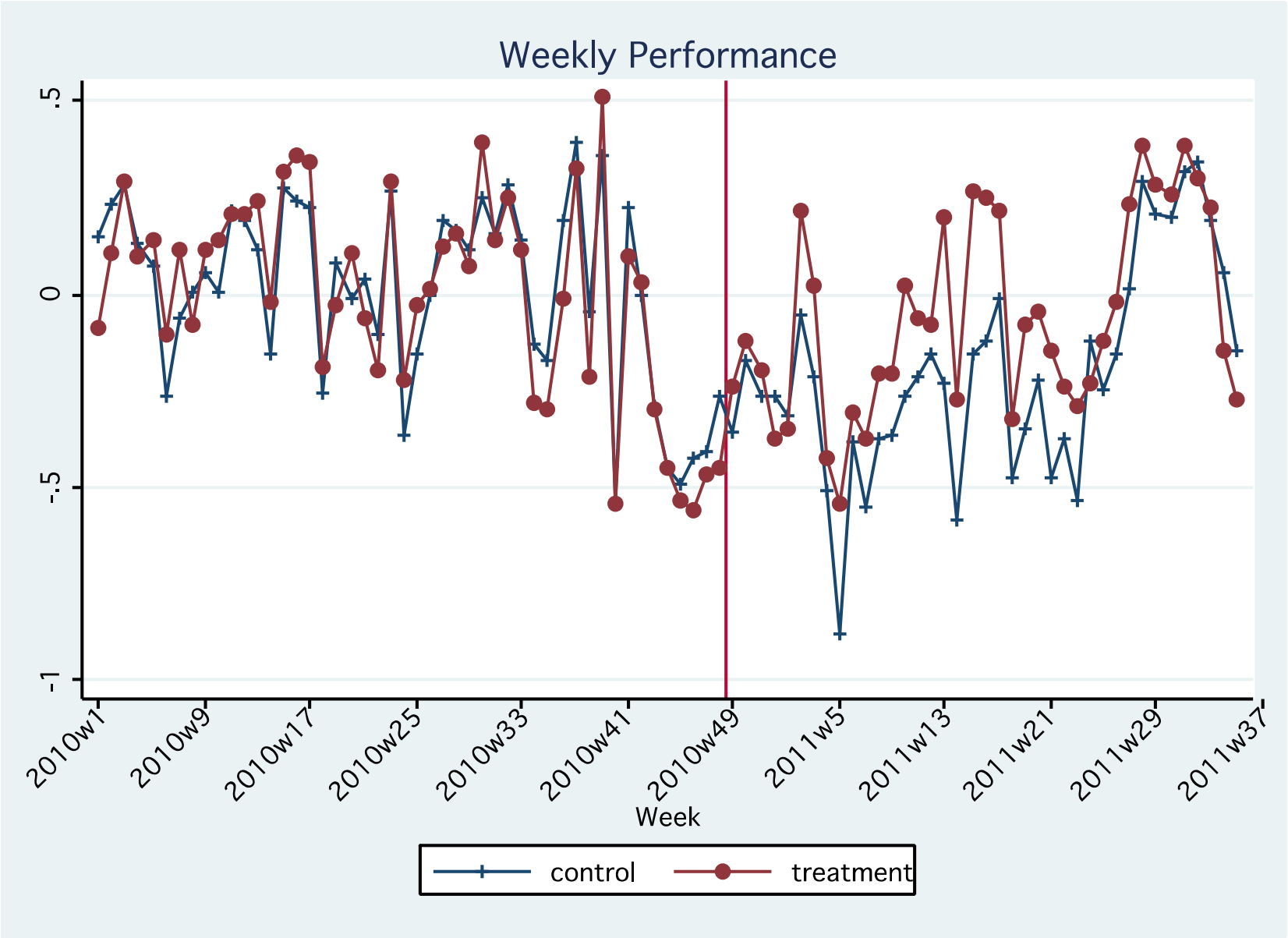


Figure 3. Control group tracks Nan Tong well

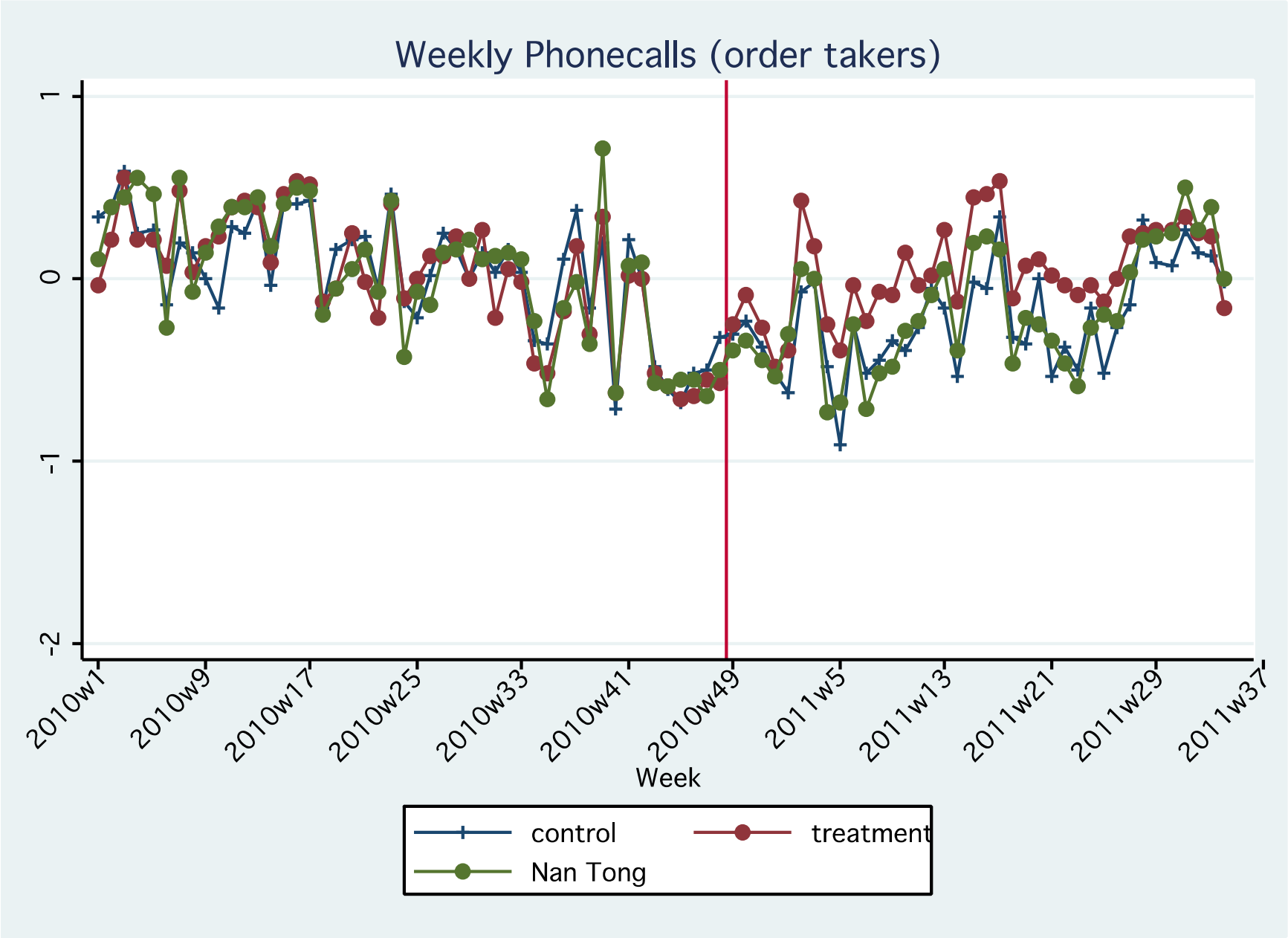


Figure 4. The treatment group has much lower attrition rate than the control group after the experiment started.

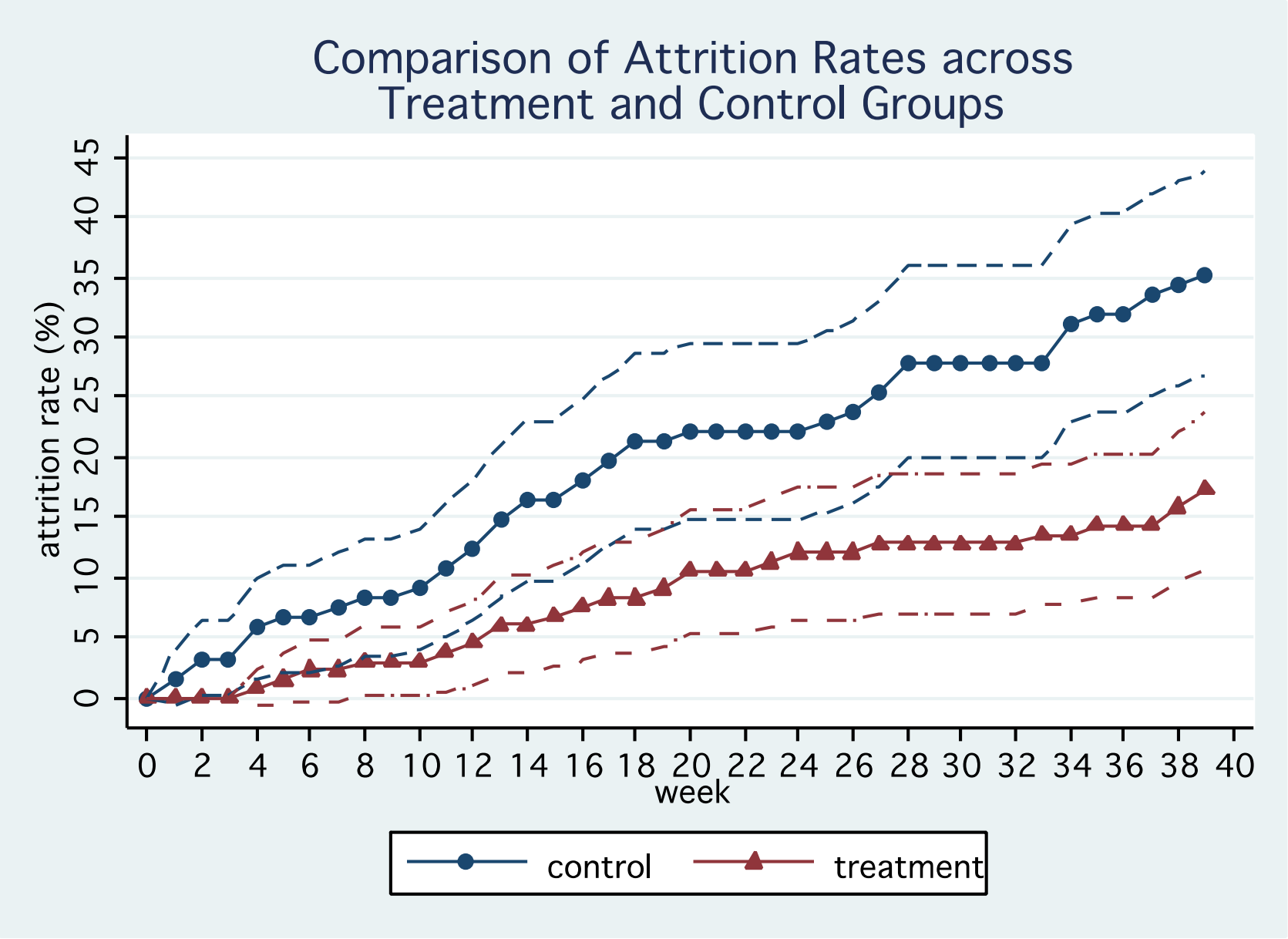


Exhibit A: Ctrip is a large and modern firm in China that utilizes comparable facilities as its counterparts in the US.

Headquarter in Shanghai

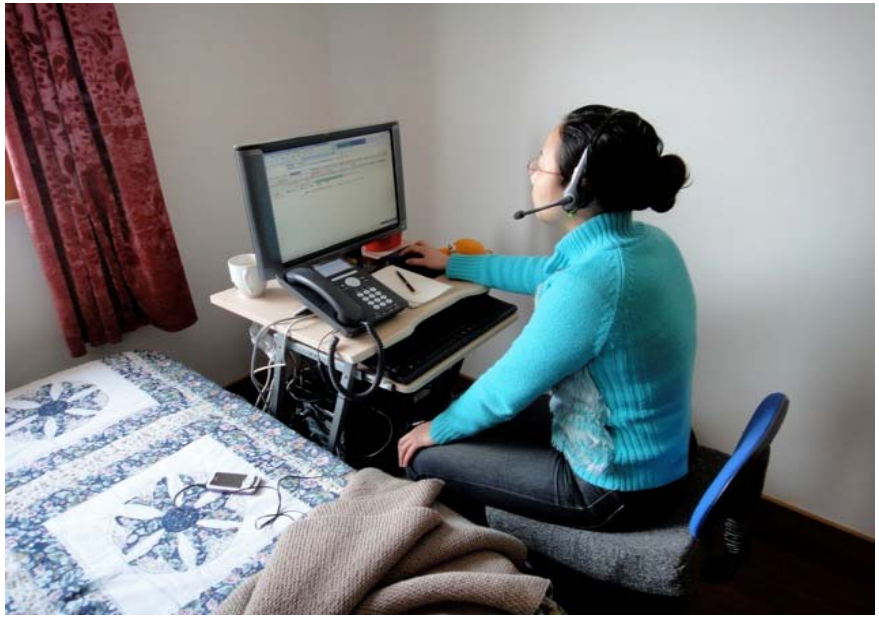
Main Lobby

Call Center Floor

Team Leader Monitoring Performance

Exhibit B: The experimental randomization, and examples of home-workers

Treatment groups were Determined by a Lottery

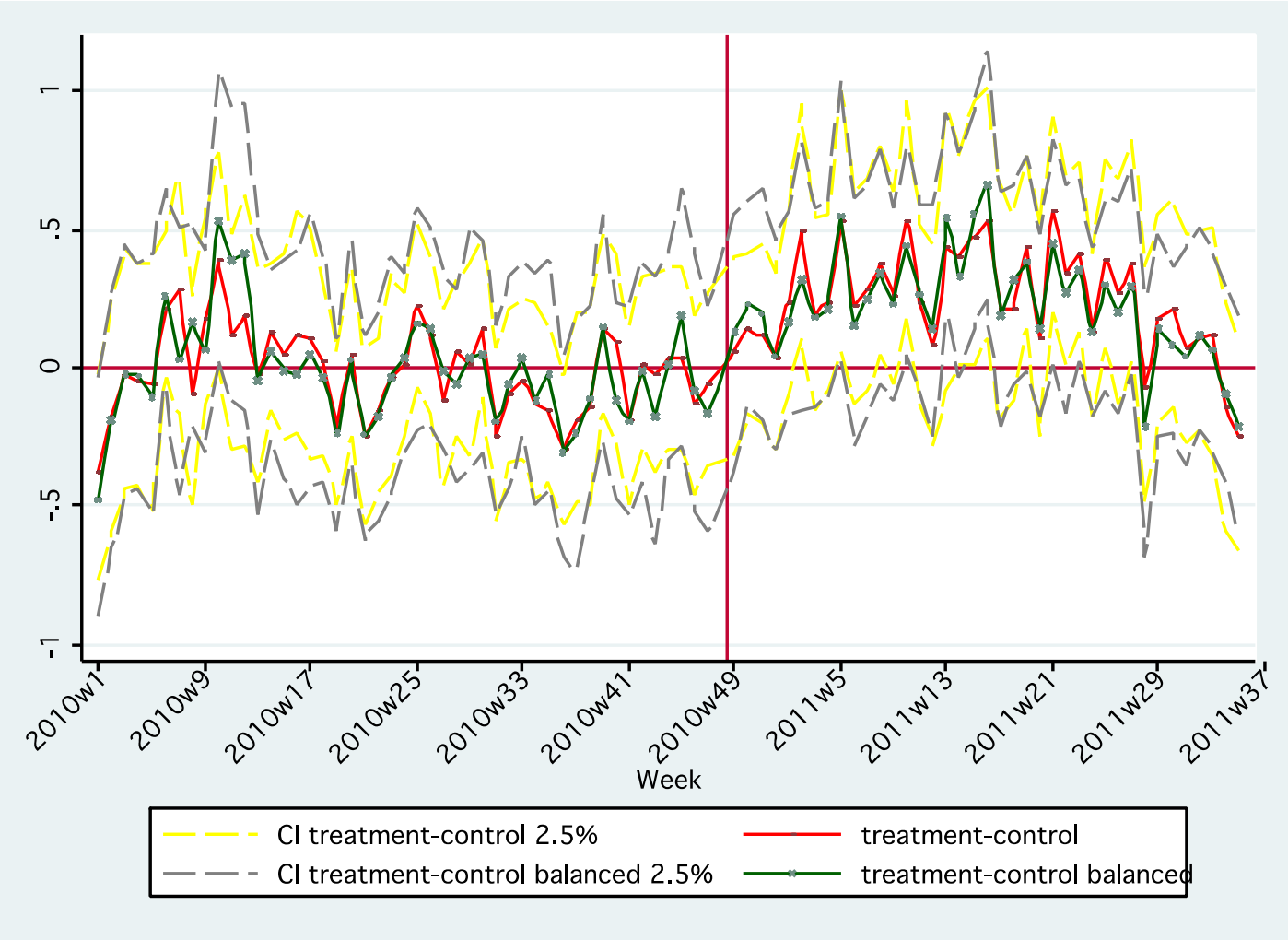


Working at Home

Working at Home

Working at Home

Appendix Figure 1: Using a balanced panel, we observe the same performance gap between treatment and control group.



Appendix Figure 2: Impact of the Program on Firm Profitability

- Office space: Imputed rent for Shanghai HQ is $5m per year. 1/4 of space is taken up central management and the rest by 3000 call center employees. Hence, estimated office space saving per employee is $1,250 per year

- Wages: Performance of the treatment group rises by about 7.5%. Salaries are about 50% performance based and 50% fixed. Given average salaries of about $10,000 per year implies a saving per employee of about $375

- Retention: CTrip estimates hiring and training cost per employee of $2000, so that reducing attrition from 40% to 20% p.a. reduces retention costs by about $400 per year.

Ignores: hiring and wage impact (probably positive), long-term performance impact (ambiguous), and assumes quality and capital equipment requirements are unchanged (as they were in the experiment)