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# An Application of the Interrupted Time Series Methodology to Evaluate Policy Impact Using Daily Data

## The Impact of COVID-19 Cash Handouts on Daily Spending

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## Volatile environment, e.g., COVID-19 pandemic, naturally led high-frequency, and granular data into mainstream empirics

- Slow-moving traditional macro data cannot adequately capture dynamics of volatile environments.
- Three areas where high-frequency, and granular data found their way into.
  - **Surveillance**: Real-time firm data at ZIP-level, WEI, stringency, mobility
  - **Evaluating policy**: Transactions, and unemployment claims in the US
  - **Evaluating adverse shocks**: Impact of weather shocks (hurricanes pre-COVID-19)

## Non-trial policy evaluation typically uses difference-in-difference (DiD), but this is not always be feasible, hence interrupted time series (ITS)

- DiD (see Goodman-Bacon (2021), and Sun and Abraham (2021)) requires observed control groups, e.g., at least one never-treated, or last-treated.

- But stimulus measures during COVID-19 were mostly **implemented nation-wide → no control group(s)**

- Fortunately, **ITS allows constructing post-intervention 'counterfactual' using out-of-sample forecasts based on pre-intervention data** (and post-intervention if exogenous)

  - Used commonly in the adjacent field of epidemiology (see Bernal et al (2017), Bernal et al (2013), and Biglan et al (2000)).

# This study then evaluates the impact of three episodes of cash transfers on daily spending

1. **CMCO Handouts**: MYR11.5 billion coinciding with the CMCO on **4 May 2020**, after the strict lockdown phases (MCO) ended on 3 May 2020
2. **BSH3 Handouts**: MYR3 billion announced on **20 July 2020**, during the RMCO
3. **BPR3 Handouts**: MYR2.82 billion announced on **26 September 2021**, after the peak of the initial primary vaccination drive

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## Daily transactions, and mobility aggregated at the national-level

1. Transactions data is collected from a representative share of FIs (60 to 70%), and the sole payment system operator in MYS
   - When disaggregated, there are 6 components
     1.1 FPX online
     1.2 MyDebit card
     1.3 ATM withdrawals
     1.4 Debit & credit card transactions (physical)
     1.5 Debit & credit card transactions (online)
     1.6 JomPAY
   - Conceptually, cash (estimated based on dynamic ATM-cashless ratio) + cashless, and physical + online, are exhaustive
   - Seasonally adjusted at source using a SARIMAX, with MYS-specific calendar effects
2. Google mobility for (i) retail & recreation, and (ii) grocery & pharmacy locations
   - Smoothed using 7-day moving averages, as the SARIMAX adjustment for transactions was done at source for this study

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## Both data sets are re-scaled as 100-base-indexed for comparability

**Transactions $Y$ was rescaled from MYR to levels observed on 1 Jan 2020**

$$Y_{i,t}^{rescaled} = 100 * \left( \frac{Y_{i,t}}{Y_{i,t=1Jan2020}} \right) \tag{1}$$

**Mobility $M$ were converted from 0-indexed to 100-indexed, with Jan-Feb 2020 median being the reference**

$$M_{i,t}^{rescaled} = M_{i,t} + 100 \tag{2}$$

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## CMCO Handouts: Total spending, and most categories increased visibly post-disbursement, before returning roughly to trend



Daily Transactions and Mobility During the 2Q 2020 Cash Handouts

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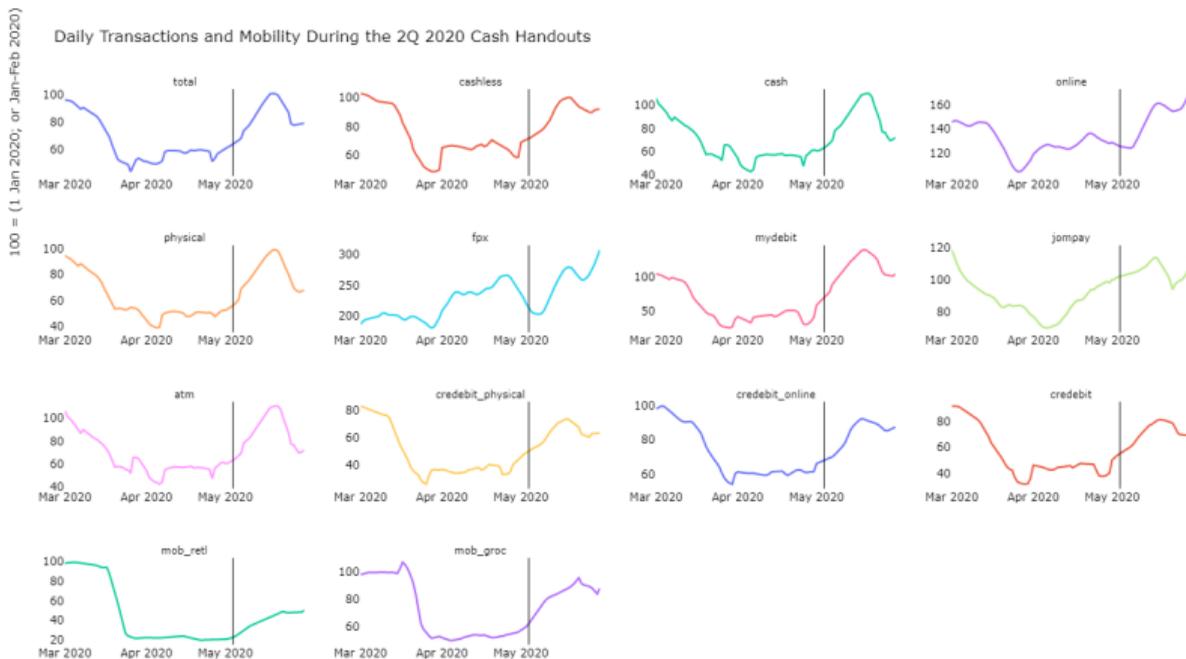
# **BSH3 Handouts**: Less prominent increase in total spending, and its disaggregation, than during the CMCO



Daily Transactions and Mobility During the BSH3 Cash Handouts

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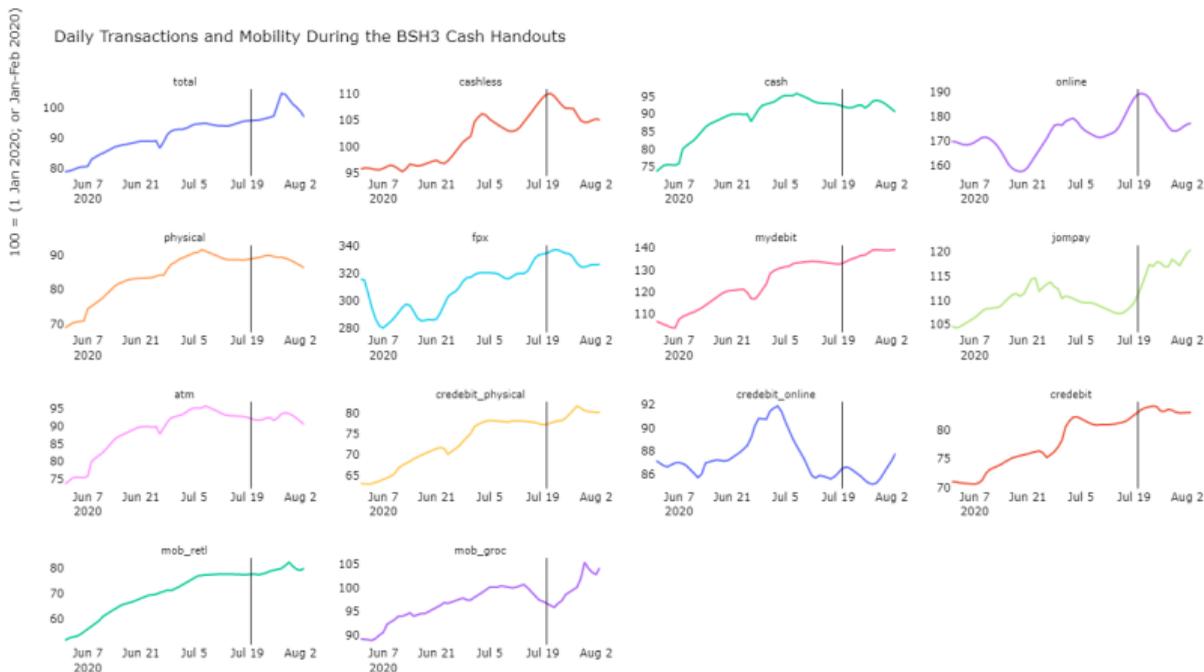
# **BPR3 Handouts**: Unclear pre- versus post-disbursement trends, with spending mostly flat post-disbursement



Daily Transactions and Mobility During the BPR3 Cash Handouts

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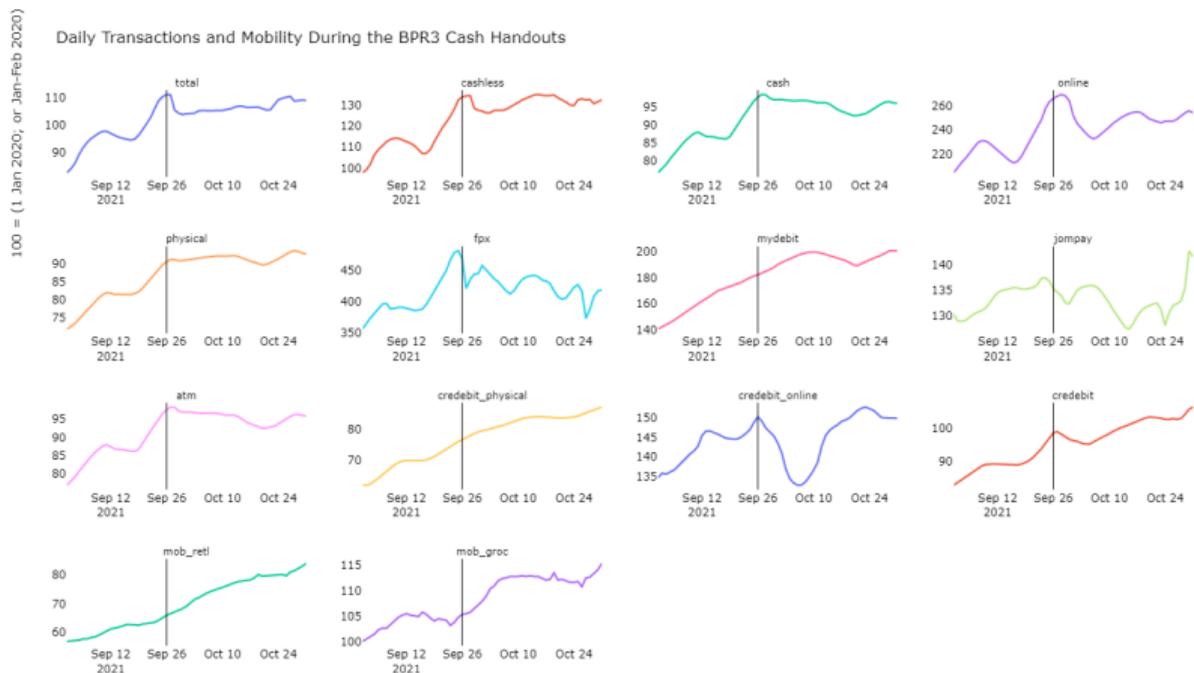
## **Methodology**: ITS using AR(n)-X, with lag order chosen by HQIC

1. Determine appropriate transformation using unit root tests, e.g., Augmented Dickey-Fuller (*log-difference for all three episodes*)

2. Estimate AR(n)-X using pre-intervention data, with *n* chosen by HQIC ($n = 1$ for all three episodes), and mobility as exogenous

$$y_{t,t\leq-1} = \mathbf{y_{t-n,t\leq-1}}\beta + \mathbf{x_{t,t\leq-1}}\gamma + \varepsilon_{t,t\leq-1} \tag{3}$$

3. Generate dynamic forecast of transactions (log-difference) as the post-intervention 'counterfactual'

$$\widehat{\mathbf{y_{t\geq0}}} = \mathbf{y_{t-n,t\geq0}}\widehat{\beta} + \mathbf{x_{t,t\geq0}}\widehat{\gamma} \tag{4}$$

4. Convert 'counterfactual' back to log-levels

5. Calculate impact as difference between observed and 'counterfactual' transactions

$$\theta_t = y_{t,t\geq0} - \widehat{y_{t,t\geq0}} \tag{5}$$

6. Calculate spending multiplier as the ratio of cumulative impact to the quantum of handouts in MYR

$$\lambda = \frac{\sum_{t=0}^{T} \theta_t}{G} \tag{6}$$

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# **CMCO Handouts**: Spending briefly overshoots counterfactual, but quickly converges within 21 days



Single Entity Interrupted Time Series: Observed, Counterfactual, and Pre-Event Predicted Daily Transactions

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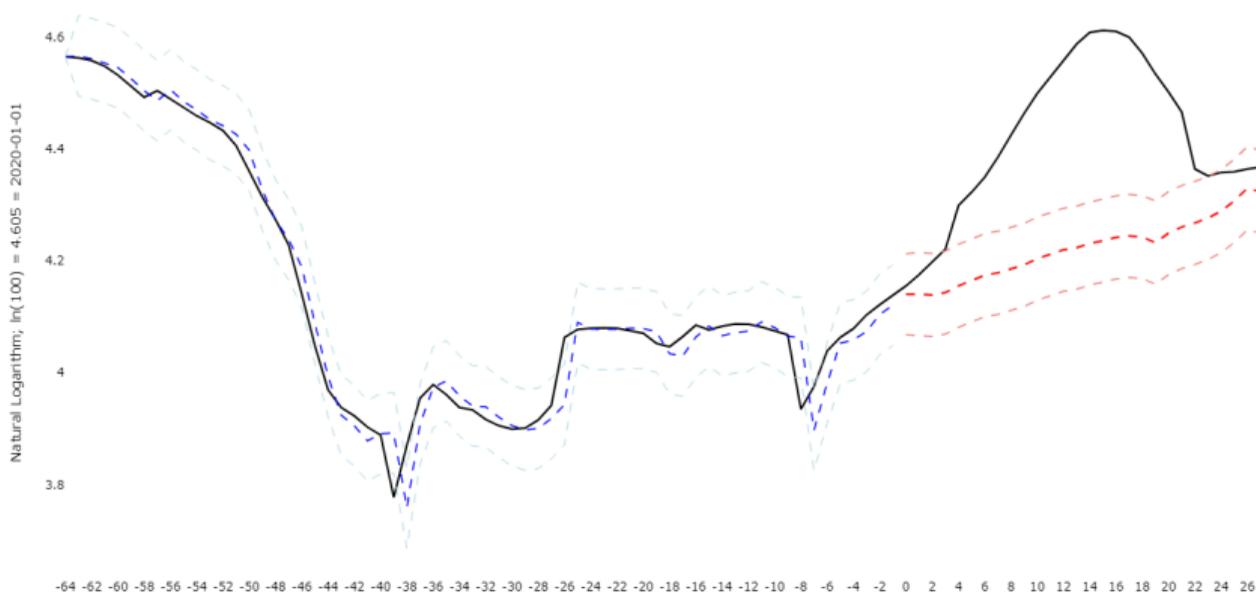
# BSH3 Handouts: Spending converges within 14 days, likely reflecting smaller quantum, and more accommodative economic conditions



Single Entity Interrupted Time Series: Observed, Counterfactual, and Pre-Event Predicted Daily Transactions

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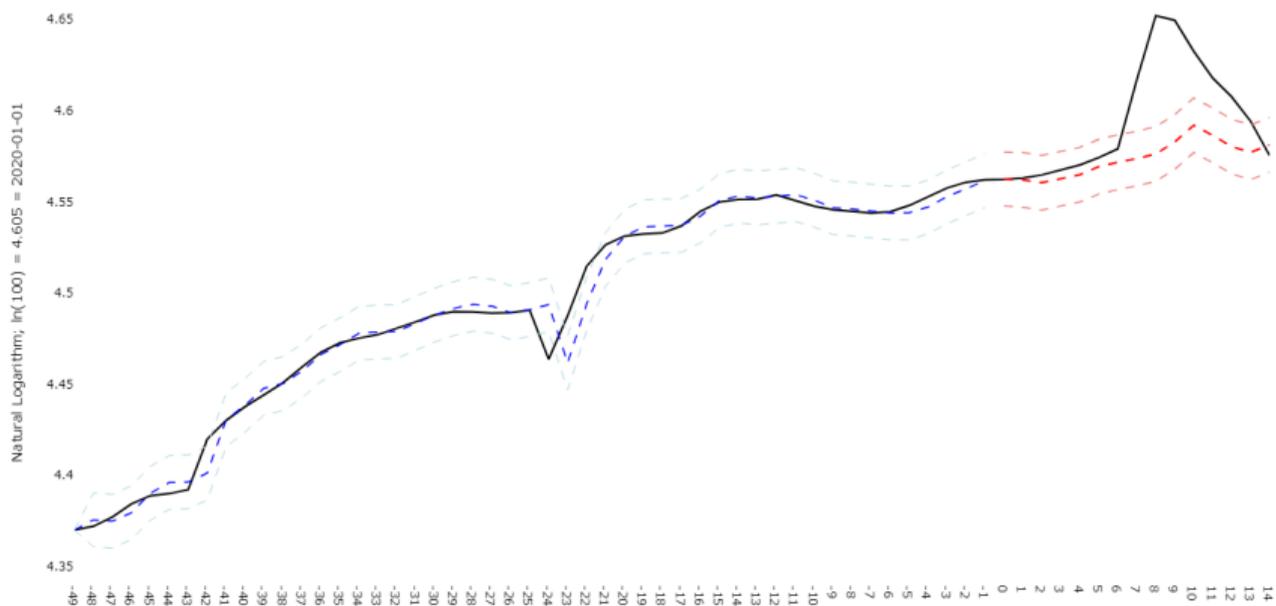
# BPR3 Handouts: Negative impact, then positive impact for 20 days, reflecting prior aggressive loosening of NPIs, and high vaccine coverage



Single Entity Interrupted Time Series: Observed, Counterfactual, and Pre-Event Predicted Daily Transactions

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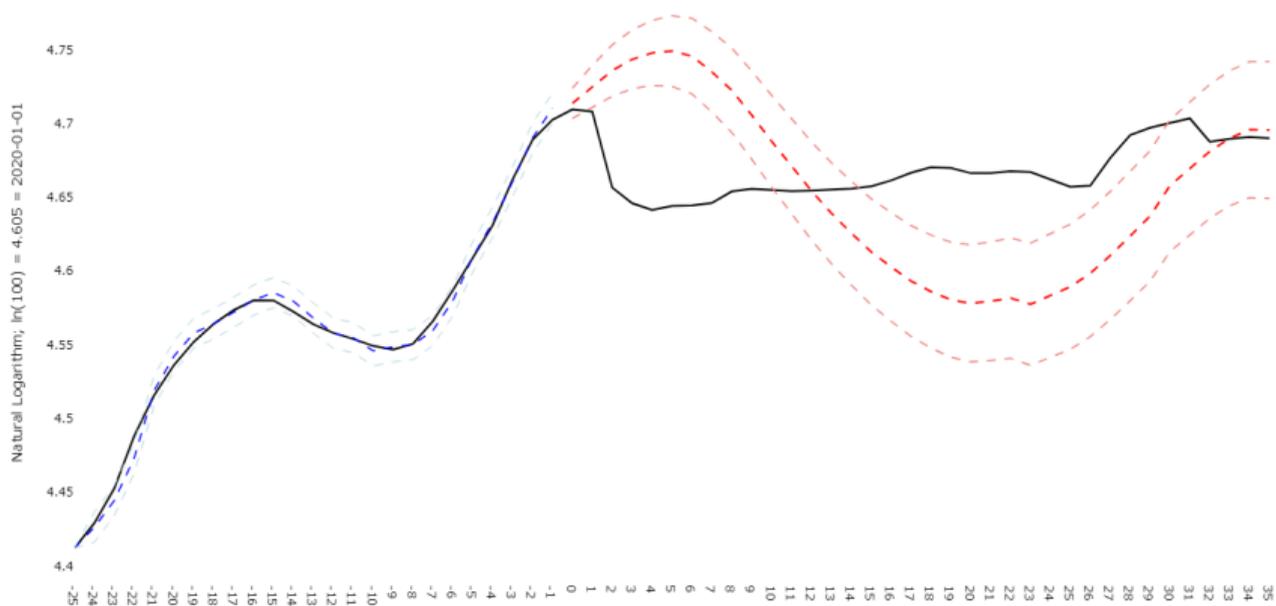
## Impact estimates present neatly the 'counterfactual'-observed gap

(a) CMCO (May 2020)
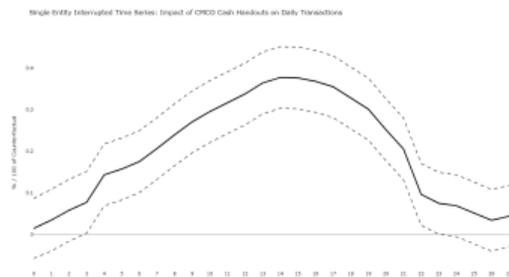
(b) BSH 3 (July 2020)
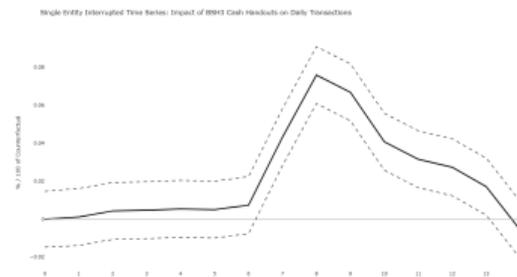




(c) BPR 3 (September 2021)
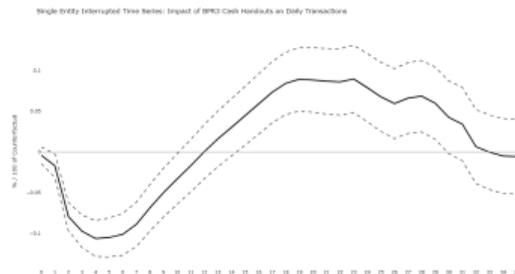
# Cumulative impact peak at different days post-intervention, reflecting quantum, and overall economic conditions

(a) CMCO (May 2020)

(b) BSH 3 (July 2020)





(c) BPR 3 (September 2021)

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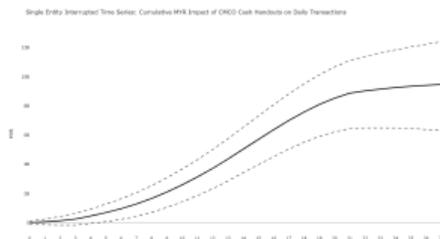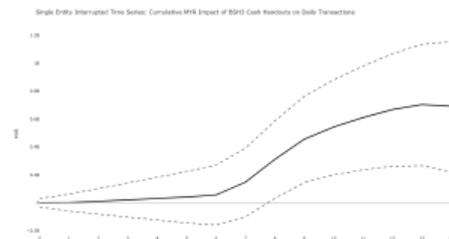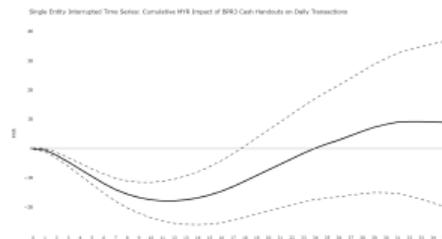
# Estimated multipliers are higher than pre-pandemic estimates for the CMCO episode, but lower for the BSH3, and BPR3 episodes



Single Entity Interrupted Time Series: Spending Multipliers on Daily Transactions (Cumulative Impact / Total Handouts)

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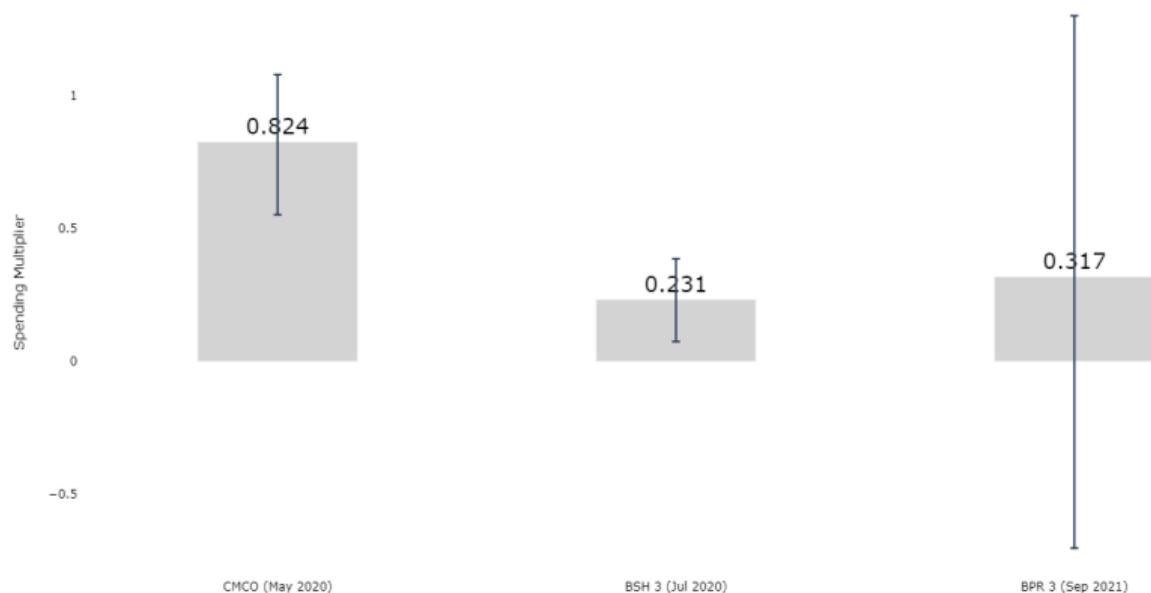
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# Conclusion

- Choice of using ITS to evaluate impact of nation-wide handouts squares with applications in observational studies in epidemiology

- **Main strength**: Rich disaggregation by type, even at national-level allowed detailed descriptive analysis of trends

- **Several limitations**
    - Lack of highly disaggregated data — open access, anonymised, sufficiently aggregated versions, will fuel research and policy analytics
    - ITS is ultimately a compromise when DiD, or controlled ITS, cannot be implemented
    - Actual disbursement dynamics are not captured (requires line items)

- Direct cash transfers are high-powered interventions to boost spending

- Possibly higher multiplier when compounded with other income support tools (CMCO > BSH3 > BPR3)

- Spending multiplier may be innately higher during times of crisis / stress

- Scope to study interaction with NPIs, timing, loan defaults, and subsistence.

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# All codes can be found on GitHub

**github.com/suahjl/impact-single-its**