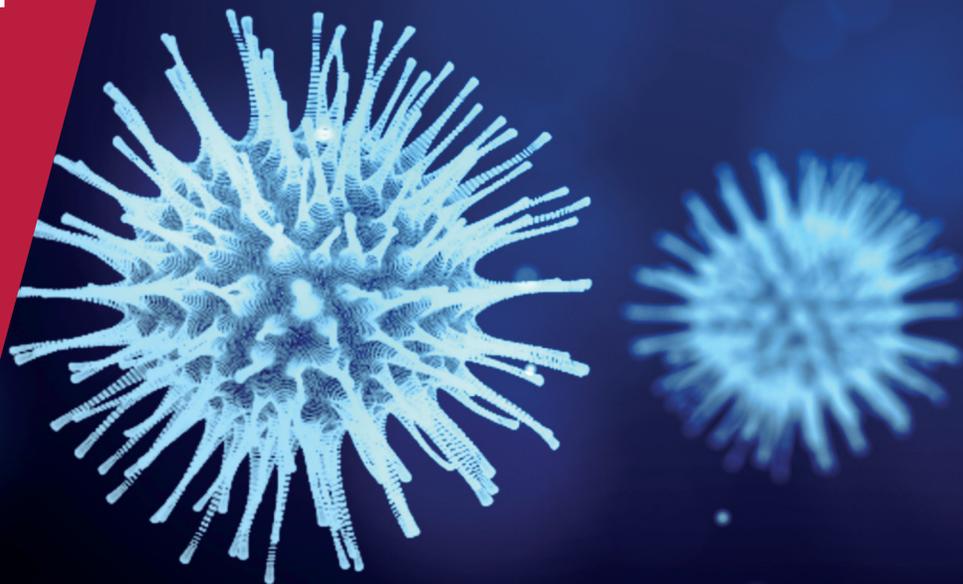


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COVID ECONOMICS
VETTED AND REAL-TIME PAPERS

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**SPENDING FROM
STIMULUS PAYMENTS**

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**THE RACE BETWEEN
VACCINATION AND INFECTION**

Claudius Gros and Daniel Gros

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Ethics

Covid Economics will feature high quality analyses of economic aspects of the health crisis. However, the pandemic also raises a number of complex ethical issues. Economists tend to think about trade-offs, in this case lives vs. costs, patient selection at a time of scarcity, and more. In the spirit of academic freedom, neither the Editors of *Covid Economics* nor CEPR take a stand on these issues and therefore do not bear any responsibility for views expressed in the articles.

Submission to professional journals

The following journals have indicated that they will accept submissions of papers featured in *Covid Economics* because they are working papers. Most expect revised versions. This list will be updated regularly.

<i>American Economic Journal, Applied Economics</i>	<i>Journal of Economic Theory</i>
<i>American Economic Journal, Economic Policy</i>	<i>Journal of the European Economic Association*</i>
<i>American Economic Journal, Macroeconomics</i>	<i>Journal of Finance</i>
<i>American Economic Journal, Microeconomics</i>	<i>Journal of Financial Economics</i>
<i>American Economic Review</i>	<i>Journal of Health Economics</i>
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<i>American Journal of Health Economics</i>	<i>Journal of Labor Economics*</i>
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<i>Journal of Economic Growth</i>	<i>Review of Economics and Statistics</i>
	<i>Review of Economic Studies*</i>
	<i>Review of Financial Studies</i>

(*) Must be a significantly revised and extended version of the paper featured in *Covid Economics*.

Covid Economics

Vetted and Real-Time Papers

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Who spent their COVID-19 stimulus payment? Evidence from personal finance software in Japan¹

Michiru Kaneda,² So Kubota³ and Satoshi Tanaka⁴

Date submitted: 30 March 2021; Date accepted: 31 March 2021

In response to the COVID-19 crisis, governments worldwide have been formulating and implementing different strategies to mitigate its social and economic impacts. We study the household consumption responses to Japan's COVID-19 unconditional cash transfer program. Owing to frequent delays in local governments' administrative procedures, the timing of the payment to households varied unexpectedly. Using this natural experiment, we analyze households' consumption responses to cash transfers using high-frequency data from personal finance management software that links detailed information on expenditure, income, and wealth. We construct three consumption measures: one captures the baseline marginal propensity to consume (MPC), and the other two are for the lower and the upper bound of MPC. Additionally, we explore heterogeneity in MPCs by household income, wealth, and population characteristics, as well as consumption categories. Our results show that households exhibit immediate and non-negligible positive responses in household expenditure. There is significant heterogeneity depending on various household characteristics, with liquidity constraint status being the most crucial factor, in line with the standard consumption theory. Additionally, this study provides policymakers with insights regarding targeted cash transfer programs, conditioning on labor income, and liquidity constraints.

1 All data has been anonymized prior to treatment and analyzed at Money Forward, Inc. before being shared externally. The views and opinions expressed in this paper are solely those of the authors and do not reflect those of Money Forward, Inc. We thank Masao Fukui, Toshio Taki, and Shoichi Uchinami for their helpful comments and advice.

2 Researcher, Money Forward Lab.

3 Associate Professor, Waseda University.

4 Associate Professor, University of Queensland.

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1 Introduction

In response to the Coronavirus disease 2019 (COVID-19) pandemic, many countries have conducted non-pharmaceutical interventions to restrict social and economic activities, such as enforcing social distancing, travel bans, school closures, patients' quarantine, and large-scale lockdowns. These interventions have affected workers' and families' income and spending patterns, making it difficult for some of them to pay for essential goods. and make some of them difficult to pay for essentials goods. Consequently, there has been a growing demand for household income support to compensate for these losses. In addition, since the COVID-19 shock has disproportionately affected vulnerable workers, such as service sector employees, females, low-income families, and working mothers (Kikuchi et al., 2021), the primary role of fiscal stimulus packages has become social protection. Many countries have expanded their unemployment benefits and started job retention programs. Furthermore, rapid changes in the economic environment have made people demand immediate support. To shorten the administrative procedures, some countries have provided simple cash transfers to most families without strict conditions on economic and social characteristics, such as income level and employment status.

The Japanese cash-transfer program, called the Special Cash Payment (SCP), is the simplest among COVID-19 fiscal stimulus programs over the world. The government paid 100,000 Japanese yen (approximately 950 US dollars) to every individual, from babies to the elderly, living in Japan, regardless of their social and economic status. In most cases, the total amount for each family was deposited into the household head's bank account. Owing to the historic magnitude of the economic downturn and the extraordinary budget size, an evaluation of this program is needed. Moreover, the policy design is ideal for obtaining economic evidence on households' reactions to fiscal stimuli. In particular, filling this knowledge gap is important for policymakers, given that the COVID-19 crisis is far from over, and many countries, including Japan, might have to implement similar measures again in the near future. What is the overall effect on consumption? What kind of goods are purchased? Do they help vulnerable families purchase necessities, or do the rich buy luxury goods?

We study households' responses to the SCP program using high-frequency transaction data from the Money Forward ME, a personal finance management service that allows users to keep track of banking accounts, asset holdings, credit card spending, cash payments, and digital point services. The dataset includes de-identified information about inflows and outflows from various financial accounts, detailed purchases by item, and individual heterogeneity in levels of income, assets, and population characteristics. We obtain the exact date of the SCP deposit and the subsequent household financial transactions and

consumption patterns.

The crucial factor in estimating the pure consequence of the cash-transfer program is tackling it as a “natural experiment.” In Japan, bank account information is not connected to population records, such as individual identification numbers. To deposit the SCP, each local office needs to manually collect bank account numbers. This huge paperwork burden significantly delays the cash distribution process in some local offices. From the viewpoint of households, this lag leads to a nearly random timing of payment in the short term. We observe considerable heterogeneity in payment timings, ranging from May to August. This feature guarantees random assignment and removes possible statistical bias caused by macro-level consumption swings in response to COVID-19 infections.

To estimate the marginal propensity to consume (MPC) for SCP payments, we define the baseline measure of total consumption as well as its lower and upper bounds. We first define the lower bound of consumption as the sum of expenditures on food and necessities, services, non-durable and durable goods, payments, and other uncategorized spending explicitly recorded in Money Forward ME. Next, we construct the baseline measure of consumption as the lower bound plus the cash withdrawal net of the recorded cash payment. In 2019, according to the Ministry of Internal Affairs and Communications, 73.2% of consumer purchases were paid in cash. Although they were not recorded on the Money Forward ME system, some of them were manually input into the software by the users. Our baseline measure captures these purchases under the assumption that most of the new cash withdrawals responding to the SCP payment were used for consumption. Finally, we make the upper bound by summing up the baseline measure and other unclear transactions, possibly including both consumption and financial transfers.

Our results show an immediate increase in household consumption right after the SCP payment for all the baseline and upper/lower-bound cases. These consumption measures gradually declined after the initial spike. The implied MPCs are 0.16 for the baseline case, 0.06 for the lower bound, and 0.27 for the upper bound within six weeks of receipt. These numbers are lower than Baker et al. (2020), who study similar households’ transaction data to evaluate the U.S. COVID-19 cash transfer program, but higher than Japanese MPCs estimated from the past transfer programs (Shimizutani, 2006; Hsieh et al., 2010). Moreover, we explore how household MPCs vary across categories of consumption. Most categories show significant increases in spending but these magnitudes are different.

We also examine MPC heterogeneity by income, asset holdings, and demographic characteristics. As the standard theory of intertemporal optimization of consumption indicates, liquidity constrained households significantly respond to the stimulus payment more. Since our dataset includes a rich set of both income and wealth information, it allows us to define

liquidity-constrained households as those with less net liquid assets than their monthly labor income. The liquidity-constrained households clearly show a higher consumption response than the non-liquidity-constrained households in our data. The result is consistent with the recent literature on wealthy hand-to-mouth households [Kaplan et al. \(2014\)](#).

A more practical policy-relevant result is about the heterogeneity of labor income. The actual 2020 SCP payment was uniform, but the government originally planned a targeting transfer to families whose income in 2020 was limited and had declined from 2019. We first examine the MPCs of the subsamples defined by the 2020 labor income quartile. We find a non-negligibly larger MPC of the lowest income groups than the others, which may justify the conditional cash transfer to economically disadvantaged families. Next, we conduct a counterfactual analysis of the original targeting plan. We identify needy households that would have received the targeting transfers under the income restrictions of the original policy. Contrary to looking at only 2020 labor income, the targeting policy does not find clear results of vulnerable families' higher MPC. Since the original plan required each recipient's labor income in 2020 to be below that in 2019, the target group would have eliminated people who would have had no labor incomes in both 2019 and 2020. This group would have had the largest MPC, while they would have been included in the non-targeted group.

There is a growing body of literature exploring the consumption responses to cash transfers under the COVID-19 crisis. For example, [Baker et al. \(2020\)](#) investigated consumption responses to the Coronavirus Aid, Relief, and Economic Security (CARES) Act cash transfer in the U.S. using personal finance management software data similar to ours. The CARES Act was also examined by [Coibion et al. \(2020\)](#) using a large-scale survey, and [Misra et al. \(2021\)](#) and [Karger and Rajan \(2020\)](#) using transaction data of debit cards. Outside of the U.S., [Feldman and Heffetz \(2021\)](#) investigated one-time and universal cash-transfers in Israel. [Bounie et al. \(2020\)](#) also measured the MPCs in the COVID-19 crisis using French transaction data, although it was about a back-to-school allowance for parents. The paper closest to ours is [Kubota et al. \(2020\)](#), which examined Japan's SCP payment policy using a bank account data. To provide policy implications immediately, [Kubota et al. \(2020\)](#) considered only gross financial outflows from bank account as an upper bound of consumption. Our study advances their result by looking at direct records of expenditure by category, as well as detailed asset and income information over various financial accounts.

2 Institutional background and model specification

2.1 Japan's special cash payment program

Japan's first COVID-19 case was confirmed on January 16, 2020, and the infected person had returned from Wuhan, China. The number of COVID-19 cases grew slowly in Japan until the second half of February, after which it accelerated exponentially. The public worried that the pandemic was more severe than the observed data, given Japan's weak surveillance and limited capacity for Polymerase chain reaction (PCR) testing. As in many other countries, the Japanese government has implemented various measures to prevent the outbreak of COVID-19, including requesting nationwide school closure on February 27, and Japan's first declaration of the state of emergency on April 7 for seven prefectures, including Tokyo.^[1] On April 16, the declaration was extended to the rest of the country for an indefinite period. It was a request-based lockdown with no penalties for social activities; however, this announcement effectively reduced the infection. The Japanese government eventually lifted the state of emergency for the whole country by May 25.

Although the COVID-19 cases were on average milder than in most other countries, Japan experienced a severe recession. The real gross domestic product (GDP) dropped by 10.3% in the second quarter of 2020, which was mainly driven by a large decline in household consumption. The average hours of work fell by 3.9% and 9.3% in April and May, respectively. The economic crisis was exacerbated by the declaration of the state of emergency, which reduced people's mobility by 20%, as evaluated by cell phone Global Positioning System (GPS) data (Watanabe and Yabu, 2020, 2021)^[2]. In particular, the public raised concerns about vulnerable workers in the face-to-face service sector (Kikuchi et al., 2021).

To mitigate the negative economic impact of COVID-19, Prime Minister Shinzo Abe approved a conditional cash transfer program on April 3, 2020, which eligibility condition was determined by labor income in 2019 and 2020. However, on April 16, this plan was replaced by an unconditional transfer scheme due to a more practical suggestion by the coalition partner, Komeito. This new unconditional transfer was the SCP program, which provided 100,000 Japanese yen (approximately 950 US dollars) to all residents in Japan without any condition on age, income, family size, or nationality. This amount is approximately 42% of the median monthly earned income of the Japanese full-time workers. Each municipality

¹The other prefectures for which the Japanese government declared the state of emergency are Kanagawa, Saitama, Chiba, Osaka, Hyogo, and Fukuoka.

²These studies found the information effect to have the largest impact on the public, as the state of emergency revealed the severity of the pandemic.

in Japan was responsible for distributing SCP payments. They determine the start date of application depending on their administrative capacity, by notifying all the households residing in the municipalities to apply for the SCP online or by mail. In the application, each household head was asked to provide a bank account number to receive the total payments for all the household members at once. After the evaluation, the total amount for all family members was deposited into the household head's bank account.

The payment dates of the SCP varied across households due to the administrative capacity of local governments and the experience of office staff. Although the transfer started in the first week of May in some regions and most municipalities had distributed the application forms by the end of May, there were significant differences in the timing of payment across municipalities. According to a survey of 43 large municipalities³, as of the third week of June, three cities had completed distribution to less than 10% of the residents, and eight had finished less than 20%. They cited the significant amount of time needed to reply to the numerous inquiries and to check mailed envelopes as reasons for the delay. However, six municipalities finished cash transfers to more than 80% of the residents in the same week. In addition, there was a significant difference with respect to the payment day, even if households submitted applications on the same day to the same local office. Since many households applied soon after the arrival of the submission form, a few hours difference in submission resulted in a lag of several days in payment. Furthermore, the submission methods caused variation in the timing of payments; for example, postal applications were significantly faster than online applications due to insufficient preparation.

Figure 1 shows the histogram of the number of SCP deposits to households in our dataset from May 4 and August 30. While the majority of the deposits occurred between late June and early July, the earliest payment started in May and the last payment in our sample was in the final week of August. As we discussed earlier, these variations in the timing of payments were largely driven by administrative delays, and can thus be regarded as unpredictable from the household's perspective.

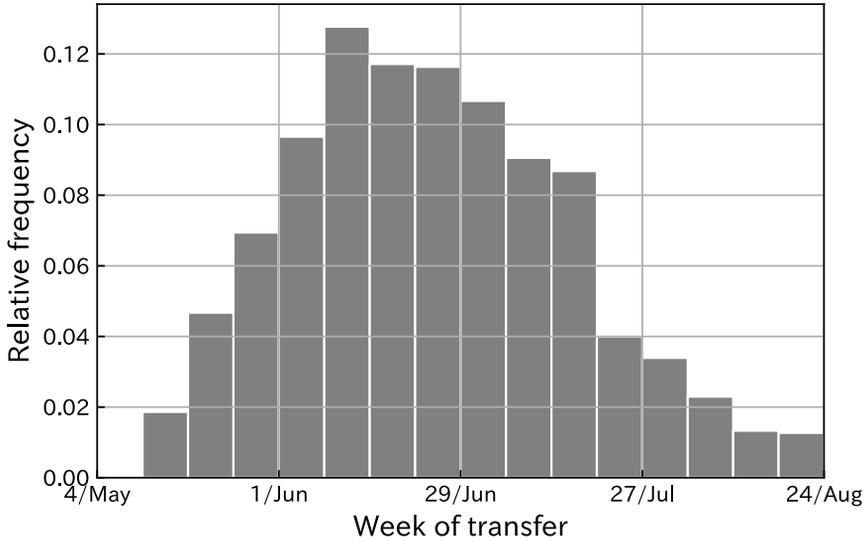
2.2 Regression model specification

We exploit the variations in the timing of payments across households to estimate the effects of the SCP payments on their spending responses. Our regression has the following specifications:

$$y_{it} = \alpha_i + \alpha_t + \sum_{k=t}^{\bar{t}} \gamma^k P_i D_{it}^k + u_{it}, \quad (1)$$

³Asahi Shinbun, morning edition, June 28.

Figure 1: The distribution of the SCP payment week



where the dependent variable y_{it} is the spending by individual i in week t . Later, we introduce three measures of consumer spending to estimate the baseline and lower/upper MPCs. α_i represents individual fixed effects and control for time-invariant individual-specific factors. α_t are week fixed effects that control seasonally specific fluctuation of consumption, such as Christmas sales. u_{it} is the idiosyncratic error term.

D_{it}^k are indicators that take a value of one if the current week t is k -weeks after the week of the SCP transfer. P_i is the amount of the SCP payment, which is a multiple of JPY 100,000 by the number of people in the household. We let $k \in [\underline{t}, \bar{t}]$ be the event time relative to the week of households' SCP receipt. The previous week of the deposit corresponds to $k = -1$, and the week of payment is $k = 0$. We set $\underline{t} = -5$ and $\bar{t} = 10$ in our empirical analysis. The coefficient γ^k (for $k \geq 0$) captures the household's dynamic spending responses to the fiscal payment at k -weeks after the deposit. We also examine the lead terms (for $k < 0$) to test for the presence of the pre-trend in the k weeks preceding the payment. We normalize the coefficient γ^{-1} to 0 in our analysis.

3 Data

We describe the data for the estimation in this section.

3.1 Money Forward ME

We use de-identified transaction-level data from Money Forward ME, an online service, and a smartphone app for personal finance management. This service reports real-time transactions and visually represents monthly summaries of bank accounts, credit cards, securities, pensions, e-money, and retail shop points. Users can add up to ten financial accounts for free, or add unlimited accounts by paying JPY 500 (approximately USD 5) per month. All users can keep track of automatically recorded expenditures or manually input cash payments by consumption category.

We first select users whose accounts recorded the SCP deposits. These accounts show income with the content name “special (TOKUBETU)” or “payment (KYUFU),” and the number multiples of JPY 100,000 between May 4 and August 30, 2020. Moreover, we choose only active users who have at least one transaction record every week between March 30 and November 8, 2020. We omit the top 1% income users and top 1% users of the maximum weekly payment. Finally, we get 232,589 users.

We convert the raw daily transaction data to account-level panel data of weekly balances and transactions. The dataset contains various asset holdings and account balances, such as demand-deposit accounts, saving accounts, mutual funds, bonds, including corporate, government bonds, and foreign, stocks, pensions, e-money, shop points, airline miles, forex, CFDs, cash, land, home, and precious metals. Money Forward ME also holds a rich dataset of debt information, including loans, such as car, mortgage, personal, and student, as well as credit card balances. In addition, we observe income information, such as labor income, business income, pension, stock dividends, and real-estate income. Finally, our dataset also contains some population characteristics, including sex, age, family structure, occupation, own/rent housing status, and residential prefecture.

3.2 Asset, income, and population characteristics

Following the recent literature on household consumption, We construct gross/net and liquid/illiquid asset holdings [Kaplan et al. \(2014\)](#). We first define gross liquid assets as cash, e-money, checking accounts, saving accounts, and securities. Net liquid assets are liquid assets minus credit card debt. We also define gross illiquid assets as the sum of real estate,

cash value of life insurance, pension, and other uncategorized assets. Then, we calculate net illiquid assets as gross illiquid assets minus mortgage, student, and other loans. Finally, we define gross total assets as the sum of gross liquid and gross illiquid assets, and net total assets as the sum of net liquid and net illiquid assets.

We construct two measures to define household income. The first is wage and salary income, which are payments from employers explicitly recorded on the system or manually defined by users. This definition excludes the business income of the self-employed. The second is the total income, including financial and business income. We use the first measure as our benchmark in the main text and report the regression results with the second in the Appendix. We estimate each user's yearly income by doubling the sum of all incomes between April and September 2020.

In Table [1](#), we report the summary statistics of account holders' assets, income, and population characteristics. First, the users are relatively young⁴. Second, the share of female users is small, possibly because the SCP is paid to the household heads. Third, regarding location, many users live in Tokyo, as shown in Figure [A.2](#) in the Appendix. The income data are close to a public survey, the Basic Survey on Wage Structure. This survey reports that the 25%, 50%, and 75% quartiles of annual wage and salary incomes were 2.31, 2.97, and 3.99 million Japanese yen in 2019, which is consistent with our data that records after-tax income deducting about 20% for tax and social insurance fees⁵. However, our record of the wealth is smaller than that of the Family Income and Expenditure survey. This survey shows that the 20%, 40%, 60%, and 80% quintiles of gross total assets were 2.49, 6.78, 13.48, and 27.02 million Japanese yen, respectively, and that of net total assets were -2.41, 3.36, 10.77, and 25.63 million Japanese yen, respectively, in 2019. Our data show smaller measures mainly because only about half of users input the cash value of the house in Money Forward ME. The bottom column of Table [1](#) shows that approximately 40% of users answered "living in their own houses." This number is comparable to the 61% measured in the Housing and Land Survey of Japan given that Money Forward ME users are biased to young.

3.3 Expenditure

We classify household expenditures into six categories:

1. Food and necessities: Includes food made at home, daily necessities, and utilities.

⁴Figure [A.1](#) shows a comparison between the age distribution in our sample and that in census data in .

⁵Moreover, our total income data are consistent with the Family Income and Expenditure survey. It shows that 20%, 40%, 60%, and 80% quintiles of total incomes were 2.36, 3.51, 5.00, 7.46 million Japanese yen, respectively, in 2020.

Table 1: Summary statistics (account level)

	N	Mean	St. Dev.	25%	Median	75%
SCP Payment (JPY)	232,589	225,294	131,464	100,000	200,000	300,000
Week of Deposit	232,589	25.928	3.097	24	26	28
Age	228,644	42.967	91.813	31	37	45
Female dummy	229,810	0.282	0.450	0	0	1
Yearly labor income (JPY)	232,589	4,040,333	3,019,680	2,359,586	3,605,994	5,237,372
Yearly total income (JPY)	232,589	5,956,317	4,460,009	3,334,804	5,029,328	7,514,006
Gross liquid assets (JPY)	232,589	9,037,081	67,006,965	788,135	2,863,172	8,788,839
Net liquid assets (JPY)	232,589	8,638,142	67,008,374	483,642	2,555,419	8,454,560
Gross illiquid assets (JPY)	232,589	2,294,896	12,768,976	0	0	0
Net illiquid assets (JPY)	232,589	-2,983,116	15,783,263	0	0	0
Gross total assets (JPY)	232,589	11,331,977	69,128,440	843,462	3,189,144	10,229,096
Net total assets (JPY)	232,589	5,655,027	69,310,247	11,355	1,631,627	7,457,214
Own house dummy	147,046	0.398	0.489	0	0	1

2. Services: Our definition is slightly narrower than usual because we select services associated with possible new coronavirus transmission. It includes dining outside the home, transportation and travel, education, entertainment, and health care services. Given this definition, this category excludes home entertainment.
3. Non-durables: Includes non-durable goods, such as clothes, medicines, and home entertainment, except food and necessities and services.
4. Durables: Includes furniture, electric appliances, and cars.
5. Payments: Sum of loan, mortgage, rent, and insurance payments.
6. Uncategorized expenditures: Items that are not categorized as one of the above; however, they are bought at stores or paid for by credit cards, electronic payments, or cash.

Furthermore, we add two payment categories.

- ATM: This is the net amount of cash withdrawal from bank accounts mainly through ATMs. In Japan, cash is the dominant payment method. According to the Ministry of Internal Affairs and Communications, the share of cash payments was 73.2% in 2019. Moreover, the Japan Bankers Association reports that 49.1% of the outflow from bank accounts is cash withdrawal. Our definition is a partial net cash withdrawal because we deduct the amount of purchases by cash manually recorded by users from total cash withdrawals from their bank accounts. In other words, this ATM category includes two possibilities: cash payments not manually recorded and the amount of money saved in users' wallets or strongboxes.

Table 2: Summary statistics (weekly transactions)

	N	Mean	St. Dev.	25%	Median	75%	Public
Food and necessities	7,442,848	21,056	59,941	6,380	14,375	26,798	24,651
Services	7,442,848	12,904	53,608	0	2,473	11,128	18,989
Non-durable	7,442,848	9,432	36,317	0	3,575	10,016	10,001
Durable	7,442,848	6,914	96,568	0	0	0	11,766
Payments	7,442,848	23,216	183,897	0	0	9,568	22,001
Uncategorized expenditures	7,442,848	17,942	130,544	0	1,100	10,000	-
ATM	7,442,848	14,459	84,340	0	0	0	(-4,479)
Other transactions	7,442,848	54,035	419,016	0	3,131	21,685	28,499
Total expenditures	7,442,848	91,463	268,104	23,753	49,441	104,121	87,408
Total expenditures and ATM	7,442,848	105,922	284,483	27,514	57,424	119,918	-
All transactions	7,442,848	159,957	525,575	35,903	76,299	158,018	115,907

Notes: The last column reports the mean values of the 2020 Family Income and Expenditure survey. The sample includes wage-earners. We rearrange the small categories into our definitions to be consistent as much as possible. The ATM is calculated from cash holdings at the end of the survey month compared to the last month. It is excluded from calculating total values.

- Other transactions: This category includes taxes, social security payments, allowance for family members, business payments, and donations. In addition, there are other outflows from bank accounts.⁶ These outflows potentially include savings or investments if the bank account or the investment account is not registered at Money Forward ME.

Based on the above classification, we define the baseline measure and the lower and upper bounds of total consumption. We consider the sum of the total expenditures and ATM as our benchmark expenditure measure. Given that Japan is a cash economy, it is likely that cash withdrawals will eventually be spent by the individual. Therefore, adding ATM to the reported consumption expenditures constructs a reliable consumption measure. Nevertheless, there are possibilities of underestimating true consumption expenditures under the baseline case, since some of those expenditures, such as bank transfers to stores, are potentially included in “other transactions.” Therefore, we construct the upper bound of consumption including both baseline and other transactions. Similarly, the benchmark may underestimate the true consumption, since some of the cash withdrawals might not be spent on consumption expenditures, but rather spent on transfers or investments. Therefore, we define the lower bound of consumption as the sum of all explicitly recorded expenditures.

Table 2 summarizes the weekly expenditure by consumption category. We also report the mean value calculated by the 2020 Family Income and Expenditure Survey, in the last

⁶We cancel out bank transfers from one’s own bank account to another owned bank account if the two accounts are registered at Money Forward ME.

column. Overall, the mean expenditures of Money Forward ME users are consistent with the result of the public survey. However, our values are somewhat higher, possibly because Money Forward ME has a relatively smaller number of old-age users who tend to consume less. Another potential reason is the response bias, since the Family Income and Expenditure Survey requires respondents to fill in all payments to the survey sheets by hand, which may cause respondents to record fewer amount of purchases, compared to Money Forward ME's automatic recording system. We record 91,463 Japanese yen on average as the amount of weekly consumption. After adding other transactions, the total weekly transaction is 159,957 Japanese yen. The purchase is not so frequent because the first quartile is zero, except for food and necessities. The frequencies of durable good purchases and cash withdrawals are once or less a month.

4 Results

In this section, we present the estimation results of regression (1).

4.1 Benchmark results

Figure 2 illustrates the estimates of γ_k for the three regressions with different dependent variables. In the figure, *Expenditures+ATM* draws our baseline consumption measure's response to the SCP receipts. Similarly, the responses of the lower and upper bounds of consumptions are represented by *Expenditures* and *All transactions*, respectively.

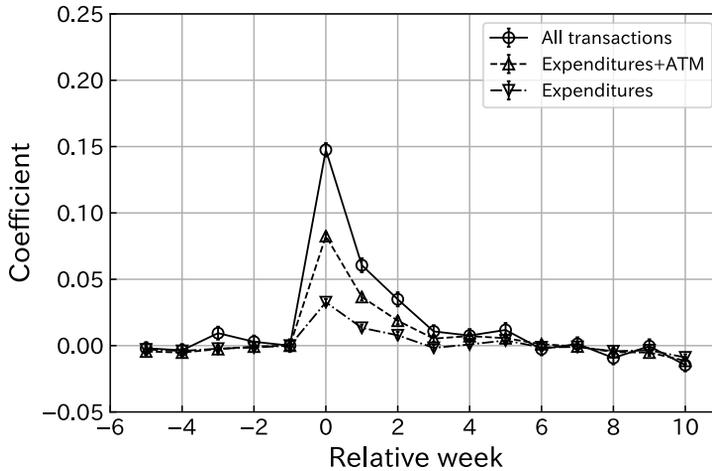
Figure 2 shows a clear spike in consumption response right after the receipt of the payment, evaluated by all three measures.⁷ The positive effect gradually declines and persists for roughly six weeks. These weekly estimates for the coefficients are shown in Table 3. The estimated cumulative MPCs for six weeks are 0.06, 0.16, and 0.27 for the lower measure, the benchmark, and the upper measure, respectively.

4.2 Heterogeneous response by individual characteristics

Next, we turn to heterogeneity in the consumption responses among individuals based on their observable characteristics. The literature on MPC documents significant heterogeneity

⁷Note that this consumption hike in the week of SCP payment for Money Forward ME users may be sharper than for other households. Right after the SCP deposit, the system automatically sent notifications on the users' smartphones. They were sent as general notifications about a large transaction. From July 15, Money Forward ME started to show special notifications. Municipalities also sent notifications mainly by mail, but the timing was not uniform across local offices.

Figure 2: Consumption responses of all users



among households in their consumption response to transitory income shocks (Misra and Surico, 2014; Alan et al., 2018; Parker, 2017; Aguiar et al., 2020; Gelman, 2020). Studies have reported heterogeneous consumption responses across recipients in the context of stimulus packages for COVID-19 (Baker et al., 2020; Coibion et al., 2020; Karger and Rajan, 2020; Misra et al., 2021; Chetty et al., 2020). Therefore, we explore the heterogeneity in consumption response with respect to households' labor income, financial constraints, and other observable characteristics.

Figure 3 shows the consumption response for each quartile group by labor income. The bottom quartile group shows the strongest consumption response, whereas the other three quartile groups show similar responses, implying that heterogeneity is more relevant for those in the low-income group rather than in the middle or high ones.

We consider the liquidity constraint in Figure 4. This is a crucial factor in determining MPC. If a household has insufficient assets and difficulty borrowing money, it may use a large portion of cash transfers to smooth intertemporal consumption allocation. We classify a user to be liquidity-constrained if his/her net liquid asset holding is less than his/her monthly labor income at the end of the month before the SCP receipt⁸. In our dataset, 19% of users

⁸In Broda and Parker (2014)'s household survey, the authors determine the liquidity constraint status by asking "In case of an unexpected decline in income or increase in expenses, do you have at least two months of income available in cash, bank accounts, or easily accessible funds?" In a similar survey by Coibion et al. (2020), the question is "Suppose that you had to make an unexpected payment equal to one month of your after-tax income, would you have sufficient financial resources (access to credit, savings, loans from relatives

Table 3: Regression results of all users

Relative week	All transactions	Expenditures+ATM	Expenditures
-5	-0.0020 (0.0047)	-0.0044 (0.0027)	-0.0029 (0.0026)
-4	-0.0035 (0.0047)	-0.0052 (0.0024)	-0.0040 (0.0023)
-3	0.0094 (0.0049)	-0.0026 (0.0025)	-0.0023 (0.0024)
-2	0.0029 (0.0047)	-0.0007 (0.0026)	-0.0014 (0.0024)
-1	0.0000 (0.0048)	0.0000 (0.0028)	0.0000 (0.0027)
0	0.1475 (0.0051)	0.0826 (0.0026)	0.0327 (0.0024)
1	0.0606 (0.0053)	0.0367 (0.0027)	0.0134 (0.0025)
2	0.0349 (0.0053)	0.0188 (0.0028)	0.0078 (0.0026)
3	0.0107 (0.0047)	0.0053 (0.0023)	-0.0017 (0.0022)
4	0.0076 (0.0049)	0.0072 (0.0025)	0.0009 (0.0023)
5	0.0118 (0.0053)	0.0056 (0.0027)	0.0039 (0.0026)
6	-0.0026 (0.0047)	0.0011 (0.0028)	-0.0013 (0.0026)
7	0.0013 (0.0050)	-0.0006 (0.0026)	-0.0010 (0.0025)
8	-0.0093 (0.0048)	-0.0049 (0.0026)	-0.0042 (0.0025)
9	-0.0004 (0.0052)	-0.0052 (0.0026)	-0.0035 (0.0024)
10	-0.0147 (0.0047)	-0.0114 (0.0025)	-0.0089 (0.0024)
Observations	7442848	7442848	7442848
R^2	0.0002	0.0003	0.00005

Notes: This table reports coefficients from Equation (1). Standard errors are reported in parentheses and clustered at the user level.

were liquidity constrained under this definition. Figure 4 shows consumption responses with respect to the individual liquidity constraint status. By comparing the left and right panels of the figure, it is clear that liquidity-constrained households respond more sharply to SCP (or friends, etc.) to pay for the entire amount?"

Figure 3: Consumption responses grouped by labor income

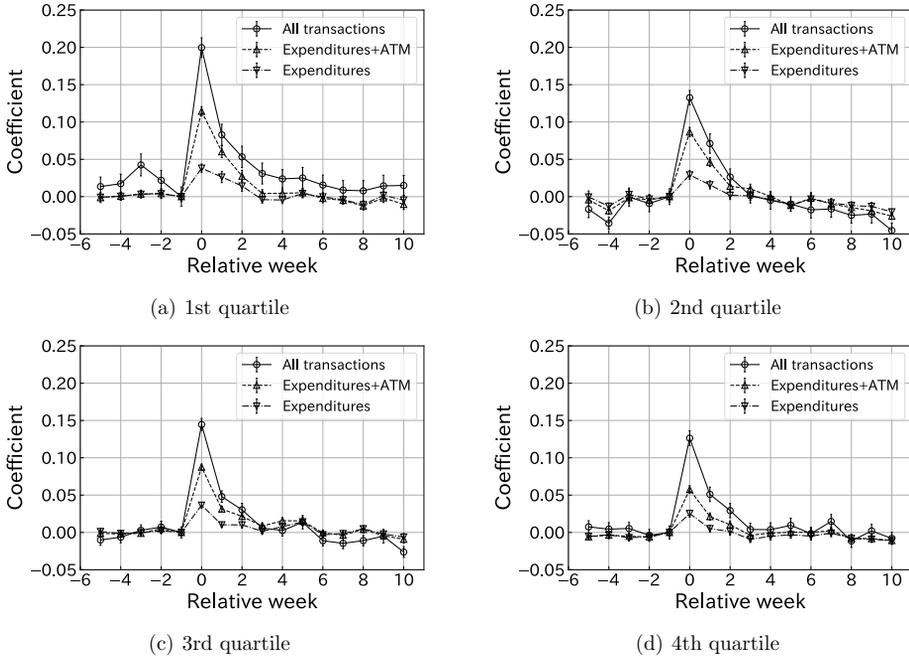
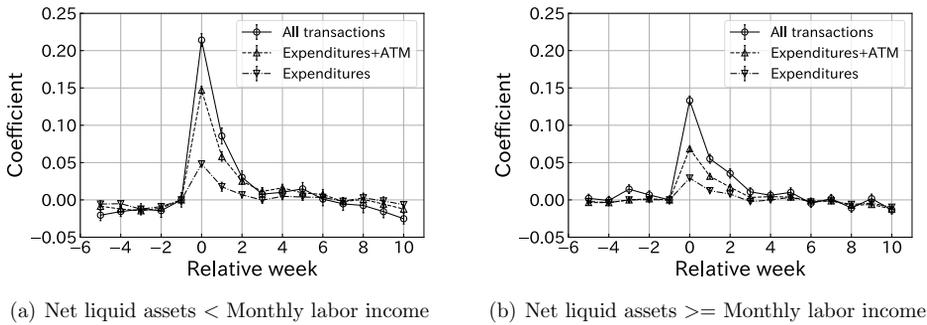


Figure 4: Consumption responses grouped by liquidity constraints using labor income



payments, especially in the transfer week. The results confirm the important role of liquidity constraints in illustrating heterogeneity in consumption responses, as documented in the literature⁹. For example, our result is consistent with [Kubota et al. \(2020\)](#), who study the

⁹This result is possibly due to the strong cash demand of liquidity-constrained households for daily goods. We look at the difference in food and necessities consumption depending on liquidity constraints. However,

same SCP program with different definitions of consumption and dataset. Supplementary Figure A.3 in the Appendix plots the consumption response by liquidity constraint status and housing status (owning or renting). It shows that households with a liquidity constraint respond more than households without a constraint, even when they own a house. This result confirms the existence of wealthy hand-to-mouth households documented in the literature (Kaplan et al. (2014)).

In addition, we explore heterogeneity by households' other observable characteristics. The results are reported in the Appendix. Figure A.4, A.5, and A.6 show the consumption responses by age, family size, and family type, respectively. We find that the consumption response is larger if the household head is older and that one-person households' responses are weaker than those of other households. We also find that married households respond more than single households, while having a child in a household does not seem to affect the consumption response.

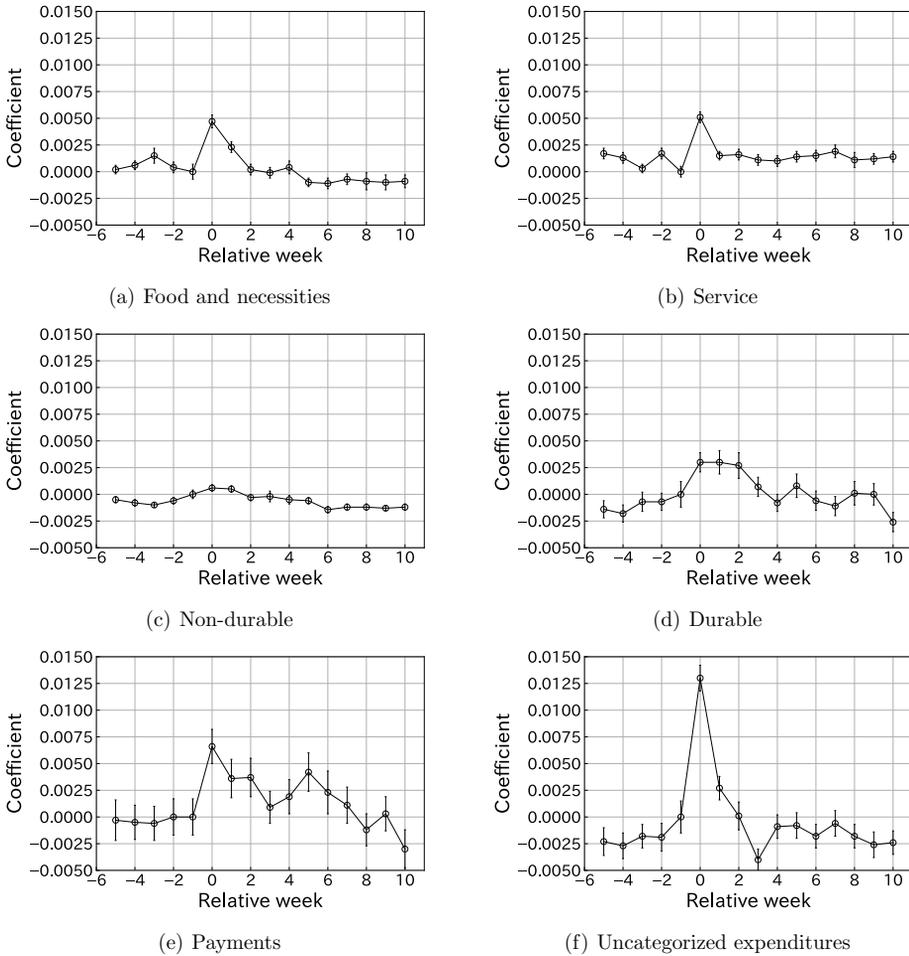
4.3 Heterogeneous responses across consumption categories

Next, we examine the responses by consumption categories. Figure 5 shows that payments and uncategorized expenditures exhibit large responses. These consumptions are volatile, as suggested by the large standard deviations in Table 2. The SCP may stimulate households to purchase special, occasional, and expensive items. The response of durable goods looks moderate but is actually large, given that its average monthly spending is low (6,914 Japanese yen). Our results indicate an approximately 15% increase in monthly durable good spending¹⁰ which is lower but comparable to the 27.4% and 16.6% increase in the Family Income and Expenditure Survey in June and July 2020, respectively. We also find a statistically significant rise in the consumption of food and necessities, and services. Contrary to durable goods, the fluctuations of these items are unclear in the Family Income and Expenditure Survey. This is an advantage of analysis with a valid identification strategy using natural experiments and detailed microdata. The increase in spending on service is also notable under suppressed service demand due to the COVID-19 pandemic. Finally, we do not find an increase in the consumption of non-durable goods.

the statistical results are unclear. This may be because those daily goods tend to be purchased by cash, which is not explicitly observed in the data.

¹⁰The sum of the coefficients of durable goods is about 0.01 with four weeks after the SCP payment in Figure 5(d). Given that the average SCP payment is 232,589 Japanese yen, durable good expenditure increased by 2,300 yen. Since the SCP payment was concentrated in June and July, we expect that about 1,000 yen was spent in each month, and given the average monthly durable good consumption, 6,914 yen, we estimate the increase in durable goods as about 15%.

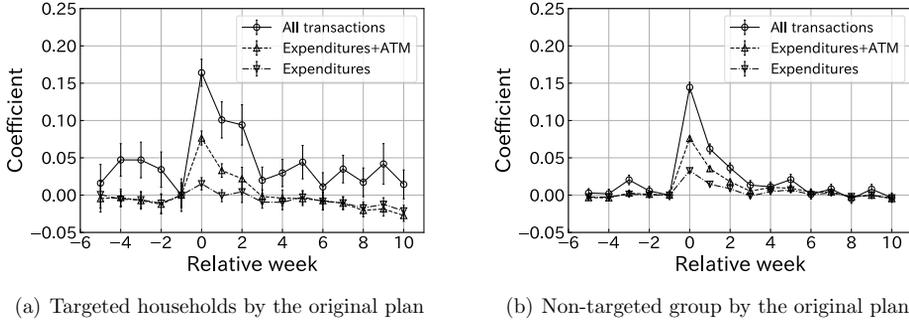
Figure 5: Consumption responses for each expenditure category



4.4 Counterfactual policy analysis

In response to the COVID-19 crisis, the Japanese government initially planned a *targeted* cash transfer program. On April 3, 2020, Prime Minister Shinzo Abe announced an emergency economic stimulus package of 300,000 Japanese yen for every household whose income had declined significantly due to the COVID-19 crisis. Specifically, Mr. Abe planned to target households i) whose income from February through June 2020 had decreased compared to the same periods in 2019, *and* whose monthly income is equal to or less than the residential tax exemption cutoff, or ii) whose income from February through June 2020 had dropped to

Figure 6: Counterfactual policy analysis: Comparing consumption responses for targeted and non-targeted households according to the initial plan using labor income



lower than half of their 2019 income, *and* whose monthly income is equal to or less than the double of the residential tax exemption cutoff¹¹. We conduct our counterfactual analysis by estimating the MPC for the households targeted by the initial plan. Although Mr. Abe’s plan was replaced by the universal cash transfer program with a lower payment amount, it is important for policymakers and researchers to explore a counterfactual scenario with the original, targeted transfer program. This exercise also has implications for the ongoing debate regarding the second-round stimulus payment program. As of March 2021, as we are writing this paper, the next cash transfer program is still one of the most debated policy issues. On February 9, 2021, 79 Diet members of the Liberal Democratic Party requested *conditional* cash transfers for economically distressed families. Our counterfactual exercise can provide policymakers with insights regarding this issue.

Figure 6 plots the results of the estimations. In terms of All transactions, the consumption response by the targeted group shows a higher spike compared to that of the non-targeted group, especially one or two weeks after the SCP receipt. However, it is unclear because All transactions of the targeted group show significantly positive coefficients before the SCP deposit and the large standard errors. This result may be caused by a sample selection problem that the targeted group also includes high income households whose salaries and financial accounts are not correctly recorded in our database. In terms of Expenditure and Expenditure+ATM, we do not see a clear difference between the two estimates. Figure 6 looks inconsistent with the previous result of heterogeneity based on labor income level in Figure 3. The reason for the difference is that, under Mr. Abe’s initial plan, there is a restriction that 2020 household labor income must be below that in 2019. This restriction

¹¹For a single-person household, the cutoff of monthly income for residential tax exemption was 100,000 Japanese yen. This cutoff increased by 50,000 Japanese yen with each additional household member.

eliminates people who have no labor incomes both in 2019 and 2020. This group has the largest MPC, while they are included in the non-targeted group. Therefore, even if a policy targets households who were supposed to be covered by the initial plan, the average consumption response per recipient would not be higher than that of the universal program implemented by the Japanese government. To summarize, the policy consequences may be very sensitive to any small change in details. A simpler policy, such as the contingent on only the current labor income, may be more predictable and intuitive, as shown in Figure 3.

5 Conclusion

This study examines the effects of the Japanese unconditional cash transfer program on consumption using high-frequency information on assets, income, and expenditure obtained from personal financial management software data, provided by Money Forward ME. Owing to the significant delay in local governments' administrative procedures, there has been a significant and unexpected variation in the timing of payment. Using this natural experiment, we estimate the pure effects of the stimulus payment package on household consumption.

Our results demonstrate significant heterogeneity depending on various household characteristics, and highlight liquidity constraints as the most crucial factor, which is consistent with the standard consumption theory. These findings indicate the potential effectiveness of targeting policies depending on liquidity constraints; however, it might be unrealistic for the Japanese government to identify household wealth information. Moreover, we find that labor income inequality has a large impact on households' consumption responses. In addition, we examine household responses across consumption categories. Most categories show significant increases in spending but these magnitudes are different. Finally, we analyze the Japanese government's original targeting policy contingent on labor income as a counterfactual exercise, and find that the policy effects exhibit high sensitivity to policy details. Our results would be useful in future policy discussions.

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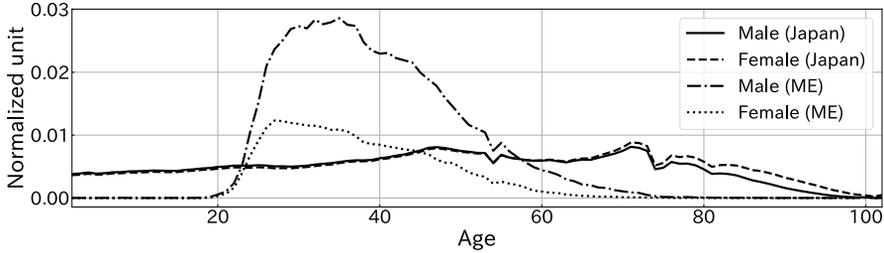
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A Appendix

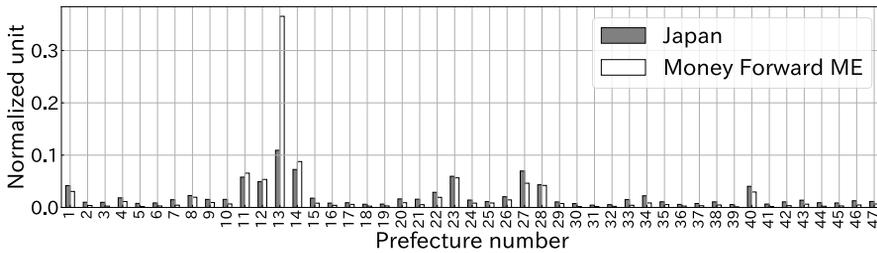
A.1 Population distribution

Figure A.1: Age composition of population



Notes: The solid and dashed lines show the male and female populations in Japan, respectively, taken from the census data. The dot-dashed and dotted lines show the male and female population of the Money Forward ME users, respectively, used in this analysis. Both Japanese and Money Forward ME user data were normalized so that the total number of males and females is 1.

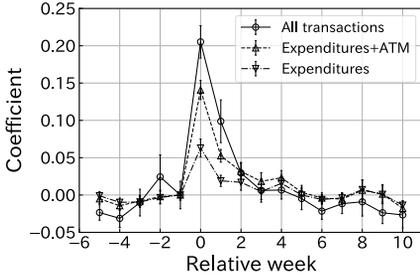
Figure A.2: Normalized population by prefecture



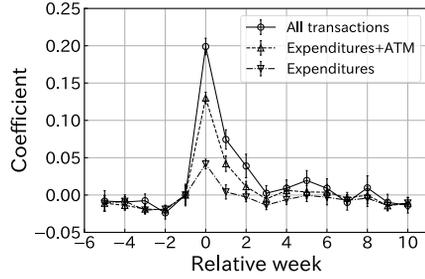
Notes: The filled and unfilled bars represent the population of each prefecture in Japan taken from the census data and the Money Forward ME users used in this analysis. Both data were normalized so that the total number is 1.

A.2 Additional figures and tables

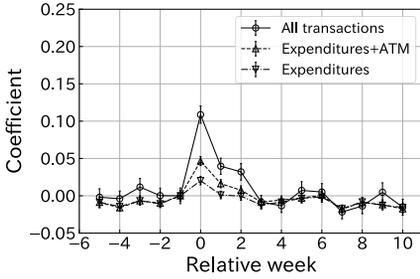
Figure A.3: Consumption responses grouped by liquidity constraints using labor income and house status



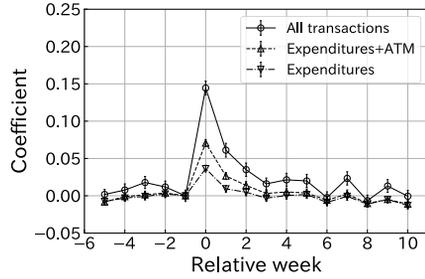
(a) Net liquid assets < Monthly labor income and rental house



(b) Net liquid assets < Monthly labor income and own house

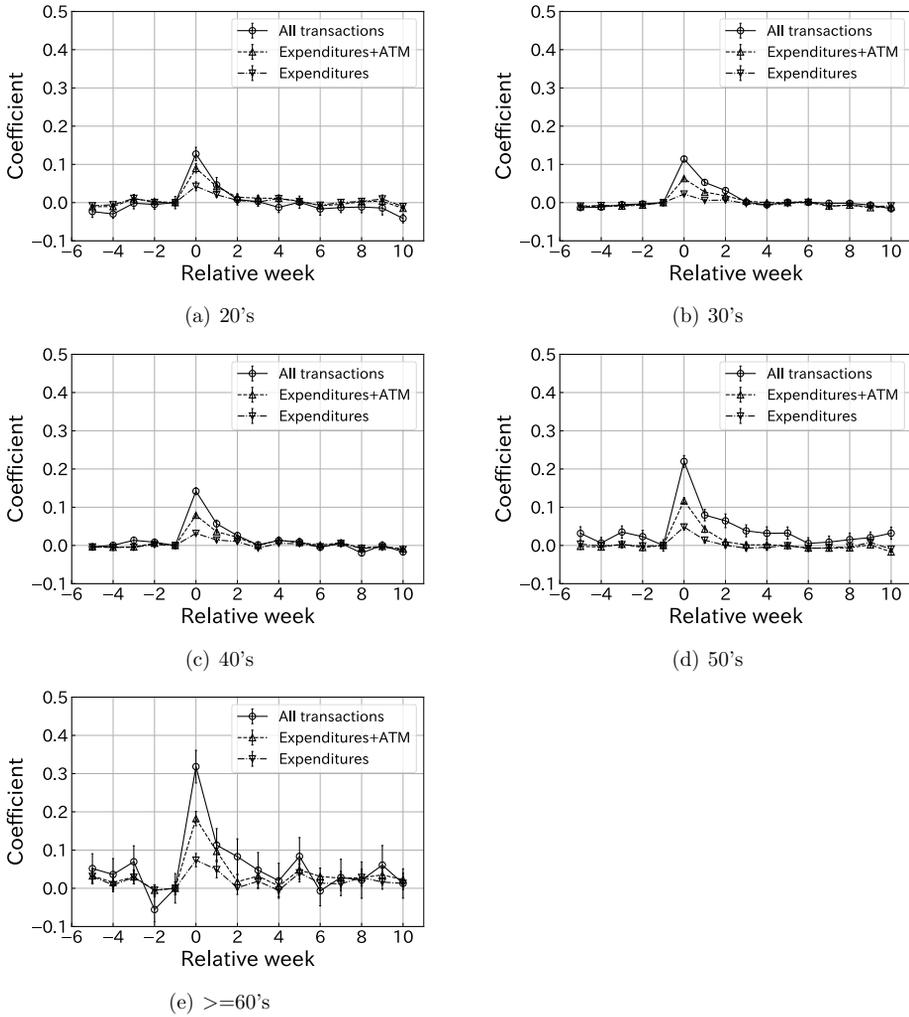


(c) Net liquid assets >= Monthly labor income and rental house



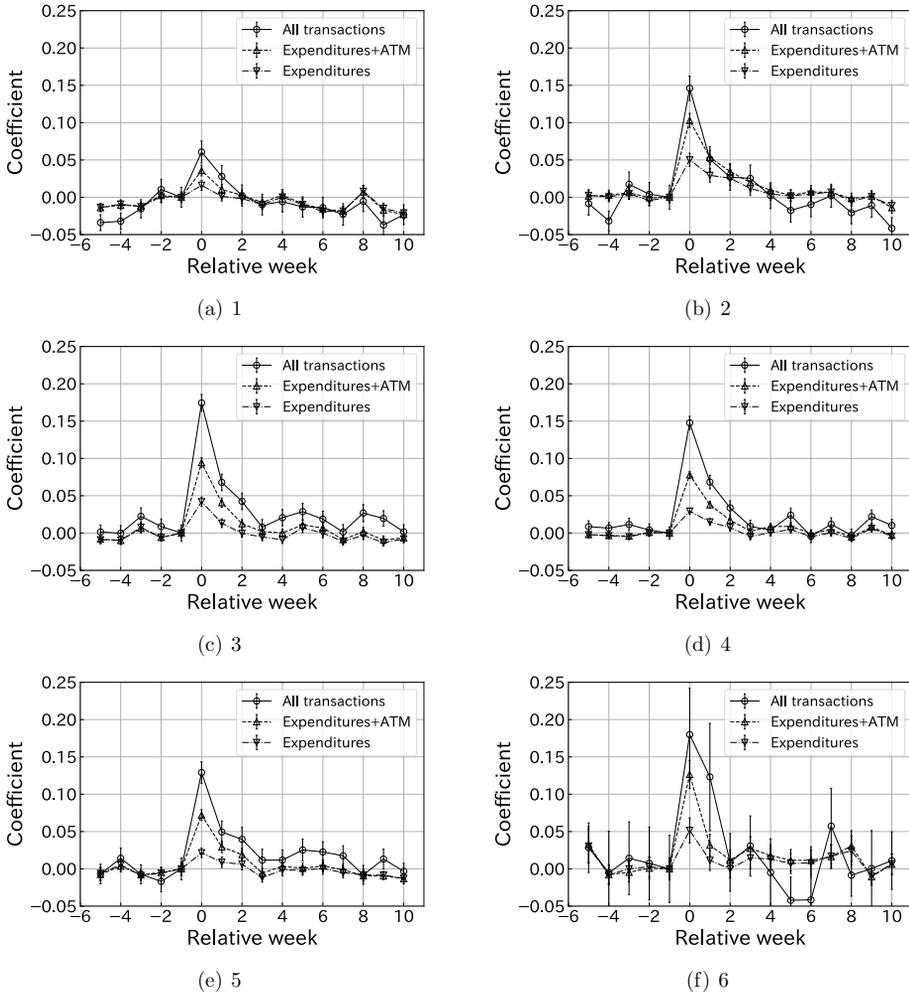
(d) Net liquid assets >= Monthly labor income and own house

Figure A.4: Consumption responses grouped by age



Covid Economics 75, 7 April 2021: 1-29

Figure A.5: Consumption responses grouped by family size



Covid Economics 75, 7 April 2021: 1-29

Figure A.6: Consumption responses grouped by family type

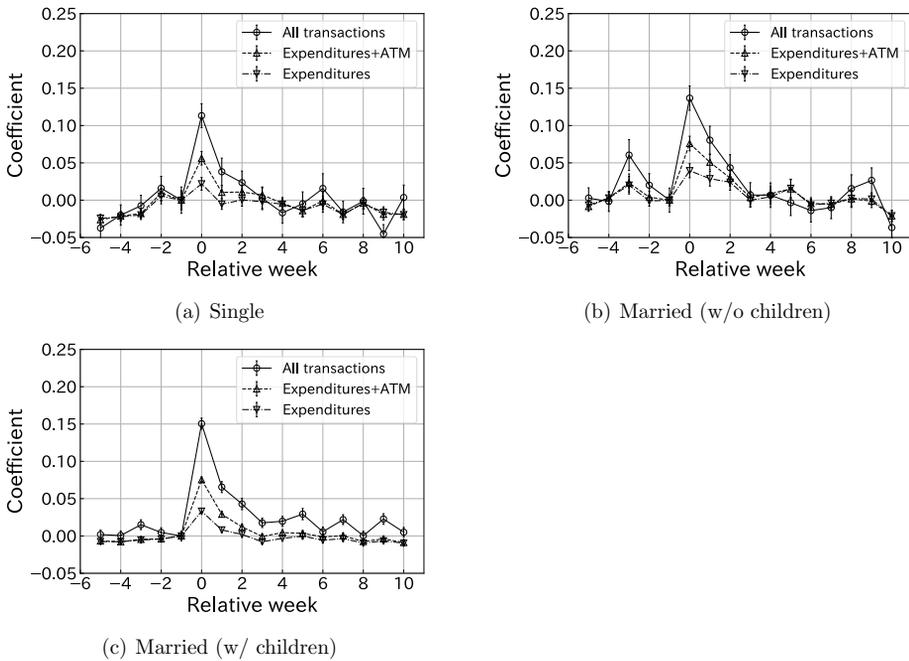


Table A.1: Regression results for each consumption category

Relative week	Food and necessities	Services	Non-durable	Durable	Payments	Uncategorized expenditures
-5	0.0002 (0.0004)	0.0017 (0.0005)	-0.0005 (0.0003)	-0.0014 (0.0008)	-0.0003 (0.0019)	-0.0023 (0.0013)
-4	0.0006 (0.0004)	0.0013 (0.0005)	-0.0008 (0.0003)	-0.0018 (0.0008)	-0.0005 (0.0016)	-0.0027 (0.0012)
-3	0.0015 (0.0007)	0.0003 (0.0004)	-0.0010 (0.0002)	-0.0007 (0.0009)	-0.0006 (0.0016)	-0.0018 (0.0011)
-2	0.0004 (0.0005)	0.0017 (0.0005)	-0.0006 (0.0003)	-0.0007 (0.0008)	0.0000 (0.0017)	-0.0019 (0.0013)
-1	0.0000 (0.0007)	0.0000 (0.0005)	0.0000 (0.0004)	0.0000 (0.0012)	0.0000 (0.0017)	0.0000 (0.0015)
0	0.0047 (0.0006)	0.0051 (0.0005)	0.0006 (0.0003)	0.0030 (0.0009)	0.0066 (0.0016)	0.0130 (0.0012)
1	0.0023 (0.0005)	0.0015 (0.0004)	0.0005 (0.0003)	0.0030 (0.0011)	0.0036 (0.0018)	0.0027 (0.0011)
2	0.0002 (0.0005)	0.0016 (0.0005)	-0.0003 (0.0003)	0.0027 (0.0012)	0.0037 (0.0018)	0.0001 (0.0013)
3	-0.0001 (0.0005)	0.0011 (0.0005)	-0.0002 (0.0005)	0.0007 (0.0009)	0.0009 (0.0015)	-0.0040 (0.0010)
4	0.0004 (0.0006)	0.0010 (0.0005)	-0.0005 (0.0004)	-0.0008 (0.0008)	0.0019 (0.0016)	-0.0009 (0.0011)
5	-0.0010 (0.0004)	0.0014 (0.0005)	-0.0006 (0.0003)	0.0008 (0.0011)	0.0042 (0.0018)	-0.0008 (0.0012)
6	-0.0011 (0.0005)	0.0015 (0.0005)	-0.0014 (0.0003)	-0.0006 (0.0009)	0.0023 (0.0020)	-0.0018 (0.0011)
7	-0.0007 (0.0005)	0.0019 (0.0006)	-0.0012 (0.0003)	-0.0011 (0.0009)	0.0011 (0.0017)	-0.0006 (0.0012)
8	-0.0009 (0.0008)	0.0011 (0.0007)	-0.0012 (0.0003)	0.0001 (0.0011)	-0.0012 (0.0015)	-0.0018 (0.0011)
9	-0.0010 (0.0007)	0.0012 (0.0005)	-0.0013 (0.0002)	0.0000 (0.0010)	0.0003 (0.0016)	-0.0026 (0.0012)
10	-0.0009 (0.0006)	0.0014 (0.0005)	-0.0012 (0.0003)	-0.0026 (0.0009)	-0.0030 (0.0018)	-0.0024 (0.0011)
Observations	7442848	7442848	7442848	7442848	7442848	7442848
R^2	0.00002	0.00002	0.00002	0.00001	0.000007	0.00003

A.3 Results using total income

Figure A.7: Consumption responses grouped by total income

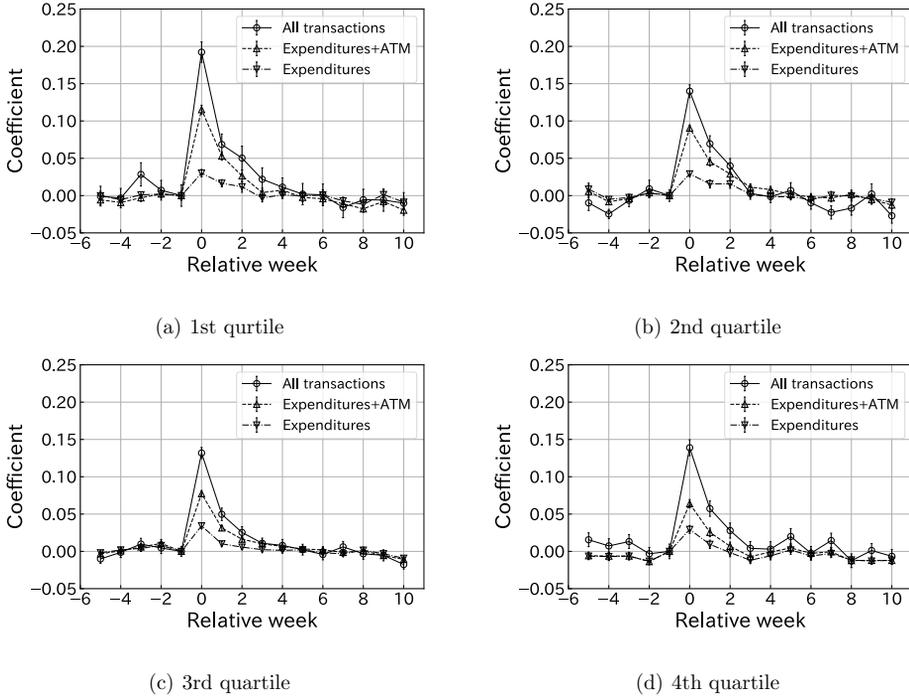


Figure A.8: Consumption responses grouped by liquidity constraints using total income

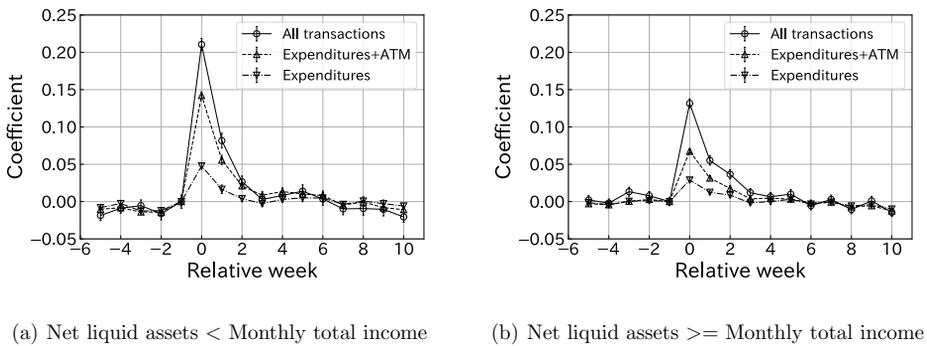
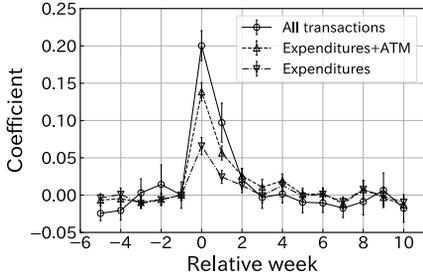
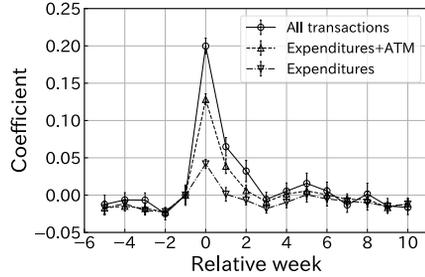


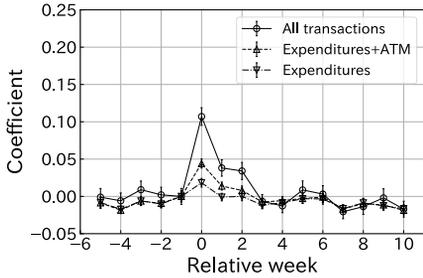
Figure A.9: Consumption responses grouped by liquidity constraints using total income and housing status



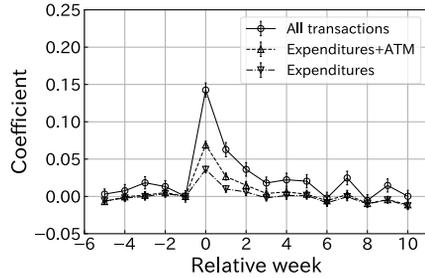
(a) Net liquid assets < Monthly total income and rental house



(b) Net liquid assets < Monthly total income and own house

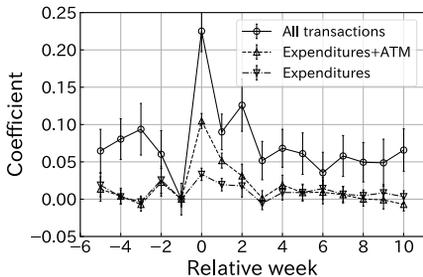


(c) Net liquid assets \geq Monthly total income and rental house

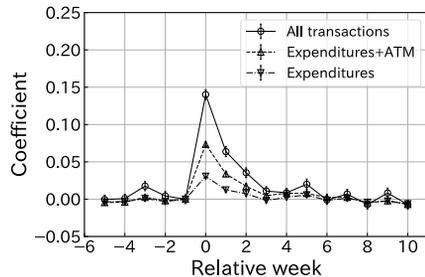


(d) Net liquid assets \geq Monthly total income and own house

Figure A.10: Counterfactual policy analysis: Comparing consumption responses for targeted and non-targeted households according to the initial plan using total income



(a) Targeted households by the original full policy



(b) Non-targeted group by the original full policy

International firms and COVID-19: Evidence from a global survey¹

Floriana Borino,² Eric Carlson,³ Valentina Rollo⁴ and Olga Solleder⁵

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This paper investigates whether international exposure played a role in how companies were impacted and which strategies they used in response to the COVID-19 crisis. Our conceptual framework generates two testable hypotheses. First, international firms are more likely to be affected, both through demand and supply channels, than domestic firms due to their exposure to domestic and foreign lockdowns. Second, despite higher exposure, we expect international firms to be more resilient to the crisis than domestic firms. The resilience of international firms stems from their connectivity and productivity. Our empirical analysis corroborates both sets of hypotheses. The tests are based on a unique firm-level data set covering 4,433 enterprises in 133 countries, collected by the International Trade Centre under the COVID-19 Business Impact Survey. At the policy level, the results underscore the importance of global connectedness and international trade for promoting resilience to external shocks.

- 1 Views expressed in this paper are those of the authors and do not necessarily coincide with those of International Trade Centre (ITC), United Nations (UN) or the World Trade Organization (WTO). The designations employed and the presentation of material in this paper do not imply the expression of any opinion whatsoever on the part of ITC, UN or the WTO concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Mention of firms, products and product brands does not imply the endorsement of ITC, UN or the WTO.
- 2 Associate Programme Officer, Division of Market Development, International Trade Centre.
- 3 Doctoral student, American University.
- 4 Economist, Division of Market Development, International Trade Centre.
- 5 Economist, Division of Market Development, International Trade Centre.

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INTERNATIONAL FIRMS AND COVID-19: EVIDENCE FROM A GLOBAL SURVEY

1. Introduction

The spread of the novel coronavirus worldwide in 2020 forced governments to impose strict containment measures in the first wave of the pandemic. These have included lockdowns, travel restrictions, prohibitions of large gatherings, as well as temporary closures of schools and office buildings. These measures, taken to protect public health, have hampered both supply and demand, as factories slowed production and consumers stayed home (Brinca et al., 2020). Global trade and financial linkages have complicated and compounded the effects of the pandemic as economic slowdowns in one country have spilled over to its partners (Baldwin & Freeman, 2020; Pahl et al., 2020). Furthermore, the fast spread of the virus resulted in a global shock with many countries being affected at the same time.

In response to the crisis, a growing body of literature has emerged pointing to the benefits of global connectedness in the time of COVID-19 (Bonadio et al., 2020; Espitia et al., 2021; Hyun et al., 2020). Many of these papers focus on the costs and benefits of global value chain participation. They find that, while participating in global value chains leaves firms more vulnerable to shocks, international connectivity has also helped these firms survive. This literature also shows that reshoring and concentrating production in a single country is hardly risk-free, given the potential for localized environmental upsets like floods, earthquakes (Baldwin & Tomiura, 2020; Stelling et al., 2020). Nevertheless, governments around the world have pushed for increased localization of production in the wake of the pandemic. Since February 2020, there has been a rise in trade policy activism and many countries have established export prohibitions and restrictions in order to mitigate domestic shortages at a national level (Evenett et al., 2021; WTO, 2020a).

Despite this quickly expanding literature, because of the logistical hurdles associated with large-scale data collection, there have been few systematic cross-country studies of the impact of the pandemic on firms engaged in international trade (referred hereafter as international firms). Using a novel dataset collected between April and August 2020 comprising 4,433 enterprises across 133 countries, this paper shows that, despite being more strongly affected by the crisis, through both supply and demand channels, international firms have been able to take more resilient actions than firms that only operate domestically. For example, we find that international firms were less likely to lay off workers or file for bankruptcy than domestic firms and were more likely to adopt remote work. This is because engagement in trade provides a network of trading partners and economic gains that can facilitate recovery.

Our paper is related to work focusing on the firm-level effects of the COVID-19 crisis. Most of these papers focus on firms in individual countries. Severe impacts have been documented across countries in terms of revenue loss, business closures, and layoffs (see Dai et al. (2020) for evidence in China and Adams-Prassl et al. (2020); Fairlie (2020) for evidence in the United Kingdom, United States, and Germany). Other firm-level surveys have stressed the need for liquidity. Using a survey of American businesses, Bartik et al. (2020) find that firms with more cash on hand are more confident about their prospects for surviving the crisis. Similarly, Buchheim et al. (2020) find that firms with better pre-crisis liquidity are more optimistic about the duration of the crisis. Using enterprise data from Ireland, McGeever et al. (2020) find that SMEs will require liquidity in the coming months to manage persistent operating costs.

Furthermore, this branch of literature finds that small and medium-sized enterprises (SMEs) are disproportionately affected by the COVID-19 pandemic because of their prevalence in the most affected sectors (ITC, 2020). These include accommodation and food services, cultural and creative sectors, and wholesale and retail services, heavily impacted by a drop in demand (OECD, 2020a). Moreover, SMEs have generally lower cash reserves and smaller inventories and supplier networks. Sourcing from new suppliers, or absorbing price increases, is more challenging for a small firm with limited supply options and capital,

meaning that COVID crisis can impact SMEs faster and harder than large firms. According to Lindsay et al. (2020), 50 per cent of SMEs in the United States had already shut down or had laid off or furloughed employees by May 2020 — only a few months into lockdowns — and 27 per cent stated that they will be obliged to take such measures in the next few weeks if the situation does not improve.

While there have been a few cross-country studies, the existing literature on the firm-level effects of COVID-19 focuses on small samples of countries. For example, using a sample of firms from 51 developing countries, Apedo-Amah et al. (2020) provide an assessment of the short-term impact of the pandemic. They find that the COVID-19 shock has been severe, with persistent negative impacts on sales. They also find that many firms have avoided layoffs by reducing workers' hours and have increasingly come to rely on digital solutions as a response to the shock. Similarly, Beck et al. (2020) use a sample of nearly 500 firms across 10 developing countries and find that most firms have tried to limit layoffs and payroll reduction, choosing instead to reduce investment.

While this line of research provides a good description of how firms have responded to the crisis, it is important to extend this work to firms engaged in international trade. While local outbreaks of the virus have disrupted production for all firms within the same region, experience has shown that firms that source inputs from different locations confront an additional risk: even if the virus does not affect the production site, they nevertheless need inputs from a potentially affected area (Miroudot, 2020). A growing body of literature has shown that the productivity slowdown originating in the Hubei province of China quickly propagated through the global economy through international trade networks (P. Eppinger et al., 2020; Gerschel et al., 2020; Miroudot, 2020; Ramelli & Wagner, 2020).

This is similar to the contagion through international trade networks that has been observed following natural disasters, such as the 2011 tsunami in Japan or the floods in Thailand in the same year. For example, Boehm et al. (2019) study the effect of the Japanese tsunami on US manufacturing by differentiating between Japanese affiliates and others. They find that the Japanese affiliates, who source a larger fraction of their intermediates from Japan, were more affected than firms with fewer Japanese ties.

Transportation networks also represent a potential source of disruption. International companies still producing during the lockdown became more dependent on the stability and pricing of international transportation networks. For example, quarantine measures for air or sea crews and additional sanitary controls related to COVID-19 delay trade. While domestic transport networks and logistics are also disrupted, there is an additional vulnerability for international freight and a risk specific to international production networks (Miroudot, 2020).

By focusing on firms that operate internationally through export and/or imports, the results from our paper contribute to understanding how international firms around the world cope with crises. The findings can help designing policies aimed at smoothing the impact of the COVID-19 shock and helping businesses recover from the current and future crises. The finding that internationally trading firms are more resilient indicates that companies need more, not less, trade.

The remainder of the paper is organized as follows. In section 2, we present the conceptual framework and offer empirical predictions. Section 3 describes the data. Section 4 presents the results, and section 5 concludes.

2. Conceptual framework

In this section we lay out a simple conceptual framework for understanding how the COVID-19 crisis is likely to affect firms, how firms can respond to the crisis, and why international firms are different from those that only operate domestically.

2.1. International firms more exposed to COVID-19 crisis

The COVID-19 crisis has been both a demand and a supply shock (Brinca et al., 2020). On the demand side, policies like lockdowns and stay-at-home orders have caused consumers to reduce their economic activity. On the supply side, lockdowns have forced firms to halt production while policies like trade and travel restrictions have made it difficult for firms to access inputs.

Prior literature suggests that trading firms are more susceptible to shocks than firms that only operate domestically. For example, Vannoorenberghe (2012) shows export intensity had a positive and substantial effect on sales volatility, due to exposure to demand shocks in multiple markets. Kurz and Senses (2016), using firm- and transaction-level data from US manufacturing firms between 1991 and 2005, found that the employment of importers was more volatile than that of domestic firms. Their study also found a non-monotonic relationship between export status and employment volatility. A higher share of exports is associated with higher levels of employment volatility for exporters.

In line with the findings that international firms face more volatility than domestic firms, we expect international firms to face more severe effects of the COVID-19 crisis than domestic firms. This is because the special nature of the COVID-19 together with their interactions with both foreign and domestic markets leave them exposed to a wider set of shocks. Because the COVID-19 shock has been ubiquitous throughout the global economy, we expect international firms to experience more severe supply and demand shocks than domestic firms. As shown in Figure 1, shocks that negatively affect the domestic market, impact negatively both domestic and international firms, while shocks that affect foreign markets only negatively impact international firms.

We define foreign supply shocks as any shocks in a foreign country that make production more difficult. For example, in the early days of the pandemic, countries in Asia had instituted lockdowns while countries in the Americas remained open. As a result, firms operating solely in the Americas saw little change in their domestic markets. However, American businesses that bought inputs from Asian firms experienced difficulties accessing supplies.

Foreign demand shocks, on the other hand, are defined as any shocks in a foreign country that inhibit sales abroad. For example, manufacturers around the world experienced reductions in the demand for their goods when shops and retail outlets in partner countries shut down. In addition, in the early days of the pandemic, many countries restricted exports in order to shore up national production (WTO, 2020a). Such export bans reduce the size of the available consumer base for international firms, causing revenues to fall.

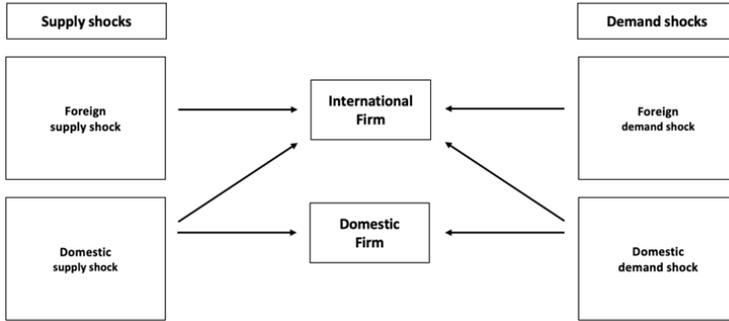


Figure 1. How International firms are doubly affected by COVID-19 crisis

2.2. International firms more resilient to COVID-19 crisis

Firms can respond to shocks in a number of ways. For example, one way that firms can cope with a supply shock is by finding alternative sources of inputs. During the second World War, when U.S. businesses experienced a drop in the labor supply as prime-age men were deployed overseas, firms drew from alternative sources of labor. While men of working age fought abroad, American businesses hired prime-age women, many of whom were new to the labor market (Goldin & Olivetti, 2013).

Firms may respond to a demand shock by scaling down production, which can involve laying off workers or reducing investments, or by creating new products. During the financial crisis of 2008, for example, many firms were forced to decrease production as consumers cut back their spending (Fabiani et al., 2015). As another example, Mayer et al (2016) show that multiproduct French firms shifted their product mix to their best performing goods in the face of demand shocks like trade liberalization.

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Rather than employing single coping mechanisms in isolation, firms use a cocktail of responses to deal with crises and shocks (Fabiani et al., 2015). For example, a firm may, at once, try to find new suppliers, move sales online, and institute a policy of remote work. This coincidental use of several coping mechanisms is especially salient for the COVID crisis which has had myriad effects on firms. Therefore, we group individual coping mechanisms together into broader strategies. Specifically, we define two types of strategies: retreating and resilient.

A retreating strategy undermines the long-term competitiveness of the business. Coping mechanisms that are part of a retreating strategy include filing for bankruptcy, selling assets, or laying off employees. The consequences of these actions may be difficult to undo.

A resilient strategy, on the other hand allows firms to adjust to the crisis and to return in full force once the crisis abates. One set of resilient actions are those that manage to keep the basic form of the business intact. These include temporarily laying off employees, working remotely, rescheduling bank loans, increasing marketing efforts, sourcing from new suppliers, and shifting sales online. Another set of resilient actions involve developing new products or temporarily loaning employees to other businesses, such as manufacturers of personal protective equipment, who need workers.

Despite being more strongly affected by the pandemic, international firms are likely to respond more resiliently to shocks than domestic firms. First, international firms are more connected than domestic firms. This increased connectivity gives them a larger pool of alternative suppliers and consumers to turn to. Second, international firms tend to be more productive than domestic firms. Their higher productivity and profitability allow them to continue paying expenses when revenue drops and allows them to spend money on measures like developing new products, increasing marketing or moving sales online.

The resilience of trading firms is consistent with prior literature. For example, looking at firm-level data, Todo et al. (2015) demonstrate that firms with extensive networks of foreign suppliers had a quicker recovery after the Great East Japan Earthquake. This is because firms can receive supports and find substitutes for damaged partners through supply chain networks, speeding up recovery. In contrast, domestic firms must rely on input and product markets in their home country. This can make it difficult to adjust sourcing strategies, for example, because all potential suppliers are experiencing the same shock as current suppliers.

Furthermore, Eppinger et al. (2018) show that, in the wake of the 2008 financial crisis, exporters saved more jobs, stayed more productive and were more likely to survive. Similarly, using data on US manufacturing plants, Bernard and Jensen (1999) show that exporters have significantly lower failure rates than non-exporters. This is likely a result of their higher size, productivity, and profitability.

Compared to domestic only firms, international firms tend to be more productive and profitable than firms that only operate domestically (Bernard et al., 2007; Pavcnik, 2002). Even after controlling for factors such as size and industry, international firms tend to be more productive, more capital and skill intensive, and more financially sophisticated than otherwise comparable domestic only firms (Alvarez & Lopez, 2005; Helpman et al., 2017; Manova, 2013).

All these characteristics imply that international firms are likely to be more resilient to the COVID crisis relative to domestic only firms. The profitability and productivity advantages of international firms allow them to weather crises and avoid retreating coping mechanisms, such as laying off employees or filing for bankruptcy. The higher capital and skill intensity imply that international firms can more easily institute remote work since nonproduction workers don't need to be on site at all times (OECD, 2020b). In addition, the financial sophistication allows international firms to develop strategies with longer time horizons.

2.3. Empirical predictions

The conceptual framework outline above and the existing literature suggest the following testable hypotheses:

1. Because the COVID-19 crisis was a global shock, affecting both supply and demand, we expect that international firms are more likely to experience difficulties both accessing inputs and selling output compared to domestic firms.
2. Nonetheless, we expect international firms to be more resilient to the crisis than domestic firms because international firms have more tools to respond to the crisis, for example, by curtailing layoffs, avoiding bankruptcy filings, and adopting remote work.

3. Data

We use data from the COVID-19 Business Impact Survey, an online survey of the International Trade Centre (ITC), a joint agency of the United Nations and World Trade Organization. Participation in the survey was voluntary, anonymous and without payment. The survey was available in eight languages. The voluntary nature of the survey may have attracted businesses that experienced a stronger impact of COVID-19, but this should be the same for international and domestic firms, thus not affecting our results. While the sample of our survey has some limitations, it allows for important insights.

The sample is large and includes firms from most sectors, countries, and firm-size categories comprising 4,433 establishments from 133 countries. Survey data was collected between April 10, 2020 and August 24, 2020. The survey instrument includes questions about firm characteristics like size, sector, and trade status, as well as age and gender of the manager. It also includes questions about the effects of the COVID-19 crisis, such as the ability to purchase inputs and sell outputs as well as questions about coping mechanisms (the questionnaire can be found in the Appendix).

In addition to establishment-level data, we use country-level information on government policies. These data come from the Oxford COVID-19 Government Response Tracker (OxCGRT) managed by the Blavatnik School of Government. The OxCGRT data contains the start of government-mandated closures of all but essential businesses. We use these dates to calculate a firm-level control variable, namely the number of days each firm has spent in lockdown before participating in the survey. Table A6 in the Appendix describes in more detail all the variables used in the paper.

3.1. Descriptive statistics

Our data set includes micro, small, medium-sized, and large firms, across different sectors and regions of the world. Table 1 summarizes the key features of the sample used in this paper. The firm size distribution is similar to that observed in previous research, with the majority of the firms in the sample being SMEs and a minority of firms being large (Luttmer, 2007). In addition, most of the firms in the sample operate in the service sectors, followed by manufacturing, and by the primary sector. Nearly three quarters of our observations come from Asia, a substantial set of observations come from Africa and the Americas (14% and 8%, respectively), and a small set of observations come from Europe and Oceania (3% and 0.4%, respectively). The majority of firms only operate domestically (55%) while 45% of firms are international, meaning that they export and/or import.

Compared to domestic firms, international firms tend to be larger and are more likely to operate in manufacturing. Nearly half of domestic firms in the sample are micro firms, compared to only one in five international firms. In contrast, fewer than 5% of domestic firms have at least 100 employees (the cut off for large firms used in this paper) while 25% of international firms have at least 100 employees. With respect to the sectoral composition of firms, only 23% of domestic firms are in the manufacturing sector compared to 40% of international firms and 30% of domestic firms operate in the primary sector compared to 15% of international firms. Finally, the regional distribution of firms by international orientation mirrors the overall distribution except that a relatively larger share of domestic firms is located in Asia while a relatively larger share of international firms is located in the other regions.

	Trade Status		Overall
	Domestic	Int'l	
<i>Firm size</i>			
Micro (1-4 employees)	47.78	19.50	35.20
Small (5-9 employees)	37.27	30.17	34.11
Medium (20-99 employees)	10.69	25.57	17.31
Large (≥ 100 employees)	4.26	24.76	13.38
<i>Sector</i>			
Manufacturing	22.55	40.36	30.38
Primary	30.07	14.80	23.36
Services	47.38	44.84	46.27
<i>Region</i>			
Asia	82.18	64.15	74.16
Africa	11.63	17.71	14.34
Americas	4.97	11.72	7.97
Europe	1.08	5.72	3.15
Oceania	0.13	0.70	0.38
<i>Share of total</i>	55.48	44.52	100.00

Table 1. Descriptive statistics

Source: ITC COVID-19 Business Impact Survey. Data collected from 21 April to 24 August 2020.

Table 2 shows the ways in which firms in the sample were affected by the COVID-19 crisis, which has left few firms untouched. The crisis has affected firms' ability to access inputs as well as sell output. About 62% of all firms report having difficulty accessing inputs and 80% of firms report reductions in sales. This is in line with previous literature showing that firms are hit by multiple channels, with depressed demand being the most frequently reported concern in recent firm surveys and becoming more prominent over time (Dai et al., 2020a; Balleer et al., 2020).

As suggested in the conceptual framework, these demand and supply difficulties are greater for companies that exported and/or imported. This is confirmed in our data, where international firms are slightly more likely to have experienced difficulties accessing inputs than firms that only operate domestically. Almost 63% of international firms experienced input disruptions while 62% of domestic firms reported difficulties accessing inputs. Furthermore, international firms were more likely to have experienced reductions in sales compared to firms that only operate domestically. Roughly 83% of international firms experienced reductions in sales while 77% of domestic firms reported reductions in sales.

	Trade status		Overall
	Domestic	Int'l	
<i>Input/output effects</i>			
Difficulty accessing inputs	61.53	62.73	62.06
Reduced sales	76.91	83.01	79.63
<i>Other business effects</i>			
Reduced logistics services	35.08	49.68	41.57
Reduced certification services	4.54	11.11	7.47

Table 2. Effects of COVID-19 crisis on firms in sample

Source: ITC COVID-19 Business Impact Survey. Data collected from 21 April to 24 August 2020.

Note: Respondents were asked 'How have your business operations been affected by the coronavirus?'; 'Has the coronavirus (COVID-19) pandemic affected the ability to purchase inputs for your enterprise and/or sell outputs?'; and 'Has the coronavirus (COVID-19) pandemic affected your enterprise in any of the following ways (multi-select)?'

In addition, the majority of international firms faced problems related to logistics services, compared to 35% for domestic firms. While domestic transport networks and logistics were also disrupted, there was an additional vulnerability for international freight and a risk specific to international production networks (Miroudot, 2020). This is consistent with evidence from a recent report by the International Finance Corporation (IFC, 2020). They find that ocean and air freight, on which international firms rely, were more negatively affected than land freight, which is used more by domestic firms. International firms were also more likely to face problems with certification services, which are required to signal that their products meet international quality standards. This is consistent with the fact that countries around the world have enacted new, stricter standards and regulations for imported goods (WTO, 2020b).

	Trade status		
	Domestic	Int'l	Overall
<i>Coping strategy</i>			
Retreat	46.95	29.97	39.39
Resilient	53.05	70.03	60.61
<i>Specific coping mechanisms</i>			
Temporarily reduced employment	38.90	45.93	42.03
Increased marketing efforts	20.47	27.65	23.67
Teleworking	15.23	41.35	26.86
Online sales	14.67	24.26	18.94
Laid off employees	14.15	19.78	16.66
Sourcing from new suppliers	12.33	13.53	12.87
Customized/new products	9.13	15.85	12.12
Rescheduling of bank loans	8.22	18.54	12.82
Filed for bankruptcy	2.60	1.13	1.94
Loaned employees to other enterprises	2.29	3.40	2.78
Other	28.17	9.60	19.90
None	6.40	5.50	6.00

Table 3. Coping mechanisms employed by firms in sample

Source: ITC COVID-19 Business Impact Survey. Data collected from 21 April to 24 August 2020.

Note: Note: Respondents were asked 'Have you adopted any of the following strategies to cope with the crisis?' Categorizations: Retreat – filed for bankruptcy, laid off employees, or took no action. Resilient – all other strategies; chose one or more options: temporarily reduced employment; teleworking; rescheduled bank loans; greater marketing; online sales; launching new or customized products, sourcing from new suppliers, or loaned employees to other enterprises. Firms adopting multiple coping mechanisms were classified as retreating if they took any retreating action.

Table 3 shows that firms met the challenge posed by the crisis using a variety of strategies. Some firms adopted retreating responses to the crisis, such as laid off employees, took on new debt or filed for bankruptcy. About 39% of enterprises in the sample took this approach, which undermined the long-term

competitiveness of the company. International firms were significantly less likely to adopt this sort of approach, than those selling only domestically.

For the most part, firms in the sample adopted resilient strategies to cope with the crisis, maintaining competitiveness. While, overall, about 61% of firms adopted resilient strategies, international firms were more likely to adopt a resilient approach than domestic only firms.¹ Among international firms, 70% applied a resilient strategy compared to 53% of domestic firms. The most common coping mechanisms were temporarily reducing employment, increasing marketing efforts, and teleworking. International firms were more likely than domestic firms to adopt these measures. For example, nearly 41% of international firms adopted remote work while only 15.3% of domestic firm did the same. The least common coping mechanisms were filing for bankruptcy and loaning employees to other enterprises. For example, only 1.9% of firms filed for bankruptcy overall with 2.6% of domestic firms taking this action compared to only 1.1% of international firms.

4. Empirical framework

To study the impact of the COVID-19 crisis on firms, we use the following estimating equation for firm i :

$$y_i = \beta_0 + \beta_1 INTL_i + \beta_2 LOCKDOWN_i + \sum \gamma_{IND} \delta_i^{IND} + \sum \eta_{SIZE} \delta_i^{SIZE} + \sum \zeta_{COUNTRY} \delta_i^{COUNTRY} + \varepsilon_i \quad (1)$$

where y_i is the outcome variable, $INTL_i$ is an indicator that the firm operates internationally (either through imports or exports or both) and $LOCKDOWN_i$ is a measure of government-imposed economic restrictions faced by the firm. The main coefficient of interest is β_1 which compares the effects of the crisis for international firms relative to domestic firms².

Our lockdown measure is the days that elapsed between the day each firm responded to the survey and the beginning of government-mandated lockdowns in each country.³ We include this variable in order to compare firms operating in similar conditions with respect to containment measures. Because firms from the same country could fill the questionnaire at different times, this variable is firm specific. In addition, we control for industry, size, and country fixed effects shown as δ_i^{IND} , δ_i^{SIZE} , and $\delta_i^{COUNTRY}$, respectively. In our sample, compared to domestic firms, a larger share of international firms operates in the manufacturing industry and a smaller share of international firms operates in the primary sector. We therefore control for industry as the COVID-19 crisis affected some industries more than others. In addition, international firms tend to be larger than domestic firms. We control for size because larger firms may react differently to shocks than smaller firms. Finally, some countries have larger shares of international firms than others. We include country FE so that the estimate of β_1 does not reflect country-level differences in firms' experiences.

We first look at the demand and supply effects of the crisis. In particular, we look at difficulty accessing inputs, and difficulty selling outputs. In addition, we look at difficulty with logistics services and certification services.

To see how firms respond to the crisis, we estimate how much more likely international firms are to adopt resilient strategies than domestic firms. In addition, we also look at specific coping mechanisms to show that international firms are more likely to preserve their labor force, more likely to adopt remote work, and less likely to file for bankruptcy.

¹ Some firms employed multiple coping mechanisms to respond to the crisis. In cases where firms used a combination of retreating and resilient mechanisms, the strategy is coded as "Retreat".

² The regressions presented in the main body of the paper are unweighted. In the Appendix, we show that the results are robust to alternative weighting methods and specifications.

³ Lockdown variable coded as 0 whenever a firm submitted survey responses prior to the start of lockdowns in their country.

5. Results

5.1. Impact of COVID-19 on business operations

In this section, we look at the effect of lockdowns on business operations. We estimate a linear probability model⁴ based on (1) that estimates the chances of experiencing a given outcome. The estimating equation is given by:

$$\Pr(Y_i = 1) = \beta_0 + \beta_1 INTL_i + \beta_2 LOCKDOWN_i + \sum Y_{IND} \delta_i^{IND} + \sum \eta_{SIZE} \delta_i^{SIZE} + \sum \zeta_{COUNTRY} \delta_i^{COUNTRY} + \varepsilon_i \quad (2)$$

We use a linear probability model instead of other nonlinear dichotomous response models for ease of interpretation. Since we are not estimating the structural parameters of a discrete choice model but the marginal effects of international exposure, coefficients from the linear probability model provide a more direct summary of the data. In addition, over the range of probabilities of the dependent variables in our sample, a nonlinear model would not offer a significantly better fit of the data (Hellevik, 2009). While our framework is not causal, nevertheless we find significant differences between international and domestic firms that point to the benefits of participating in international markets during times of crisis.

We test if international firms were more affected by the COVID-19 crisis along supply and demand channels than domestic firms. Based on the framework in Section 2, we expect international firms to have more difficulty accessing inputs and selling output than domestic firms. This is because international firms experience supply and demand disruptions from domestic lockdowns as well as lockdowns in partner countries.

Table 4 shows that international firms are more likely than domestic firms to experience difficulty accessing inputs and difficulty selling output. The probability that an international firm had difficulty accessing inputs is 0.129 larger than the probability for an otherwise comparable domestic firm and the probability that an international firm experienced a reduction in sales is 0.063 larger than the probability for a domestic firm. These numbers are economically large. A representative international firm has a 63% chance of facing difficulties accessing inputs (Table 2). If the same firm only sourced domestically, they would only have a 50% chance of facing such difficulties. A representative international firm has an 83% chance of experiencing reduced sales. If the same firm only sold output domestically, they would have about a 77% chance of seeing their sales decreased. These results support the idea that international firms were more exposed to the economic effects of the pandemic, experiencing both domestic and international shocks to supply and demand from COVID-19 lockdowns.

Figure 2 shows how these input and output effects have evolved over the duration of lockdown measures for international and domestic firms. Panel (a) shows firms' difficulty accessing inputs and panel (b) shows the reduction in firms' sales. Though small, the coefficients on lockdown duration are negative and statistically significant for difficulty accessing inputs.

The negative effect of lockdown duration on firms' difficulties accessing inputs suggest that as lockdowns have dragged on, supply chains have learned to cope. For example, toward the beginning of the pandemic, firms may have struggled as they adjusted to more socially-distanced operations. However, as lockdowns continued, some suppliers may have revised their production and delivery strategies to meet the moment.

⁴ We use a linear probability model for ease of interpretation. However, the results are robust to nonlinear specifications and estimates from logit models are shown in the Appendix. I

Dependent variable:	Difficulty accessing inputs	Reduced sales	Reduced logistics services	Reduced certification services
	(1)	(2)	(3)	(4)
International	0.129*** (0.0206)	0.0629*** (0.0174)	0.154*** (0.0213)	0.0365*** (0.0112)
Days since lockdown	-0.00266*** (0.000746)	0.000134 (0.000630)	-0.00160** (0.000770)	-0.00101** (0.000405)
Sector FE	✓	✓	✓	✓
Size FE	✓	✓	✓	✓
Country FE	✓	✓	✓	✓
N	4015	4015	4031	4031

Table 4. Channels through which COVID-19 affects business operations

Source: ITC COVID-19 Business Impact Survey. Data collected from 21 April to 24 August 2020.

Note: Results of linear probability model reported. Dependent variables are “Difficulty accessing inputs”, “Difficulty selling output”, “Reduced logistics services”, and “Reduced certification services”. Respondents were asked “How has the coronavirus (COVID-19) pandemic affected the ability to purchase inputs for your enterprise and/or sell output?” and “Has the coronavirus (COVID-19) pandemic affected your enterprise in any of the following ways?” Difficulty accessing inputs includes domestic and foreign inputs. Difficulty selling output includes selling to domestic consumers, foreign consumers, and businesses. Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. This result is robust to alternative measures of economic lockdown.

In addition, Table 4 confirms the findings in Section 3 that international firms have been more likely to report being affected by a reduction of logistics services needed to manage supply chains and more likely to report issues accessing certification services. Relative to domestic only firms, international firms have a 0.154 and 0.037 higher probability of being affected by reduced logistics and certification services, respectively. These results are economically large. For example, a representative international firm has a 50% chance of reporting being affected by reduced logistics services. If that same firm sourced domestically, they would have a 35% chance of being affected. This is consistent with findings in a recent IFC report showing that air and ocean freight, on which international firms rely, were more affected by the crisis than land freight, more commonly used by domestic firms (IFC, 2020). A representative international firm has an 11% chance of being affected by reduced certification services. If this firm only operated domestically, its chances of experiencing reduced certification services drops to 7.3%.⁵

This is important, as literature shows that logistics and certification services contribute to firms’ abilities to compete in the international market. Logistics costs make up a significant share of the final price of goods for SMEs and firms in developing countries (Schwartz et al., 2009). In addition, formal certification allows firms to signal the quality of their products. Meeting international certification standards helps businesses in developing countries penetrate new markets and reduce costs associated with customs regulations (Goedhuys & Sleuwaegen, 2013; Henson et al., 2010; Latouche & Chevassus-Lozza, 2015; Martinus et al., 2015). Therefore, the difficulties associated with accessing logistics and certification services stemming from

⁵ Table A1 in the Appendix shows that results are robust to the use of logistic and probit specification.

COVID-19 lockdowns could lead to an increase in product prices and a decrease in firm competitiveness, especially for SMEs in developing countries.

Panels (c) and (d) of Figure 2 show how difficulty with logistics and certification services, respectively, have evolved over the duration of lockdown measures for international and domestic firms. Though small, the coefficients on lockdown duration are negative and statistically significant for reduced logistics services and reduced certification services. Indeed, logistics services may have become more important as buyers and sellers increasingly rely on delivery for remote sales and returns and consequently problems with logistics services increases as firms stay longer in lockdown.

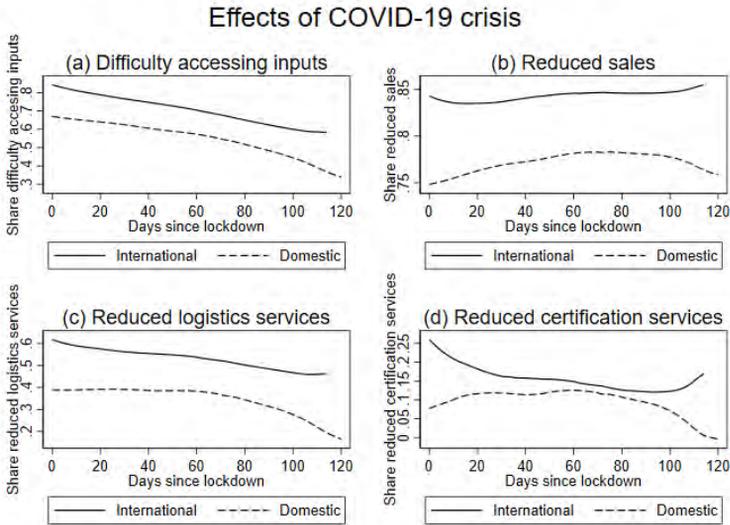


Figure 2. Predicted probability of facing specific input and output effects

Source: ITC COVID-19 Business Impact Survey. Data collected from 21 April to 24 August 2020.

Note: Prediction based on sample enumeration based on regression in Table 4.

5.2. Coping with COVID-19

In this section, we test whether international firms, despite being more affected by the pandemic, are more likely to adopt resilient coping strategies. Table 5 shows that international firms are more likely to take resilient approaches to overcome the COVID-19 crisis than domestic firms. The probability that an international firm adopts a resilient approach, as opposed to a retreating approach, is 0.10 higher than the probability for a domestic firm (Table 5). This is economically significant. Table 3 shows that international firms have a roughly 70% chance of adopting a resilient strategy. A comparable firm only operating domestically would have about 60% chance of responding resiliently. This suggests that businesses with more international exposure are better positioned to weather the crisis than other firms.

Previous research have shown that international companies are more competitive and productive (Bernard et al., 2007). This is because only the most competitive and productive firms decide to enter international markets. In addition, participation in trade can boost the capacity of firms to connect with buyers, suppliers, and institutions and to change according to market needs. As a result, international firms have more physical, financial, and social assets to draw on to ride out the storm. The increased resilience of international firms can also be explained by the fact that international firms enjoy a more diversified portfolio of suppliers and buyers. This diversity helps international firms to buffer negative shocks by allowing more flexible decisions in production and market management (Hyun et al., 2020).

When we look at specific coping mechanisms (Table 5), we see that international firms are less likely to take retreating measures like laying off workers and filing for bankruptcy than domestic firms. International firms are also more likely to adopt remote work compared to domestic firms. In particular, the probability that an international firm laid off employees is 0.04 lower than the probability for a domestic firm and the probability that an international firm filed for bankruptcy is 0.01 lower than the probability for a domestic firm. These results are economically large. For example, a representative international firm has a 20% chance of laying off employees. If this firm only operated domestically, they would have a 24% chance of laying off employees, a 1.2-fold increase.

With respect to a specific resilient action, the probability that an international firm adopted telework is 0.10 greater than the probability for a domestic only firm. This estimate is economically large as well. The average international firm in the sample had a 41% chance of adopting telework. If this firm only operated domestically, it would have a 31% chance of adopting telework—a decrease of nearly 24%.

Dependent variable:	<u>Resilient</u>	<u>Laid off employees</u>	<u>Filed for bankruptcy</u>	<u>Telework</u>
	(1)	(2)	(3)	(5)
International	0.101*** (0.0202)	-0.0352** (0.0145)	-0.00969* (0.00582)	0.0962*** (0.0163)
Days since lockdown	-0.000649 (0.000733)	0.00192*** (0.000525)	0.000458** (0.000211)	-0.000927 (0.000590)
Sector FE	✓	✓	✓	✓
Size FE	✓	✓	✓	✓
Country FE	✓	✓	✓	✓
N	4031	4031	4031	4031

Table 5. Coping strategies of international firms

Source: ITC COVID-19 Business Impact Survey. Data collected from 21 April to 24 August 2020.

Note: Results of linear probability model reported. Dependent variables are “Resilient”, “Laid off employees”, “Filed for bankruptcy”, and “Telework”. Respondents were asked “Have you adopted any of the following strategies to cope with the crisis?” In constructing the Resilient variable, responses are categorized as follows: Retreat – filed for bankruptcy, laid off employees, sold off assets, took on new debt or took no action. Resilient – all other responses. Standard errors in parentheses.

* p<0.10, ** p<0.05, *** p<0.01.

Lockdown duration does not have a significant effect on firms’ chances of adopting resilient strategies or instituting remote work. However, firms were slightly more likely to layoff employees and file for bankruptcy as lockdowns continued. This reveals the accumulating strain created by persistent containment measures. Firms may have depleted the resources that allowed them to retain workers and pay off loans as lockdowns dragged on.

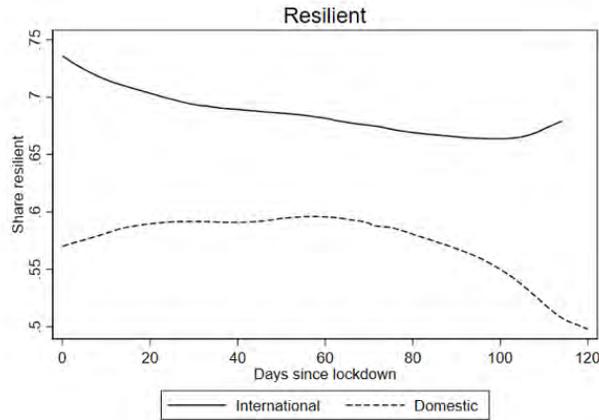


Figure 3. Predicted probability of adopting resilient strategy

Source: ITC COVID-19 Business Impact Survey. Data collected from 21 April to 24 August 2020.

Note: Prediction based on sample enumeration based on regression in Table 5.

6. Conclusions

The COVID-19 pandemic has shown that global value chains are sensitive to shocks in the international production network. Containment measures taken to slow the spread of the disease have also hampered supply and reduced demand across the world. These supply chain disruptions have led some policymakers to push for the localization and regionalization of value chains (Seric et al., 2020). Such policies are based on the assumptions that contradict the finding of this paper which demonstrates that international exposure helped firms cope during the crisis.

Using a novel firm-level dataset from the ITC COVID-19 Business Impact Survey, this paper highlights the following main findings. First, consistent with previous research by Ramelli and Wagner (2020) and Vannoorenberghe (2012), we find that international firms were hit harder by the COVID-19 pandemic along supply and demand channels compared to domestic firms due to their exposure to international markets. International firms were more likely to report difficulties accessing inputs as well as difficulties selling output compared to firms with no international exposure. Second, we find that international firms proved more resilient to the COVID-19 crisis than domestic firms. International firms were less likely than their domestic counterparts to lay off workers or file for bankruptcy and more likely to adopt countermeasures to continue production, such as telework.

These results underscore the importance of global connectedness and international trade for strengthening a business. Turning inwards is unlikely to remove the risk of shocks from suppliers. Rather, by relying solely on domestic supply, it would merely reshore this risk. A more diversified international production network, on the other hand, allows firms to find new consumers and suppliers in the face of a major external shock.

The contribution of this paper is twofold. First, the paper shows the two sides of international firms: they are more exposed to shocks, particularly those that are global in nature, and this could lead to poorer outcomes during a crisis; but they are more resilient and adaptable, which could lead to better outcomes during and after the crisis. Second, it provides empirical evidence against anti-trade views amplified during the pandemic and calling for localization of value chains, onshoring and nearshoring. The empirical evidence is based on novel firm-level data on the effect of COVID-19 on domestic and international firms in 133 countries.

This paper focuses on the firm-level effects of the COVID-19 crisis. Further research could investigate whether the findings can be generalized to other types of external shocks. Another policy-relevant avenue

for further research is to identify the specific characteristics of international firms that make them more resilient to shocks. This would allow governments to help businesses increase their resilience and be better prepared to any crisis, being it related to human health, financial system, or climate change.

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Appendix

7. Sensitivity analyses

To test the sensitivity of our results, we ran our regressions using different model specifications and different weighting schemes. In addition, and not reported in this section but available upon request, we ran each model on different samples, for example excluding one country at a time to test for the presence of outlying regions, and we also use different definitions of lockdowns. The results are robust to the procedure.

7.1. Alternative specifications

To test for the robustness of the linear probability model we run each binary dependent variable model using a logit and a probit specification. All models include fixed effects for country, sector, and establishment size.

A. Input/output effects						
	Difficulty accessing inputs			Reduced sales		
	Original (LPM)	Logit	Probit	Original (LPM)	Logit	Probit
International	0.129*** (0.0206)	0.626*** (0.0998)	0.376*** (0.0600)	0.0629*** (0.0174)	0.414*** (0.113)	0.240*** (0.0649)
Days since lockdown	-0.00266*** (0.000746)	-0.0137*** (0.00355)	-0.00800*** (0.00210)	0.000134 (0.000630)	0.00131 (0.00379)	0.000575 (0.00224)
Sector FE	✓	✓	✓	✓	✓	✓
Size FE	✓	✓	✓	✓	✓	✓
Country FE	✓	✓	✓	✓	✓	✓
N	4015	3962	3962	4015	3870	3870
B. Other business effects						
	Reduced logistics services			Reduced certification services		
	Original (LPM)	Logit	Probit	Original (LPM)	Logit	Probit
International	0.154*** (0.0213)	0.678*** (0.0941)	0.417*** (0.0578)	0.0365*** (0.0112)	0.497*** (0.170)	0.259*** (0.0856)
Days since lockdown	-0.00160** (0.000770)	-0.00773** (0.00362)	-0.00448** (0.00215)	-0.00101** (0.000405)	-0.0151** (0.00701)	-0.00810** (0.00359)
Sector FE	✓	✓	✓	✓	✓	✓
Size FE	✓	✓	✓	✓	✓	✓
Country FE	✓	✓	✓	✓	✓	✓
N	4031	3970	3970	4031	2886	2886

Table A1. Business effects, alternative binary dependent variable models

Source: ITC COVID-19 Business Impact Survey. Data collected from 21 April to 24 August 2020.

Note: Results of linear probability model, logit model, and probit model reported. Dependent variables are “Difficulty accessing inputs”, “Difficulty selling output”, “Reduced logistics services”, and “Reduced certification services”. Respondents were asked “How has the coronavirus (COVID-19) pandemic affected the ability to purchase inputs for your enterprise and/or sell output?” and “Has the coronavirus (COVID-19) pandemic affected your enterprise in any of the following ways?” Responses included reduced logistics services and reduced certification services. Difficulty accessing inputs includes domestic and foreign inputs. Difficulty selling output includes selling to domestic consumers, foreign consumers, and businesses. Standard errors in parentheses. All models control for days since initial lockdown and include sector, size, and country fixed effects.

* p<0.10, ** p<0.05, *** p<0.01.

	Original (LPM)	Logit	Probit
<i>Dependent variable: Resilient</i>			
International	0.101*** (0.0202)	0.521*** (0.101)	0.312*** (0.0603)
<i>Dependent variable: Laid off employees</i>			
International	-0.0352** (0.0145)	-0.336** (0.140)	-0.182** (0.0756)
<i>Dependent variable: Filed for bankruptcy</i>			
International	-0.00969* (0.00582)	-0.657* (0.391)	-0.279* (0.168)
<i>Dependent variable: Telework</i>			
International	0.0962*** (0.0163)	0.588*** (0.109)	0.350*** (0.0631)
<i>Controls</i>			
Days since lockdown	✓	✓	✓
Sector FE	✓	✓	✓
Size FE	✓	✓	✓
Country FE	✓	✓	✓
N	4031	4031	4031

Table A2. Coping strategies, alternative binary dependent variable models

Source: ITC COVID-19 Business Impact Survey. Data collected from 21 April to 24 August 2020.

Note: Results of linear probability model, logit model, and probit model reported. Dependent variables are “Laid off employees”, “Filed for bankruptcy”, “Reduced investment”, and “Telework”. Respondents were asked “Have you adopted any of the following strategies to cope with the crisis?” Standard errors in parentheses. All models control for days since initial lockdown and include sector, size, and country fixed effects.

* p<0.10, ** p<0.05, *** p<0.01.

7.2. Weighting methods

To control for differences in the number of observations in each country, we apply several weighting methods. The aim is to statistically reduce the weight of respondents from small countries with a large number of responses.

First, for comparison, we show the baseline results with no analytical weights. Next, we weight observations by the country’s share of the global population divided by the number of firms observed from each country.

That is, $w_i^{POP} = \left(\frac{POP_j}{\sum POP_c}\right) / n_j$ where w_i^{POP} is the analytical weight for firm i , POP_j is the population of country j , and n_j is the number of firms from country j in our sample. Finally, we weight observations based on the country’s share of global GDP divided by the number of firms observed in the country. That is, $w_i^{GDP} =$

$(\frac{GDP_i}{\sum GDP_c})/n_j$, where w_i^{GDP} is the analytical weight for firm i , GDP_j is the GDP of country j . Results are robust to the inclusion of the different weights.

Dependent variable	Panel A: Difficulty accessing inputs			Panel B: Reduced sales		
	Original (no weight)	Population weight	GDP weight	Original (no weight)	Population weight	GDP weight
International	0.129*** (0.0206)	0.181*** (0.0180)	0.105*** (0.0190)	0.0629*** (0.0174)	0.131*** (0.0153)	0.174*** (0.0160)
Days since lockdown	-0.00266*** (0.000746)	0.00153*** (0.000589)	0.00624*** (0.000411)	0.000134 (0.000630)	-0.00329*** (0.000499)	-0.00685*** (0.000347)
Sector FE	✓	✓	✓	✓	✓	✓
Size FE	✓	✓	✓	✓	✓	✓
Country FE	✓	✓	✓	✓	✓	✓
N	4015	4015	4015	4015	4015	4015
Dependent variable	Panel C: Reduced logistics services			Panel D: Reduced certification services		
	Original (no weight)	Population weight	GDP weight	Original (no weight)	Population weight	GDP weight
International	0.154*** (0.0213)	0.219*** (0.0180)	0.279*** (0.0183)	0.0365*** (0.0112)	0.0593*** (0.0112)	0.0225* (0.0117)
Days since lockdown	-0.00160** (0.000770)	-0.00426*** (0.000588)	-0.00387*** (0.000397)	-0.00101** (0.000405)	0.0000306 (0.000365)	0.00271*** (0.000255)
Sector FE	✓	✓	✓	✓	✓	✓
Size FE	✓	✓	✓	✓	✓	✓
Country FE	✓	✓	✓	✓	✓	✓
N	4031	4031	4031	4031	4031	4031

Table A3. Business effects, alternative weighting

Source: ITC COVID-19 Business Impact Survey. Data collected from 21 April to 24 August 2020.

Note: Results of linear probability model reported. Dependent variables are “Difficulty accessing inputs”, “Difficulty selling output”, “Reduced logistics services”, and “Reduced certification services”. Respondents were asked “How has the coronavirus (COVID-19) pandemic affected the ability to purchase inputs for your enterprise and/or sell output?” and “Has the coronavirus (COVID-19) pandemic affected your enterprise in any of the following ways?” Responses included reduced logistics services and reduced certification services. Difficulty accessing inputs includes domestic and foreign inputs. Difficulty selling output includes selling to domestic consumers, foreign consumers, and businesses. Standard errors in parentheses. All models control for days since initial lockdown and include sector, size, and country fixed effects. * p<0.10, ** p<0.05, *** p<0.01.

	Original (no weight)	Population weight	GDP weight
<i>Dependent variable: Resilient</i>			
International	0.101*** (0.0202)	0.0747*** (0.0160)	0.119*** (0.0164)
<i>Dependent variable: Laid off employees</i>			
International	-0.0352** (0.0145)	-0.0675*** (0.0133)	-0.00368 (0.0143)
<i>Dependent variable: Filed for bankruptcy</i>			
International	-0.00969* (0.00582)	-0.0120*** (0.00380)	-0.00783*** (0.00243)
<i>Dependent variable: Telework</i>			
International	0.0962*** (0.0163)	0.0553*** (0.0173)	0.100*** (0.0170)
<i>Controls</i>			
Days since lockdown	✓	✓	✓
Sector FE	✓	✓	✓
Size FE	✓	✓	✓
Country FE	✓	✓	✓
N	4031	4031	4031

Table A4. Coping strategies by international firms, alternative weighting

Source: ITC COVID-19 Business Impact Survey. Data collected from 21 April to 24 August 2020.

Note: Results of linear probability model reported. Standard errors in parentheses. Dependent variables are “Resilient”, “Laid off employees”, “Filed for bankruptcy”, “Reduced investment”, and “Telework”. Respondents were asked “Have you adopted any of the following strategies to cope with the crisis?” In constructing the Resilient variable, responses are categorized as follows: Retreat – filed for bankruptcy, laid off employees, sold off assets, took on new debt or took no action. Resilient – all other responses. All models control for days since initial lockdown and include sector, size, and country fixed effects.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

ITC COVID-19 Business Impact Survey

COVID-19 BUSINESS IMPACT SURVEY QUESTIONNAIRE (ENGLISH)
How is your company affected by the coronavirus pandemic? Your feedback matters and will help inform assistance from Governments and Donors. This anonymous survey will take less than 10 minutes to complete. The International Trade Centre, a United Nations agency, appreciates your participation during this difficult time.
Q1. Which country is your company based in? (single-select from the list of countries)
Q2. How have your business operations been affected by the coronavirus (COVID-19) pandemic? <ul style="list-style-type: none"> - Not affected - Slightly affected - Moderately affected - Strongly affected
Q3. Do you think there is a risk that your business will permanently shut down because of this crisis, and if so, when could this closure occur? (single select) <ul style="list-style-type: none"> - 1 month or less - 3 months - 6 months or more - Business closure not envisaged
Q4. Has the coronavirus (COVID-19) pandemic affected the ability to purchase inputs for your enterprise and/or sell outputs? (multi-select) <ul style="list-style-type: none"> - Difficulty accessing inputs domestically - Difficulty importing inputs from abroad - Lower domestic sales to consumers - Lower domestic sales to businesses - Increased domestic sales - Difficulty exporting - Improved exporting - Don't know
Q5. Has the coronavirus (COVID-19) pandemic affected your enterprise in any of the following ways? (multi-select) <ul style="list-style-type: none"> - Temporary shutdown - Employee absences due to sickness or childcare - Clients not paying their bills - Reduced logistics services - Reduced certification services - New problems with infrastructure, e.g. internet or roads - Increased administrative bottlenecks - Reduced investment - None of the above - Other - Don't know
Q6. Please specify which other effect. (Open ended question)
Q7. Have you adopted any of the following strategies to cope with the crisis? (multi-select) <ul style="list-style-type: none"> - Temporarily reduced employment - Laid off employees - Loaned employees to other enterprises - Teleworking - Rescheduling of bank loans - Increased marketing efforts - Online sales - Customized / new products - Started sourcing from new suppliers - Filed for bankruptcy - Other

COVID-19 BUSINESS IMPACT SURVEY QUESTIONNAIRE (ENGLISH)

Q8. Please select the top three government measures that would be most helpful as you cope with the COVID-19 crisis.

- Employment programmes (i.e. temporary unemployment programmes or social security waivers)
- Financial programmes, such as low interest credit line or credit guarantees
- Tax waivers or temporary tax breaks
- Reduction of tariffs on imported inputs
- Rent subsidies
- Cash transfers
- Support to self-employed people
- Other

Q9. Please specify which other measure. (Open ended question)

Q10. How easy is it to access information and benefits from government COVID-related SME assistance programmes?

- Very easy
- Easy
- Standard
- Difficult
- Very difficult

Q11. How many full-time employees does the business have? (single select)

- 0
- 1-4
- 5-19
- 20-99
- 100-249
- 250 and more

Q12. What is the main sector of activity of the business? (single select)

- Agriculture
- Mining and natural resources
- Agri-food processing
- Non-food manufacturing
- Retail and wholesale
- Travel and transport
- Accommodation and food services
- Information technology
- Finance
- Other services

Q13. What is the gender of the top manager of the business? (single select)

- Female
- Male
- Don't know

Q14. What is the age of the top manager of the business?

- 34 years and younger
- 35 years of age and older
- Don't know

Q15. Is this establishment currently registered with or licenced by a national authority? (single select)

- Yes, registered business
- Freelancing/independent/consultant
- No, unregistered business
- Do not know

Q16. Does the business participate in international trade? (single select)

- No, we buy and sell within our country only
- We import but do not export
- We export but do not import
- We export and import

COVID-19 BUSINESS IMPACT SURVEY QUESTIONNAIRE (ENGLISH)

Q17. Please provide your email address if you would like to receive a copy of the report based on the responses to this survey and agree to be contacted by the International Trade Centre about future opportunities in your country. Your data will be kept confidential. (open-ended)

Country	Obs.	% in total	Country	Obs.	% in total	Country	Obs.	% in total
Afghanistan	5	0.11	Gambia	29	0.65	Pakistan	439	9.88
Albania	4	0.09	Georgia	2	0.04	Palestine	38	0.85
Algeria	7	0.16	Germany	7	0.16	Panama	8	0.18
Angola	1	0.02	Ghana	27	0.61	Paraguay	1	0.02
Anguilla	1	0.02	Greece	2	0.04	Peru	68	1.53
Argentina	7	0.16	Guatemala	17	0.38	Philippines	495	11.14
Armenia	1	0.02	Guinea	43	0.97	Poland	4	0.09
Australia	10	0.22	Haiti	1	0.02	Portugal	6	0.13
Austria	1	0.02	Honduras	5	0.11	Qatar	2	0.04
Azerbaijan	3	0.07	Hong Kong, China	1	0.02	Republic of Korea	9	0.2
Bangladesh	16	0.36	Hungary	5	0.11	Romania	3	0.07
Belarus	1	0.02	India	76	1.71	Russia	5	0.11
Belgium	3	0.07	Indonesia	20	0.45	Rwanda	8	0.18
Benin	61	1.37	Iran	11	0.25	Saint Lucia	6	0.13
Bhutan	42	0.94	Iraq	893	20.09	Samoa	1	0.02
Bolivia	10	0.22	Italy	20	0.45	Saudi Arabia	5	0.11
Bosnia and Herzegovina	2	0.04	Jamaica	4	0.09	Senegal	31	0.7
Botswana	11	0.25	Japan	5	0.11	Serbia	2	0.04
Brazil	43	0.97	Jordan	26	0.58	Sierra Leone	2	0.04
Burkina Faso	30	0.67	Kenya	70	1.57	Slovenia	4	0.09
Cambodia	286	6.43	Lao People's Democratic Republic	43	0.97	Somalia	6	0.13
Cameroon	16	0.36	Lebanon	2	0.04	South Africa	25	0.56
Canada	4	0.09	Liberia	2	0.04	Spain	25	0.56
Central African Republic	1	0.02	Lithuania	1	0.02	Sri Lanka	76	1.71
Chad	3	0.07	Madagascar	7	0.16	Sweden	1	0.02
Chile	2	0.04	Malaysia	5	0.11	Switzerland	7	0.16

China	169	3.8	Mali	7	0.16	Tanzania	10	0.22
Chinese Taipei	5	0.11	Malta	2	0.04	Thailand	6	0.13
Colombia	115	2.59	Mauritania	1	0.02	Togo	8	0.18
Comoros	1	0.02	Mauritius	3	0.07	Tunisia	12	0.27
Congo	6	0.13	Mexico	28	0.63	Turkey	97	2.18
Costa Rica	20	0.45	Moldova	3	0.07	Turkmenistan	1	0.02
Cote d'Ivoire	32	0.72	Mongolia	4	0.09	Uganda	31	0.7
Croatia	1	0.02	Morocco	27	0.61	Ukraine	5	0.11
Cuba	1	0.02	Mozambique	5	0.11	United Arab Emirates	10	0.22
Czech Republic	1	0.02	Myanmar	343	7.72	United Kingdom	15	0.34
Democratic Republic of Congo	5	0.11	Namibia	2	0.04	United States	12	0.27
Denmark	1	0.02	Nepal	36	0.81	Uruguay	3	0.07
Dominican Republic	4	0.09	Netherland Antilles	3	0.07	Uzbekistan	2	0.04
Ecuador	11	0.25	Netherlands	5	0.11	Venezuela	5	0.11
Egypt	28	0.63	New Zealand	3	0.07	Vietnam	10	0.22
El Salvador	12	0.27	Nicaragua	16	0.36	Zambia	17	0.38
Ethiopia	9	0.2	Niger	2	0.04	Zimbabwe	16	0.36
Fiji	2	0.04	Nigeria	89	2			
France	10	0.22	North Macedonia	1	0.02			

Table A5. Observations by country

Description of variables

Name	Description	Source
<i>Dependent variables</i>		
Difficulty accessing inputs	Respondents were asked, "Has the coronavirus (COVID-19) pandemic affected the ability to purchase inputs for your enterprise and/or sell outputs? " Constructed variable includes difficulty accessing domestic and foreign inputs	ITC COVID-19 Business Impact Survey
Reduced sales	Respondents were asked, "Has the coronavirus (COVID-19) pandemic affected the ability to purchase inputs for your enterprise and/or sell outputs? " Constructed variable includes difficulty selling to domestic and foreign consumers as well as to businesses	ITC COVID-19 Business Impact Survey

Reduced use of logistics services	Respondents were asked, "Has the coronavirus (COVID-19) pandemic affected your enterprise in any of the following ways?"	ITC COVID-19 Business Impact Survey
Reduced use of certification services	Respondents were asked, "Has the coronavirus (COVID-19) pandemic affected your enterprise in any of the following ways?"	ITC COVID-19 Business Impact Survey
Resilient	Respondents were asked, "Have you adopted any of the following strategies to cope with the crisis?". Constructed variable "Resilient" includes two mutually exclusive choices: "Retreat" and "Resilient". The baseline response is "Retreat". Categorizations: Retreat – chose on or more of the following options: filed for bankruptcy, laid off employees, other, or took no action. Resilient – chose one or more of the following options: temporarily reduced employment, loaned employees to other enterprises, teleworking, rescheduled bank loans, increased marketing efforts, online sales, customized/created new products, or sourcing from new suppliers. Respondents who adopted multiple coping mechanisms were classified as Retreating if at least one mechanism they used belonged to the "Retreat" category.	ITC COVID-19 Business Impact Survey
Laid off employees	Respondents were asked, "Have you adopted any of the following strategies to cope with the crisis?"	ITC COVID-19 Business Impact Survey
Filed for bankruptcy	Respondents were asked, "Have you adopted any of the following strategies to cope with the crisis?"	ITC COVID-19 Business Impact Survey
Telework	Respondents were asked, "Have you adopted any of the following strategies to cope with the crisis?"	ITC COVID-19 Business Impact Survey
<i>Independent variables</i>		
International	Respondents were asked, "Does the business participate in international trade?". The constructed variable is an indicator that equals 1 if business imports, exports, or both and 0 otherwise	ITC COVID-19 Business Impact Survey
Days since lockdown	Time from start of lockdown to survey response. Lockdown defined as government-mandated closure or work from home of all nonessential businesses. This variable is firm specific.	Oxford COVID-19 Government Response Tracker
<i>Controls</i>		
Sector	Respondents were asked, "What is the main sector of activity of the business?" Sector dummy variables include three categories: Primary, Services, and Manufacturing.	ITC COVID-19 Business Impact Survey
Size	Respondents were asked, "How many full-time employees does the business have?". Size dummies include four categories: Micro, Small, Medium-sized, and Large.	ITC COVID-19 Business Impact Survey
Country	Respondents were asked, "Which country is your company based in?"	ITC COVID-19 Business Impact Survey
<i>Weights</i>		
Population weight	Country's share of world population divided by number of establishments observed in that country.	UN World Population Projections and ITC COVID-19 Business Impact Survey
GDP weight	Country's share of world GDP divided by number of establishments observed in that country.	World Bank Databank and ITC COVID-19 Business Impact Survey

Table A6. Description of variables used in regressions

Household division of labor during two waves of COVID-19 in Italy¹

Daniela Del Boca,² Noemi Oggero,³ Paola Profeta⁴ and Maria Cristina Rossi⁵

Date submitted: 28 March 2021; Date accepted: 30 March 2021

Using survey data collected in November 2020 from a representative sample of Italian working women, we analyze the effects of the second wave of COVID-19 on working arrangements, housework and childcare. By comparing our results to findings from similar data collected in April 2020 on the same sample, we explore whether and how the intra-family allocation of work and household duties changed since the first wave of the pandemic. We find that the increased gender gap in the household division of labor during the first wave of COVID-19 pandemic persisted during the second wave. We show that the brunt of domestic chores and childcare remains on women even after accounting for different working arrangements. In fact, the amount of time women spend on housework, childcare, and home schooling is unaffected by their partners' working arrangements. By contrast, men contribute fewer hours to housework and home schooling when their partners are at home. Even when working-from-home and/or non-working men devote more hours to domestic activities, the additional time spent at home does not seem to lead to a reallocation of couples' roles in housework and childcare. Our empirical results also show that educational attainment plays a role and that women with higher levels of education express less concern about potential loss of earnings or pension coverage.

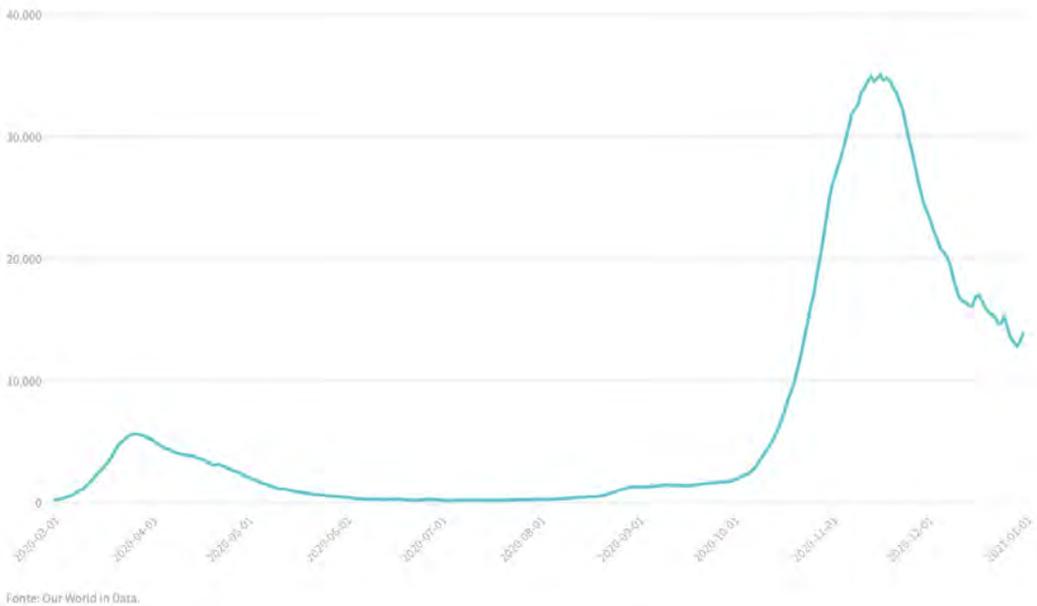
- 1 This research was supported by funding from Programma europeo REC – Rights, Equality and Citizenship (Grant Agreement number: 820763) and coordinated by the Dipartimento per le Pari Opportunità della Presidenza del Consiglio dei Ministri.
- 2 Professor, University of Turin and Collegio Carlo Alberto.
- 3 Assistant Professor, University of Turin and CeRP-Collegio Carlo Alberto.
- 4 Professor, Bocconi University and Axa Research Lab on Gender Equality, Dondena.
- 5 Professor, University of Turin and Collegio Carlo Alberto.

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1. Introduction

The current COVID-19 crisis has affected the lives of millions of people around the world, with detrimental effects on their economic, health and educational outcomes. Italy was the first European country to report coronavirus cases and still has one of the highest rates of infection and fatality. At the time of this writing, Italy has seen two main waves of the pandemic. The first was marked by school closures starting on February 25, 2020, and triggered a strict lockdown between March 9 and May 3 as the central government and regions raced to curb the spread of the virus. This was Europe’s toughest lockdown and longest closure of schools¹. The COVID-19 infection rate slowed significantly over the summer months, but surged again in October as a second wave of the virus spread rapidly throughout the country. The lack of restrictive measures had caused a significant increase in the infection rate and by mid-November, 2020, the number of reported cases was six times higher than in first wave. Graph 1 shows the difference between the two waves.

Graph 1. Number of COVID-19 cases (New cases, daily)



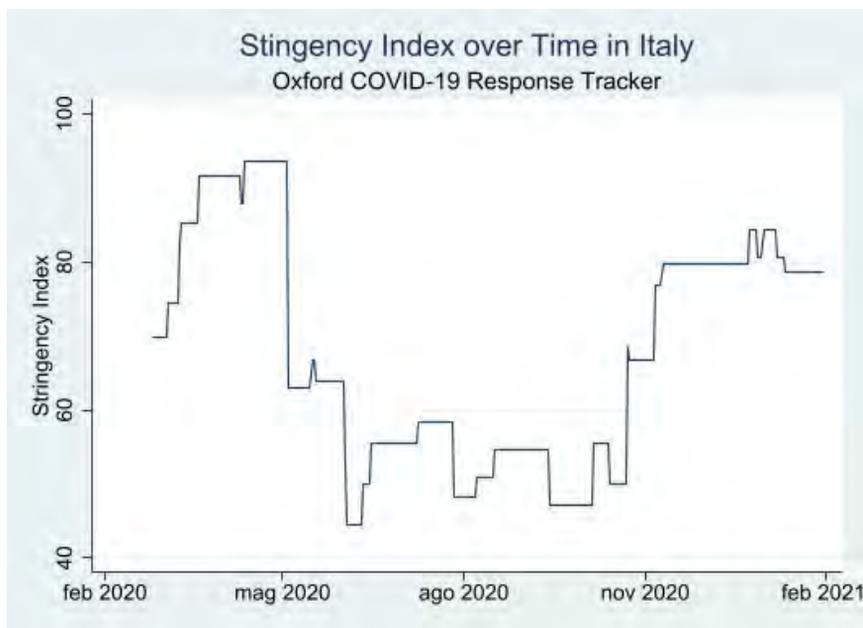
Source: World data Oxford Martin Oxford.

Less stringent measures were implemented during the second wave in an attempt to reduce the spread of the growing epidemic.

CovidEconomics 75, 7 April 2021: 60-80

As Graph 2 shows, the measures adopted during the first phase of the pandemic were much stricter relatively to the second. The nine metrics used to calculate the Stringency Index are: school closures; workplace closures; cancellation of public events; restrictions on public gatherings; closures of public transport; stay-at-home requirements; public information campaigns; restrictions on internal movements; and international travel controls (World in Data Oxford Martin, Oxford).

Graph 2. Stringency Index over time in Italy.



Source: Oxford Coronavirus Government Response Tracker (OxCGRT).

Social distancing measures adopted by most governments to fight the spread of the virus, especially those of remote work and school closures, have placed an additional burden on families. Several recent studies have investigated the consequences of the COVID-19 outbreak on female and male employment, and a few others have focused on its immediate effects on family work, and particularly on housework and childcare.

In our previous work (Del Boca et al., 2020), we used representative data collected during the first wave of the epidemic, i.e., April 2020, to show that most of the additional housework and childcare associated to COVID-19 fell on women, even though childcare activities were more equally shared within the couple than domestic chores. In this paper, we investigate how and to what extent family roles have changed in comparison to the first wave and to pre-COVID times.

In addition to analyzing the consequences of the first phase of COVID-19 on working arrangements, housework and childcare, we extend the time horizon of the study by investigating the new intra-family division of work and family work during the second wave of the pandemic (November 2020).

Our goal is to explore the link between different working arrangements and the household division of labor and understand whether family roles have changed compared to the first wave and pre-COVID times.

First, we evaluate whether the measures adopted in the second wave had a milder impact on working arrangements than the first wave, as expected, and whether the impact was greater on women. Then we investigate the effects of working arrangements due to COVID-19 on the number of hours spent on housework and childcare by women and their partners, as we hypothesize different impacts on the division of labor within the household depending on the working arrangements of women and their partners. In particular, we study whether the impact of COVID-19 on the household division of labor is related to the amount of time women and their partners have to spend at home due to the emergency restrictions. We also explore the determinants of women's feelings of economic insecurity regarding several dimensions: loss of earnings, job insecurity, investments and their expected levels of future pensions. Our results show that educational attainment is important and more relevant than having a partner in reducing women's feeling of insecurity.

2. The literature

Evidence from past economic crises suggests that recessions often affect men's and women's employment differently and that they have a greater negative effect on men (Rubery and Rafferty, 2013; Hoynes, Miller and Schaller, 2012). The 2008 financial crisis, for instance, led to much greater job losses in male-dominated sectors of the economy (notably construction and manufacturing), while women's working hours actually increased. As reported in recent studies (Hupkau and Petrongolo, 2020; Alon et al., 2020), the current recession is instead likely to have a similar impact on male and female employment, since the social measures implemented have affected sectors where both genders are employed (ILO, 2020). However, across much of the Western world, the economic shock from the pandemic has hit women even harder than men, as many of the jobs lost have been in service sectors with large female workforces, such as retail, restaurants and hospitality.

The current COVID-19 crisis is not just an economic crisis, but also a health and social one. The labor market is just one dimension of human work, and COVID-19 is also likely to have major

consequences on domestic work, due to the increase in housework and childcare demands resulting from the closing of schools and nurseries. Many working mothers are struggling to make it work, because of the need for at least one parent to stay home and mind the children (Queisser, Adema and Clarke, 2020). Preliminary evidence from Spain (Farré and Gonzalez, 2020), the UK (Sevilla and Smith, 2020), and Italy (Del Boca et al., 2020 and Mangiavacchi et al., 2020) shows that there was an initial shift towards a more equal distribution of household and childcare tasks between men and women during the first months of the pandemic, even though most of the extra work caused by the crisis fell to women. A comparative analysis of a novel data set including Italy, the UK, and the USA confirms these results (Biroli et al., 2020). D'Ambrosio et al. (2020) collected and analyzed a new data set of 1,700 cohabiting partners during 2020ⁱⁱ to compare the impact of COVID-19 and the severity of measures adopted on the time allocation and well-being of couples in several European countries including Italy, Spain, France, Belgium, Germany, Luxembourg and Sweden. They found that in Italy, because of the longer school closures, the increase in women's childcare time has been much higher than in Spain or Germany, where the adopted measures did not appear to have exacerbated the gender gap within the family.

The disaggregation of household activities shows that, when both partners share more housework as a consequence of COVID-19, there are differences in tasks. Carlson et al. (2020) report that in terms of housework activities, men in the US contribute more to grocery shopping, and in terms of childcare activities, men spend more time playing with the children, while women are more involved in supervising their schooling.

In the long run, the stringent measures adopted impose large economic costs by curtailing labor demand as well as supply. Albanesi and King (2021) analyzed the US data during and after the pandemic and concluded that the adverse impact of the pandemic on employment, unemployment and non-participation rates has mostly impacted women, particularly mothers. Both labor demand factors, such women's disproportionate representation in service occupations most vulnerable to the pandemic, and labor supply factors, like closures of childcare centers and in-person schools, have contributed to this outcome. Béland et al. (2020) and Gupta et al. (2020) analyze the US case and show that significant short-term employment effects characterize states that implemented stricter stay-at-home orders. On the other hand, the length of school closures over time is also likely to negatively affect the labor supply of mothers and fathers. Amuedo Dorantes et al. (2020) show that school closures have reduced the number of weekly working hours more significantly among mothers.

In this paper, we focus on Italy, which provides an important context for this analysis. In fact, Italy has traditionally been characterized by a large gender gap both in the labor market and within the family.ⁱⁱⁱ This situation has been exacerbated by the pandemic. In 2020, female labor participation rates have declined from 50% to 48.6% (vs. an average of 62% in the rest of the European Union). Moreover, the number of inactive women has increased dramatically: three out of four women in Italy do not participate in the labor market.

Our contribution to the existing literature is related to the novelty of our data set which allows comparison of women's and their partners' contribution to the labor market, to housework, and to childcare during the first two waves of the COVID-19 pandemic in Italy.

3. Data and descriptive statistics

In this paper, we analyze data collected in November 2020, i.e., during the second wave of COVID-19 in Italy, from a representative sample of Italian women who were in employment before the COVID-19 outbreak.^{iv} We then compare our results to findings from similar data collected in April 2020, during the first wave.

Our sample is made up of 699 Italian women who were working before the COVID-19 emergency, and Table 1 reports the descriptive statistics. The average age in our sample is 45 and almost half (46%) of respondents have a university degree. More than half (55%) of those interviewed live in the northern regions, with 55% of them living with their children, and 72% with a partner.

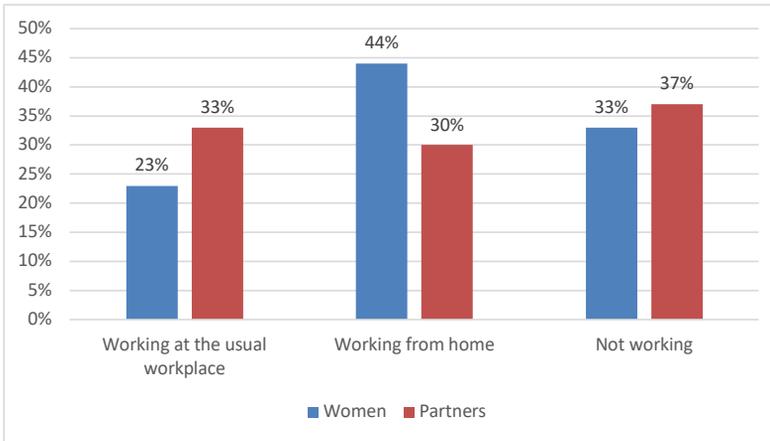
Table 1. Descriptive statistics.

	<i>Mean</i>	<i>Std. Dev.</i>	<i>Min</i>	<i>Max</i>
Age	44.96	9.50	26	65
Has a college degree	0.46	0.50	0	1
North	0.55	0.50	0	1
Center	0.20	0.40	0	1
South	0.25	0.43	0	1
Has children	0.55	0.50	0	1
Has a partner	0.72	0.45	0	1
Working at the usual workplace	0.58	0.49	0	1
Working from home	0.24	0.43	0	1
Not working or other	0.18	0.38	0	1

Note: The sample is made up of 699 observations.

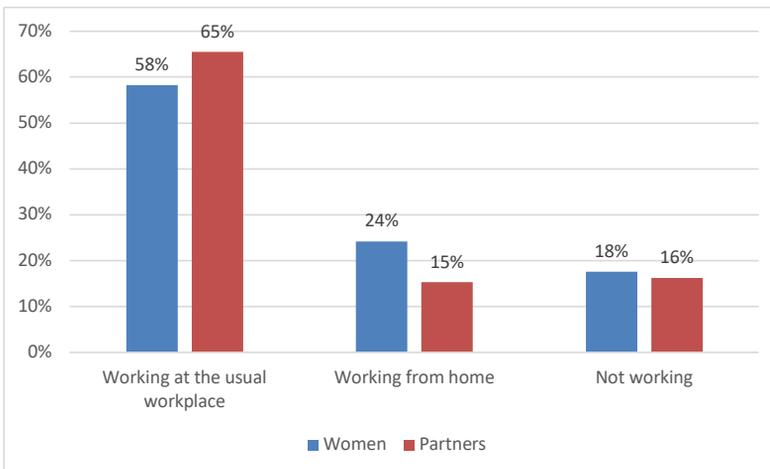
Looking at working arrangements, we notice that the majority (58%) of women who had jobs before the COVID-19 emergency are working at their usual workplace during the second wave of the pandemic. However, almost one fourth (24%) are working from home and 18% of them are not working at all.^v These percentages are different from those found in the data collected in April 2020, during the first wave of COVID-19. In Figure 1 and Figure 2 we show the working arrangements of women and their partners during the first and the second waves, respectively.

Figure 1. Working arrangements during the first wave of COVID-19.



Note: Percentage of working women and their partners by working arrangement in April 2020.

Figure 2. Working arrangements during the second wave of COVID-19.

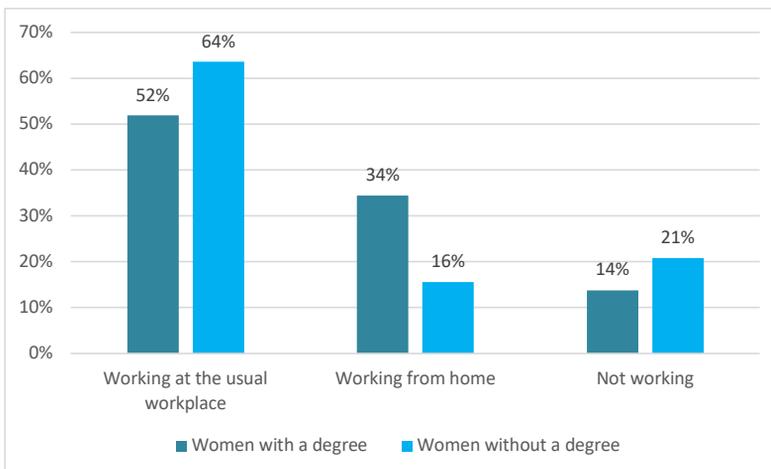


Note: Percentage of working women and their partners by working arrangement in November 2020.

As a consequence of less restrictive measures implemented in the second wave, many more individuals are working at their usual place in November 2020. However, the share of individuals either working from home or not working 9 months after the outbreak of COVID-19 is much lower compared to the very first months of the pandemic. In terms of gender differences, while the proportion of individuals not working was higher among men in the first wave (37% of men vs. 33% of women), this is not the case in the second wave (16% of men vs. 18% of women). As in the previous wave, more men remained at their usual workplace than women in November 2020 (65% of men vs. 58% of women), while more women worked from home (24% of women vs. 15% of their partners).

Since the consequences of COVID-19 on working arrangements may differ significantly according to educational attainment, in Figure 3 we disaggregate women between those who have a university degree and those who do not. It appears that women without a degree are more likely to continue working at their usual workplace, which may be due to the fact that they are more likely to be employed in jobs that can be only done in person, such as cashiers, waitresses, hairdressers, beauticians, etc. Conversely, the opposite holds for women with higher levels of education, who are twice as likely to work from home (34% vs. 16%), since they are likely employed in sectors that allow telecommuting (school, offices etc.). A higher number of women with lower levels of education are still not working during the second wave of COVID-19 (21% vs. 14%). This is consistent with the fact that these women are more likely to work in jobs with more limited labor protections.

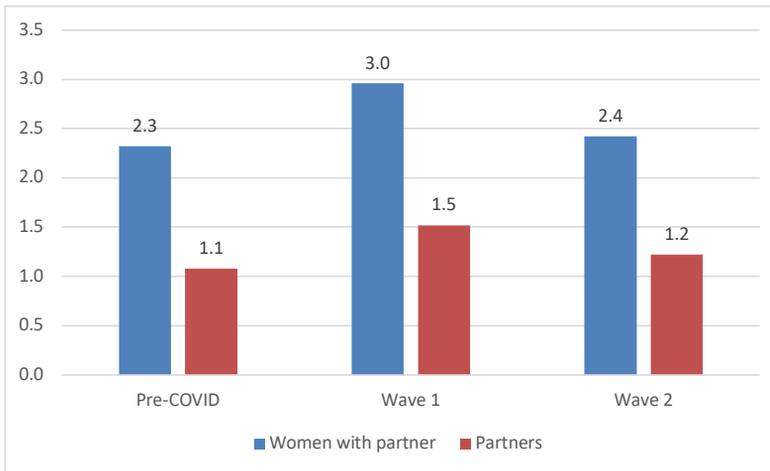
Figure 3. Working arrangements during the second wave of COVID-19 by educational status.



Note: Percentage of working women by working arrangement and educational status in November 2020.

Not only has COVID-19 affected working arrangements in the labor market, but it has also had major consequences on family work. Figure 4 shows the distribution of the daily hours of housework^{vi} spent by working women and their partners before the emergency during the first and second waves of COVID-19. While the women and their partners both dedicate less time to housework during the second wave than in the first, women always spend more time than men on household chores (Figure 4).

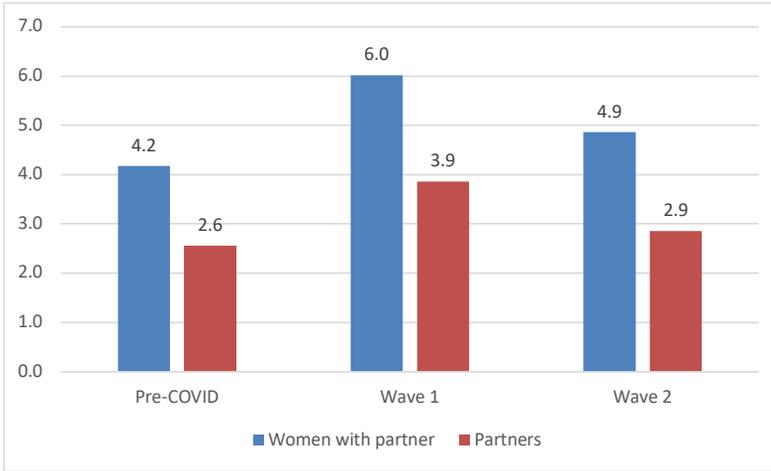
Figure 4. Hours of housework before the emergency, during the first wave, and during the second wave of COVID-19.



Note: The sample is made up women cohabiting with a partner.

A similar trend emerges for childcare when comparing the number of hours spent before the emergency, during the first and the second waves of COVID-19. Figures 5 and 6 show the daily hours devoted to childcare, and home schooling in particular, by working women and their partners. Our data show that both women and men spend less time taking care of their children during wave 2 than during wave 1. Women spend many more hours per day on childcare, and the gap not only increased during the emergency (from 1.6 to 2.2 hours per day), but never returned to pre-COVID levels. During the second wave, mothers spend an average of two more hours than fathers taking care of their children. In other words, the gap in domestic activities widened during the first wave of the COVID-19 pandemic and has persisted during the second wave, notwithstanding the milder containment measures implemented.

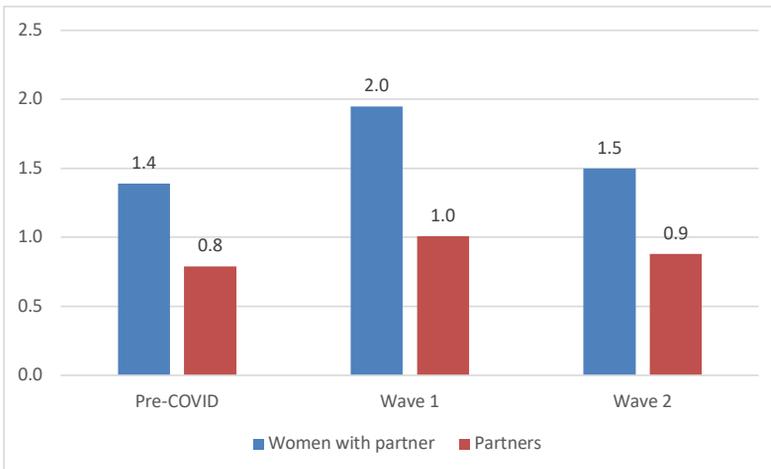
Figure 5. Hours of childcare before the emergency, during the first wave, and during the second wave of COVID-19.



Note: The sample is made up of women with children cohabiting with a partner.

Figure 6 shows the hours dedicated to childcare by both partners and confirms the trend observed for housework. Women and their partners dedicate less time to the education of their children during the second wave than during the first, but women still spend more time than men on home schooling. In fact, as of November 2020, women spend an hour and a half per day on home schooling, while their partners spend less than one hour, confirming previous results (Carlson 2020).

Figure 6. Hours of home schooling before the emergency, during the first wave, and during the second wave of COVID-19



Note: The sample is made up of women with children cohabiting with a partner.

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4. Empirical analysis

In the previous section, we provided an overview of how the second wave of COVID-19 affected the working arrangements and family workload of working women and their partners, comparing the results to the pre-COVID period and the early months of the pandemic. Now we turn to the question of how the intra-family equilibrium of work and household work changed over the longer term by analyzing the amount of time women and men spent on housework and childcare in relation to their working arrangements. In Table 2, we show the hours of housework and childcare during the second wave of COVID-19 according to all the possible combinations of working arrangements between women and their partners.

The first panel of Table 2 shows that women do a disproportionate amount of the housework, spending significantly more hours on unpaid domestic work than their partners in almost all possible combinations of working arrangements. The biggest discrepancy (1.81 hours) occurs when men keep working at the usual place while women work from home. However, in the reverse scenario, where women keep working at the usual place and men work from home, women still devote more time to housework than men (2.92 vs. 1.40 hours per day). Even in symmetric situations, i.e., when working arrangements are the same for both partners, the bulk of household chores is borne by women. The second panel of Table 2 reports similar findings for childcare. In 6 out of 9 combinations of working arrangements between women and their partners, women spend significantly more time taking care of their children. The largest differences in time devoted to childcare are reported when men keep working at the usual place while women work from home or do not work. In contrast, men never spend significantly more time on childcare than their spouses. In symmetric situations, women still shoulder the burden. In fact, when both partners work at their usual workplace, women spend on average 1.41 more hours on childcare, or up to 1.83 more hours when both partners work from home.

Table 2. Hours of housework and childcare during the second wave of COVID-19.

Panel a) Men and women's hours of housework during the second wave of COVID-19 by working arrangement.

	Partners working at the usual workplace	Partners working from home	Partners not working
Women working at the usual workplace	Women 2.31 Partners 1.17 Difference 1.14*** N=241	Women 2.92 Partners 1.40 Difference 1.52*** N=25	Women 2.35 Partners 1.52 Difference 0.84** N=31
Women working from home	Women 2.56 Partners 0.75 Difference 1.81*** N=57	Women 2.82 Partners 1.43 Difference 1.39*** N=44	Women 1.91 Partners 1.30 Difference 0.61** N=23
Women not working	Women 2.53 Partners 1.04 Difference 1.49*** N=47	Women 1 Partners 3.37 Difference -2.37 N=8	Women 2.68 Partners 1.43 Difference 1.25*** N=28

Note: The sample is made up of women cohabiting with a partner (N=504).

Panel b) Men and women's hours of childcare during the second wave of COVID-19 by working arrangement.

	Partners working at the usual workplace	Partners working from home	Partners not working
Women working at the usual workplace	Women 3.59 Partners 2.18 Difference 1.41*** N=162	Women 4.56 Partners 3.44 Difference 1.12** N=16	Women 3,3 Partners 3,4 Difference -0,1 N=20
Women working from home	Women 5.85 Partners 2.92 Difference 2.92*** N=39	Women 5.86 Partners 4.03 Difference 1.83*** N=29	Women 5 Partners 4.46 Difference 0.54 N=13
Women not working	Women 8.90 Partners 2.86 Difference 6.03*** N=29	Women 13.2 Partners 6.4 Difference 6.8 N=5	Women 5.58 Partners 3.63 Difference 0.98* N=19

Note: The sample is made up of women with children cohabiting with a partner (N=332).

4.1 Household allocation of time

To better understand what determines the amount of time partners spend on domestic responsibilities, we now estimate a set of multivariate regressions using linear probability models. In Tables 3 and 4 we show the individual and family characteristics associated with the hours spent by working women and their partners on housework, childcare and home schooling.

Table 3. Multivariate regression model of hours spent on housework by women and their partners during the second wave of COVID-19.

	(1) Hours spent on housework by women	(2) Hours spent on housework by partners
Woman's age	0.009 (0.008)	-0.022*** (0.008)
Woman having a degree	-0.125 (0.155)	-0.042 (0.156)
Woman having children	0.444*** (0.155)	0.173 (0.156)
Centre	-0.015 (0.196)	0.158 (0.198)
South	0.899*** (0.177)	0.294* (0.178)
Woman working from home	0.070 (0.189)	-0.363* (0.191)
Woman not working	0.125 (0.210)	0.013 (0.212)
Partner working from home	0.288 (0.221)	0.697*** (0.223)
Partner not working	-0.190 (0.213)	0.467** (0.215)
Constant	1.497*** (0.397)	1.928*** (0.401)
Observations	504	504
R-squared	0.082	0.045

Note: Coefficient estimates from OLS regressions. The sample is made up of women cohabiting with a partner. The baseline category for working arrangements is "working at the usual workplace." The average time spent by women on housework is 2.42 hours and the average spent on housework by men is 1.22. Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

The empirical results reported in Table 3 show that women spend time on housework no matter what their working arrangement; this contrasts with what we observed in the first wave of COVID-19, when women working at their usual workplace were less likely to do housework (Del Boca et al., 2020). Having children and living in the South of Italy increase women's probability of working more hours by approximately 1.3 hours. The driver of the extra time spent on domestic chores thus seems to be more culturally rooted than ruled by working necessity. The asymmetry between partners' genders can be seen by comparing the two columns in Table 3, which shows that working arrangements do affect the amount of time members of a couple spend on housework. The second column of Table 3 shows that men spend more hours on housework if they are working from home or not working. Also, while women's housework is not affected by their partners' working arrangement, it seems that men are less likely to spend time on household tasks when their partners

are working from home. Finally, while in the first column we notice that women spend more time on housework when there are children in the household, this does not hold true for men.

Instead, the amount of time each partner devoted to childcare was more similar. As can be seen in the first two columns in Table 4, there is a symmetric effect on children's care when one of the partners is absent from home. Both fathers and mothers spend more time with their children if they work from home or do not work. Working-from-home mothers devote 1.6 more hours to the care of their children than mothers not at home and working-from-home fathers devote 1.30 more hours to the care of their children than fathers not at home. Also, non-working mothers spend almost 4 more hours on childcare than women who keep working at their regular workplace, and non-working fathers spend an hour and half more on childcare than men who keep working at their regular workplace.^{vii}

As for home schooling (the last two columns in Table 4), the working arrangements of either member in the couple have no effect on how many hours the woman devotes to her children. Men, instead, seem to "take advantage" of their partner staying home and spend approximately half an hour less on helping their children with schoolwork if their partner works from home or does not work at all. Column 4 in Table 4 focuses specifically on the home-schooling component of childcare and shows that men spend more hours assisting with home schooling when they are not working (last column of Table 4). In contrast with the previous wave, the educational attainment of the mother is not a significant predictor of childcare.

Table 4. Multivariate regression model of hours spent on childcare and home schooling by women and their partners during the second wave of COVID-19.

	(1)	(2)	(3)	(4)
	Hours spent on childcare by women	Hours spent on childcare by partners	Hours spent on home schooling by women	Hours spent on home schooling by partners
Woman's age	-0.205*** (0.032)	-0.128*** (0.025)	-0.051*** (0.012)	-0.040*** (0.010)
Woman having a degree	0.560 (0.568)	0.451 (0.452)	0.068 (0.205)	0.167 (0.173)
Centre	-0.301 (0.727)	-0.537 (0.579)	-0.188 (0.263)	-0.133 (0.221)
South	0.937 (0.643)	0.919* (0.512)	0.315 (0.232)	0.083 (0.196)
Woman working from home	1.601** (0.696)	0.437 (0.554)	-0.157 (0.252)	-0.356* (0.212)
Woman not working	3.951*** (0.793)	0.215 (0.631)	0.041 (0.287)	-0.425* (0.241)
Partner working from home	0.685 (0.824)	1.262* (0.656)	0.344 (0.298)	0.394 (0.251)
Partner not working	-0.616 (0.792)	1.558** (0.630)	0.314 (0.286)	0.535** (0.241)
Constant	12.692*** (1.546)	7.747*** (1.231)	3.673*** (0.559)	2.637*** (0.471)
Observations	332	332	332	332
R-squared	0.216	0.122	0.072	0.071

Note: Coefficient estimates from OLS regressions. The sample is made up of women with children cohabiting with a partner. The baseline category for working arrangements is "working at the usual workplace." Home schooling is included in childcare. The average hours spent on childcare by women are 4.86 and the average hours spent on childcare by men are 2.86; the average hours spent on home schooling by women are 1.50 and the average hours spent on home schooling by men are 0.88. Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

To conclude, we found that the amount of time spent on housework, childcare, and home schooling by women does not depend on their partners' working arrangements. Instead, men devote less time to housework and home schooling when their spouses are at home. Hence, the extra family work due to COVID-19 is a burden mainly borne by women, regardless of the time men spend at home. Even though working-from-home and non-working fathers spend more hours on family work, the increased time spent at home does not seem to lead to a reallocation of couples' roles in housework chores and childcare. Thus, our results do not support the hypothesis of a potential change in the role of partners as a consequence of the pandemic.

4.2 Women's Work, Housework and Feelings of Insecurity

Lastly, we analyze women's feelings of economic insecurity about expected future outcomes. As other studies have shown, COVID-19 has not only impacted labor markets, housework and childcare, but also emotions and feelings of anxiety. D'Ambrosio et al. (2020) compared several countries during 2020 and found that women are more likely than men to have experienced increased anxiety and fear after the onset of the pandemic. In order to analyze these aspects, in Table 5 we use as dependent variables four dummies indicating whether the respondent reported that she is concerned (1) about losing her job/closing her business, (2) about earning less money, (3) that the return on her investments will decrease, (4) that she will have a lower pension when retired, given potential gaps in employment. Women not working during the second wave of COVID-19 are those most concerned about losing their jobs, closing their businesses, or earning less money in the future. However, women with higher levels of education feel less insecure about their future, meaning that they are in a better position to cope with the current and future situation.

Table 5. Multivariate regression model of being concerned about the future during the second wave of COVID-19.

	(1) Job loss	(2) Earning less money	(3) Lower return on investments	(4) Lower pension levels
Woman's age	-0.007*** (0.002)	-0.005*** (0.002)	-0.000 (0.002)	-0.000 (0.002)
Woman having a degree	-0.100** (0.039)	-0.078** (0.037)	0.026 (0.039)	-0.078** (0.037)
Woman having a partner	0.032 (0.044)	-0.052 (0.042)	-0.029 (0.044)	-0.074* (0.043)
Women having children	-0.005 (0.040)	0.041 (0.038)	0.052 (0.040)	0.069* (0.039)
Center	0.005 (0.049)	-0.044 (0.046)	-0.070 (0.049)	-0.055 (0.047)
South	0.053 (0.045)	0.082* (0.042)	0.016 (0.045)	0.014 (0.043)
Woman working from home	-0.031 (0.046)	-0.030 (0.043)	0.010 (0.046)	-0.032 (0.044)
Woman not working	0.213*** (0.050)	0.109** (0.047)	0.042 (0.051)	0.064 (0.049)
Constant	0.747*** (0.102)	0.932*** (0.096)	0.591*** (0.102)	0.722*** (0.098)
Observations	699	699	699	699
R-squared	0.058	0.037	0.008	0.022

Note: Coefficient estimates from OLS regressions. The baseline category for working arrangements is "working at the usual workplace." Mean values of the dependent variables from column (1) to (4) are 0.47, 0.68, 0.60, and 0.66, respectively. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

We also investigate how working arrangements, together with other individual characteristics, affect women's dissatisfaction with their current situation. In Table 6, we use as dependent variables four dummies indicating whether the respondent reported that she is currently dissatisfied with her household income, health status, partner, or life in general. The results show that women not working several months after the outbreak of COVID-19 are more likely to feel dissatisfaction in all of the above-mentioned areas. Once again, women with higher levels of education (university graduates) are less likely to be dissatisfied with their income and life in general.

Table 6. Multivariate regression model of being dissatisfied during the second wave of COVID-19.

	(1) Dissatisfied with household income	(2) Dissatisfied with health status	(3) Dissatisfied about the partner	(4) Dissatisfied about life in general
Woman's age	0.002 (0.002)	0.002 (0.002)	0.003* (0.002)	0.001 (0.002)
Woman having a degree	-0.109*** (0.039)	-0.006 (0.031)	-0.042 (0.035)	-0.097*** (0.036)
Woman having a partner	-0.089** (0.044)	-0.035 (0.036)		-0.161*** (0.041)
Women having children	0.015 (0.040)	0.005 (0.033)	0.048 (0.035)	-0.051 (0.037)
Center	0.101** (0.048)	0.037 (0.039)	0.004 (0.045)	0.053 (0.045)
South	0.074* (0.044)	0.026 (0.036)	-0.013 (0.040)	0.043 (0.041)
Woman working from home	-0.096** (0.046)	-0.026 (0.037)	0.064 (0.041)	0.008 (0.042)
Woman not working	0.178*** (0.050)	0.073* (0.041)	0.107** (0.047)	0.161*** (0.046)
Constant	0.436*** (0.102)	0.118 (0.083)	-0.026 (0.091)	0.417*** (0.094)
Observations	699	699	504	699
R-squared	0.064	0.012	0.025	0.066

Note: Coefficient estimates from OLS regressions. The baseline category for working arrangements is "working at the usual workplace." Mean values of the dependent variables from column (1) to (4) are 0.47, 0.19, 0.17, and 0.31, respectively. Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

5. Concluding Remarks

In our previous work (Del Boca et al., 2020), we examined the consequences that the first wave of COVID-19 and the lockdown adopted by the Italian government had on working arrangements, housework and childcare. In this paper, we use data from a new survey administered in November

2020 to analyze the new intra-family allocation of work and the household division of labor during the second wave, and compare it with the first.

As discussed in the introduction, despite the expanding spread of the virus, the measures adopted in the second wave of COVID-19 were less restrictive than during the first wave and therefore had less of an impact on working arrangements. Nonetheless, the second wave had a significant impact on household allocation of time. Even though both women and their partners spent less time on housework during the second wave than the first, women continued to spend more time than men on housework and childcare.

The discrepancy in the number of hours spent by women and men on childcare not only widened during the emergency but continues to persist, with women spending an average of 2 more hours per day than men, a greater difference than in pre-COVID times. Hence, the gap in household care related activities, which was exacerbated by the outbreak of the COVID pandemic, shows no sign of closing, despite the introduction of milder containment measures during the second wave.

We found that the household division of labor is highly skewed against women even after accounting for different working arrangements. Our data shows that the time spent on housework, childcare, and home schooling by women does not depend on their partners' working arrangements. Instead, men devote less time to housework and home schooling when their spouses are at home. Hence, the extra family work due to COVID-19 is a burden mainly borne by women, regardless of the time men spend at home. Even if working-from-home and non-working fathers spend more hours on family work, the increased time spent at home does not seem to lead to a reallocation of couples' roles in housework and family care. Thus, our results do not support the hypothesis of a potential change in the role of partners within the household after the pandemic. The growth in the burden of housework and childcare on working women after several months of COVID 19 due to the restrictive measures and school closures are likely to have negative impact not only on women's employment rates but also on their labor supply. In fact, non-participation rates have increased more significantly among women than among men.

COVID-19 is therefore having a long-lasting impact on women. All the dynamics highlighted above, and particularly the increased insecurity for women in the labor market and the rise in female inactivity, may be widening the gender pension gap too.

From a policy perspective it is also important to stress that the COVID-19 pandemic is substantially affecting subjective well-being, with women being increasingly concerned about losing their jobs, having to close their businesses, and earning less money in the future. However, women with higher

levels of education are less concerned about future outcomes than their less educated counterparts, exacerbating the gap of satisfaction related to higher standards of living.

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ⁱ From March to May 2020, Italian school closures lasted 103 days as opposed to an average of about 50-55 days in other European countries.

ⁱⁱ <https://humanities.uni.lu/virtual-faculty/how-do-different-confinement-measures-affect-people-across-europe>

ⁱⁱⁱ The Harmonised European Time Use Survey statistics (HETUS) data shows that there are particular patterns of how women and men use their time: women are, on average, more involved in household and care activities than men. Women perform more food management, cleaning, ironing and laundry tasks, while men are more involved in construction and gardening. While men and women both participate in childcare, it seems that women are relatively more involved in physical care, supervision and accompanying their children, while men seem to participate relatively more in teaching, playing and talking with their children https://ec.europa.eu/eurostat/statistics-explained/index.php?title=How_do_women_and_men_use_their_time_-_statistics&oldid=463738

^{iv} The survey was administered by Episteme, a professional survey company, with CAWI (computer-assisted web interviewing) interviews in November 2020. For additional information on the survey, also see Del Boca et al. (2020). In particular we started from a national representative sample of 1,249 working women (aged 25-64) in Italy who were surveyed in April 2019, July 2019, March 2020 and November 2020.

^v “Not working” includes being on paid or unpaid leave, on payroll subsidies, fired, resigned, retired, or other.

^{vi} The question about housework includes examples, e.g., cleaning and cooking.

^{vii} Mangiavacchi et al. (2020) report that the contribution of fathers to childcare and home schooling affects children’s outcomes in a positive and significant way. This is a very important result, especially during a period of school closures in which children’s educational outcomes are reduced and inequality among children is growing (Moroni et al., 2020).

How fast must vaccination campaigns proceed in order to beat rising Covid-19 infection numbers?¹

Claudius Gros² and Daniel Gros³

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We derive an analytic expression describing how health costs and death counts of the Covid-19 pandemic change over time as vaccination proceeds. Meanwhile, the disease may continue to spread exponentially unless checked by Non Pharmacological Interventions (NPI). The key factors are that the mortality risk from a Covid-19 infection increases exponentially with age and that the sizes of age cohorts decrease linearly at the top of the population pyramid. Taking these factors into account, we derive an expression for a critical threshold, which determines the minimal speed a vaccination campaign needs to have in order to be able to keep fatalities from rising. Younger countries with fast vaccination campaigns find it substantially easier to reach this threshold than countries with aged population and slower vaccination. We find that for EU countries it will take some time to reach this threshold, given that the new, now dominant, mutations, have a significantly higher infection rate. The urgency of accelerating vaccination is increased by early evidence that the new strains also have a higher mortality risk. We also find that protecting the over 60 years old, which constitute one quarter of the EU population, would reduce the loss of live by 95 percent.

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- 2 Professor, Institute for Theoretical Physics, Goethe University Frankfurt.
- 3 Distinguished Fellow, (Centre for European Policy Studies (CEPS).

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1 Introduction

After a first and second wave, Europe faces in the spring of 2021 a rapidly spreading third Covid-19 outbreak. There is an ongoing race between mass scale vaccination campaigns and the disease, which continues to evolve and to spread [2]. The emergence of a new and more infectious strand [3] means that strict containment measures need to be put in place to prevent exponential growth of cases, hospitalizations and fatalities. At the same time, vaccines have become available, with vaccination campaigns protecting a growing proportion of the population, slowing and eventually also stopping the spread of the SARS-CoV-2 virus [4]. The ultimate aim is 'herd' or population immunity, when a high enough percentage of the population has developed immunity through infection or vaccination.

However, vaccination takes time, mostly due to the limited availability of the vaccine, in part also due to bottlenecks in distribution and implementation. In this respect we point out that the production of SARS-CoV-2 vaccines is observed to increase approximately linearly with time and that this observation is in line with the prediction that firms processing batch orders minimize their adjustment costs when ramping-up production linearly [5].

For policy makers, a core question is whether it may be possible to lift NPIs at least partially already comparatively early in the vaccination campaign. To this respect we concentrate here not on the number of infections, but on the medical costs, which we take to be proportional to the number of lives at risk. The number of fatalities and hospitalizations for Covid-19 tend to be highly correlated. Moreover, the number of Covid-19 related fatalities constitute a key determinant for the imposition of lock-downs and other NPIs which come with severe economic and social cost in terms of lost output and employment.

The central issue for policy makers today, especially in Europe, is at what point the vaccination campaign has acquired sufficient speed to overcome the increase in infections, which occur in many countries despite partial lock-downs.

To determine this, three factors need to be taken into account:

- The age-dependency of the case fatality rate, which has been established to increase approximately exponentially with age [6].
- The population structure for the elderly, which is to first order linear at the top, which means that the size of age cohorts increases gradually top-down from the maximum age (about 100 years).
- The functional dependency of daily vaccinations rates, which are observed to increase in most countries approximately linearly over time. Modulo organizational problems and reserves for the second jab, vaccination rates are determined in the end by the availability of vaccines.

These three building blocks, which constitute the foundations of our analysis, are laid out separately below.

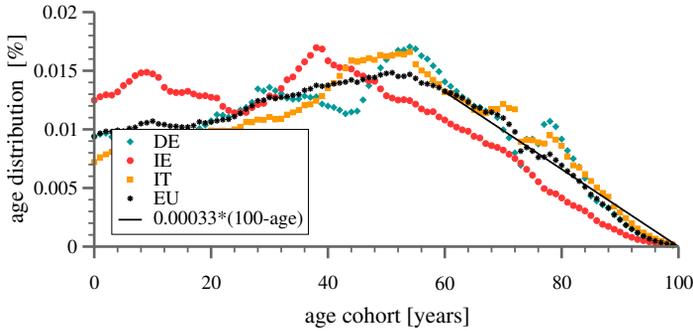


Figure 1: **Age distribution of selected EU countries.** Fractional age cohorts for Germany (DE), Ireland (IE), Italy (IT) and EU27 (EU). Also shown is a linear interpolation for the EU data (black line), for ages 60 and above. Data from [7].

2 Modeling framework

2.1 Age-dependency of the mortality risk

It has been widely documented that the risk to die from a Covid-19 infection raises strongly with age. A meta-study suggests an exponential relationship [6], which can be parameterized as

$$IFR \approx 0.01e^{-7.529+0.121*a} \sim e^{a/a_0} \quad a_0 = 8.26 \quad (1)$$

where $a \in [0, 100]$ is the age cohort. The infection fatality rate $IFR \in [0, 1]$ is very high for $a = 100$, namely $IFR(100) = 0.93$.

The constant a_0 denotes the half live age difference in terms of mortality. To be more precise, for an age difference of 8.26 years the risk increases by a factor of 2.78 ($= \ln(1)$). The risk doubles for an age difference of 5.7 years.¹

2.2 Age pyramid

The age pyramid for a range of selected countries is presented in Fig. 1, where the age cohorts are given in percentage, viz relative to the entire population. One notices that the age pyramid closes quadratically at the top. The relevant range for the quadratic dependency is however somewhat restricted, applying only for ages about 85 and above.

Most Covid-19 vaccination campaigns currently in place follow, to a varying extend, top-down strategies [9]. In order to quantify the impact on expected

¹Statistics from the CDC of the US show that the over 85 years old have a Covid mortality rate 7900 times higher than that of the 5-17 years old. This translates also into a doubling age difference of about 8 years ($= (85-11)/\ln(7900)$ [8]).

fatality counts we use a simple linear approximation for age pyramids, as included in Fig. 1. This approximation is intended as an overall fit to ages 60 and above.

In the following we set the maximum age to zero, counting down from 100. The actual age is then $100 - x$. The age density, denoted by $\rho(x)$, varies by cohorts. Countries with population pyramids closing linearly at the top are described by

$$\rho(x) = px, \quad \int_0^{\delta A} \rho(x) dx = v, \quad v = \frac{p(\delta A)^2}{2}, \quad (2)$$

where v is the number of people (relative to the total population) vaccinated top-down to an age difference δA .

Fitting to aggregate European demographic data yields $p \approx 0.00033$, as shown in Fig. 1, with little difference across the major EU member countries. This value for p refers to the case that $\rho(x)$ is measured relative to the total population, in terms of percentiles of cohorts by year. The linear approximation holds down well to 60 years. Below this age the size of the cohort no longer increases (and even falls in some countries, like Italy). Here we concentrate on the age cohorts from 60 years up, which are the ones subject to the highest mortality risk, constituting the largest proportion of the overall loss of life. The case of Germany illustrates this proposition. Taking into account the combined effect of (1) and the age distribution, as presented in Fig. 1, one finds that about 1.5 million above an age of sixty die in the hypothetical scenario that the entire population would be eventually infected with the SARS-CoV-2 virus. In contrast, the fatality count would include only 75 thousand below sixty, a factor twenty less. We thus feel justified concentrating our analysis on the age cohorts above 60, for which the population pyramid is approximately linear.

The ‘over 60’ account for about 26 percent of the total population of the EU, with their shares ranging from 20 percent in the case of Ireland and 29 percent in the case of Italy. This implies that vaccinating about one fourth of the population will avoid 95 percent of the fatalities (19/20). This calculation based solely on age represents of course an approximation.

Due to vaccine hesitancy the uptake among the elderly could be less than 100 percent. But these factors are also present among all age groups, reducing thus the overall benefit from a vaccination campaign, but not necessarily the advantage of age-sensitive vaccination. Vaccine hesitancy is in particular likely to be lower among the elderly, implying that the share of the benefits from offering vaccination to the elderly first might be even higher than the 95% suggested on demographic considerations alone. A factor suggesting otherwise may however be ‘long Covid’ [10].

There is also evidence that immunity wanes more quickly at higher ages [11], implying that the re-infection risk is higher for the elderly. This effect plays out however on a time scale beyond that of most vaccination campaigns.

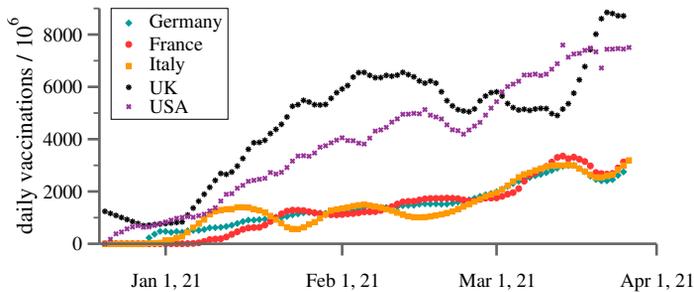


Figure 2: **Growth of daily vaccination rates.** Per million daily vaccinations in Italy, France, Germany, the United Kingdom (UK) and the United States (USA). The growth is roughly linear, modulo in part substantial fluctuations. Data smoothed over seven days, from [12].

2.3 Vaccination campaigns

It is not possible to vaccinate the entire population instantly, because vaccines have to be first mass-produced and then distributed. This is illustrated in Fig. 2, where the daily vaccination rates are shown for a range of selected countries. Daily rates may vary, in particular for smaller countries, when larger batches are delivered from abroad. The availability of imports explains also the faster vaccination campaign of the UK.² But for larger units, like the EU or the US, the trend is linear. Overall, vaccination rates can be expected to track deliveries, with eventual organizational problems leading only to temporary delays. EU member countries agreed to place joint Advance Purchase Agreements with the deliveries distributed on a per capita basis [5]. As a consequence, the vaccination curves for EU member countries all follow the same trend.

Over the course of several months, the daily vaccination rates shown in Fig. 2 raise roughly linearly, in line with production capacities. This linear ramp-up has been predicted [5]. The reason is that Covid-19 vaccine were ordered ahead of their approval in large batches. But ramping up production capacities implies large adjustment costs. Minimizing these adjustment costs, subject to fulfill the order within a certain time period leads then to a linear ramping-up of production capacities [5].

Given these considerations, and the data presented in Fig. 2, we assume that the number of daily jabs, viz the vaccination rate, increases linearly. The fraction of the population v vaccinated top down increases then with the square

²According to records of the European Commission at least one third of all the doses used in the UK were imported from the EU

of time t ,

$$v = v(t) = \frac{1}{2} \left(\frac{t}{t_0} \right)^2 = \frac{p}{2} (\delta A)^2, \quad \delta A = \frac{t}{t_0 \sqrt{p}} \equiv a_0 g_v t. \quad (3)$$

The parameter t_0 denotes the time needed to vaccinate one half of the population. Given the increase of cohort sizes with age, one finds that the age of the youngest cohort that can be fully vaccinated, denoted δA , falls linearly over time, see (2). The factor a_0 in the last definition is the characteristic age determining the exponential functionality of the IFR, as defined by (1).

An order of magnitude estimate for the length of vaccination campaigns, t_0 , can be evaluated from available data. For example, in Israel it took about 10 weeks (from the beginning of January to mid-March) to fully vaccinate one half of the population, resulting in an estimate of $t_0 = 10$ (weeks). In the EU, only about 5 percent of the population has been fully vaccinated over the same period corresponding to an estimate of $t_0 = 10\sqrt{10} \approx 32$ (weeks).

In our framework ‘vaccinated’ implies full immunity, which is attained for most Covid-19 vaccines only after the second jab. For simplicity we abstained here to model reduced levels of immunity, like 95%, which would lead only to higher order corrections. Note that only a certain fraction of all jabs, typically of the order of 50%, are administered following a strict age criterion.

The time needed to vaccinate the entire population, i.e. to the point $v = 1$, is equal $\sqrt{2}t_0$. The parameter t_0 thus does not denote the full length of the vaccination campaign, but the time needed to vaccinate 50% of the population. At that point more than 99% of the fatalities can be avoided and NPIs can be lifted. t_0 provides thus a good parametrization of the effective length of the vaccination campaign.

3 Flattening the health cost curve

Putting the three basic elements – the exponential age-dependency of the case fatality rate, the linear functionality of population pyramid, and the linear in increase of daily vaccinations rates – together, we proceed to calculate the impact of a vaccination campaign on mortality rates.

We concentrate on the *growth* of health costs (here proxied by fatalities) because the key concern for policy makers remains to ‘flatten the curve’, i.e. to prevent an explosive increase in hospitalizations which could overwhelm health systems.

3.1 Putting the building blocks together

We assume that full vaccination provides a high level of protection against severe illness and death, as confirmed not only by trial data [13], but also by real world application [14] [15]. For our model we assume furthermore that vaccination is allocated strictly by age, starting with the oldest. In practice the situation is more complicated. Firstly, because a substantial fraction of the available vaccine

is reserved in most countries for potential spreaders [9], independent of their age. Secondly, one needs to distinguish between people having received one or two shots. Both effects could be incorporated into the framework developed here. In order to clarify the mechanisms at work, we study in the following the idealized situation that ‘vaccinated’ implies full protection.

People belonging to the elderly group, as specified above, have the risk $R_v \in [0, R_{\max}]$ to die from a Covid-19 infection, with R_v being determined by

$$\frac{R_v}{R_{\max}} = \frac{p}{v} \int_0^{\delta A} x e^{-x/a_0} dx = \frac{pa_0^2}{v} \left[1 - \left(1 + \frac{\delta A}{a_0} \right) e^{-\delta A/a_0} \right], \quad (4)$$

where the exponential $\exp(-x/a_0)$ describes the age dependency of the IFR. For (4) we used $a_0^2 d[(x/a_0 + 1) \exp(-x/a_0)]/dx = -x \exp(-x/a_0)$. As a function of the population density parameter p we then have

$$\frac{R_v(p)}{R_{\max}} = \frac{pa_0^2}{v} \left[1 - \left(1 + \frac{\delta A}{a_0} \right) e^{-\delta A/a_0} \right], \quad \delta A = \sqrt{2v/p}, \quad (5)$$

where v is fixed when comparing two countries with different p . Note that $R_v(p)$ is in general a non-linear function of p , with the dominant term being however a linear contribution.

3.2 Small vaccination limit

For the limit $\delta A \rightarrow 0$ one finds

$$\begin{aligned} (1 + \tilde{A})e^{-\tilde{A}} &\approx (1 + \tilde{A}) \left(1 - \tilde{A} + \frac{1}{2}(\tilde{A})^2 - \frac{1}{6}(\tilde{A})^3 \right) \\ &= 1 - \frac{1}{2}(\tilde{A})^2 + \frac{1}{3}(\tilde{A})^3, \end{aligned} \quad (6)$$

where we introduced the abbreviation $\tilde{A} = \delta A/a_0$. Together with the prefactor (5), we then have

$$\frac{R_v}{R_{\max}} \rightarrow \frac{pa_0^2}{v} \left(\frac{1}{2} \left(\frac{\delta A}{a_0} \right)^2 - \frac{1}{3} \left(\frac{\delta A}{a_0} \right)^3 \right) = 1 - \frac{2}{3} \left(\frac{\delta A}{a_0} \right), \quad (7)$$

when making use of $\delta A = \sqrt{2v/p}$. The oldest have in our framework the risk R_{\max} to die when infected, which is consistent with the infection fatality rate being $R_{\max} \exp(-x/a_0)$.

3.3 Balancing condition

Health costs are determined by the per-person risk to die from an infection, times the probability to catch the virus. We multiply (5) with the fraction of vaccinated, v , in order to obtain an expression for total, and not for relative numbers. The medical costs C^{med} per time unit can then be written as

$$C^{\text{med}} = c_0^M \left(1 + \frac{\delta A}{a_0} \right) e^{-\delta A/a_0} I(t), \quad (8)$$

where the number of infected, $I(t) \in [0, 1]$, is defined relative to the total population. The expected costs of intensive care is c_0^M for the case that nobody has yet been vaccinated. With $\delta A = \sqrt{2v/p}$ the representation

$$C^{\text{med}} = c_0^M \left(1 + \sqrt{\frac{v}{v_0}} \right) e^{-\sqrt{v/v_0}} I(t), \quad v_0 = \frac{a_0^2 p}{2} \tag{9}$$

is obtained. The reference vaccination fraction v_0 , as defined above, can be estimated to be $8.26^2 \cdot 0.00033/2 \approx 0.011$ for a typical EU country, viz roughly one percent.

As argued above, a key concern for policy makers remains ‘to flatten the curve’. This means that the key aspect is evolution of medical costs over time, as expressed by the time dependence $\delta C = (dC^{\text{med}}/dt)/c_0^M$. We have

$$\begin{aligned} \delta C &= \left(1 + \sqrt{\frac{v}{v_0}} \right) e^{-\sqrt{v/v_0}} \dot{I}(t) \\ &- \left(1 + \sqrt{\frac{v}{v_0}} \right) e^{-\sqrt{v/v_0}} I(t) \frac{\dot{v}}{2\sqrt{vv_0}} \\ &+ e^{-\sqrt{v/v_0}} I(t) \frac{\dot{v}}{2\sqrt{vv_0}}. \end{aligned} \tag{10}$$

The turning point, $\delta C = 0$, is given by

$$\frac{\dot{v}}{v_0} = 2 \left(1 + \sqrt{\frac{v}{v_0}} \right) \frac{\dot{I}}{I}, \tag{11}$$

where \dot{I}/I is the (relative) increase of the incidence. Given that v_0 is about one percent, one arrives hence to the following rule of thumb:

“For every proportional increase \dot{I}/I of the incidence, one needs to vaccinate an additional percentage of at least twice that amount in order to outrun the virus.”

This lower bound holds for $v \rightarrow 0$, becoming larger when vaccination progresses. Vaccinating faster reduces daily Covid-19 fatalities, which increase when vaccination speeds falls below the above threshold. We have so far concentrated exclusively on the fact that vaccines are highly effective against severe cases and death, not only in clinical trials, but also in reality, up to 99% among the over 60 [14].

The evidence regarding the impact of vaccines on the spread of infections is less clear [16]. However, any impact of vaccination on infectiousness would not change the balancing condition (11), which applies in general. However, with vaccination reducing infectiousness, the growth of the disease slows down (to a lower value for \dot{I}/I), making it easier to reach the point where the curve ‘flattens’.

3.4 Time evolution

The balancing condition (10) can be used to analyze a range in different situations. Of interest is to combine (10) with the observed linear increase in vaccination rates, using $v = (t/t_0)^2/2$. One obtains

$$\frac{t}{t_0} = \left(2v_0 + \frac{t}{t_0} \sqrt{2v_0} \right) t_0 \frac{\dot{I}}{I}. \quad (12)$$

An important result is that the duration t_0 of the vaccination campaign matters in absolute numbers, given that t_0 rescales \dot{I}/I on the right-hand side of (12). Slow campaigns are substantially less effective in controlling third-wave outbreaks, as measured by the relative increase \dot{I}/I in infected.

The threshold relation (12), which determines whether medical costs are kept from rising, can be rewritten in terms of the two structural parameters p and a_0 ,

$$\frac{t}{t_0} = \left(a_0^2 p + \frac{t}{t_0} a_0 \sqrt{p} \right) t_0 \frac{\dot{I}}{I}, \quad v_0 = \frac{a_0^2 p}{2}, \quad (13)$$

see (9).³

The parameter a_0 represents a fixed characteristics of the disease. However, the slope p of the population pyramid differs in part substantially across countries, with younger countries having a smaller slope parameter (in absolute terms). Among EU member states, the differences in the slope of the pyramid at old age is minor, as shown in Fig. 1. However some developing countries (e.g. Nigeria) have a much younger population, with pyramid slope parameters about one half of that of Italy. This implies that younger countries can contain health costs even with substantially slower vaccination campaigns.⁴

4 Containment scenarios

For two scenarios, namely for comparatively slow/fast vaccination campaigns, we examine to which extent progress in vaccinating the population can offset the growth of the pathogen.

4.1 Aggressive new mutations can be controlled by fast vaccination campaigns

We denote vaccination campaigns to be fast when it takes about 10 weeks, as for Israel, to fully vaccinate one half of the population. In units of weeks, the

³We concentrate on the general analytical solution in order to avoid having to make too many specific assumptions about the way the pandemic spreads. For a more detailed, structural approach see [17].

⁴However, countries with a younger population, like Nigeria, are often also much poorer and might face logistical difficulties distributing vaccines which have to be kept constantly at very low temperatures.

balancing condition (12) takes then the form

$$\frac{t}{t_0} = \left(0.22 + 1.48 \frac{t}{t_0} \right) \left[\frac{\dot{I}}{I} \right]_{\text{week}}, \tag{14}$$

when using $v_0 \approx 0.011$. An increase in the number of infected, by a weekly rate of $\Delta I = [\dot{I}/I]_{\text{week}}$, will not lead to an increase of the weekly death count if the balancing condition (14) is satisfied. At $t = t_0$, when half of the population has been vaccinated, this can be achieved for $\Delta I = 1/(0.22 + 1.48) = 0.59$, earlier on for respectively smaller ΔI . Fast vaccination campaigns are hence able to control even rapidly expanding new mutations. For a refinement of the above estimates one could use the v_0 appropriate for the country in question, here Israel, which would be slightly smaller. In Table 1 the containment efficiency is listed for selected values of t/t_0 .

4.2 Control deteriorates for slow vaccination campaigns

As a second example we consider a comparatively slow vaccination campaign, as for the EU, with t_0 being about 32 weeks. The balancing condition is then

$$\frac{t}{t_0} = \left(0.7 + 4.7 \frac{t}{t_0} \right) \left[\frac{\dot{I}}{I} \right]_{\text{week}}. \tag{15}$$

After four months, half way through the campaign, when $t/t_0 = 1/2$, weekly $\Delta I = 0.5/(0.7 + 4.7 * 0.5) = 0.16$ can be controlled.

In reality vaccination campaigns do not strictly follow age, prioritizing also additional groups in occupations requiring close physical contact, like teachers and medical personal. However, it seems that the priority given to these other groups does not have a major impact on the distribution of vaccines. In Israel, one of the few countries with data on vaccination by age, in early January 2021, over 75 percent of the over 60 years old had received at least one dose, but only 15 percent of those between 15 and 59 [18].

Table 1: **Containment thresholds.** For two different vaccination campaign lengths t_0 (in weeks), the maximal weekly increases in infected, $\Delta I = [\dot{I}/I]_{\text{week}}$ that can be contained when vaccinating top-down a progressively larger fraction $v = (t/t_0)^2/2$ of the population. Given are the thresholds for ΔI at distinct stages of the campaign, viz for $t/t_0 = 1/10, 1/4, 1/2, 1$. Note that the absolute value of t_0 matters, as expressed by (12).

	t/t_0	1	0.5	0.25	0.1
	v in percent	50	12.5	3.2	0.5
EU	$t_0 = 32$	0.19	0.16	0.13	0.09
ISR	$t_0 = 10$	0.59	0.52	0.42	0.27

4.3 Taking into account the impact of infections on transmission rates

We have so far concentrated on the relationship between the observed value of the increases in cases, ΔI , and the speed of the vaccination campaign needed to prevent an increase in the medical costs. However, one could also consider that progressing vaccination reduces the pool of susceptibles. To illustrate the potential impact of this effect we assume that vaccination fully protects also against transmission. This might not correspond fully to reality but it has the advantage of providing an upper bound for the benefits from vaccination. The resulting new thresholds are as shown in Table 2.

Public discussion usually concentrates on the need to keep the reproduction number, R , below one, which is equivalent to keeping the growth rate, g , below zero. This goal is easier to achieve when a certain proportion of the population is fully vaccinated and hence immune. The first row in Table 2 indicates that for the EU the vaccination campaign would on its own be sufficient to offset the natural growth in cases with reproduction number, R , up to 1.37 only when 50% of the population has been vaccinated.

The reproduction number of the new variant B.1.1.7 has been estimated to be 0.6 points higher than the original SARS Coronavirus 2 [3]. This implies that without NPIs the growth rate of the new strain is likely to be higher than the threshold that can be reached with the slow EU vaccination campaigns. By contrast, the high speed campaign of Israel could deal with an R value per week of 1.59 already mid-way in the (shorter) vaccination campaign.

More in general, a comparison of Tables (1) and (2) shows that the impact of vaccination on the balancing condition becomes significant only after the second half of the vaccination campaign (i.e. for $t/t_0 \in [0.5, 1]$).

5 Inter-temporal considerations

We have so far concentrated on the evolution of fatalities as a function of the speed of the vaccination campaign and on the combination of the age specific

Table 2: **Containment thresholds with vaccination reducing transmission.** As for Table 1, the maximal weekly reproduction number Δ_I that can be contained, adjusted for the reduction in infections due to vaccination. Given are the thresholds in terms for $\Delta I/(1 - v)$ at distinct stages of the campaign, viz for $t/t_0 = 1/10, 1/4, 1/2, 1$. Compare (12).

	t/t_0	1	0.5	0.25	0.1
	v in percent	50	12.5	3.2	0.005
EU	$t_0 = 32$	0.37	0.19	0.14	0.09
ISR	$t_0 = 10$	1.16	0.59	0.43	0.27

infection fatality rates with the slope of the age pyramid. In principle, policy makers should look at the sum of all future health costs. We provide an analytical solution for this sum below. However, policy making seems to be guided de facto mainly by short-term considerations [19], namely, whether the pressure on the health system and the number of fatalities can be contained in the short run [20].

5.1 Health costs saved

The reduction in the risk to die once infected, as given by (4), can be calculated from the product of the percentage vaccinated, v , the age specific case fatality rate and the infection rate. The overall reduction in health costs is then proportional to $R_v v$,

$$C_{\text{saved}}^{\text{medical}} = \int_0^{T_v} v R_v (I_0 e^{gt}) dt \tag{16}$$

$$= p I_0 R_{\text{max}} \int_0^{T_v} [1 - (1 + g_v t) e^{-g_v t}] e^{gt} dt ,$$

where T_v is the vaccination period considered. The growth rate g of infections, which is taken here to be given, is related by $g = (R - 1)/\tau$ to the reproduction number R , where τ is the characteristic transmission or 'generation' time. It determines the percentage increase of the \dot{I}/I , or $I = I_0 \exp(gt)$, where I_0 is the incidence at the start of the vaccination campaign. The integral on the right-hand side of (16) is⁵

$$\frac{e^{gT_v} - 1}{g} - \frac{e^{(g-g_v)T_v} - 1}{g - g_v} - g_v \int_0^{T_v} t e^{(g-g_v)t} dt , \tag{17}$$

with

$$\int_0^{T_v} t e^{(g-g_v)t} dt = \frac{1}{(g - g_v)^2} [((g - g_v)t - 1) e^{(g-g_v)t}]_{t=0}^{t=T_v} . \tag{18}$$

Considering (17) and (18) together one finds that the solution contains two parts, one of which depends only on g and the other one depends only on $g - g_v$. A new strand of the virus with a higher infectiousness (i.e. a higher g) would thus require a faster vaccination campaign as already found above.

5.2 Short- and long-term health costs savings

The small- t expansion of (16) is

$$C_{\text{saved}}^{\text{medical}} \approx p I_0 R_{\text{max}} \int_0^{T_v} \left[\frac{(g_v t)^2}{2} \right] e^{gt} dt \approx \frac{p I_0 g_v^2 R_{\text{max}}}{6} T_v^3 . \tag{19}$$

⁵We neglect discounting given that the period considered is in weeks. Conventional social discount rates would be essentially be zero of this unit [19].

Initially, when vaccination rates increase linearly with time, the reduction in health costs achieved by immunizing a growing fraction v of elderly scales only with the third power of the vaccination period T_v . This holds even when the pathogen continues to spread exponentially, which enter only in higher orders.

In the opposite limit, when T_v is large, there is only a finite number of lives to be saved. This is due to the exponential decay of IFR, with decreasing age cohorts. We therefore find

$$C_{\text{saved}}^{\text{medical}} \approx \frac{pkI_0R_{\text{max}}}{g} e^{gT_v} \quad (20)$$

for large vaccination periods T_v . This relation is however only valid as long as the incidence rate $I = I_0 \exp(gt)$ remains below unity.

Discussion

A key aim for policy makers grappling with a potential third wave of the Covid-19 pandemic in early 2021 is to ‘flatten the curve’, i.e. to keep hospitalizations and fatalities from rising exponentially [21].

We have concentrated on three key factors shaping the problem. First, the mortality risk from a Covid-19 infection increases exponentially with age. Second, the sizes of age cohorts decrease at the top of the population pyramid. Third, vaccination proceeds at an increasing speed. Taking these factors into account, we derived an expression for a critical threshold, finding that vaccination campaigns above/below this threshold are able/unable to maintain current fatality levels when the daily case numbers continue to raise at a given rate. Countries with a comparatively young/old population have it easier/harder to reach this threshold, which is otherwise directly controlled by the speed of the vaccination program.

Vaccine hesitancy and other factors, such as waning immunity with age, can reduce the overall effect of vaccination campaigns. Moreover, there are other, less age specific cost of the disease, like ‘long Covid’ [22]. Incorporating these factors would refine the model, making it at the same time necessary to estimate larger numbers of parameters.

A central insight of our study is that it hurts twice when vaccination is slow. On top of the slow increase in the number of the protected, there is a second effect in addition to the direct time delay. Consider two vaccination campaigns, one taking twice the time then the other, $2t_0$ instead of t_0 , to vaccinate 50% of the population. The control capabilities halfway through the campaign, respectively at $t = t_0$ and at $t = t_0/2$, are not identical. We find that the capability of slow vaccination programs to control aggressive new Covid-19 strains are not just delayed, but strongly reduced.

Vaccination reduce also the spread of the virus. This provides an additional element which increases the importance of vaccination speed. However, this element becomes significant only in the second half of a vaccination campaign. Here again the length of the vaccination campaign matters as this phase of

reduced transmission is reached twice as fast. To vaccinate fast is substantially more important than generally acknowledged.

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