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Recommended Citation

Shachat, J., Walker, M. J., & Wei, L. (2020). The impact of the Covid-19 pandemic on economic behaviours and preferences: Experimental evidence from Wuhan. *ESI Working Paper 20-33*.

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The Impact of the Covid-19 Pandemic on Economic Behaviours and Preferences: Experimental Evidence from Wuhan

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The impact of the Covid-19 pandemic on economic behaviours and preferences: Experimental evidence from Wuhan*

Jason Shachat[†] Matthew J. Walker[‡] Lijia Wei[§]

August 20, 2020

Abstract

We examine how the emergence of Covid-19 in Wuhan, and the ramifications of associated events, influence pro-sociality, trust and attitudes towards risk and ambiguity. We assess these influences using an experiment consisting of financially incentivized economic tasks. We establish causality via the comparison of a baseline sample collected pre-epidemic with five sampling waves starting from the imposition of a stringent lockdown in Wuhan and completed six weeks later. We find significant long-term increases - measured as the difference between the baseline and final wave average responses - in altruism, cooperation, trust and risk tolerance. Participants who remained in Wuhan during the lockdown exhibit lower trust and cooperation relative to other participants. We identify transitory effects from two events that permeated the public psyche. First, in the immediate aftermath of the Wuhan lockdown, there is a decrease in trust and an increase in ambiguity aversion. Second, the news of a high-profile whistleblower's death also decreases trust while heightening risk aversion.

Keywords: Covid-19, Social Preferences, Cooperation, Trust, Risk Preferences

JEL Codes: C93, D64, D81, D91, I18

*All experiments in this study were approved by the Academy of Humanities and Social Sciences, Wuhan University. The authors gratefully acknowledge Natural Science Foundation of China under grant number 71403192, and by the ESRC/FNR under grant number ES/P011829/1. All authors contributed equally to this work. Declarations of interest: none.

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1 Introduction

In December 2019, a novel coronavirus and associated disease (Covid-19) emerged in the city of Wuhan, capital of China’s Hubei province. Public health campaigns worldwide have sought to align private and collective interests, promoting behavioural change as the first line of defence in mitigating the virus’s impact on individuals’ well-being and livelihoods. Collective action during a public health emergency relies first and foremost on the pro-social and cooperative behaviours of individuals, their trust in others and the interplay between their decision-making and perceptions of risk (Van Bavel et al., 2020).

In this paper, we report on a set of experiments designed to monitor the evolution of altruism, cooperation, trust and attitudes towards risk and ambiguity in China during the period from late January to early March 2020. That is, we directly measure economic preferences *during* the early stages of the Covid-19 crisis. Our sample is drawn from a population of 9,000 pre-registered Wuhan University students. We administered a standard set of economic games and individual decision-making tasks to a repeated cross-section of 396 subjects from this population in their place of residence, via the WeChat social media platform. All tasks were financially incentivized. We also have data from a pre-crisis baseline sample of 206 subjects, collected from the same population in May 2019. An advantage of our design is that we can assess long- and short-term effects of the pandemic, using a consistent response elicitation method.

Sampling during the crisis took place over five waves and encompassed a period in which several key events permeated the public psyche. We implemented the first sampling wave on January 24/26. Person-to-person transmission of Covid-19 was publicly confirmed on January 20 and three days later the central government of China imposed a strict lockdown in Wuhan, quickly followed by lockdowns in other cities of Hubei province. By the time of our first sampling wave, the daily search index on the word pneumonia using China’s main search engine Baidu had risen abruptly to over 760,000 and China Central Television was devoting more than 80 percent of its news coverage to pneumonia-related stories (see

the top panel of Figure 1).¹ The second sampling wave was implemented on February 4/6, the third on February 7/8. These two waves straddled the well-publicised death of Dr. Li Wenliang, a high-profile Chinese whistleblower which sparked outrage among ordinary citizens. To gain insight into the magnitude with which this event resonated in the Chinese public’s consciousness, compare the two search index series in the bottom panel of Figure 1.² The red series tracks the search index on Li Wenliang and the blue series tracks the search index on Zhong Nanshan, one of China’s leading medical scientists who warned about the transmissibility of Covid-19 after a visit to Wuhan on January 20.³ While the Zhong Nanshan index spiked to over 1 million around the date of his visit to Wuhan, the Li Wenliang index increased nearly five times more than this to over 5 million, following the announcement of his death in the early hours of February 7. The fourth sampling wave was implemented two weeks after this event, on February 21/22. We followed up with the final wave two weeks later, on March 6/7, just days before the WHO declared the Covid-19 outbreak a global pandemic.

Our first set of experiment findings relate to the long-term effects of the crisis. The long-term is defined here as the change in average responses between the pre-crisis baseline sample and the final sampling wave. We observe significant long-term increases in altruism, trust and risk tolerance. There is also some evidence of a significant long-term improvement in cooperation rates. We identify a differential effect in certain behaviours among those subjects quarantined in Wuhan during the lockdown, where the perceived (and objective) risk from the virus is highest during this period (see also Bu et al., 2020). These subjects display significantly lower levels of trust and cooperation than others.

Our second set of findings concern transitory effects during the crisis. We observe marked

¹In China, Covid-19 was referred to as pneumonia early on.

²This event was also widely covered by media outlets in the Western world. See, for example: <https://www.theguardian.com/global-development/2020/feb/07/coronavirus-chinese-rage-death-whistleblower-doctor-li-wenliang>.

³Zhong Nanshan is often referred to as the public face of China’s fight against the virus. See, for example: <https://www.npr.org/2020/04/15/835308147/meet-dr-zhong-nanshan-the-public-face-of-the-Covid-19-fight-in-china?t=1596625232619>.

changes in behaviour during the sampling period, in the immediate aftermath of two events. The first of these events is the lockdown of Wuhan city, after which we observe greater cooperation and risk tolerance. Subjects also display lower levels of trust and greater ambiguity aversion around this time. This is perhaps unsurprising, since late January was the moment of greatest uncertainty about the virus in Wuhan. Indeed, our measure of ambiguity aversion returns to pre-crisis levels by the final wave of sampling. Additionally, there is a temporary and significant fall in our behavioural measure of trust on the day after the death of Dr. Li Wenliang. This event is associated with a short-term increase in risk aversion and - on one measure - a fall in cooperation rates. All these measures later return to levels recorded before this event.

Our study contributes to an established economics literature assessing how formative experiences and events influence economic preferences and behaviour. Standard economic models assume that individuals' preferences are stable over time. This assumption is at odds with studies in psychology, which emphasise the importance of personal experiences in decision-making (Hertwig et al., 2004) and has been challenged by a series of empirical works in economics and finance (e.g. Choi et al., 2009; Malmendier and Nagel, 2011; Guiso et al., 2018; Andersen et al., 2019).

There are several experimental studies investigating the impact of traumatic events on risk-related attitudes. The evidence here is mixed and appears to be context-specific. Many studies report that individuals become more risk averse for various time horizons after experiencing a natural disaster (Kim and Lee, 2014; Cameron and Shah, 2015; Beine et al., 2020), yet others find a preference for risk-seeking after such an event (Eckel et al., 2009; Page et al., 2014; Hanaoka et al., 2018; Kuroishi and Sawada, 2020). Callen et al. (2014) uncover a preference for certainty among survey respondents exposed to violence in Afghanistan during the 2000s, although Vieider (2018) suggest that their results are confounded by noise. Brown et al. (2019) document a significant positive relationship between the intensity of violent crime and risk aversion across local municipalities in Mexico. Cavatorta and Groom (2020)

observe that Palestinian individuals affected by the deterrent wall between the West Bank and Israel are more risk tolerant and more ambiguity averse.

To our knowledge, there is less empirical evidence regarding the effect of crises on social preferences and trust. Fisman et al. (2015) find that subjects are more selfish in times of economic recession than times of prosperity, whereas Voors et al. (2012) report that exposure to violence in rural Burundi promotes altruistic behaviours. Cassar et al. (2017) find that villagers affected by the 2004 tsunami in Thailand trust more after the disaster. David and Sade (2020) find that at the outbreak of the Covid-19 crisis, subjects are more willing to trust financial advice, and certain age groups display lower algorithm aversion, relative to a comparable pre-crisis sample.

Our study also contributes to a rapidly growing literature assessing the impact of the Covid-19 pandemic on economic preferences and beliefs (Angrisani et al., 2020; Binder, Forthcoming; Brück et al., 2020; Coibion et al., 2020; Fetzer et al., Forthcoming; Li et al., 2020). Various studies into the effect of the crisis on pro-social and risk-related behaviours are ongoing and the results are not yet available for comparison (Duch and Jiao, 2020; Lohmann et al., 2020; Théroude and Zylbersztein, 2020).⁴ Pro-sociality has already been observed to decrease in southern Spain during the pandemic, with a larger fall for older people when there is a higher perceived mortality risk (Brañas-Garza et al., 2020). Li (2020) conducted an online experiment in China in early March 2020, eliciting incentivized measures of attitudes towards risk and ambiguity. He finds that ambiguity averse subjects are more pessimistic about the impact of the pandemic on economic growth and are more likely to reduce consumption and increase savings as a result.

At least two other studies report evidence on economic preferences from the epicentre of the Covid-19 outbreak. Bu et al. (2020) administer a survey to a panel of graduate students at the Wuhan University of Science and Technology before initial reports of the virus emerged

⁴A search of the AEA RCT Registry on 22 July 2020 for project titles containing the words ‘Coronavirus’ or ‘Covid-19’ returned a total of 63 uncompleted trials.

and afterwards in their place of quarantine.⁵ They observe a significant decrease in levels of financial risk taking and planned risk taking between waves and exploit geolocation data to show that those subjects quarantined in Wuhan allocate 45 percent less to a hypothetical gamble relative to those based in other provinces of China.⁶

In related work, Guo et al. (2020) deploy the same set of decision-making tasks as implemented in this study but using a quite different design intended to measure the behavioural effects of priming Wuhan University subjects with viral social media videos connected to the Covid-19 crisis. Unlike the current paper, theirs is not an event study: they only elicit responses at a single point in time, late January 2020. In their study, subjects are randomly assigned to watch one of two videos, which had been circulating widely and anonymously on Chinese social media, before making decisions. The video showed either the visit of a prominent Government leader to Wuhan, or the arrival of health care volunteers into the city. They find that the top-down communication conveyed in the leadership video induces greater pro-sociality, but undermines trust, relative to a control condition. By contrast, the bottom-up communication conveyed in the volunteer video increases pro-sociality, without a negative effect on trust.

Our study continues in Section 2 with an outline of the experimental design, including details of sampling, the decision-making tasks and protocol. In Section 3, we present the main experiment results. We conclude in Section 4 with a discussion of our findings in context of the related literature and a brief consideration of policy implications.

⁵Wuhan University of Science and Technology is a separate research institution to Wuhan University.

⁶The authors conduct a repeat survey in April 2020, in which they observe that financial risk taking rebounds after the quarantine in Wuhan ends, suggesting that the effects of the Covid-19 pandemic on economic preferences are likely to be short-lived.

2 Experimental Design

2.1 Sampling information

A timeline of our experimental sessions and events related to the Covid-19 pandemic is presented in Figure 2. All subjects in our experiments were Wuhan University students, randomly selected from a population of 9,000 subjects who had previously registered to participate in decision-making experiments. Subjects were not informed about the tasks that they would be asked to complete before registering for an experimental session.

Our baseline sample consists of 206 subjects recruited from this population, in May 2019, for an unrelated research project investigating the impact of the experimental interface on economic decision-making. Following the lockdown of Wuhan city on 23 January 2020, we collected comparable data from a further 396 (different) subjects from the same population, spread evenly across five sampling waves.⁷ The first wave of 79 subjects was collected on January 24/26, in the immediate aftermath of the lockdown and enforced quarantine. The second and third waves of 79 and 80 subjects, respectively, were collected on February 4/6 and 7/8, immediately before and after the death of Dr. Li Wenliang. The fourth wave of 78 subjects was collected on February 21/22, by which point there were over 63,000 confirmed cases and 2,250 deaths in Hubei province. The final wave of 80 subjects was collected on March 6/7, as the national epidemic transformed into a global pandemic with case numbers rising internationally. By this stage, the number of local confirmed cases in Wuhan had dropped from thousands to less than one hundred per day, with almost no local confirmed cases in China outside of Wuhan.^{8,9}

⁷In separate work in progress, “Does the interface matter? Economic decision making via smartphones or laptops,” we find that subjects’ interface affects certain risk-related behaviours. Accordingly we maintain a consistent experimental interface between the pre-crisis baseline sample and the subsequent experimental waves. We also exclude from our analysis data a further four subjects in our 2020 waves and eighteen subjects in our baseline sample who completed the tasks using a computer after we asked them to complete tasks using a mobile phone.

⁸Virus case data is obtained from WHO situation reports, which can be found at: <https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports/>.

⁹As a robustness check, on February 15 and 16 we followed up with 92 randomly selected subjects of the baseline sample and elicited repeat responses for the same set of tasks. In unreported results, we find similar

In total, we recruited 602 subjects across the pre-crisis and crisis samples. The average age in our full sample is 20 and 41 percent of subjects are female. Demographic characteristics are similar across all five sampling waves during the crisis.¹⁰ We note that the proportion of male subjects is lower in our pre-crisis sample (31 percent). Thus, we check the robustness of all results after controlling for gender and other demographic variables. We also have geo-location data, which we use to identify those subjects based in Wuhan during the crisis (around 10 percent of the sample). Since most students from areas outside of Wuhan had already left the city in early January to celebrate the Lunar New Year holiday, we can use this to exploit quasi-random variation in exposure to the virus and associated events across China.

2.2 Economic games

The following two sub-sections describe the decision-making tasks that were implemented in our experiment.¹¹ We employed a standard set of incentivized two-person games used in the experimental economics literature to measure strategic behaviours. In each game, subjects were randomly matched into pairs within the session and assigned to the role of either player 1 or player 2. Details of the games and what they measure are summarized below:

- Dictator game. Player 1 is allotted 5 RMB and decides how to allocate this sum of money between the two players in the pair. Player 1's allocation is final. Player 2 has no decision to make. Amounts allocated by player 1 provide a measure of subjects' altruism.

trends between this re-sample and the closest wave, Wave 3, in our cooperation, altruism and ambiguity aversion measures.

¹⁰See Appendix Table A1 for further details, including about mobile phone display size and operating system. At 21 percent, the iOS share in our sample is in line with the market share in China at the time of the experiment (see <https://gs.statcounter.com/os-market-share/mobile/china>).

¹¹We collected data from a further four tasks designed to inform on subjects' levels of cognitive reasoning, lying propensity and time preferences. Since these behaviours are not of direct interest to the current research question, we do not report on them here. For completeness, details of these tasks are included in the experiment instructions.

- Ultimatum game. Player 1 is allotted 8 RMB and proposes an allocation of this sum between the two players in the pair. Player 2 can choose to accept or reject the allocation. In case of rejection, both players receive zero payoff for the task. Acceptance rates capture subjects' perceptions of fairness; offers capture expectations about reciprocity.
- Trust game. Player 1 is allotted 8 RMB and decides how much of this sum of money to send to player 2. Any money sent is multiplied by a factor of three before reaching player 2. Any money not sent is kept by player 1. Player 2 observes the multiplied transfer and decides how much of it to return to player 1. Any money not returned is kept by player 2. Amounts sent capture subjects' trust; amounts returned capture subjects' trustworthiness.
- Prisoner's Dilemma game. Each player makes a simultaneous decision to Cooperate or Defect. The choices are framed neutrally as options C or D. If both players choose Cooperate, both players earn 6 RMB. If both players choose Defect, both players earn 3 RMB. If one player chooses Cooperate and the other player chooses Defect, the cooperating player earns 0 RMB and the defecting player earns 9 RMB. Choices in this game provide a measure of subjects' cooperative tendencies.
- Stag Hunt game. Each player makes a simultaneous decision to choose a Safe or Risky option. The choices are framed neutrally as options A or B. If both players choose Safe, both players earn 3 RMB. If both players choose Risky, both players earn 8 RMB. If one player chooses Safe and the other player chooses Risky, the safe player earns 3 RMB and the risky player earns 0 RMB. As suggested by Skyrms (2004), we interpret a Risky choice as the intention to cooperate. We measure the level of cooperation in the Stag Hunt game as the percentage of players choosing the Risky action.

2.3 Individual decision-making tasks

In addition to the economic games described in the previous sub-section, we elicited information about subjects' attitudes towards risk and ambiguity by implementing the following incentivized decision-making tasks:

- Risk attitude elicitation (gain domain). Subjects are presented with a series of nine pairwise choices between a lottery (option A) and a sure amount of money (option B). The lottery remains fixed across all choices: a 50 percent chance of receiving 9 RMB, and a 50 percent chance of receiving 3 RMB. The sure amount increases uniformly with each choice from 3 RMB to 9 RMB in increments of 0.75 RMB.¹² After all choices have been made, the system randomly selects one of the nine pairs of options and, depending on the option chosen for this pair, determines the payoff for the task. A later switching point (higher certainty equivalent) indicates greater willingness to take risks.¹³
- Risk attitude elicitation (loss domain). Identical to the risk attitude elicitation in the gain domain except that now the lotteries and sure amounts are framed as losses and the sure amount decreases uniformly with each choice from 9 RMB to 3 RMB. A later switching point (higher certainty equivalent) indicates greater willingness to take risks. The payoff-relevant amount was subtracted from the subject's earnings at the end of the experiment.¹⁴
- Ambiguity attitude elicitation. Identical to the risk attitude elicitation except that now, if subjects choose the lottery, a ball is randomly drawn from an opaque urn. The urn contains both red and blue balls, but the number of each colour is unknown. If the draw is red, they earn 9 RMB. If the draw is blue, they earn 3 RMB.¹⁵ A later

¹²This task is an adaptation of the well-established Holt and Laury (2002) multiple price list format.

¹³We exclude data from 29 subjects who switch more than once in this elicitation task.

¹⁴We exclude data from 13 subjects who switch more than once in this elicitation task.

¹⁵This task is based on the original thought experiment of Ellsberg (1961).

switching point (higher certainty equivalent) indicates greater willingness to seek out unknown situations.¹⁶

2.4 Procedural details

Invitations to participate in an experimental session were sent using the cloud-based Ancademy platform.¹⁷ Ancademy is based on the open interface of WeChat. Upon joining a session, subjects were redirected to a welcome screen describing the general experiment guidelines. The economic games and individual decision-making tasks were then completed sequentially, with instructions provided on arrival at each task.¹⁸ Feedback was provided only after completion of all tasks. We excluded from a session either the Ultimatum or Trust game task.¹⁹ At the end of a session, subjects answered a short questionnaire eliciting standard demographic information, before viewing a screen containing his or her decision outcomes and payment information.

Subjects were paid based upon the outcomes of all tasks. We made payments via the WeChat pay facility on the same day. The experimental tasks were computerized using oTree (Chen et al., 2016). Subjects were instructed to complete the tasks using their mobile phone and we were able to check compliance with this instruction in the data. Subjects were able to contact the experimenter via WeChat during the course of a session in case of any questions. No subject could participate in more than one session. Sessions lasted approximately forty-five minutes and payments averaged 65.68 RMB (about 9.5 US dollars), including a participation fee of 10 RMB.

¹⁶We exclude data from 21 subjects who switch more than once in this elicitation task.

¹⁷<https://www.ancademy.org/>.

¹⁸An English translation of the original experiment instructions for each task is available in the Supplementary Materials.

¹⁹We did this to minimize the possibility of second-mover learning (due to the sequential nature of the tasks) as well as subject confusion due to the equivalence in stake size between those tasks.

3 Results

In Figure 3, we plot the evolution of mean responses for the experimental tasks over time, with associated 95 percent confidence intervals. The corresponding descriptive statistics are contained in Table 1.

3.1 Pro-social, cooperative and trust behaviours

Regarding the economic games, we find that levels of altruism trend upwards during the crisis. On average, the amount allocated by player 1s in the Dictator game is significantly higher in Wave 5 - 39 percent of endowment - than in the pre-crisis baseline sample - 29 percent of endowment (p -value < 0.05).²⁰ On the other hand, there is no significant difference in Dictator game allocations between subjects in Wave 1 and the baseline (p -value = 0.42). Offers in the Ultimatum Game are also significantly higher in Wave 5 than in the pre-crisis sample, rising from 38.5 to 44.8 percent of the endowment (p -value = 0.05). Together, our observations from the Dictator game and first-mover behaviour in the Ultimatum game suggest that actual fairness norms and beliefs about perceived fairness norms were more salient in Wuhan in early March 2020 than at the beginning of the lockdown period or before the Covid-19 outbreak.

The evidence on cooperation is more mixed. In the Prisoner's Dilemma game, the proportion of cooperative choices is 15 to 18 percentage points higher in the early stages of the crisis, after the lockdown of Wuhan (Waves 1 and 2), compared to the pre-crisis baseline and these differences are significant (respectively, p -value < 0.01 and p -value < 0.05). Cooperation remains elevated in Wave 5, although the difference versus the baseline is not statistically significant (p -value = 0.19). Cooperation in the Stag Hunt game is higher in absolute terms, remaining generally above 80 percent, but does not differ significantly between the first and last waves of the crisis sample or in Wave 1 relative to its baseline level

²⁰Unless otherwise indicated, p -values refer to two-tailed Wilcoxon rank-sum tests of wave averages (subject as unit of observation).

(respectively, p -value = 0.68 and p -value = 0.47). Reassuringly for the congruence of our two measures, the time trends of cooperation rates are similar in the Prisoner’s Dilemma and Stag Hunt games during 2020 (see Figure 3).

We also observe significantly lower trust levels after the Wuhan lockdown. Amounts sent by first movers in the Trust game fall from 3.39 to 1.75 between the pre-crisis and Wave 1 samples (p -value < 0.05). Amounts sent recover sharply in Wave 2, nearly tripling to 4.95, which is substantially higher than the baseline level (p -value < 0.05). Trust levels remain significantly higher in early March than at the beginning of the lockdown (Wave 5 versus Wave 1, p -value < 0.01).²¹

Another pattern that we can infer from Table 1 is the pronounced fluctuation in behaviours during the second, third and fourth waves of 2020. As described earlier, data for Waves 2 and 3 were collected either side of the controversial death of Dr. Li Wenliang, with Wave 4 responses elicited two weeks later. This high-profile event appeared to significantly undermine trust (p -value = 0.1) and cooperation as measured in the Stag Hunt game (p -value < 0.01). Cooperative choices in the Prisoner’s Dilemma fall during this period too, with cooperation rates 14 percentage points lower by Wave 4 compared to Wave 2 (p -value = 0.1). We further observe a 13.8 percent decline in rates of giving in the Dictator game between Waves 2 and 3, although this difference is not significant at conventional thresholds (p -value = 0.22). Although the trend towards less trusting and less cooperative behaviour is clear, it does not persist: by Wave 5 (four weeks after Wave 3), none of these behavioural measures are significantly different from their Wave 2 level.

The results of a regression analysis reinforce our aggregate findings (see columns 1 to 5 in Table 2). For the measures of pro-sociality and trust, we use OLS regression and for the measures of cooperation, we use logistic regression. In all regression specifications,

²¹It is difficult to draw valid inferences from unconditional statistics on second-mover decisions in the Trust and Ultimatum games, since the distribution of first-mover amounts sent/offered varies between waves. Thus, we conduct an additional regression analysis of second-mover decisions in which we obtain estimates for the interaction terms between each Wave dummy and the amount sent/offered, after controlling for variation in these amounts. The results of this analysis can be found in Table A2 of the Appendix.

we include dummies for the five 2020 sampling waves (with the pre-crisis baseline as the reference sample) and control for subject age, gender, location, mobile phone display size and operating system. Robust standard errors are calculated.

As in the aggregate analysis, allocations in the Dictator game remain significantly higher in Wave 5 versus the pre-crisis baseline sample after accounting for covariates (p -value < 0.01). In the Ultimatum game specification, the coefficient estimate for the Wave 5 dummy is positive but only marginally significant (p -value = 0.1). Cooperative choices in the Prisoner's Dilemma are also significantly more likely in Waves 1 and 2 (both p -values < 0.01) and in Wave 5 (p -value < 0.05) than in the baseline. Meanwhile, amounts sent in the Trust game are 1.11 RMB lower in Wave 1, 2.01 RMB higher in Wave 2 and 1.43 RMB higher in Wave 5 versus the baseline (respectively, p -value < 0.05 , p -value < 0.01 and p -value < 0.05). The Wave 5 dummy in the Trust regression is significantly higher than the Wave 1 dummy (p -value < 0.01 , two-tailed Wald test). We also reject linear hypothesis tests that the coefficient estimates for the Wave 2 and 3 dummies in the Stag Hunt regression are equal in favour of the alternative that they are lower in Wave 3 (p -value = 0.09, two-tailed Wald test). Similar qualitative results are found for the comparisons of Wave 2 and 4 dummies in the Prisoner's Dilemma and Trust game regressions (respectively, p -value < 0.05 and p -value = 0.01, two-tailed Wald tests).

Interestingly, we observe that those individuals quarantined in Wuhan during 2020 sent significantly less money in the Trust game than those resident in other areas of China (p -value < 0.01) - this effect size is large, amounting to over 62 percent of the average amount sent in the full sample over the five sampling waves. A similar negative effect is found for the likelihood of Wuhan based subjects to cooperate in the Prisoner's Dilemma, although the evidence for this is statistically weaker (p -value < 0.1).

3.2 Attitudes towards risk and ambiguity

Consistent with many prior experimental economics studies, we find risk aversion in the gain domain across our sample - the average switching point for the pairwise lotteries ranges from 4.26 to 4.95, where a value of 5.5 would indicate risk neutrality. Unlike several post-crisis studies cited in the introduction, however, we observe an increase in risk tolerance during the early stages of the Covid-19 crisis. The average switching point is 4.67 in Wave 1 and 4.92 in Wave 2, versus 4.45 in the baseline (respectively, p -value < 0.1 and p -value < 0.01). There is evidence that the domain matters for this effect: on average, subjects are risk-loving in the loss domain but are less risk tolerant during the crisis than before. In Waves 2 and 3, the average switching points are 6.19 and 6.12, respectively, significantly lower than the 6.42 recorded in the baseline sample (both p -values < 0.05).

There is an initial rise in ambiguity aversion after the lockdown of Wuhan, with subjects in the first two waves valuing the uncertain lottery at 4.15 and 3.93 respectively, significantly below the average valuation of 4.49 before the crisis (Wave 1 p -value < 0.05 , Wave 2 p -value < 0.01). Our measure of ambiguity attitude returns close to its pre-crisis level in Wave 5, at 4.47. Risk tolerance, by contrast, remains significantly elevated at the end of the sampling period relative to the baseline, at 4.95 (p -value < 0.01).

We also observe a significant increase in risk aversion over gains between Waves 2 and 3 (p -value < 0.01), which recovers in Wave 4. This resonates with our earlier analysis of behaviour in the economic games and again suggests that the death of Dr. Li Wenliang temporarily affected sentiment among ordinary Chinese citizens. With this in mind, we note that our finding as to the long-term impact of the public health crisis on risk attitudes contrasts with Bu et al. (2020), who report a generalized increase in risk aversion in a separate population of Wuhan-based subjects. Aside from differences in dates of the baseline sample for comparison (May versus October 2019) and risk elicitation measures (incentivized lottery choices in our study versus hypothetical allocation and self-reported attitudes in theirs), one explanation for the discrepancy may be that their follow-up survey was conducted in late

February 2020, after the death of Dr. Li Wenliang.

The results of a regression analysis support our findings on attitudes towards risk and ambiguity after controlling for demographic information (see columns 6 to 8 in Table 2). The coefficient estimates for the Wave 2 and 5 dummies in the risk attitude, gain domain, specification are positive and significant (both p -values < 0.05). In the ambiguity attitude specification, the coefficient estimates for the Wave 1 and 2 dummies are negative and highly significant (both p -values < 0.01), while there is no economic or statistically significant difference for the Wave 5 sample versus the pre-crisis baseline. We reject linear hypothesis tests that the coefficient estimates for the Wave 2 and 3 dummies in the risk attitude gain regression are equal in favour of the alternative that they are lower in Wave 3 (p -value < 0.01 , two-tailed Wald test). Unlike for the economic games, we observe no significant effect of being resident in Wuhan on attitudes towards risk and ambiguity, although we note that the direction of the effect is towards greater risk and ambiguity aversion.

4 Conclusion

We provide experimental evidence of perturbations in economic preferences and pro-social behavioural tendencies caused by significant events during the Covid-19 crisis in Wuhan, China. We are able to compare participants' choices from a baseline sample and five waves of sampling after the crisis onset, using a consistent response medium (WeChat) and incentivized tasks. We also use geo-location data to exploit the quasi-random variation in subjects' exposure to the virus and test for differences in behaviour among those subjects who remained in Wuhan during the lockdown period.

We find significant long-term increases in altruism, cooperation and trust between before and after the virus outbreak. Trust and to some extent cooperation are lower among those subjects quarantined in Wuhan. We also add to the debate regarding the impact of traumatic events on risk attitudes. In our sample, subjects exhibit a greater willingness to take risks

during the crisis period. Ambiguity aversion also rises, but this increase is short-lived.

There is evidence of short-term fluctuations in preferences and behaviour in the immediate aftermath of the lockdown of Wuhan city and the death of Dr. Li Wenliang, a high-profile whistleblower on the virus. These events resonated in the collective consciousness in China and our findings suggest the importance of accounting for the path-dependence of preferences during a crisis. Many policy measures, such as local lockdowns, are short-term in nature and require strong pro-social and cooperative behaviours amongst community members to bolster the government's response.

Ultimately, to assess the behavioural impact of events surrounding the Covid-19 crisis requires robust and controlled measurements. Our study is a step in this direction. Future work will continue to study how economic preferences evolve going forward, both inside and outside of China.

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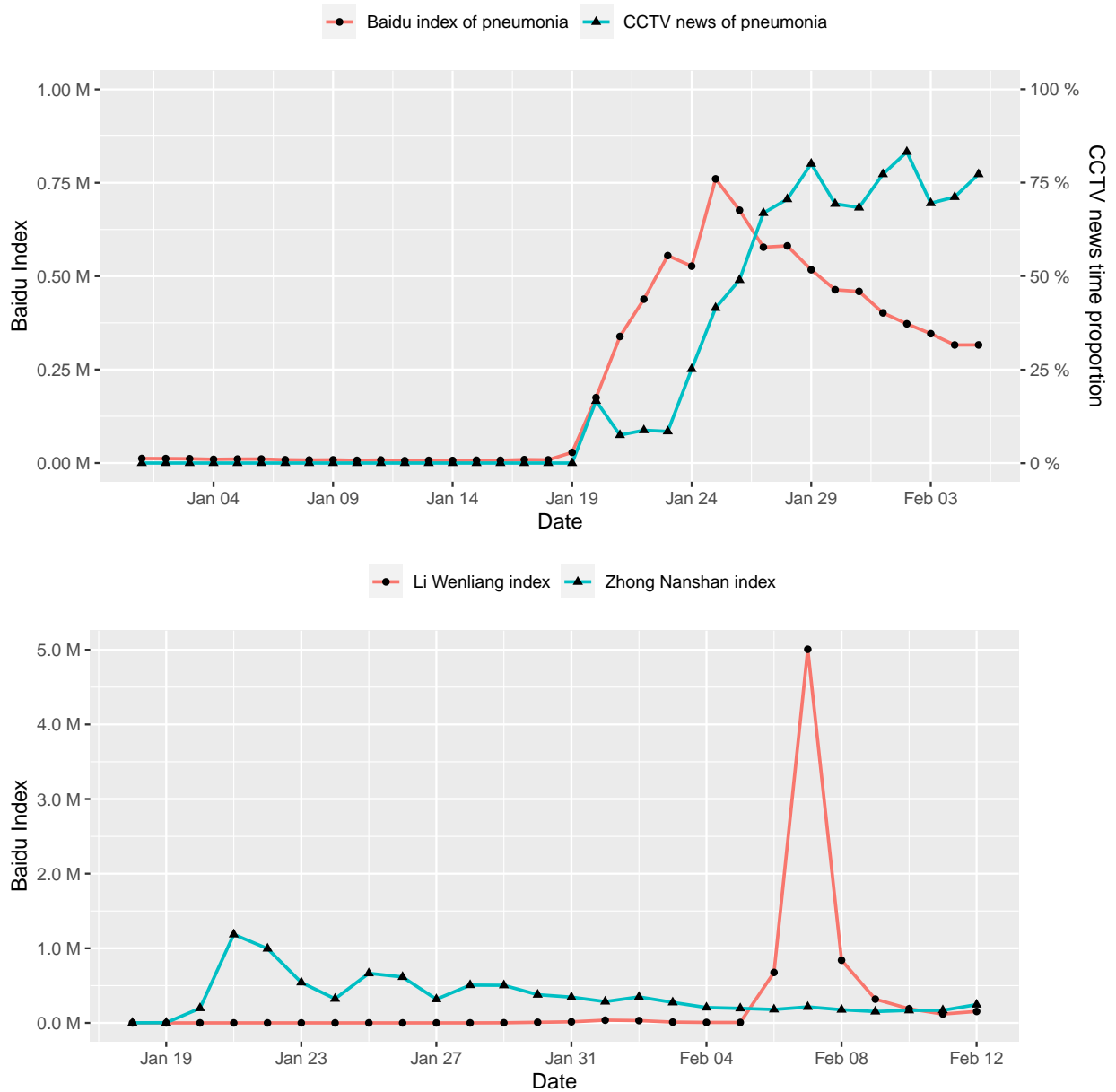


Figure 1: Public awareness of Covid-19 and related events in the early stages of the crisis

Notes. *Top panel:* The red series is the Baidu search index on the word pneumonia (in Chinese language). Max value is 760,460; The blue series is the time proportion spent covering pneumonia-related stories (later called Covid-19) on China Central Television (CCTV) news. Max value is 83%. *Bottom panel:* The red series is the Baidu search index on Li Wenliang. Max value is 5,007,063; The blue series is the Baidu search index on Zhong Nanshan, the chief scientist in China who first revealed human to human transmission of Covid-19. Max value is 1,186,091.

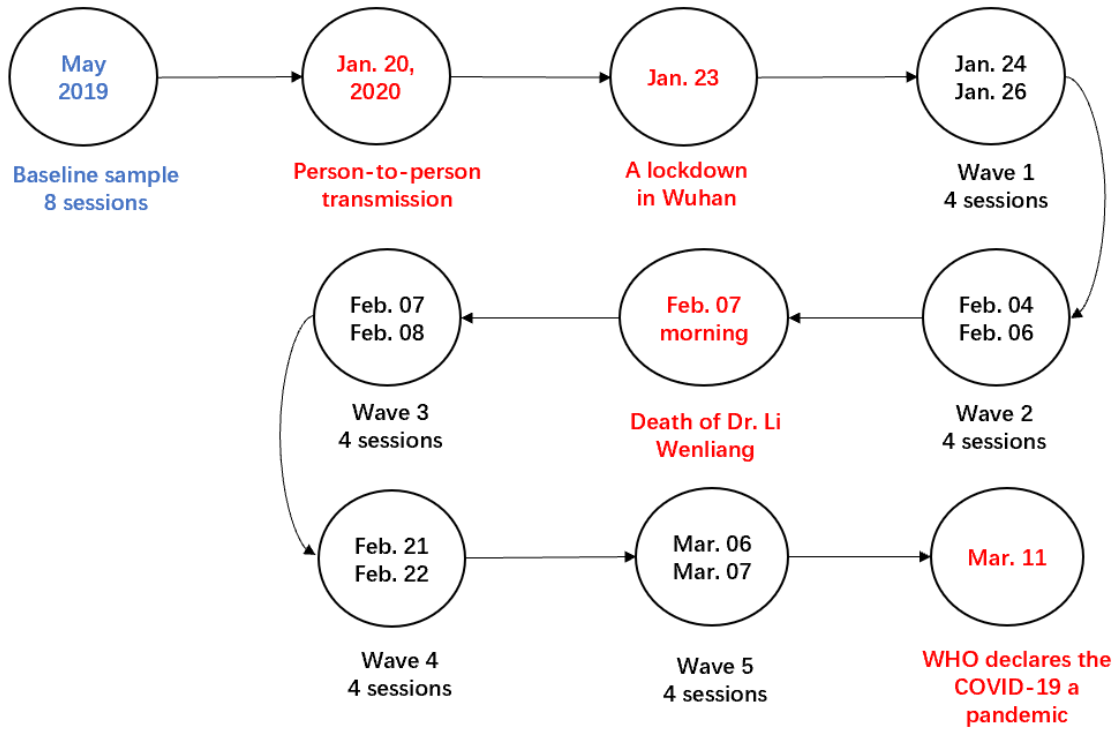


Figure 2: Timeline of events and experimental sessions

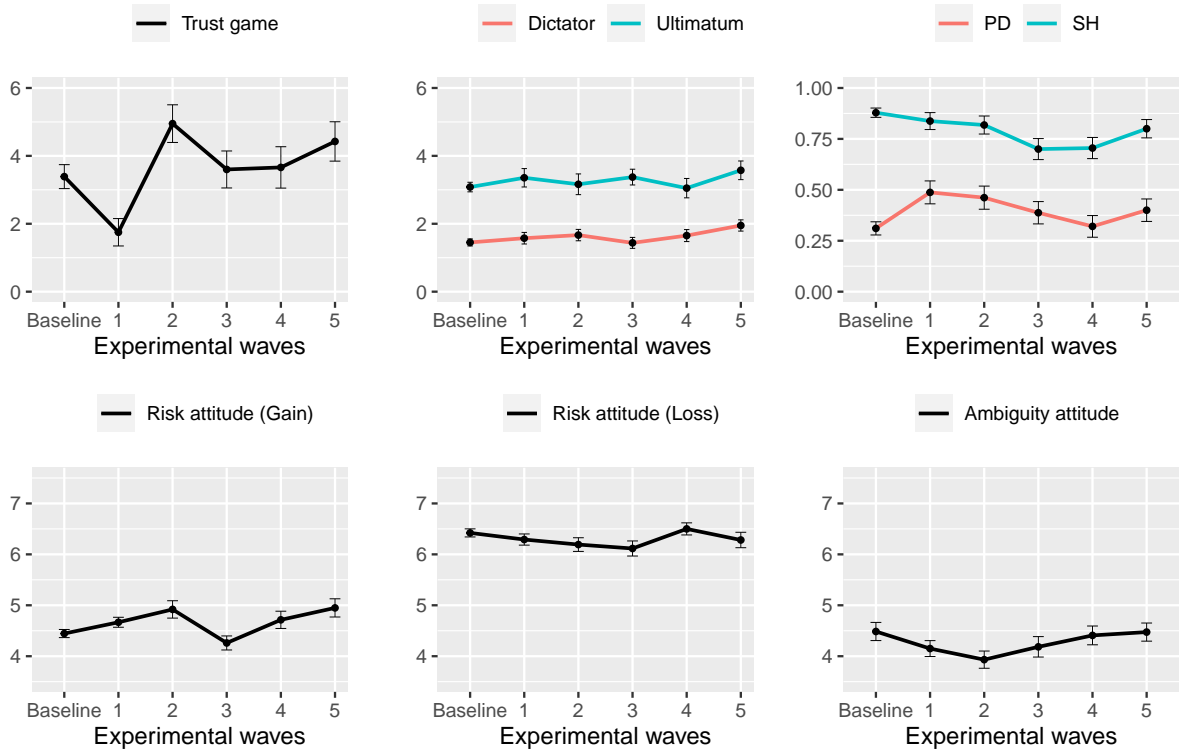


Figure 3: Time series of economic behaviours and preferences

Notes. Mean values with error bars +/- 1 standard error. For Trust game and Ultimatum game, series is amount sent/offered by first mover. PD = cooperation in Prisoner's Dilemma game, SH = cooperation in Stag Hunt game.

Table 1: Descriptive statistics over time

	Baseline		Wave 1		Wave 2	
	<i>mean</i>	<i>sd.</i>	<i>mean</i>	<i>sd.</i>	<i>mean</i>	<i>sd.</i>
Dictator game (0-5)	1.45	1.08	1.58	1.07	1.67	1.05
Stag Hunt game (0,1)	0.88	0.33	0.84	0.37	0.82	0.39
Prisoner's Dilemma game (0,1)	0.31	0.46	0.49 ^A	0.50	0.46 ^A	0.50
Trust game sent (0-8)	3.39	2.59	1.75 ^A	1.80	4.95 ^A	2.48
Ultimatum game offer (0-8)	3.08	1.04	3.36	1.21	3.16	1.31
Risk attitude, gain (1-10)	4.45	1.13	4.67 ^a	0.86	4.92 ^A	1.47
Risk attitude, loss (1-10)	6.42	1.14	6.29	0.98	6.19 ^A	1.18
Ambiguity attitude (1-10)	4.49	1.33	4.15 ^A	1.4	3.93 ^A	1.46
Number of subjects	206		79		79	
	Wave 3		Wave 4		Wave 5	
	<i>mean</i>	<i>sd.</i>	<i>mean</i>	<i>sd.</i>	<i>mean</i>	<i>sd.</i>
Dictator game (0-5)	1.44	1.01	1.65	1.12	1.95 ^A	1.04
Stag Hunt game (0,1)	0.70 ^A	0.46	0.71 ^A	0.46	0.80	0.40
Prisoner's Dilemma game (0,1)	0.39	0.49	0.32 ^c	0.47	0.49	0.50
Trust game sent (0-8)	3.6 ^c	2.44	3.66	2.73	4.43 ^B	2.59
Ultimatum game offer (0-8)	3.38	1.04	3.05	1.28	3.58 ^A	1.23
Risk attitude, gain (1-10)	4.26 ^C	1.18	4.71	1.42	4.95 ^A	1.58
Risk attitude, loss (1-10)	6.12 ^A	1.31	6.5 ^c	1.00	6.28	1.34
Ambiguity attitude (1-10)	4.18 ^A	1.75	4.41	1.55	4.47 ^C	1.55
Number of subjects	80		78		80	

The following tests are two-tailed Wilcoxon rank-sum tests.

Note: ^ap<0.1, ^Ap<0.05, ^Ap<0.01 for comparison of means Wave versus Baseline;

^bp<0.1, ^Bp<0.05, ^Bp<0.01 for comparison of means Wave 5 versus Wave 1.

^cp<0.1, ^Cp<0.05, ^Cp<0.01 for comparison of means Wave 3/4/5 versus Wave 2.

Table 2: Regression Results

	Dependent variable							
	Trust	Pro-sociality		Cooperation		Risk		Ambiguity
	UG	DG	SH	PD	Gain	Loss		
	<i>OLS</i>	<i>OLS</i>	<i>OLS</i>	<i>Logistic</i>	<i>Logistic</i>	<i>OLS</i>	<i>OLS</i>	<i>OLS</i>
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Wave 1	-1.15** (0.54)	0.28 (0.32)	0.22 (0.19)	-0.35 (0.39)	0.91*** (0.29)	0.18 (0.13)	-0.20 (0.14)	-0.41** (0.18)
Wave 2	2.00*** (0.59)	0.03 (0.37)	0.31 (0.20)	-0.45 (0.37)	0.83*** (0.29)	0.43** (0.21)	-0.29* (0.17)	-0.59*** (0.21)
Wave 3	1.00 (0.63)	0.36 (0.26)	0.09 (0.19)	-1.11*** (0.34)	0.43 (0.29)	-0.22 (0.16)	-0.40** (0.17)	-0.35 (0.23)
Wave 4	0.71 (0.65)	-0.02 (0.31)	0.24 (0.20)	-1.06*** (0.35)	0.09 (0.29)	0.23 (0.18)	0.02 (0.14)	-0.09 (0.19)
Wave 5	1.42** (0.63)	0.54 (0.33)	0.57*** (0.19)	-0.47 (0.37)	0.54* (0.28)	0.42** (0.20)	-0.21 (0.17)	-0.09 (0.20)
Wuhan in 2020	-2.24*** (0.57)	-0.20 (0.57)	-0.26 (0.24)	-0.01 (0.43)	-0.68* (0.40)	-0.05 (0.19)	-0.02 (0.18)	-0.14 (0.24)
Control variables	Demographics, phone display size & OS							
Constant	2.44 (4.42)	5.16*** (1.83)	2.70** (1.07)	1.94 (2.00)	-2.45 (1.62)	3.24** (1.38)	3.84*** (0.92)	2.12 (1.35)
Observations	153	151	304	593	594	565	581	573
R ²	0.21	0.05	0.06			0.05	0.03	0.03
Log Likelihood				-279.00	-381.70			

Note: *p<0.1; **p<0.05; ***p<0.01; coefficient estimates with robust standard errors in parentheses. For Trust and Ultimatum game (UG), dependent variable is amount sent/offered by first mover. DG = Dictator game, PD = Prisoner's Dilemma game, SH = Stag Hunt game.

Appendix

In Table A1, we present information about subject demographics, mobile devices used to complete the experiment and whether subjects were based in Wuhan during the lockdown in 2020. This information is provided both for the full sample and by experimental wave.

Table A1: Sample demographics and covariates (mean and standard deviation)

	Full sample	Baseline	Wave 1	Wave 2	Wave 3	Wave 4	Wave 5
Number of subjects	602	206	80	78	80	78	80
Age	20.41 [1.84]	20.18 [1.67]	20.11 [1.51]	20.83 [3.55]	20.70 [1.78]	21.56 [4.85]	20.23 [1.27]
Male	0.41 [0.49]	0.31 [0.46]	0.44 [0.50]	0.55 [0.50]	0.44 [0.50]	0.44 [0.50]	0.45 [0.50]
Monthly expenditure	2.58 [0.68]	2.57 [0.71]	2.54 [0.62]	2.51 [0.68]	2.63 [0.68]	2.59 [0.71]	2.65 [0.66]
Phone size (in)	5.89 [0.54]	5.74 [0.58]	6.04 [0.47]	5.93 [0.48]	5.93 [0.59]	5.99 [0.49]	5.93 [0.52]
iOS	0.21 [0.41]	0.25 [0.44]	0.19 [0.39]	0.13 [0.34]	0.25 [0.44]	0.1 [0.31]	0.26 [0.44]
Wuhan in 2020	0.10 [0.29]		0.11 [0.32]	0.10 [0.31]	0.13 [0.33]	0.06 [0.25]	0.08 [0.27]

Note:

Monthly expenditure: 1 = less than 800 RMB;
 2 = 800 ~ 1500 RMB; 3 = 1500 ~ 2500 RMB;
 4 = 2500 ~ 4000 RMB; 5 = greater than 4000 RMB.

In Table A2, we present the results of a regression analysis on second-mover behaviour in the Trust and Ultimatum game tasks. For the Trust game, we conduct an OLS estimation in which the dependent variable is the return rate (amount returned by player 2 as a proportion of the amount sent by player 1). As a consequence of this variable definition, any pair in which the first-mover sends zero is excluded from the regression. For the Ultimatum game, we conduct a Logistic regression in which the dependent variable is player 2's acceptance decision. Since the distribution of first-mover actions varies across waves, we interact the amount sent/offered with the wave dummies and with the dummy variable for being quarantined in Wuhan, to check for differential levels of reciprocity among these subjects. We control for subject age, gender, location, mobile phone display size and operating system. Robust standard errors are calculated.

As expected, there is a positive and significant correlation between amounts sent/offered and return rates/acceptances (both p -values < 0.01). A test of joint significance for the interactions between the wave dummies and amount sent/offered is not significant for the Trust game (p -value = 0.31, two-sided Wald test) but is significant for the Ultimatum game (p -value < 0.01 , two-sided Wald test). While there is no significant variation in trustworthiness across waves, acceptance rates conditional on offers in the Ultimatum game are significantly higher in Wave 1 (p -value < 0.01) and Wave 2 (p -value < 0.1) than in the pre-crisis baseline sample. Those subjects based in Wuhan during the lockdown are on average less likely to accept an offer in the Ultimatum game than those located in other areas of China (p -value < 0.01). They also display greater reciprocal considerations: for each additional unit received in the Trust and Ultimatum games, these subjects return comparatively more and display a comparatively larger propensity to accept an offer (both p -values < 0.01).

Table A2: Regression results for second mover in the Trust game and Ultimatum game

	Dependent variable:	
	Trust game return rate	Ultimatum game acceptance
	<i>OLS</i> (1)	<i>Logistic</i> (2)
First mover sent/offer	0.16*** (0.02)	2.14*** (0.50)
Wave 1 * First mover sent/offer	0.03 (0.05)	1.79*** (0.49)
Wave 2 * First mover sent/offer	-0.01 (0.03)	3.14* (1.82)
Wave 3 * First mover sent/offer	-0.03 (0.02)	-0.01 (0.43)
Wave 4 * First mover sent/offer	0.02 (0.03)	0.04 (0.37)
Wave 5 * First mover sent/offer	0.02 (0.03)	0.19 (0.53)
Wuhan in 2020	-0.40 (0.37)	-15.03*** (1.40)
Wuhan in 2020* First mover sent/offer	0.16*** (0.10)	7.82*** (0.83)
Control variables	Demographics, phone display size & OS	
Constant	-0.04 (0.70)	-8.49 (8.43)
Observations	127	151
R^2	0.44	
Log Likelihood		-27.40
Wald test for fixed coefficients p -value	0.31	< 0.01

Note: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$; coefficient estimates with robust standard errors in parentheses. In column (1), pairs in which the first mover sent zero are excluded, hence the smaller sample size.