

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

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

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

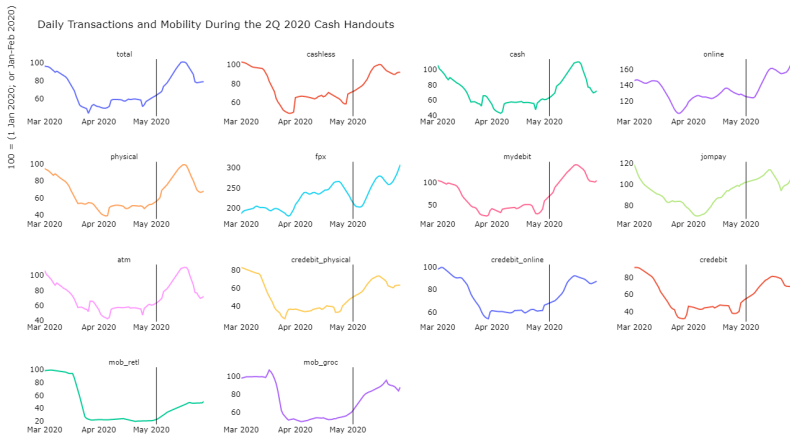
Transactions Y was rescaled from MYR to levels observed on 1 Jan 2020

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

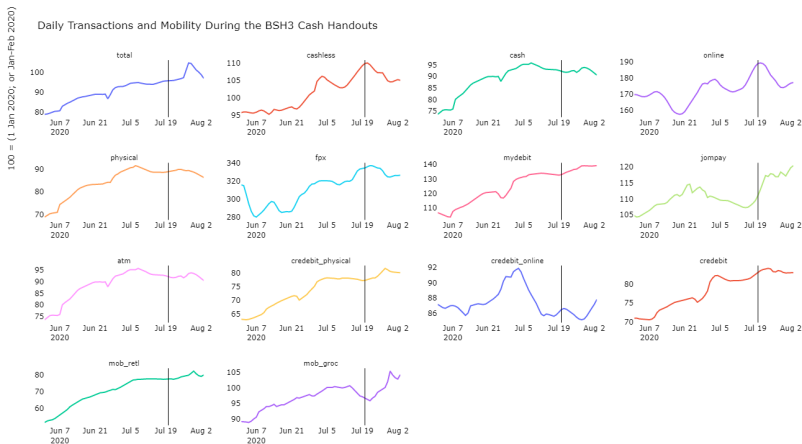
Mobility M were converted from 0-indexed to 100-indexed, with Jan-Feb 2020 median being the reference

$$M_{i,t}^{rescaled} = M_{i,t} + 100 \quad (2)$$

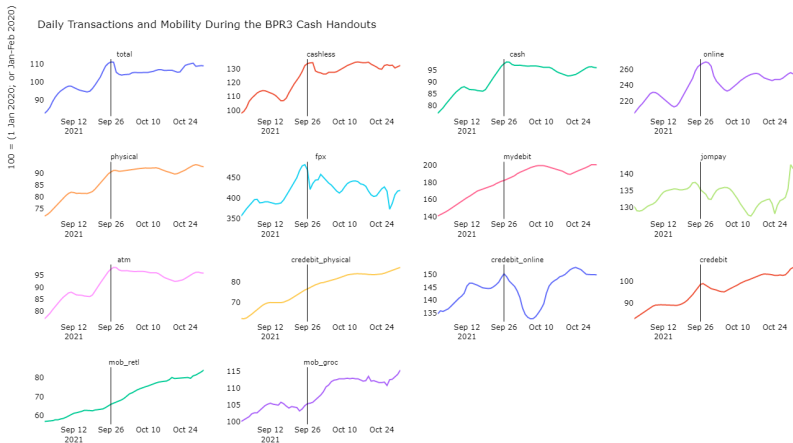
CMCO Handouts: Total spending, and most categories increased visibly post-disbursement, before returning roughly to trend



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



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



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

$$y_{t,t \leq -1} = \mathbf{y}_{t-n,t \leq -1}\beta + \mathbf{x}_{t,t \leq -1}\gamma + \varepsilon_{t,t \leq -1} \quad (3)$$

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

$$\widehat{\mathbf{y}_{t \geq 0}} = \mathbf{y}_{t-n,t \geq 0}\widehat{\beta} + \mathbf{x}_{t,t \geq 0}\widehat{\gamma} \quad (4)$$

4. Convert 'counterfactual' back to log-levels
5. Calculate impact as difference between observed and 'counterfactual' transactions

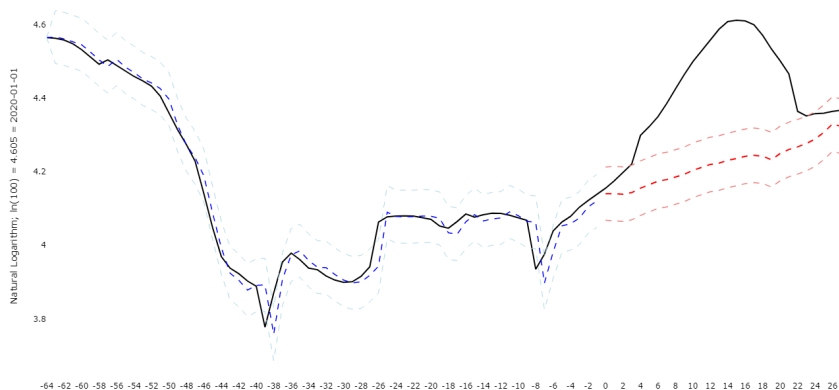
$$\theta_t = y_{t,t \geq 0} - \widehat{y_{t,t \geq 0}} \quad (5)$$

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

$$\lambda = \frac{\sum_{t=0}^T \theta_t}{G} \quad (6)$$

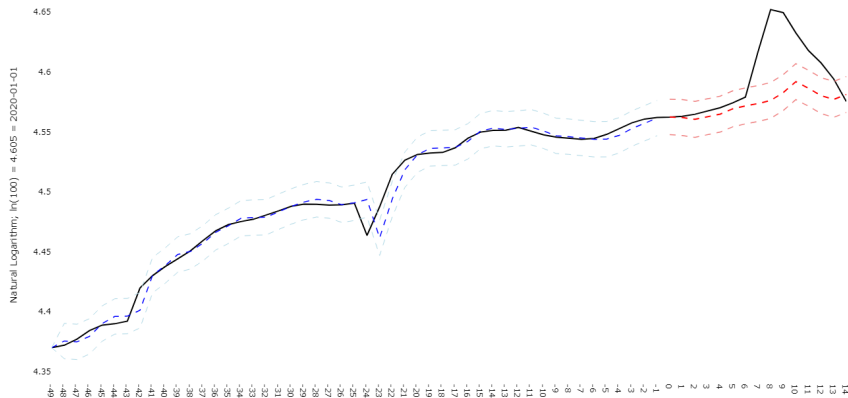
CMCO Handouts: Spending briefly overshoots counterfactual, but quickly converges within 21 days

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



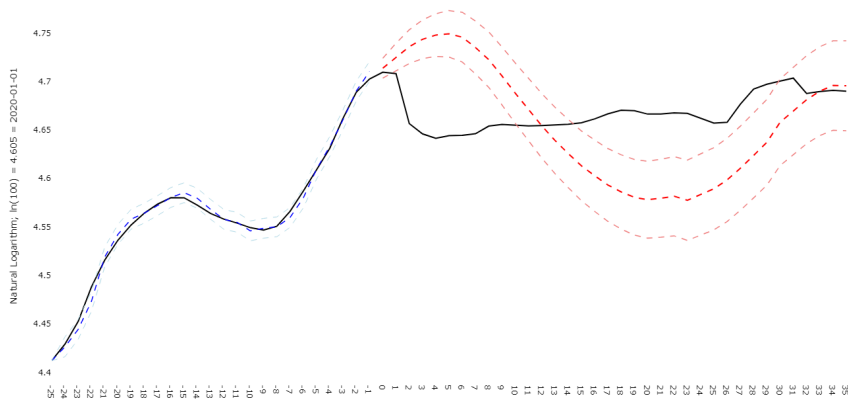
BSH3 Handouts: Spending converges within 14 days, likely reflecting smaller quantum, and more accommodative economic conditions

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



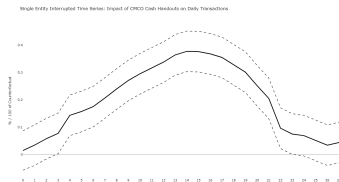
BPR3 Handouts: Negative impact, then positive impact for 20 days, reflecting prior aggressive loosening of NPIs, and high vaccine coverage

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

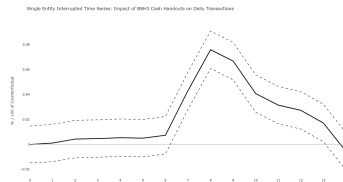


Impact estimates present neatly the 'counterfactual'-observed gap

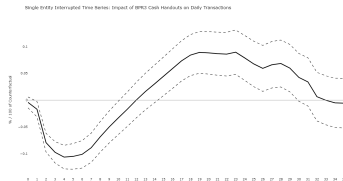
(a) CMCO (May 2020)



(b) BSH 3 (July 2020)

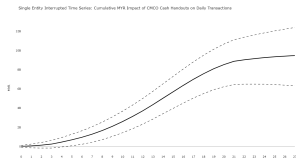


(c) BPR 3 (September 2021)

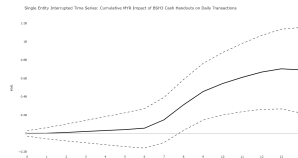


Cumulative impact peak at different days post-intervention, reflecting quantum, and overall economic conditions

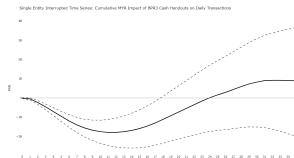
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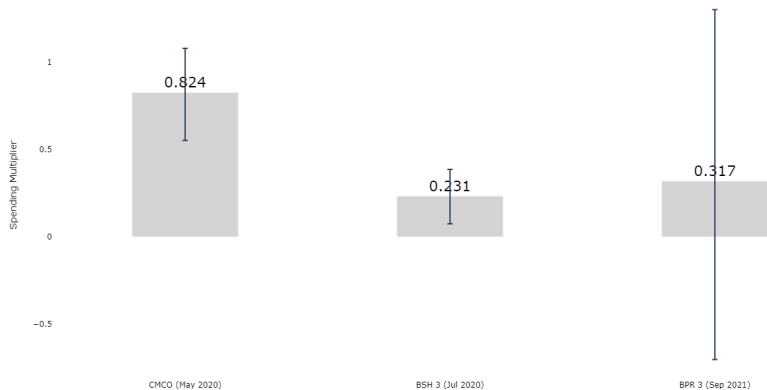


(c) BPR 3 (September 2021)



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)



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.

All codes can be found on GitHub

github.com/suahjl/impact-single-its



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