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Movement Control Measures against Covid-19: Mobility Changes in Penang and Malaysia

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EXECUTIVE SUMMARY

- The pandemic of Covid-19 has forced governments to implement lockdowns and stay-at-home orders to stop community transmissions. These have highly restricted the mobility of the population and caused unwanted damage to the global economy.
- The two main objectives of this study are: (1) to analyse the trend of new Covid-19 cases and to interpret mobility changes in Penang and Malaysia during all stages of the movement control order (categorised by MCO, CMCO, RMCO, and targeted CMCO), and (2) to ascertain the association between community mobility and new Covid-19 cases in Penang and Malaysia.
- Google mobility data are analysed alongside reported Covid-19 cases (for Malaysia, Penang and neighbouring states of Kedah and Perak), different MCO periods (MCO, CMCO, RMCO, targeted CMCO, targeted EMCO in specific locations) and SOPs, and different public holidays and festivities periods.
- The trend analysis shows movement control orders to be the most effective measure in limiting the mobility. Penang's population's movement in public spaces has been clearly affected by rising trends in new cases, be it in the state, nationally or in neighbouring states. Mobility at groceries and pharmacies saw the slightest changes. Public parks and transit stations saw great variations in mobility.
- Recommendations are proposed to (1) minimise reactions to uncertainties, and (2) maximise the ability to keep the standard of living and day-to-day outcomes as close as possible to pre-pandemic levels.
- We call for business continuity plans; for intensified steps to reduce uncertainties in external visits to premises; for enhanced self-discipline among community members to increase mutual trust; and for mobility to be adjusted based on available information.
- We also propose for clearer guidelines and SOPs to be formulated and communicated.

1.0 Introduction

Since the first Covid-19 case was discovered in Wuhan, China, in December 2019, the global number of cases has exceeded 67 million cases, with more than 1.5 million deaths (as of 7 December, 2020). In the absence of a vaccine, most governments have resorted to implementing temporary lockdowns – a form of non-pharmaceutical intervention (NPI) as a mitigation and containment measure, in hopes of curbing the spread of the disease. NPIs act to delay the spread of Covid-19, hence flattening the statistical curve of new infections. This reduces the burden on the healthcare system to ensure that it remains robust in handling the pandemic.

The lockdowns vary in stringency and can be imposed in different stages. However, they all restrict the mobility of individuals, and also reduce human-to-human contact. Where human contact is unavoidable, social distancing[1] measures are put into place, where adherence is highly encouraged and requested.

Lockdowns and movement restriction orders have strong negative effects on economy, however. Forcing economic activities to slow down or even come to a standstill has drastically reduced global output, and all countries have seen large contractions in Gross Domestic Product (GDP) growth.

Most production and services sectors have been affected, resulting in disruptions to the global supply chain. Recovery is predicted to be further threatened by continuing supply shocks, which are caused by the high contraction of aggregate demand (Bonaccorsi et al., 2020). Unemployment is on a drastic rise as businesses retrench workers amidst massive pay cuts. The resulting global recession has been deemed to be the worst since World War II (World Bank, 2020). Unfortunately, in the battle between saving the economy and saving human lives, the latter has had to come before the former.

For Malaysia, the national lockdown measure, termed as the Movement Control Order (MCO), was announced on 16 March and came into effect on the 18 March, after the country recorded 190 new cases on 15 March (Tang, 2020). Essentially, the MCO[2] stipulated:

- a ban on all social and religious gatherings
- the closure of all schools and universities
- the closure of all non-essential services and businesses
- that all residents not involved in essential economic sectors do not leave their residence except to obtain food and/or groceries, or to seek medical attention.

These restrictions by the Malaysian government are the fourth strictest in South East Asia, and the 51st strictest globally (Pfordten, 2020). The MCO lasted 6 weeks, until 3 May when the government began easing restrictions through the enactment of the Conditional Movement Control Order (CMCO) and the Recovery Movement Control Order (RMCO).[3] The RMCO is expected to last until 31 December 2020. The country experienced a third wave of Covid-19 cases, however, and the CMCO was reinstated as "targeted CMCO", starting with Sabah on 13 October, followed by Selangor, Kuala Lumpur and

[1] This is now known as physical distancing by the Ministry of Health
[2] The more specific restrictions of the MCO will be explained in detail in Appendix (Table A1 and Table A2).

[3] The more specific restrictions of the CMCO and the RMCO are explained in detail in Appendix (Table A3 and Table A4**)**.

Putrajaya on 14 October, and in a majority of states in Peninsular Malaysia on 9 November. This phase of targeted CMCO ended on 6 December.

The closure of all non-essential services and businesses caused great difficulties, while the strict stay-at-home orders significantly reduced workforce and business revenue, halting or halving production across all sectors.

As mentioned earlier, the movement restrictions are meant to contain the disease by keeping the population at home and limiting mobility. The effectiveness of this measure can be analysed by studying the movement of people during the varying stages of the movement control orders. With the release of Google's community mobility dataset, analysts have been provided with the opportunity to further understand the relationship between NPIs and community mobility, as well as the behaviour and movement of people in response to the severity of the pandemic situation.

These data sets from Google have been utilised by various bodies in examining the aforementioned relationship. For instance, the Center for Disease Control and Prevention in the United States (US) used the data in analysing community mitigation measures taken to slow the infection rate (Lasry et al., 2020). Declines in mobility point to the success of NPIs, decreasing the case counts.[4]

In a separate study which looks at the effectiveness of social distancing orders and state-of-emergency declarations in certain states in the US, there was obvious reduction in mobility for public spaces and decrease time spent away from residences, indicating compliance with the measures (Wellenius et al, 2020). The general emergency declaration however had a much more modest effect on mobility when compared to the multiple specific social distancing orders, indicating the importance of specifics in the formulation of these orders.

Additionally, Pepe et al. (2020) examined the effectiveness of NPIs in encouraging social distancing in Italy, and Google's community mobility data proved useful in evaluating the impact of lockdown and social distancing policies, in addition to measuring the compliance of the population. Given how useful the community mobility reports provided by Google seem to be have been, they have been adopted as a satisfactory and acceptable instrument for the analysis performed in this paper.

Objective

This research however adopts a nuanced view of the community mobility data when compared to some recent reports which employed community mobility as proxy for social distancing (see also Badr, Du, Marshall, Dong, Squire and Gardner (2020) and Procher and Renault (2020)). Rather than adopting a normative view that a higher (or lower) mobility compared to the baseline level may be a good (or poor) measure for social distancing, this study analyses the behaviour of the general population in different situations during the time period of concern. A higher level of visits to recreation venues is not

[4] The study notes that public health efforts and individual awareness regarding health and hygiene act as counterparts in curbing the spread of the disease.

necessarily reflective of poor social distancing practices; to be sure, the standard operating procedures (SOPs) may have been well-adhered to.

The pandemic may remain longer than expected. The availability of vaccines – most still under research and testing – will not immediately neutralise the effects of the pandemic. Therefore, what is more important is to reduce uncertainties in efforts to curb the pandemic and to continue necessary daily activities with the least interruptions possible. For example, Section 3 shows that visits to groceries and pharmacies are always at a higher level on the day before tighter movement controls are imposed. Both Penang and Malaysia's mobility recorded a 30% positive change on 17 March.

The two main objectives of this study are:

- To analyse the trend of new Covid-19 cases and to interpret mobility changes in Penang and Malaysia during all stages of the movement control order (MCO, CMCO, RMCO, and targeted CMCO).
- To analyse the degree of association between community mobility and new Covid-19 cases in Penang and Malaysia.

Additionally, changes in community mobility will also be analysed through the lens of events in relation to the easing of restrictions. For example, it is informative to scrutinise mobility changes taking place specifically when new cases were declared in the state after a long period of zero cases, or when there was a spike in the number of national cases. Comparing mobility changes in the later scenarios when the restriction of movements had eased considerably provides insight into the situation. Behavioural changes and responses will also be discussed.

The data availability and the output of the study's analysis will hopefully enable the formulation of stronger policy recommendations and suggest actions that can be undertaken by different segments of the society. In the process of handling the pandemic, alongside with the rejuvenation of the economy, it is vital that an optimal balance of livelihood and lives is achieved.

2.0 Data and analytical framework

This study employs the Google mobility data, analysing them alongside the following information:

- Number of reported Covid-19 cases (for Malaysia, Penang and neighbouring states of Kedah and Perak)
- Different MCO periods (MCO, CMCO, RMCO, targeted CMCO, targeted EMCO in specific locations) and SOPs
- Different public holidays and festive periods (see Appendix Table A5 for sources of data)

The Google mobility data was made available in late March 2020, covering the following categories of locations: retail & recreation, grocery & pharmacy, parks, transit stations, workplaces and residential. The data compare visits and length of stays with a static historic baseline (Aktay et al. 2020). The baseline of reference is the median of the corresponding day of the week in the five-week period between 3 January and 6 February 2020. The period of analysis in this study is from 15 February to 13 November 2020. For

workplaces, Google measures the relative frequency of visits as well as time and duration of the visits, to calculate how many individuals spent more than an hour at their place of work (Aktay et al., 2020). Meanwhile, the residential category displays a change in duration. It should be noted that people spend a significant amount of the day at home, and so the capacity for change is not large (Google, 2020) (see Appendix Table A6 for examples of places included in each category). The Google data is available for Malaysia and for each individual state in the country.

An important point to be made from the mobility dataset is that mobility reports show relative changes, and not absolute visitors or duration. While Google stated that gaps should be treated as true unknowns and places should not be assumed to be not busy when there is a gap, the dataset in this study noticeably does not have gaps. This means that there was sufficient information each day to generate the community mobility data for the destinations sampled for this study.

The authors acknowledge several limitations to the community mobility data. Firstly, the aggregated and anonymised data were obtained from users who granted permission to their data, and hence are not a perfect sample of the entire base of Android devices users. Based on DeviceAtlas Mobile Web Intelligence Report (February 2019)[5], around 11.4% of the Malaysian population are iOS users and hence would not have been captured in these Google mobility datasets. Secondly, the pattern of visits to groceries and pharmacies may have been similar during normal times, the authors note that during this pandemic, there may be differences in behaviour in the visits to both destinations.[6] However, the nature of the published data does not allow for such a distinction to be made.

Two types of analysis are presented in the subsequent sections:

Trend analysis. The focus in this paper is to analyse the changes and trend in mobility for retail & recreation, grocery & pharmacy, parks, transit stations, workplaces and residential in Penang and Malaysia, in the periods of MCO, CMCO, RMCO and targeted CMCO.

Non-linear correlation. This is followed by a nonlinear correlation analysis of the Google mobility changes in Penang, with the new cases in Penang, neighbouring states and Malaysia. The study employs a non-linear correlation, specifically the nlcor package in R[7] to explore the non-linear correlation variables between variables.[8] According to Ranjan and Najiri (2019), linear correlations are typically estimated while the data may have a non-linear correlation but with little to no linear correlation. That is why such non-linearly correlated variables can be easily overlooked. Additionally, non-linear correlations are quite common in real data. In this study's survey of the literature, there is a wide range of applications of non-linear correlation in the fields of biology (in Oliveira Lino et al. (2020) and Karlsson et al. (2020)), spatial analysis (in Li et al. (2020)), and health care factors and Covid-19 (in Abdulla et al. (2020)),

The nlcor package identifies multiple local regions of linear correlations to estimate the overall non-linear correlation, and returns the non-linear correlation estimate, adjusted p-value, and a plot visualizing the

[5] See DeviceAtlas. (2019).
[6] Constant pharmacy group (under Bioalpha Holdings Berhad) reported that foot traffic at the company's retail pharmacy outlets increased during the quarter ending June 2020 with higher sales of masks, gloves, sanitising products, and immunity-boosting health supplements. However, Ganesan (2020) reported that there were low footfalls and even temporary and permanent closures for some retail pharmacies. Hence, the study of how members of the public frequent pharmacies during the MCO is inconclusive.
[7] R: The R Project for Statistical Computing available under the GNU General Public License.
[8] Preliminary results also show that if there is a linear correlation, a coefficient similar to one that is generated by Pearson correlation is generated.

non-linear relationships (Ranjan and Najari, 2019; Li et al., 2020). The authors also find that the visual plot generated is useful for better deductions to be made.

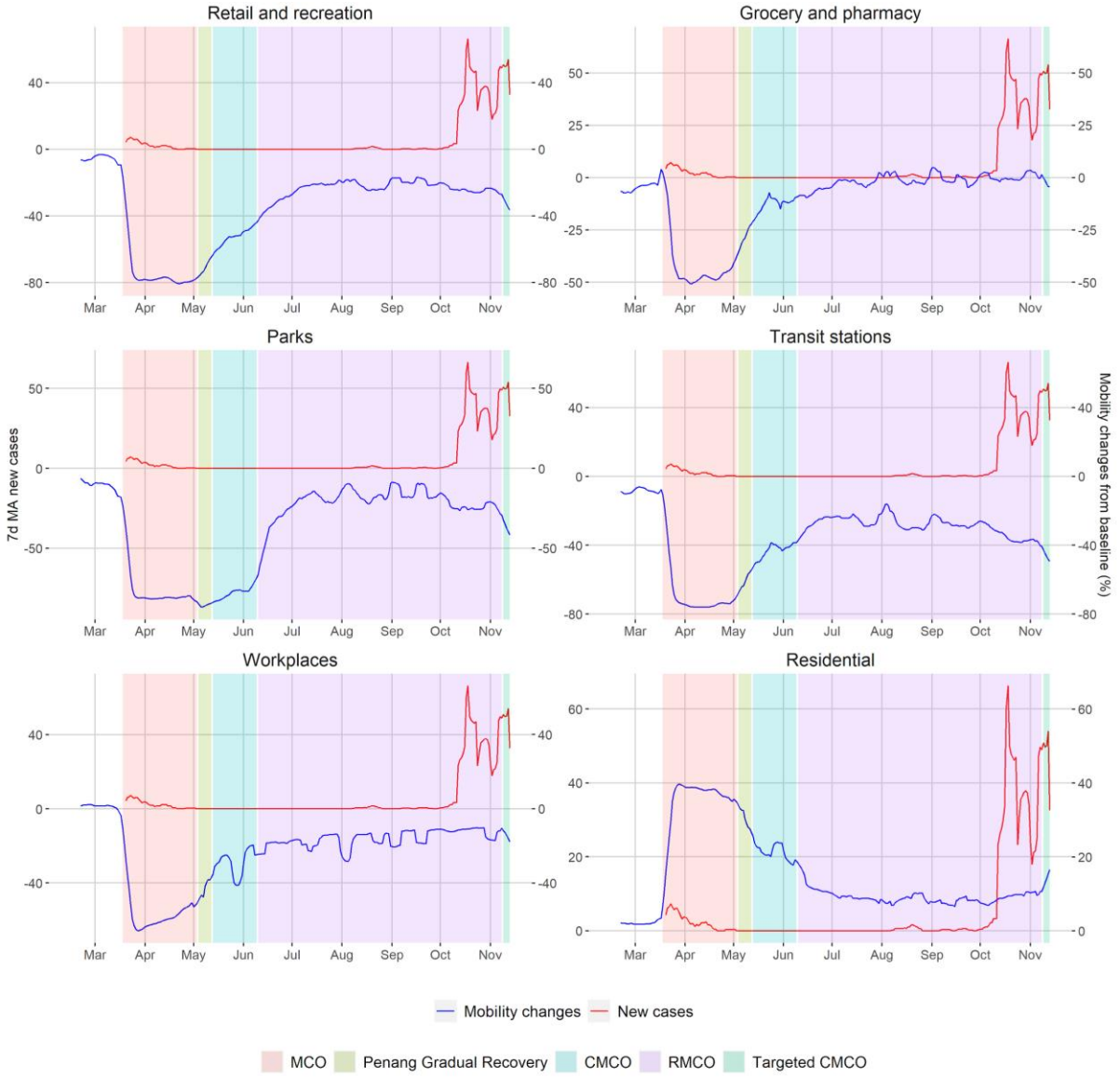
The correlation estimate is between 0 and 1. The higher the value, the more the non-linear correlation is. Since the overall non-linear correlation estimate are the mean absolute values of the local linear correlations, no negative correlation coefficient values are generated using nlcor. However, with the complement of visual plots generated by the function, a positive or negative correlation can be deduced. Additionally, the trend from the time-series plot also provides indication of the positive or negative sign.

3.0 Discussion

3.1 Community mobility changes

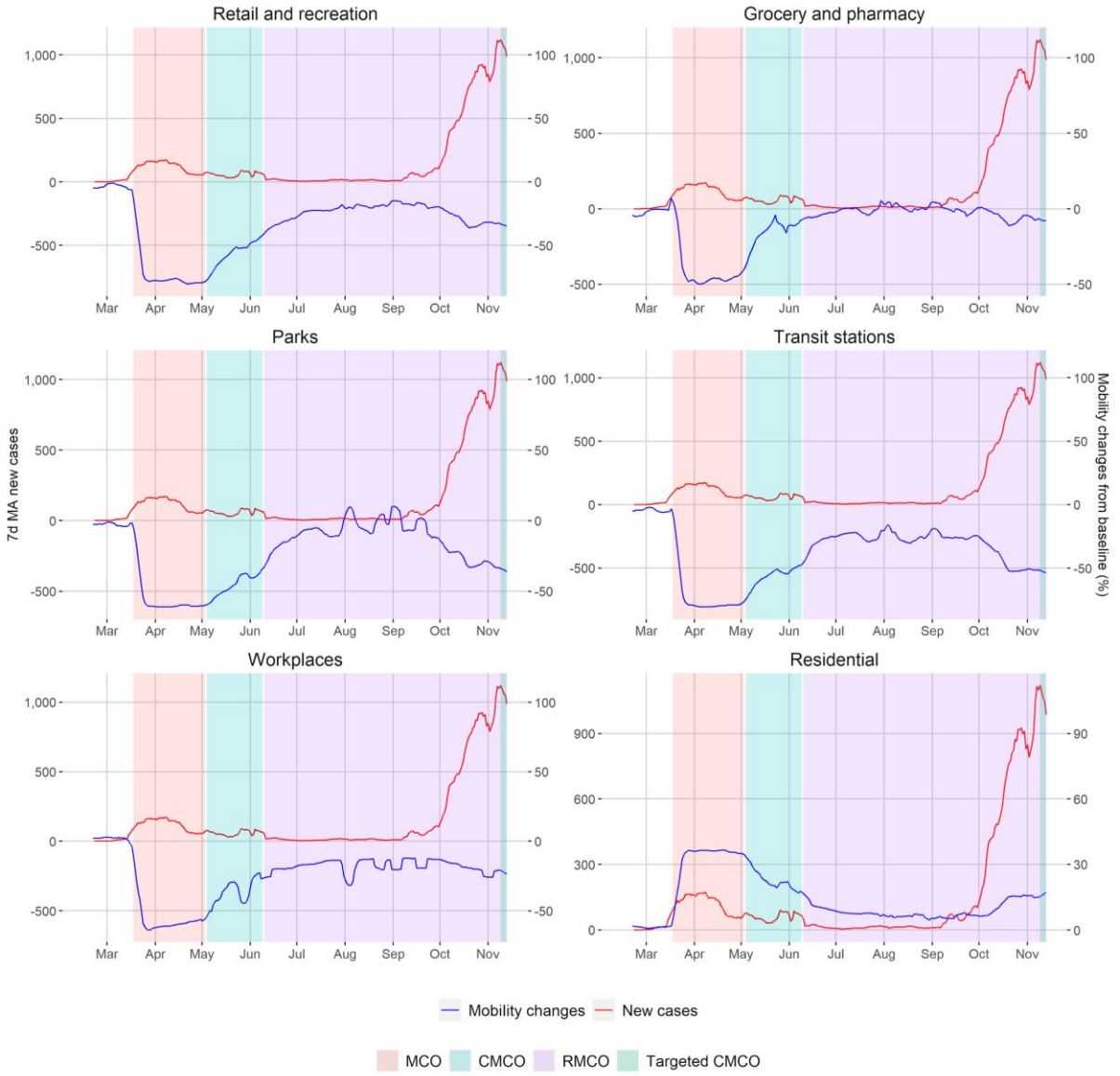
The study uses a seven-day moving average (7d MA) in analysing mobility against new cases in both Penang and Malaysia. The usage of 7d MA is a commonly accepted method in forecasting and data analysis. The moving average removes the noise in the data, and thus gives a more representative overall view in Covid-19 mobility analysis. In this instance, the 7d MA has the function of smoothening the large variations in the new cases and in the mobility changes, as well as filtering out significant weekly fluctuations observed in the mobility changes, for example, the mobility in the stages where restrictions have eased, and workplace mobility where it is expected to be higher on working days when compared to weekends.

Figure 1: 7d MA of new cases versus mobility changes at different places in accordance to stages of lockdown, Penang, 15 February – 13 November 2020



Source: Authors' calculations, derived from Google's community mobility data

Figure 2: 7d MA of new cases versus mobility changes at different places in accordance to stages of lockdown, Malaysia, 15 February – 13 November 2020



Source: Authors' calculations, derived from Google's community mobility data

Figure 1 and Figure 2 show the trend of mobility changes in Penang and Malaysia respectively, with regards to the number of new cases on a 7d MA, where different patterns of mobility changes are demonstrated.

MCO

In line with the increasing number of cases as well as the lockdown restrictions in the early period of the MCO, mobility in Penang and Malaysia underwent a great decline in all categories except residential, which predictably saw an increase instead. The MCO had confined most people to their places of residence. This also indicated a strict compliance to the MCO by the population.

Mobility in groceries and pharmacies saw the smallest change, seeing that they remain as essential places even in the lockdown. Nevertheless, they marked an approximate 50% decline in mobility.

Mobility changes for all other public spaces[9] saw a greater decline in comparison. In Penang, even as new cases were steadily decreasing in late March to early April, mobility at most public places remained low and relatively unchanged, primarily due to the lockdown measures that were still in place. These patterns also persisted nationally even with the decrease in national new cases. Workplaces were the exception; small increases were observed in mobility for both Penang and Malaysia, with the former seeing bigger changes.

Figure 1 also shows that mobility for Penang at most public spaces was seen to increase at the tail end of the MCO, while Malaysia's mobility started picking up at the beginning of the CMCO. However, it is important to note that under the Penang Gradual Recovery Strategy, MCO restrictions were enforced until 12 May (Buletin Mutiara, 2020). Nonetheless, Penang's mobility trend was found to mirror that of the national trend, with mobility notably increasing at all public spaces except parks.

It was at a period when Penang started recording zero new cases. This indicates that Penangites felt a need to leave their place of residence after a period of lockdown and were comfortable enough to return to work and revisit public spaces, even with the state government technically enforcing MCO restrictions for another week.

CMCO

As we moved into the CMCO, mobility started to increase. With the exception of parks in Penang, mobility in all public spaces saw an obvious upward trend. In contrast, mobility at residential spaces predictably saw an inverse relationship as people began venturing out to public spaces with the lifting of certain restrictions.

Data on movement in public spaces in the period of the CMCO in Penang are not expected to be greatly affected by the number of new cases or total cases, as the state had recorded zero new cases from 27 April until 6 August. However, as will be shown in the next section, Penang's mobility was associated with the changes in cases in neighbouring states.

[9] Public spaces refer to retail and recreation, groceries and pharmacies, parks, transit stations and workplaces.

It is interesting to note, however, that mobility changes for Malaysia observed a trend similar to Penang's despite a vastly different pattern in new cases recorded, and in obvious spikes.[10] As it is, we can make an inference that mobility for this period was not greatly affected by the number of reported new cases. Movement restriction orders hold a bigger influence over mobility changes.

Mobility changes for groceries and pharmacies were seen increasing to a point where it was almost close to the baseline movement of the pre-MCO period, and this held true for both Penang and Malaysia. A steady upward trend was also observed for mobility changes at retail and recreation places for Malaysia and Penang, with the reopening of malls on 8 May and 13 May respectively. However, unlike mobility for groceries and pharmacies, the positive change was still comparatively far from the baseline.

Additionally, mobility changes at workplaces and transit stations were also on the incline, with people physically returning to work and reopening of interstate borders for the purposes of work and spousal visits. The upward trend was interrupted by a small dip in late May-early June, which was attributed to the holiday weekend for Hari Raya Aidilfitri celebrations.[11]

The outlier of difference in mobility trends in this period when comparing national and state movements would be the changes for public parks. As mentioned previously, owing to the fact that public and national parks in Penang remained closed until 8 June, mobility at public parks in Penang saw little change (Figure 1). Mobility for parks in Malaysia, however, followed the inclining trend of other public spaces as detailed previously, with an especial increase in movement over the period of public holidays.

RMCO

In the beginning stages of the RMCO[12], mobility in public spaces for both Penang and Malaysia continued to increase, while mobility at residential places were predictably seeing a decline. Even so, mobility at residential places remained above the baseline. Despite increased movement across public spaces, mobility changes were still far from the pre-MCO baseline mobility. Mobility changes for groceries and pharmacies as well as workplaces saw the least vacillations, with the former's movement being almost equivalent to baseline mobility at certain periods. In contrast, mobility at parks observed the most fluctuations, especially when compared to the CMCO period. These observations applied to both Penang and Malaysia.

As we move towards the middle stages of the RMCO[13], bigger fluctuations in mobility is observed for workplaces, parks and transit stations, where the changes seemingly coincides with the occurrence of public holidays, where an inverse pattern is observed primarily between workplace mobility and mobility

[10] The sudden increase in new cases was due to detected cases among undocumented migrants who were rounded up in raids conducted by the immigration department. They were held in three immigration detention depots: Bukit Jalil, Sepang and Semenyih.
[11] See Appendix (Figure A1) for more detailed information.
[12] Early stage of the RMCO refers to the period between 10 June to 31 July.
[13] Middle stage of the RMCO refers to the period between 1st of August to 30th of September.

at parks.[14] It is interesting to see that nationally, mobility at parks was almost at pre-MCO baseline level, and fluctuated above baseline in the holiday periods. Mobility at Penang's parks, however, were still below the baseline.

Interestingly, Penangites' mobility at groceries and pharmacies, as mentioned, was approaching baseline level, but a negative effect in movement was observed with the increase of new cases. Mobility at retail and recreation in Penang also decreased with the addition of new cases. As the increase of new cases plateaued into periods of zero new cases, mobility changes somewhat conformed to the early RMCO periods, where fluctuations coincided with public holidays.

Nationally, mobility was responsive to the increase in new cases, and the sharp increases in September caused decreases in mobility. However, this decrease seemed to be less apparent when compared to Penang's[15] mobility response towards the increase of new cases, especially for retail and recreation. Parks were the one exception, where national mobility saw a significant decrease in response to increasing new cases.

In the late stage of the RMCO[16], national mobility began to decline as the country faced the height of the third wave in early October. With daily new national cases approaching the high hundreds, mostly due to burgeoning cases in Sabah, national mobility at retail and recreation, parks and transit stations saw considerable reductions, with parks seeing the biggest negative changes. Mobility continued to decline in the face of increasing cases mid-October, most notably for parks and transit stations. Mobility at groceries and pharmacies, however, remained relatively constant.

In Penang, a notable and consequential drop in mobility across public spaces was apparent with the sudden and sharp increase of new cases in the state – the majority of which were prison clusters – in mid-October. Although the decline in workplace mobility was attributed to public holidays, there was also a decrease in mobility at parks, where for other periods, there was a clearer inverse relationship. On the other hand, mobility changes at retail and recreation were smaller compared to the national differences. As with national mobility, sharper decreases in mobility were seen for parks and transit stations, when new cases in the state saw a spike in early November.

In contrast, smaller changes were observed for workplace mobility and mobility in residential areas for both Penang and Malaysia, despite the steady and monumental increase in new cases nationally. Since stay-at-home orders were not implemented nationally, big changes to workplace and residential mobility were not expected. Employees had the option to request for employees' presence at the workplace, hence the changes in mobility were considerably suppressed.

[14] See Appendix (Figure A1 and Figure A2) for more detailed information.
[15] The comparison used is the increase of new cases in Malaysia during early September versus the increase of new cases in Penang during mid-August.
[16] The late stage of the RMCO refers to the period between 1st of October to 5th of November.

Targeted CMCO

As new cases continued increasing to the tune of over a thousand daily, the Malaysian government implemented a second CMCO in most states[17] in early November. Furthermore, Malaysia marked several new highs in cases in this period of targeted CMCO.

Upon the enforcement of the second CMCO in Penang, mobility at public spaces saw negative changes, and a concurrent positive change at residential places was also observed. Essential places, groceries and pharmacies saw the smallest negative change. While mobility at most public spaces was already on the decline, with the CMCO contributing to more obvious drops in movement, mobility at the workplace saw a sharp decrease directly in line with the start of the second CMCO.

Nationally, mobility at public spaces seemingly recorded bigger negative changes when compared to Penang in the pre-CMCO period, where an obvious downward trend was observed, and vice versa for positive changes at residential places. This can be attributed to the fact that targeted CMCO was implemented in Sabah, Labuan, Selangor and Putrajaya[18] before it was enforced nationally. Mobility changes at the national level directly in response to the enforcement of the second CMCO are notably smaller when compared to Penang. While mobility in Penang saw a discernible decrease as immediate response to the CMCO, it is more difficult to make the same inference for national mobility.

Therefore, a major interpretation of the mobility trends shown above is that mobility changes across Penang and Malaysia during the pandemic has been primarily dictated by the movement restriction orders. However, the increase in mobility observed in Penang in the period of zero new cases, coupled with the sharp decreases in mobility in public spaces with the increase of new cases, suggest that mobility changes are also behavioral. This is further illustrated by the changes in Penang's mobility during RMCO in August, where decreases in movement were seen at retail and recreation, parks and transit stations when there was an increase in new cases at neighbouring Kedah and Perak.[19] However, Penang's mobility changes during the third wave may be directly attributed to the rise of new cases within the state, rather than in response to the increase of cases in neighbouring states.

This signifies that the NPI of lockdowns has shown some success in creating a form of awareness among the public, with people consciously reducing their presence in public spaces with the spiking of new cases. Mobility at public spaces was on the decline even before the enforcement of the second CMCO. However, at the same time, people were less wary than they were at the beginning of the pandemic, as seen from the higher levels of mobility in public spaces during the second CMCO when compared to the first CMCO. Additionally, more significant decreases in mobility were observed upon implementation of the second CMCO. In this sense, movement restriction orders have been the more effective tool in curbing community transmissions.

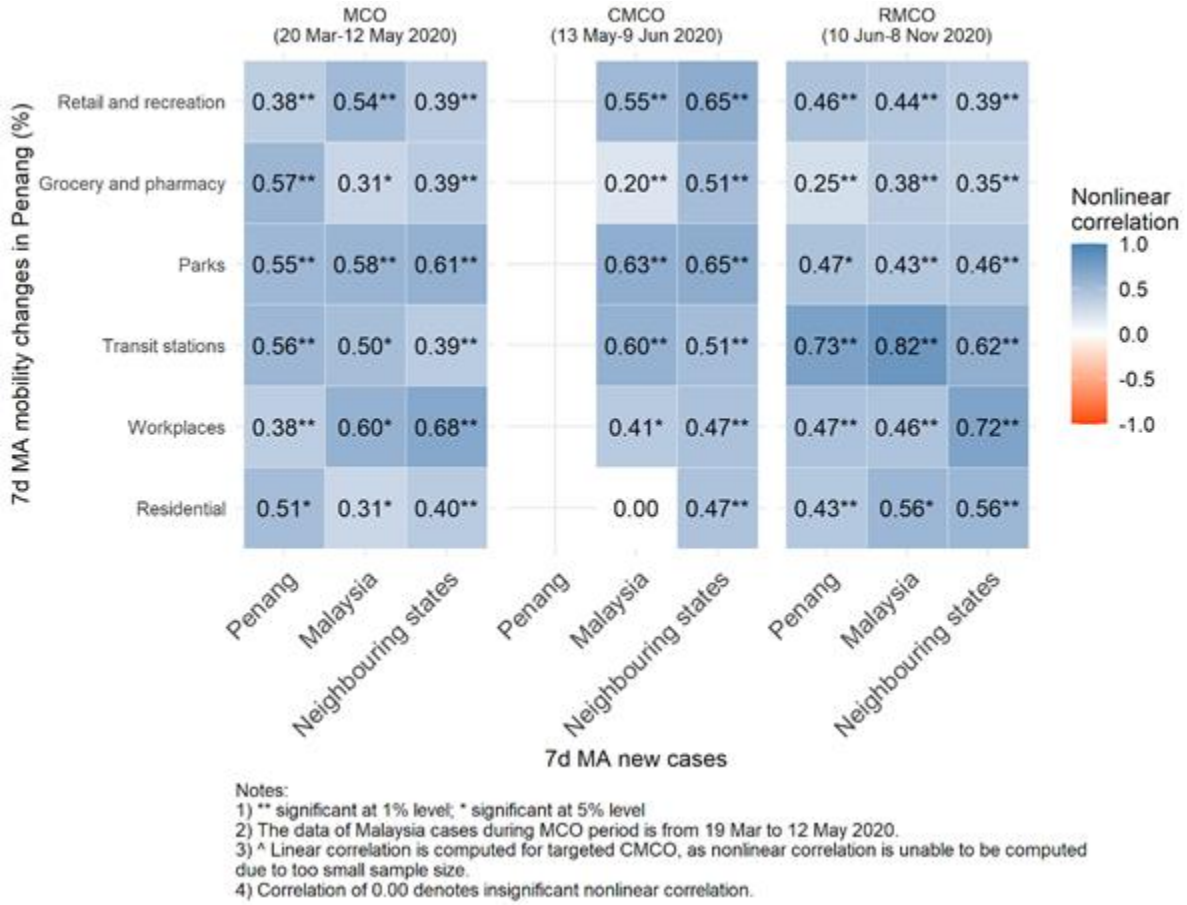
[17] The states excepted are Perlis, Kelantan, Pahang and Sarawak.
[18] Targeted CMCO/EMCO was implemented in phases across different states and districts. See Appendix (Table A7).
[19] See Appendix (Figure A3) for more detailed information.

3.2 Correlation analysis

To ensure that the analysis in the previous section is reasonably supported by the data employed, we also generated a correlation analysis to show the strength of association between new cases and the mobility changes across different categories. The usual notion of 'correlation does not imply causation' applies. The justification of employing a non-linear correlation was explained earlier in Section 2. It should be noted that the non-linear correlation results do not show the coefficient sign (i.e. positive or negative). Figure 3 shows the correlation of the 7d MA of mobility changes and new cases during the three different periods of MCO, CMCO and RMCO in Penang, Malaysia and the neighbouring states of Kedah and Perak. Categories of the different periods of MCO are in accordance to the time-series plots found in the earlier section.

Meanwhile, no correlation analysis has been generated for the period of the targeted CMCO, given that only limited data points were available at the time of writing. The minimal data points in the targeted CMCO period may not be sufficient for the authors to infer high or low correlation. The few data points may result in high but insignificant correlation coefficient values.

Figure 3: Non-linear correlation coefficients between 7d MA of new cases (in Penang, Malaysia and neighbouring states) and 7d MA of mobility changes in Penang during MCO, CMCO and RMCO

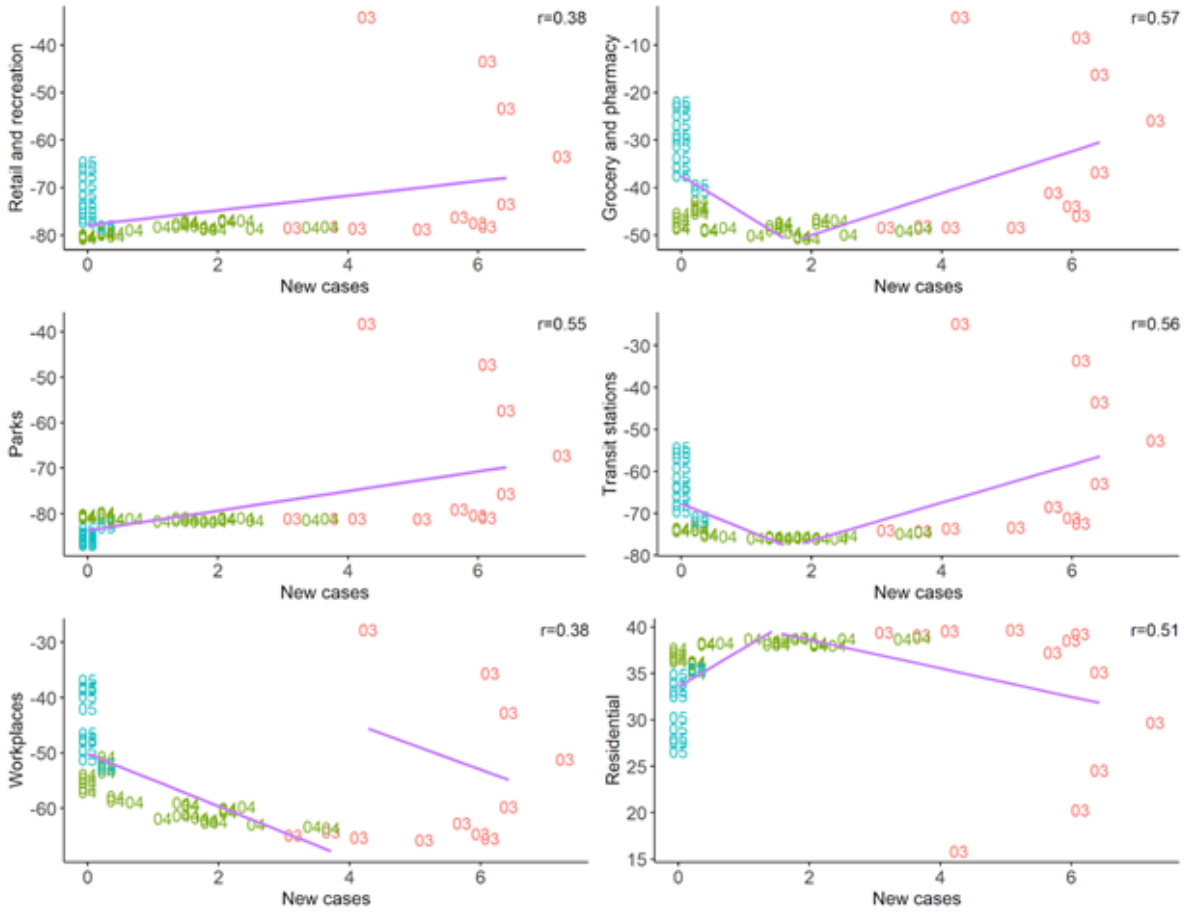


Notes:
1) ** significant at 1% level; * significant at 5% level
2) The data of Malaysia cases during MCO period is from 19 Mar to 12 May 2020.
3) ^ Linear correlation is computed for targeted CMCO, as nonlinear correlation is unable to be computed due to too small sample size.
4) Correlation of 0.00 denotes insignificant nonlinear correlation.

Source: Authors' calculations, derived from Google's community mobility data

During the MCO, Malaysia's new cases had higher correlation with Penang's mobility for the categories of retail and recreation, parks, and workplaces. This pattern could have resulted from the fact that other states in Malaysia recorded a higher number of new cases when compared to Penang during the MCO. As the non-linear correlation plots in Figure 4 show, there was gradual adjustment in mobility for March and April, before normalising in May, and this is observed across each category.

Figure 4: Non-linear correlation plots of 7d MA of mobility changes versus 7d MA of new cases, Penang, MCO (20 March – 12 May 2020)



Note: Coloured texts in each plot refer to the respective months in 2020, i.e. 03 refers to March, 04 refers to April, 05 refers to May.
Source: Authors' calculations, derived from Google's community mobility data

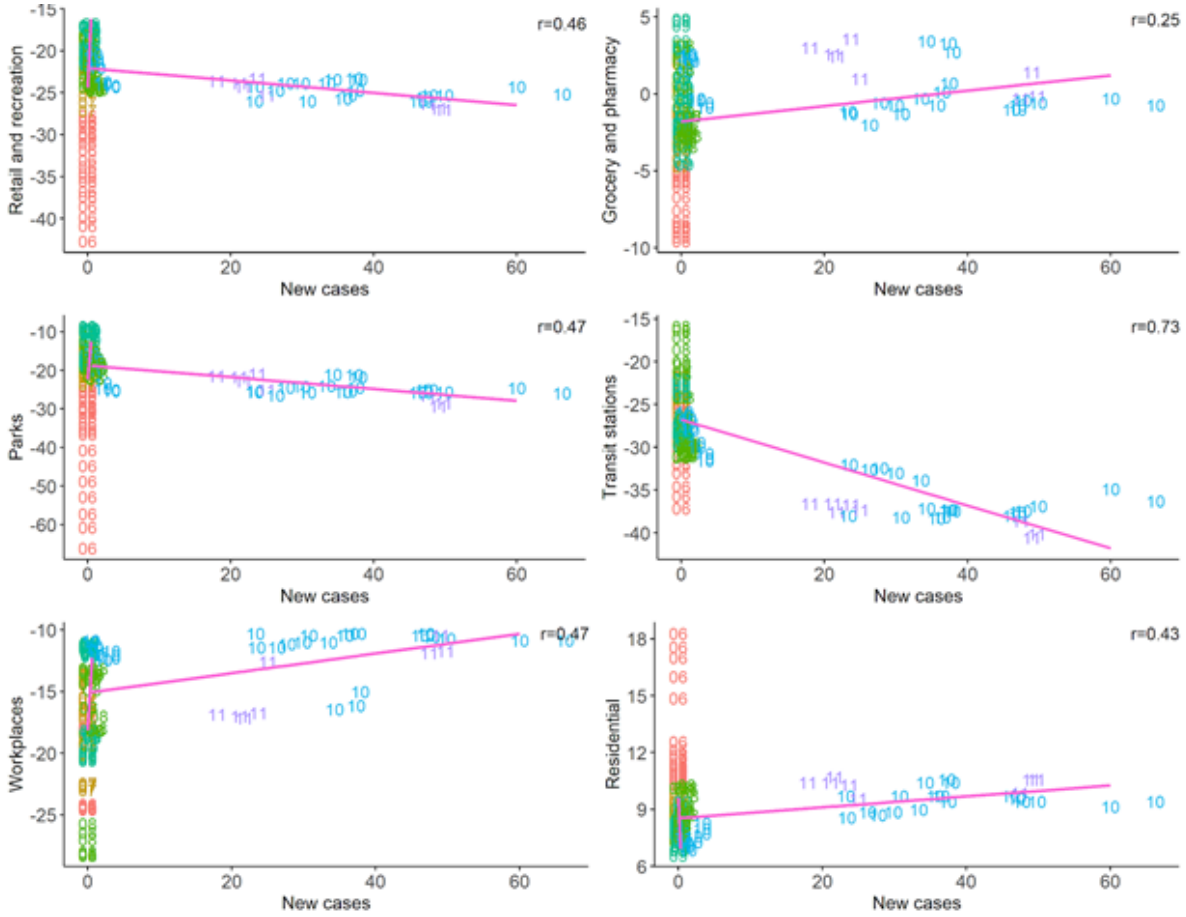
The correlation for new cases and mobility changes during the CMCO could not be calculated for Penang as the standard deviation (SD) of new cases is zero (no changes) for this period. Nonetheless, observations can still be made by using the correlation between Penang's mobility changes and new cases in Malaysia and/or Penang's mobility changes and new cases in neighbouring states.

During the CMCO, mobility for Penangites to parks and retail and recreation showed a moderately high strength of association of 0.65 for both categories in relation to neighbouring states' new cases. This is noticeably higher than the correlation during the MCO period. The moderately high correlation shows that when Penang remained a green state during this period, Penangites used the information of new cases in Kedah and Perak to adjust their mobility to the non-essential public spaces of retail and recreation and parks. In the same period, Penang's mobility correlated more strongly with the new cases in neighbouring states than those in Malaysia (except mobility at transit stations). This implies that Penangites tended to adjust their mobility based on cases happening in surrounding states rather than the national figures.

People have more freedom to adjust their mobility in the RMCO period (rationally, this should be guided by the number of new cases) and this is reflected in the correlation analysis. The correlation of transit stations mobility and new cases is the highest at 0.73, reflecting that people adjusted their mobility the most in this space, with the available information of new cases.

The non-linear correlation plots (Figure 5) also show that mobility greatly decreased in October and November as cases increased. Meanwhile, correlation for other categories remained moderately below 0.50 and ranged from 0.25 (for new cases and grocery and pharmacy) to 0.47 (for new cases and workplace; new cases and parks).

Figure 5: Non-linear correlation plots of 7d MA of mobility changes versus 7d MA of new cases, Penang, RMCO (10th June – 8th November 2020)



Note: Coloured texts in each plot refer to the respective months in 2020, i.e. 06 refers to June, 07 refers to July, 08 refers to August, 09 refers to September, 10 refers to October, 11 refers to November.
Source: Authors' calculations, derived from Google's community mobility data

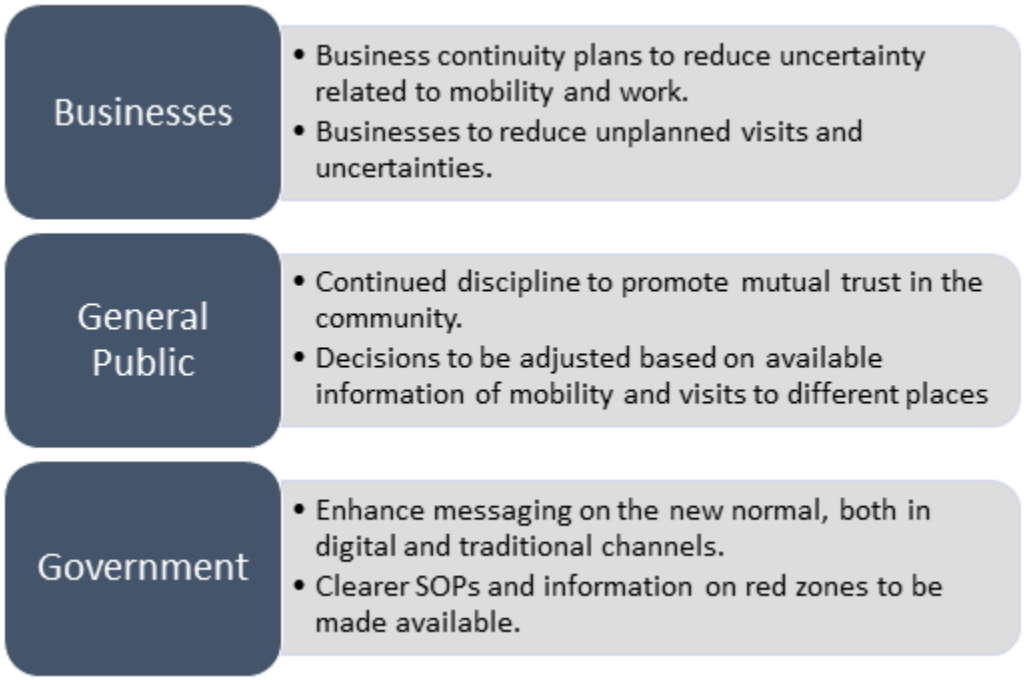
The non-linear correlation plots for (1) 7d MA of mobility changes in Penang and 7d MA of new cases in Malaysia, and (2) 7d MA of mobility changes in Penang and 7d MA of new cases in neighbouring states for all different periods of MCOs are attached in the Appendix (Figures A4 – A12).

4.0 Recommendations and conclusion

4.1 Recommendations

The aim of this paper is to analyse and provide information on trends of community mobility in Penang and Malaysia during the different phases of MCO amid ongoing efforts to curb the spread of Covid-19. The recommendations listed here are based on the principles of (1) minimising reactions to uncertainties, and (2) maximising the ability to keeping the standard of living and day-to-day outcomes as close as possible to pre-pandemic levels.

Figure 6: Recommendations for different actors in society



Business continuity plans (BCPs) are now a necessity instead of just being a good corporate guideline – Noticeably, most large corporations have BCPs in place, and most have employed measures even before the announcement of MCO by the government. Even as MCO measures are loosened, many still adopted a partial form of their corporate BCPs, which include work from home, split teams, virtual meetings and deferral of business travels (including inter-state travels). This reduces uncertainties to work arrangement, especially as future tightening of restrictions in place cannot be ruled out.

However, many SMEs may not be well-equipped with BCPs. One of the practical guides for reference for SMEs is the 'The six-step Covid-19 business continuity plan for SMEs' published by International Labour Organisation (ILO) (2020).[20] The tool in this document is designed to support SMEs during the Covid-19 pandemic, with consideration to its impact on the firm's people, processes, profits and partnerships (the "4Ps"). BCPs may reduce unnecessary mobility and may also allow employees to communicate workplace policies (such as no visits from external parties) more effectively to external stakeholders.

Businesses may reduce uncertainties in external visits to premises – By arranging for pre-planned visits by customers or vendors (for example by only accepting customers that have made prior bookings), businesses can reduce uncertainties to the number of people in their premises at any one time. Additionally, this study suggests that such measures can be employed by high-risk businesses such as hair salons and spas, reflexology and massage centres where there is close contact between service provider and customers.

Additionally, there has been some reports that some businesses were ordered to shut down temporarily due to overcrowding[21] at their premises. Setting up a "by appointment only" approach could be a good middle path in between the two extremes of (1) closure of business premises and (2) overcrowding and failure to adhere to SOPs.

Continued discipline aids in mutual trust for increased mobility – The issue of lives versus livelihoods was raised earlier in this paper. Undeniably, strict stay-at-home-only practices cannot be a sustainable long-term strategy. There is a need for economic activities to take place (work, consumption of goods and services, execution of business activities). As such, continued discipline in adhering to SOPs will allow for a safer environment for all stakeholders, and subsequently community transmissions may be reduced. It is strongly encouraged that all measures such as social distancing, wearing of face masks and registering for contact tracing via MySejahtera at all public areas be practised by everyone. Self-discipline among individuals would lead to mutual trust, and eventually allow for increased mobility.

Adjust decisions on mobility based on available information – In this paper, it is demonstrated that there are some persistent trends of mobility, for example with regard to retail and recreation and parks during public holidays, festivities, and weekends. For those who have the flexibility to make changes, the mobility trends allow for better decision making on how visits to different categories of locations can be adjusted.

Enhanced messaging on the new normal – Undoubtedly, the government has done reasonably well in mitigating the spread of Covid-19. Regular updates by the National Security Council and the Ministry of Health provided useful information flows to the public. The state government formed in the very early period of Covid-19 the 'Penang Lawan Covid-19' channel to provide regular updates to the public. The 'Penang Lawan Covid-19' campaign also focused on having prominent signboards at public areas, such as public morning markets. Traditional messaging in the form of posters and flyers should also be enhanced in areas with a high number of senior citizens.

Clear communication on SOPs and guidelines – Unfortunately, the federal government had come out with conflicting information from different ministries at certain times during the period of the MCOs. It

[20] See ILO. (2020).
[21] See Loh (2020) and Ong (2020).

was observed that conflicting information caused a lot of confusion for businesses, workers and individuals, often leading to unintentional violation of the SOPs. The SOPs and guidelines need to be standardised and streamlined, and communicated effectively to the general public.

In addition to that, the federal government also has the responsibility to ensure that all state governments are consulted and briefed comprehensively with regards to decisions concerning MCOs and corresponding SOPs.

4.2 Concluding remark

In conclusion, further research is certainly required to determine how to optimally balance the expected positive effect on public health with the negative impact on freedom of movement, the economy, and society at large. In providing the analysis of community mobility trends in Penang and Malaysia in this study, it is hoped that the above discussion and recommendations will contribute to the ongoing discussion on the balance, and this study adopts the view that all stakeholders in the economy and society are actors in overall community mobility.

5.0 References

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6.0 Appendix

6.1 Introduction

Table A1: Movement Control Order Phase 1: 18–31 March 2020

Date	Prohibited/Allowed activities	Percentage allowed to work	Travel restrictions
18 March	All non-essential services and sectors not allowed to operate. Essential services and sectors defined as: **Products:**[22] 1. Food and beverage items including imported items i. Rice ii. Sugar iii. Vegetable and animal oils and fats iv. Flour and all grain mill products v. Bread vi. Water vii. Dairy products – milk, infant formula viii. Condiments and spices ix. Dry food	SOPs for the workforce:[24] 1. Work-from-home, flexible or alternating working arrangements are encouraged 2. 50% or less workforce for **essential sectors only** allowed to work at premises 3. Name list of workers given to MITI 4. Temperatures of workers and employees to be taken daily 5. Premises must be sanitised before every shift, with sanitization of common areas to occur at least 3 times a day 6. Social distancing in common	Interstate and international travel prohibited

[22] National Security Council. (18 March, 2020). Press Release on the Movement Control Order, retrieved from https://asset.mkn.gov.my/web/wp-content/uploads/sites/3/2020/03/2.-KENYATAAN-MEDIA-MKN-PERGERAKAN-KAWALAN-COVID19-MITIfinal.pdf
[24] ibid.

Date	Prohibited/Allowed activities	Percentage allowed to work	Travel restrictions
	x. Coffee and tea xi. Canned food xii. Meat xiii. Chicken xiv. Animal feed xv. Processing of fruits and vegetables 2. Agriculture and fisheries including imports i. Fish and seafood ii. Fruits iii. Vegetables 3. Household products i. Detergents ii. Disinfectants iii. Sanitisers iv. Personal care items v. Toilet paper and tissue paper 4. Personal Protective Equipment (PPE) including fire safety equipment and medical attire, including face masks, rubber gloves, etc. 5. Pharmaceuticals – all chemical and drugs production 6. Packaging materials and printing including ink	areas 7. Masks to be worn in common spaces	

Date	Prohibited/Allowed activities	Percentage allowed to work	Travel restrictions
	7. Medical and surgical devices 8. Parts for medical devices, e.g. parts for ventilators. List of products that are part of the supply chain for essential goods to be exempted from the restriction of movement: 1. Oil and gas 2. Petrochemicals i. PTA and PET resins ii. Polyester fibres and filaments iii. Polypropylene and polyethylene iv. ABS and MABS resins v. Maleic Anhydride vi. PVC paste resins vii. Expanded EPE viii. Impact modifiers and processing aids ix. Styrene Monomer x. Styrene Butadiene Latex xi. Polystyrene 3. Chemicals and chemical products 4. Electrical and electronics (E&E) including		

Date	Prohibited/Allowed activities	Percentage allowed to work	Travel restrictions
	semiconductors **Services:**[23] 1. Banking and finance 2. Electricity and energy 3. Fire 4. Port, dock and airport services and undertakings, including stevedoring, lighterage, cargo handling, pilotage and storing or bulking of commodities 5. Postal 6. Prison 7. Production, refining, storage, supply and distribution of fuel and lubricants 8. Healthcare and medical 9. Solid waste management and public cleansing 10. Radio communication including broadcasting and television 11. Telecommunication 12. Transport by land, water or air, including e-hailing 13. Water 14. Essential services provided by government		

[23] Ministry of Human Resources. (19 March 2020). FAQs on the Movement Control Order, retrieved from https://www.mkn.gov.my/web/wp-content/uploads/sites/3/2020/03/FAQ-KSM-Edited-Version.pdf.pdf

Date	Prohibited/Allowed activities	Percentage allowed to work	Travel restrictions
	and statutory bodies 15. Defence and security 16. Industries and businesses related to defence and security 17. Food supply 18. Groceries 19. Online services 20. E-commerce 21. Wildlife 22. Hotels and accommodations		
18 March	The following activities and matters are strictly prohibited:[25] 1. Restricted movement and prohibition of gatherings including religious activities, sports, social, cultural, weddings 2. Prohibited from travelling domestically and internationally 3. Foreigners prohibited from entering the country 4. Closure of all childcare centres, primary and secondary public schools/private schools, pre-university institutions	Same as above	Same as above

[25] National Security Council. (17 March, 2020). FAQ on the Movement Control Order, retrieved from https://asset.mkn.gov.my/web/wp-content/uploads/sites/3/2020/03/FAQ-Bil1730.pdf

Date	Prohibited/Allowed activities	Percentage allowed to work	Travel restrictions
	5. Closure of all public and private universities and colleges, and vocational training institutes 6. Closure of all government and private services except essential businesses and services 7. Food premises only allowed for delivery and takeaway – dine-in is strictly prohibited 8. Closure of public parks – exercising public spaces not allowed		

Table A2: Movement Control Order (MCO) Phase 2: 1 April – 3 May 2020

Date	Prohibited/Allowed activities	Percentage allowed to work	Travel restrictions
1 April	All other prohibitions stated in MCO Phase 1 apply. Most economic sectors are not allowed to operate, with the following as exceptions which are classified as critical sectors:[26] 1. Food 2. Water 3. Energy 4. Communications and internet 5. Security and defense 6. Solid waste and public cleansing management and sewerage 7. Healthcare and medical including dietary supplement 8. Banking and finance 9. E-commerce	SOPs for workforce:[27] 1. Work-from-home, flexible or alternating working arrangements are encouraged 2. 50% or less of the workforce allowed to work 3. Name list of workers given to MITI 4. Temperatures of workers and employees to be taken daily 5. Premises must be sanitised before every shift, with sanitization of common areas to occur at least 3 times a day 6. Social distancing in common areas 7. Masks to be worn in common	1. One person allowed per car/vehicle[28] 2. Only allowed to travel within a 10km radius from home to destination[29] 3. Only critical-sector workers allowed to travel from home to work 4. Interstate travel not allowed

[26] National Security Council. (2 April 2020). FAQ for MCO Phase 2, retrieved from https://www.mkn.gov.my/web/wp-content/uploads/sites/3/2020/04/2-April-2020-FAQ-MKN-PKP-Tahap-2.pdf.pdf

[27] National Security Council. (18 March 2020). Press Release on the Movement Control Order, retrieved from https://asset.mkn.gov.my/web/wp-content/uploads/sites/3/2020/03/2.-KENYATAAN-MEDIA-MKN-PERGERAKAN-KAWALAN-COVID19-MITIfinal.pdf

[28] Malaysiakini. (30 March 2020). 'One person per car' rule effective April 1, retrieved from https://www.malaysiakini.com/news/517696

[29] Malaysiakini. (1 April 2020). MCO: Travel limited to 10km from home, retrieved from https://www.malaysiakini.com/news/518198

Date	Prohibited/Allowed activities	Percentage allowed to work	Travel restrictions
	10. Transport by land, water or air, including e-hailing	spaces	
3 April	Amended to include five more sectors – fifteen critical sectors allowed to operate:[30] 11. Port, dock, airport services and undertakings (including stevedoring, lighterage, cargo handling, pilotage and storing or bulking of commodities) 12. Production, refining, storage, supply & distribution of fuel and lubricants 13. Hotels and accommodations 14. Any services/works determined important or critical to public health or safety by the Minister 15. Logistics confined to the provision of essential services	Same as above	Same as above

[30] National Security Council. (3 April 2020). Amendments to FAQ for MCO Phase 2, retrieved from https://www.mkn.gov.my/web/wp-content/uploads/sites/3/2020/04/FAQ-MKN-BIL.-2-PB-3-APRIL-2020.pdf

Table A3: Conditional Movement Control Order (CMCO): 4 May – 9 June 2020 (reinstated in certain states in October and November)

Date	Prohibited/Allowed activities	Percentage allowed to work	Travel restrictions
4 May	1. Two persons in one car allowed, but must be immediate family members from the same household[31] 2. Allowed to travel beyond the 10km radius for necessities and medical needs. 3. Outdoor exercising and non-contact sports allowed, and most public parks are reopened to the public (with the exception of Penang)[32] 4. Most economic sectors are allowed to operate with adherence to SOP[33] except these 23 business and services sectors:[34]	1. Work-from-home, flexible or alternative working arrangements are encouraged 2. No limits for sectors not in the prohibited list[35] 3. Machine assembly and maintenance and tower crane at construction sites: not more than 10 people	Interstate travel not allowed - unless for work

[31] Tan, B. (29 April 2020). Senior minister: As part of flexible measures, govt now allows two in a car during MCO's fourth phase, retrieved from https://www.malaymail.com/news/malaysia/2020/04/29/senior-minister-as-part-of-flexible-measures-govt-now-allows-two-in-a-car-d/1861377

[32] Bernama. (11 May 2020). Public can exercise but there are still some protocols to be followed, retrieved from https://www.nst.com.my/sports/others/2020/05/591465/public-can-exercise-there-are-still-some-protocols-be-followed

[33] Social distancing, frequent hand washing, usage of masks, thermal screening at entry/exit points, sanitising business premises regularly and reporting all information of COVID-19 to MOH

[34] Ministry of Human Resources. (2020). Standard operating procedures for reopening of the economy, retrieved from https://www.mohr.gov.my/images/SOPPembukaanSemulaEkonomi010520201.pdf

[35] Ministry of International Trade and Industries. (8 May, 2020). FAQ on Conditional Movement Order, retrieved from https://www.miti.gov.my/miti/resources/MCO%20FAQ/Soalan_Lazim_MITI_(PKPB)_-_8_Mei_2020.pdf

Date	Prohibited/Allowed activities	Percentage allowed to work	Travel restrictions
	i. Entertainment and leisure: cinemas, karaokes, theme parks, museums, busking, reflexology centres, entertainment hubs and nightclubs ii. Festivals, parades and gathering: religious parades, gathering in mosques or houses of worship and anniversary celebration parades iii. Conferences and exhibitions: job fairs, wedding fairs, travel fairs, sales carnivals, and any conferences that involve mass gatherings iv. Education: All IPTA/IPTS, sports during school hours, face-to-face co-curricular activities, assemblies and events more than 10 people v. Sports: competitions that involve audiences (stadium), outdoor events that involve more than 10 people such as running, cycling and motorcycle convoy, indoor sports such as gymnasium and swimming, and contact sports such as rugby, wrestling, boxing, football and basketball vi. Social activities: any events with mass gathering such as talks, gotong-royong, wedding, open houses,		

Date	Prohibited/Allowed activities	Percentage allowed to work	Travel restrictions
	anniversary celebrations and the like vii. Transport: cruise ships viii. Business: vendors with or without premises/markets in buildings/markets without premises/grocery stores/stores selling assorted food and beverages which have too many customers at one time (subjected to a minimum of 1m distancing), Ramadan bazaars, and Hari Raya bazaars and sales carnivals ix. Centralised labour quarters (CLQ)/hostels/worker dormitories in the manufacturing sectors and others) receiving visitors, socialising and grouped sport and religious activities x. Machine assembly and maintenance (lift, escalators, boiler, etc.) in services sectors and tower crane at construction sites: work in groups with more than 10 people xi. Boutiques and fashion accessories: dress-fitting xii. Laundry (specifically self-service laundries): clothes-folding xiii. Face-to-face talks, seminars, courses		

Date	Prohibited/Allowed activities	Percentage allowed to work	Travel restrictions
	and trainings xiv. Certification for agricultural commodities xv. Barber shops and beauty salons xvi. Banking and finance: sales and marketing activities outside the premises or public areas xvii. Forest management: forest ecotourism, forestry training xviii. Mining and quarrying: new applications for theory and practical tests of explosion xix. Farming and agriculture: customer meeting days, farm products sale days, fruit festivals, courses/seminars, agriculture institutions' convocations and auctions of farm products including meats, eggs, etc. xx. Fishery: recreational fishing activities, Sea Parks, exhibitions and aquariums xxi. Creative arts: shooting activities (film/drama, documentary/commercial), concerts/arts performances, or any programmes involving public in the studio or public areas		

Date	Prohibited/Allowed activities	Percentage allowed to work	Travel restrictions
	xxii. Culture and arts: exhibitions which involve interaction between staff and visitors xxiii. Tourism and hotels: usage of hotel facilities such as prayer rooms, gymnasiums, spa, sauna, swimming pools, meeting/seminar/training rooms, restaurants and cafes (for buffet purposes)		
7–10 May			Allowed interstate workers to travel
8 May	Shopping centres, stores and roadside stalls allowed to reopen in Penang[36]		Interstate travel not allowed – unless for work
1 June			Allowed interstate travel for emergency (deaths and (medical reasons) and for visiting spouse
2 June	All childcare centres allowed to operate		
6 June	Public parks in Penang allowed to reopen[37]		
10 June			Domestic interstate travel restrictions lifted – allowed

[36] Mok, O. (8 May, 2020). Shopping malls, stores and roadside stalls in Penang reopen under strict SOPs, retrieved from https://www.malaymail.com/news/malaysia/2020/05/08/shopping-malls-stores-and-roadside-stalls-in-penang-reopen-under-strict-sop/1864299

[37] Basyir, M. (2 June, 2020). Penang to reopen recreational parks, retrieved from https://www.nst.com.my/news/nation/2020/06/597332/penang-reopen-recreational-parks

Date	Prohibited/Allowed activities	Percentage allowed to work	Travel restrictions
			to travel freely between states[38]

* Penang implemented three stages of reopening (Penang Gradual Recovery Strategy) from 4-12 May, where the first phase was from 4-7 May, the second phase from 8-12 May, and businesses were allowed to reopen from 13 May onwards with the same SOPs listed above.

[38] Tan, V. (10 June, 2020). Interstate travel resumes, more services reopen as Malaysia steps into a new normal, retrieved from https://www.channelnewsasia.com/news/asia/malaysia-recovery-mco-covid-19-interstate-travel-barber-salon-12822692

Table A4: Recovery Movement Control Order (RMCO): 10 June – 31 December 2020

Date	Prohibited/Allowed activities	Percentage allowed to work	Travel restrictions
10 June	The following activities remained prohibited:[39] 1. Sports events or competitions that involved the attendance of spectators, and sports events and competitions that involve participants from overseas to enter Malaysia 2. International tourism by Malaysian citizens and domestic tourism that involves foreign tourists to enter Malaysia from countries as stated by the Minister. 3. Activities in pubs and night clubs, unless restaurant business in pubs and night clubs. 4. Any activity that involves the attendance of many people in one particular place, that may make it hard for social distancing and adherence to the instructions of Director General.	No limit for sectors that is not in "Prohibited activities" list	1. International tourism by Malaysian citizens and domestic tourism that involves foreign tourists to enter Malaysia from countries as stated by the Minister. 2. Reciprocal Green Lane (RGL) and Periodic Commuting Arrangement (PCA) schemes with Singapore beginning 17 August 2020.[40]

[39] National Security Council. (2020). List of prohibited activities, retrieved from https://asset.mkn.gov.my/web/wp-content/uploads/sites/3/2020/08/Senarai-Aktiviti-yang-Dilarang_-18-Julai-2020.pdf

[40] Medina, A.F. (4 August, 2020). Reopening of the Malaysia-Singapore Border: Strict Health Protocols to Impact Travelers, retrieved from https://www.aseanbriefing.com/news/reopening-of-the-malaysia-singapore-border-strict-health-protocols-to-impact-travelers/

6.2 Data and analytical framework

Table A5: Data and source of data

Data	Source of data
Community mobility data	Google
New cases (Malaysia, Penang, Kedah, Perak)	Ministry of Health, Malaysia, Kedah and Perak Health Department and Penang Health Department
Different MCO periods and SOPs	National Security Council, compilation of SOPs from various different ministries and government agencies by NSC
Public holidays and festivities	Penang State government portal

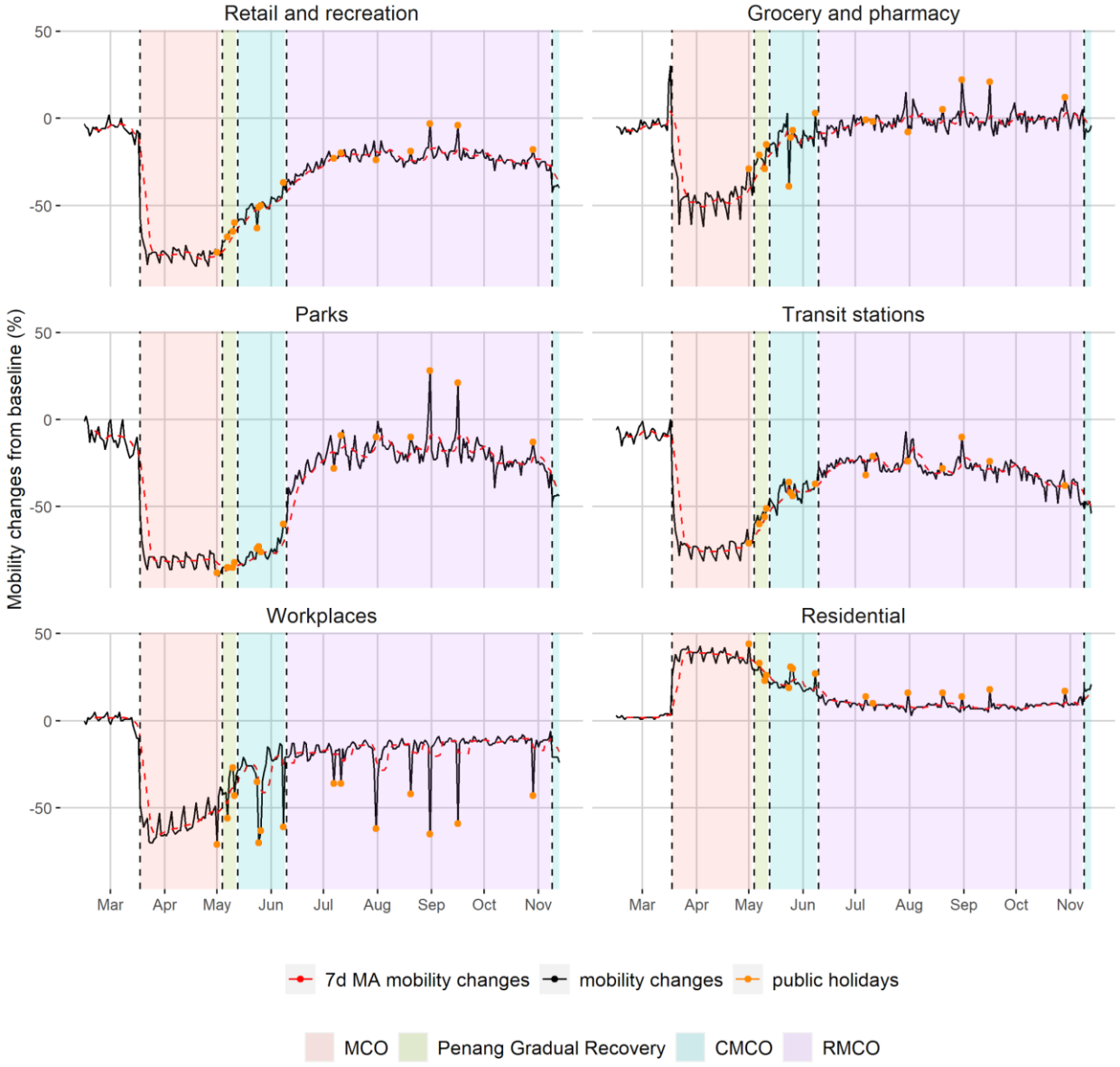
Table A6: Examples of different locations covered under different categories

Category	Locations
Retail and recreation	Restaurants, cafes, shopping centres, theme parks, museums, libraries and cinemas
Grocery and pharmacy	Grocery markets, food warehouses, farmers markets, specialty food shops, drug stores, and pharmacies
Parks	Public garden, castle, national forest, camp ground, observation deck
Transit stations	Subway station, sea port, taxi stand, highway rest stop, car rental agency

Source: Google

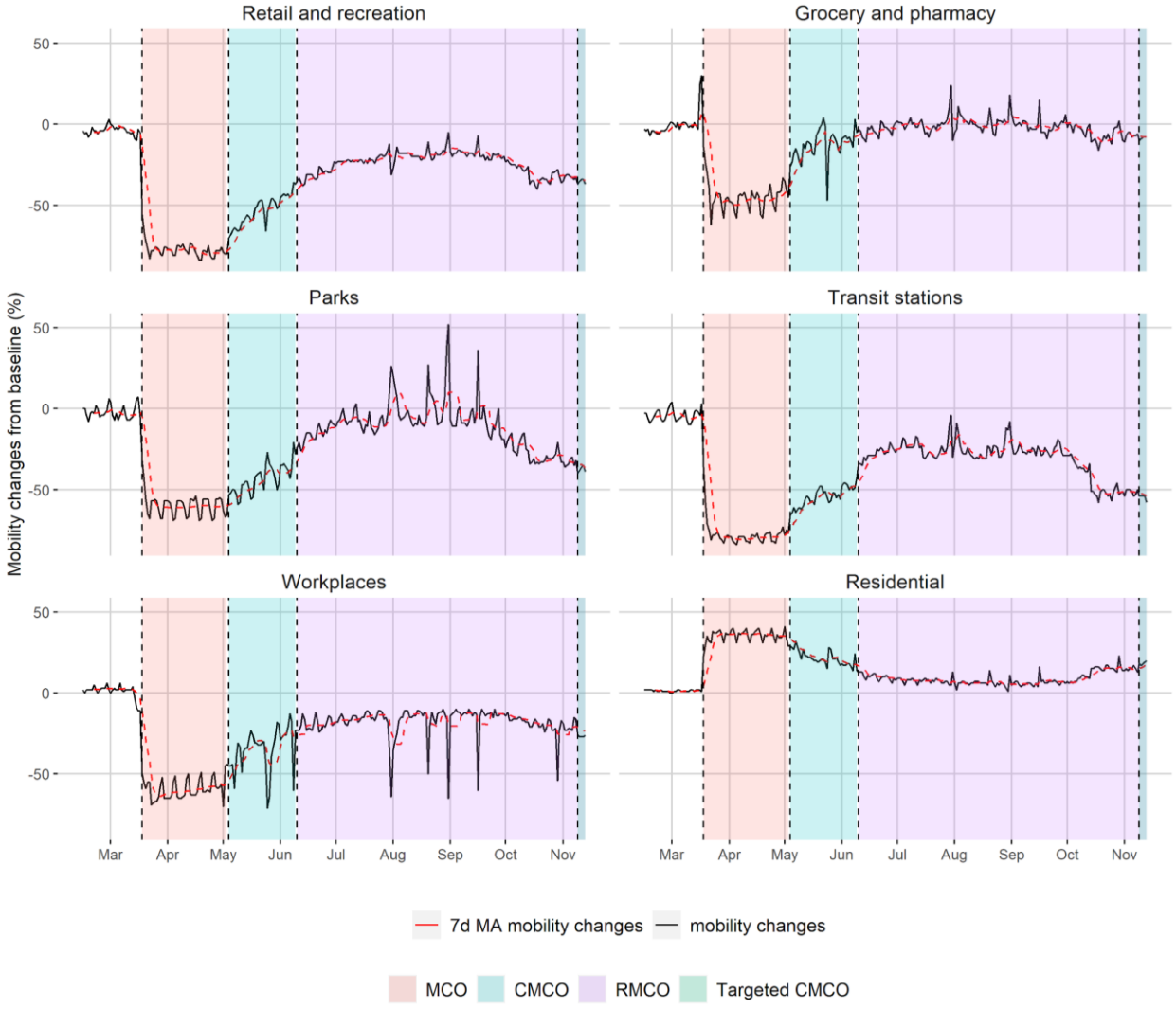
6.3 Community mobility changes

Figure A1: Daily and 7d MA of mobility changes in Penang, 15 February – 13 November 2020



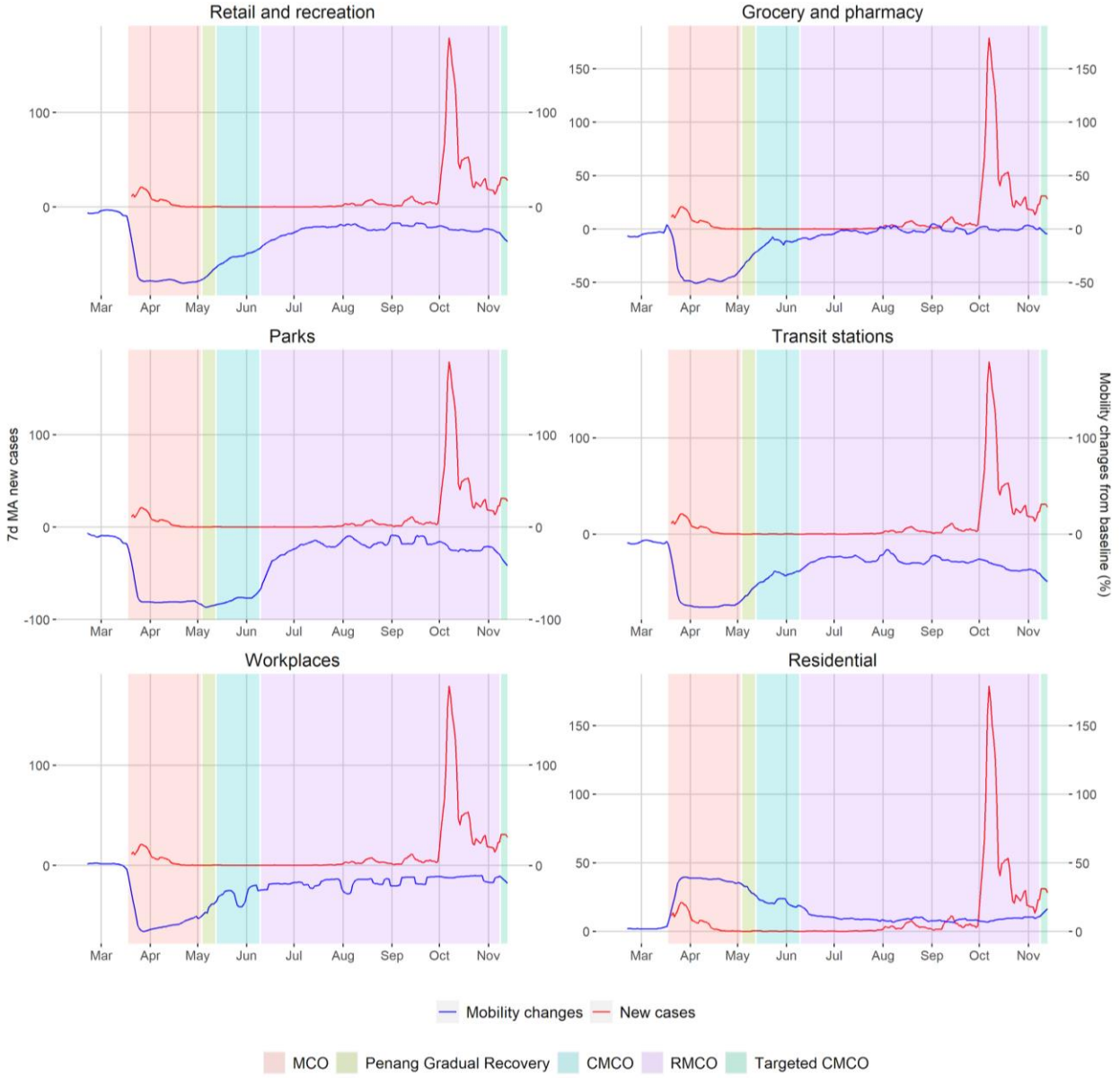
Source: Authors' calculations, derived from Google's community mobility data

Figure A2: Daily and 7d MA of mobility changes in Malaysia, 15 February – 13 November 2020



Source: Authors' calculations, derived from Google's community mobility data

Figure A3: 7d MA of new cases in neighbouring states versus mobility changes in Penang, 15 February – 13 November 2020



Source: Authors' calculations, derived from Google's community mobility data

Table A7: Areas under specific movement controls during RMCO and targeted CMCO

Areas under specific movement controls during RMCO	Type of movement control	Period of imposition
Aman Jaya, Kedah (Zon Kenanga, Zon Melur and Zon Mawar)	Administrative EMCO	Enforced 28 August 2020 – ended by phases
Kota Setar	Administrative EMCO	11 September 2020-25 September 2020
Districts of Kota Kinabalu, Penampang and Putatan, Sabah	CMCO	7 October 2020-20 October 2020
Districts of Sandakan, Papar and Tuaran	CMCO	9 October 2020-22 October 2020
Mukim Klang, District of Klang	CMCO	9 October 2020-22 October 2020
Six localities in Semporna and one locality in Kunak, Sabah	EMCO	10 October 2020-23 October 2020
Districts of Tawau, Kunak, Semporna and Lahad Datu	CMCO	13 October 2020-26 October 2020
State of Sabah	CMCO	13 October 2020-26 October 2020
Wilayah Persekutuan Kuala Lumpur, Wilayah Persekutuan Putrajaya and State of Selangor	CMCO	14 October 2020-27 October 2020
Penjara Reman and Quarters, Penang	EMCO	15 October 2020-27 October 2020
Wilayah Persekutuan Labuan	CMCO	17 October 2020-30 October 2020
Kampung Padang Che Mas, Baling, Kedah	CMCO	18 October 2020-31 October 2020
Locality of PPR Taman Harmoni, Sandakan Sabah	EMCO	23 October 2020-5 November 2020
State of Sabah	CMCO	27 October 2020-9 November

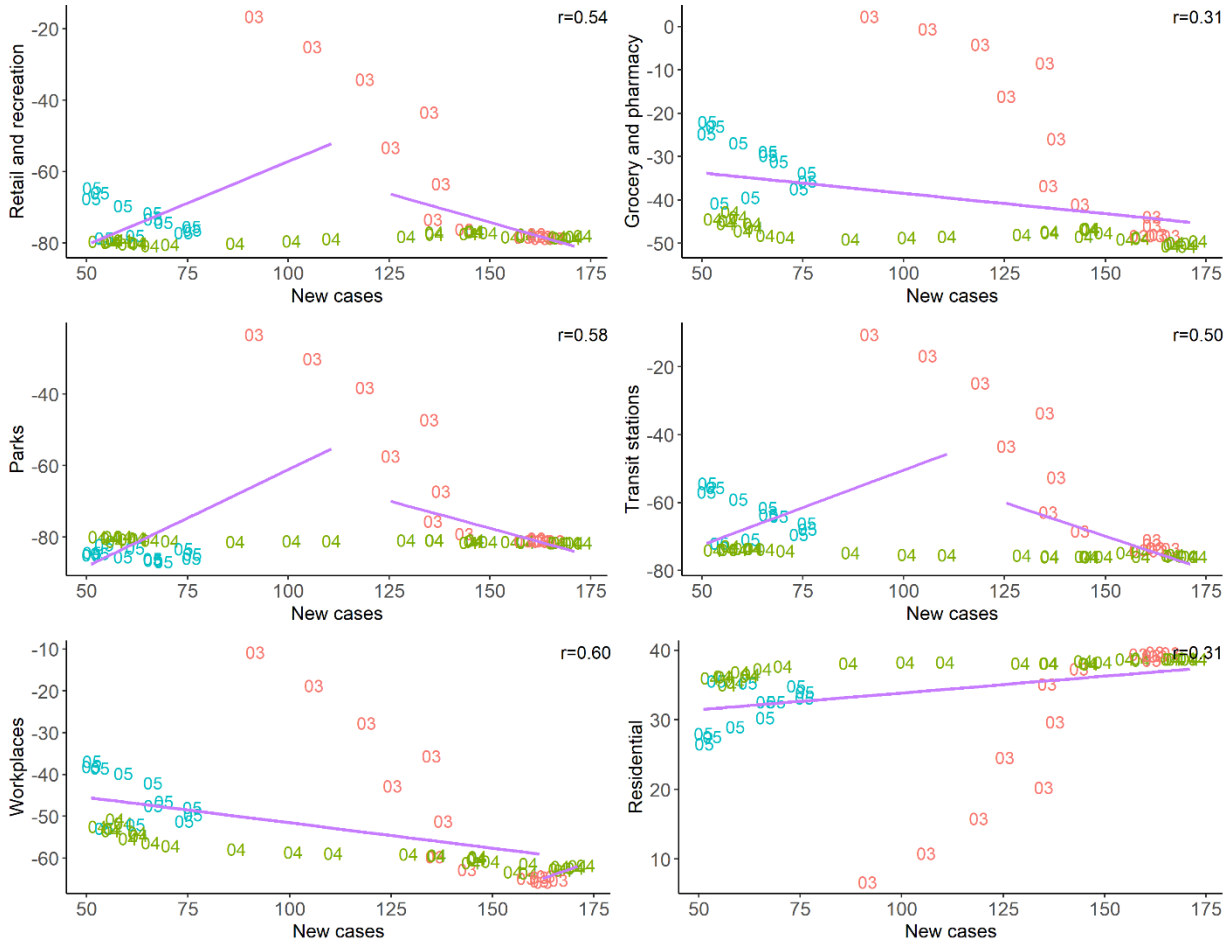
Areas under specific movement controls during RMCO	Type of movement control	Period of imposition
		2020
Taman Khazanah Indah and Pangsapuri Mutiara Kasih, Lahad Datu, Sabah Felda UMAS, Kalabakan, Sabah	EMCO	27 October 2020-9 November 2020
Prisons and quarters as announced by the government	EMCO	Based on dates and time periods as announced by the government from time to time
Wilayah Persekutuan Kuala Lumpur, Wilayah Persekutuan Putrajaya and State of Selangor	CMCO	27 October 2020-9 November 2020
Wilayah Persekutuan Kuala Lumpur, Wilayah Persekutuan Putrajaya and State of Selangor	CMCO	27 October 2020-9 November 2020
35 localities in Nilai, Negeri Sembilan	CMCO	28 October 2020-10 November 2020
Three blocks at Jalan BBN 1/7A, 1/7B and 1/7E, Bandar Baru Nilai	EMCO	28 October 2020-10 November 2020
Area of Plaza Hentian Kajang, Selangor	EMCO	28 October 2020-10 November 2020
Flat Sungai Emas, Jalan Emas 31 and Jalan Emas 32, District of Kuala Langat, Selangor	EMCO	28 October 2020-10 November 2020
Locality of Kampung. Tanjung Kapor, Kampung Pengaraban and kampong Landung Ayang, Kudat, Sabah	EMCO	30 October 2020-12 November 2020
Wilayah Persekutuan Labuan	CMCO	31 October 2020-13 November 2020
Health Ministry Training Institute	EMCO	3 November 2020-16

Areas under specific movement controls during RMCO	Type of movement control	Period of imposition
in Johor Baru		November 2020
Seremban	CMCO	5 November 2020-18 November 2020
Mukim 12, Southwest District, Penang	CMCO	6 November 2020-19 November 2020
Mukim Parit Buntar, Daerah Kerian, Perak	CMCO	7 November 2020-20 November 2020
Mukim Rasau, Dungun, Terengganu	CMCO	7 November 2020-20 November 2020
All of Peninsular Malaysia except for the states of Perlis, Pahang and Kelantan	CMCO	9 November 2020-6 December 2020
Kg Sabah Baru, Lahad Datu, Sabah	EMCO	10 November 2020-23 November 2020
Locality of PPR Taman Mesra, Sandakan	EMCO	11 November 2020-24 November 2020
Medan 88 Sepang, Selangor	EMCO	12 November 2020-25 November 2020
Locality of Kg Tanjung Kapor, Kg Pengaraban, and Kg Landung Ayang, Kudat, Sabah	EMCO	13 November 2020-26 November 2020
Wilayah Persekutuan Labuan	CMCO	14 November 2020-6 December 2020
Penempatan Telipok dan Kg Numbak, Sabah	EMCO	16 November 2020-29 November 2020
Top Glove Workers Hostel, Klang, Selangor	EMCO	17 November 2020-30 November 2020

Note: Compiled as of announcements made until 13 November 2020
Source: National Security Council (NSC)

6.4 Correlation analysis

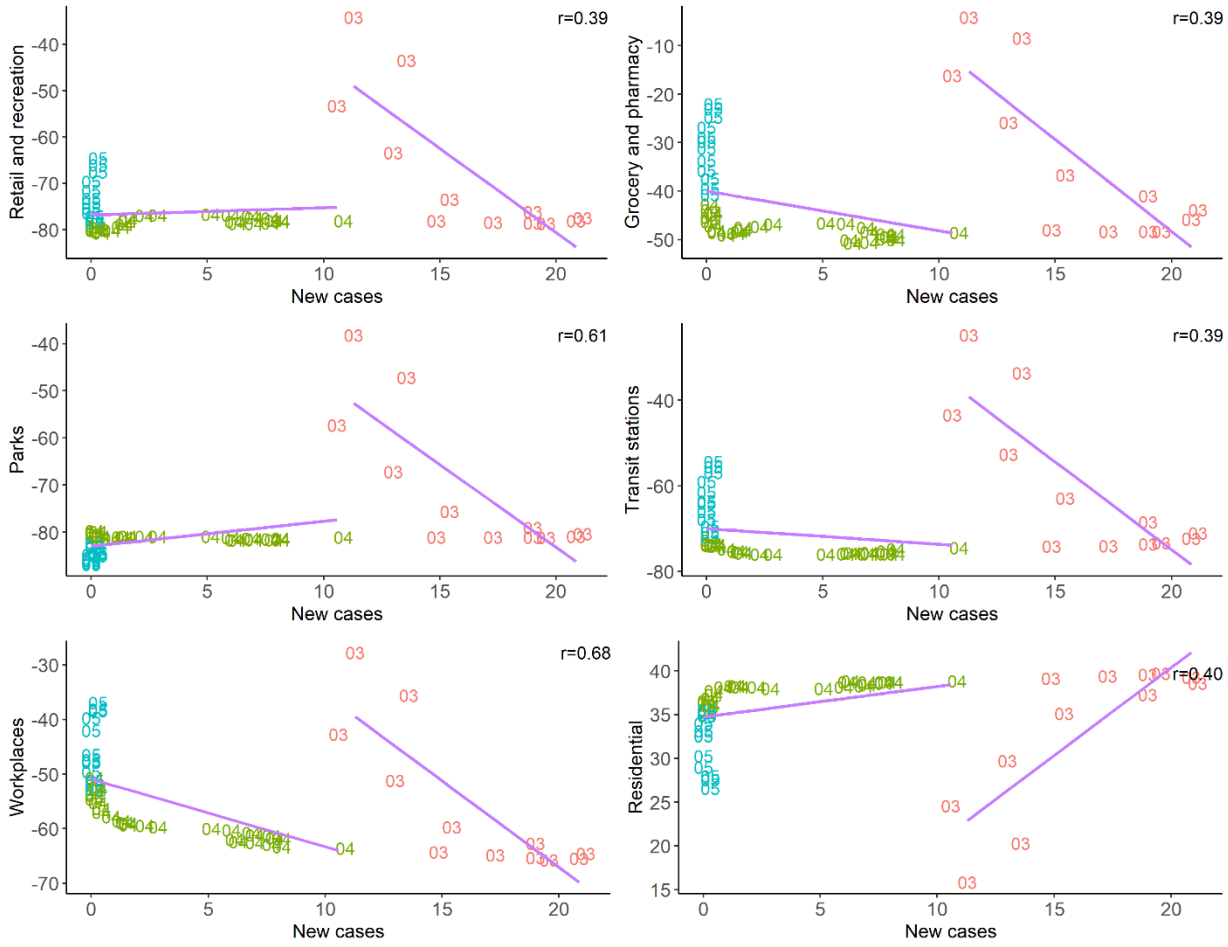
Figure A4: Non-linear correlation plots of 7d MA of mobility changes in Penang versus new cases in Malaysia during MCO (1 March – 12 May 2020)



Note: Coloured texts in each plot refer to the respective months in 2020, i.e. 03 refers to March, 04 refers to April, 05 refers to May.

Source: Authors' calculations, derived from Google community mobility data

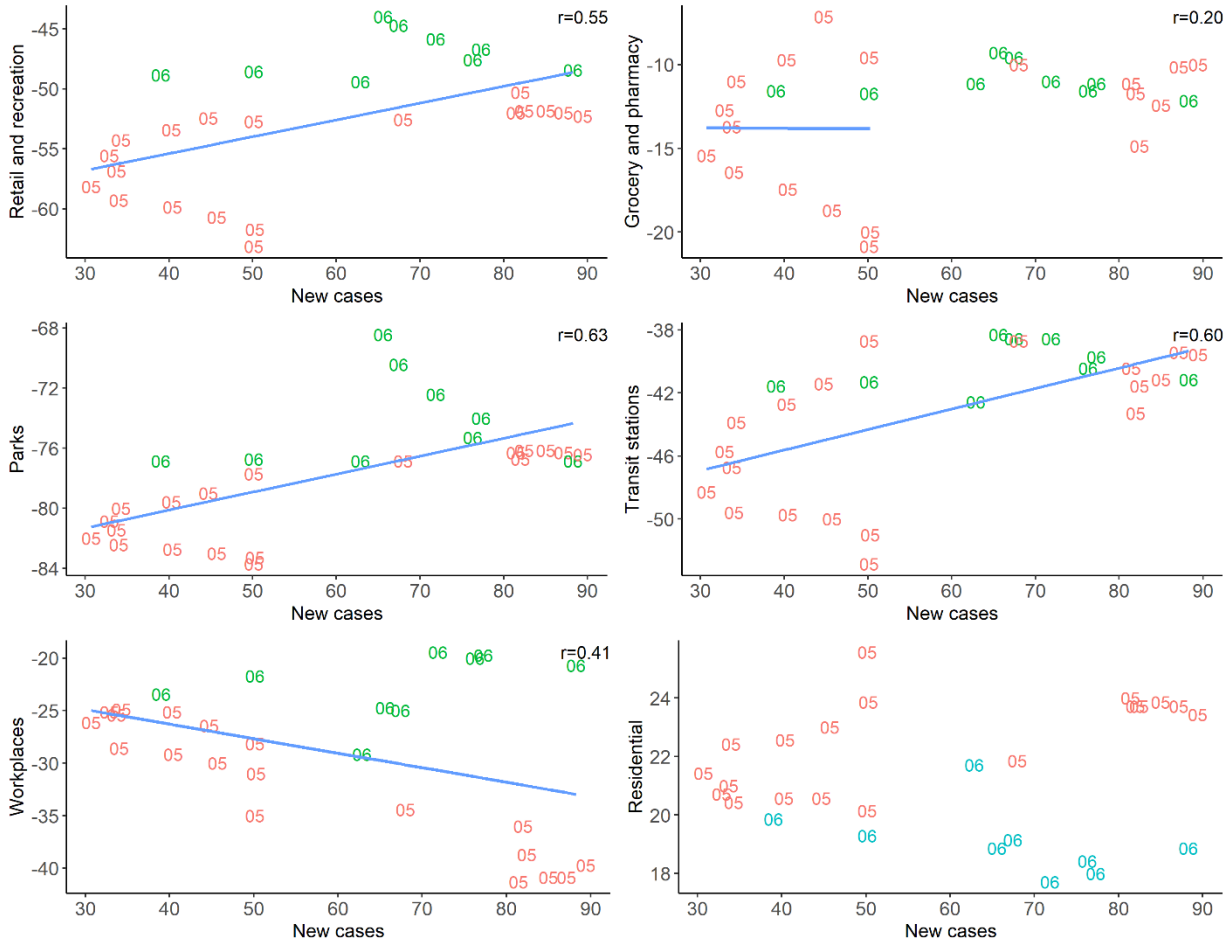
Figure A5: Linear correlation plots of 7d MA of mobility changes in Penang versus new cases in neighbouring states during MCO (20 March – 12 May 2020)



Note: Coloured texts in each plot refer to the respective months in 2020, i.e. 03 refers to March, 04 refers to April, 05 refers to May.

Source: Authors' calculations, derived from Google community mobility data

Figure A6: Non-linear correlation plots of 7d MA of mobility changes in Penang versus new cases in Malaysia during CMCO (13 May – 9 June 2020)

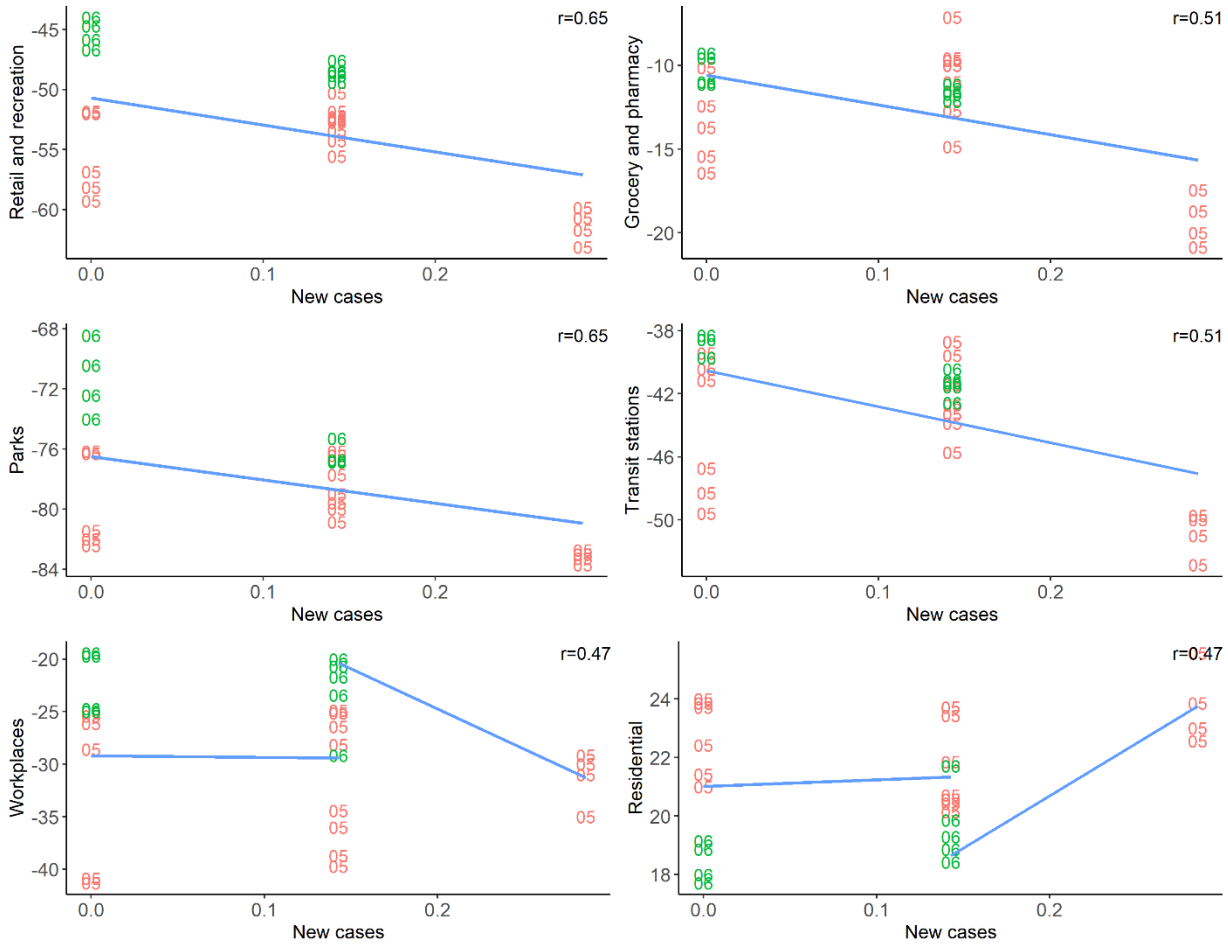


Note:

1. Coloured texts in each plot refer to the respective months in 2020, i.e. 05 refers to May, 06 refers to June.
2. Segments of plot without a straight line indicate insignificant correlation coefficients.

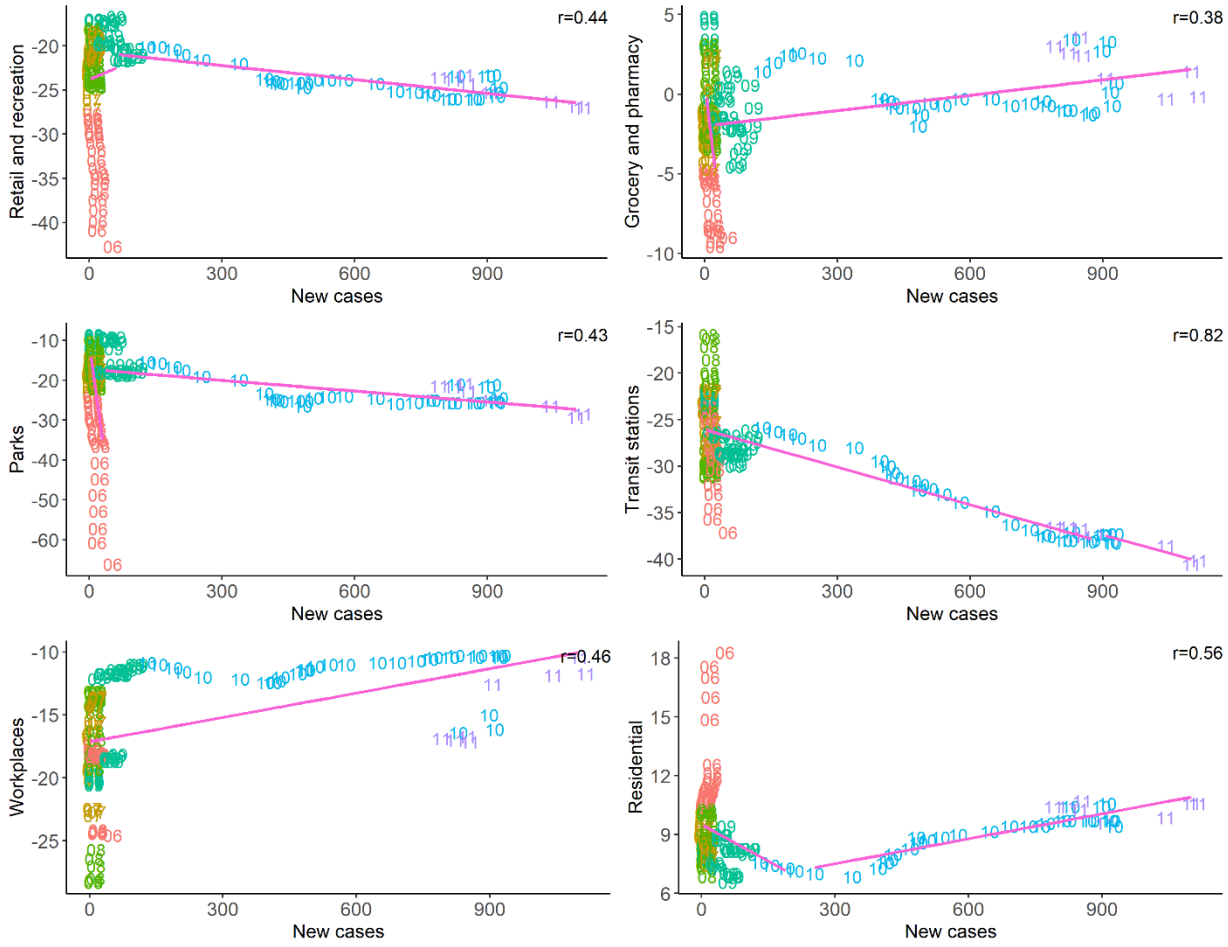
Source: Authors' calculations, derived from Google community mobility data

Figure A7: Non-linear correlation plots of 7d MA of mobility changes in Penang versus new cases in neighbouring states during CMCO (13 May – 9 June 2020)



Note: Coloured texts in each plot refer to the respective months in 2020, i.e. 05 refers to May, 06 refers to June.
Source: Authors' calculations, derived from Google community mobility data

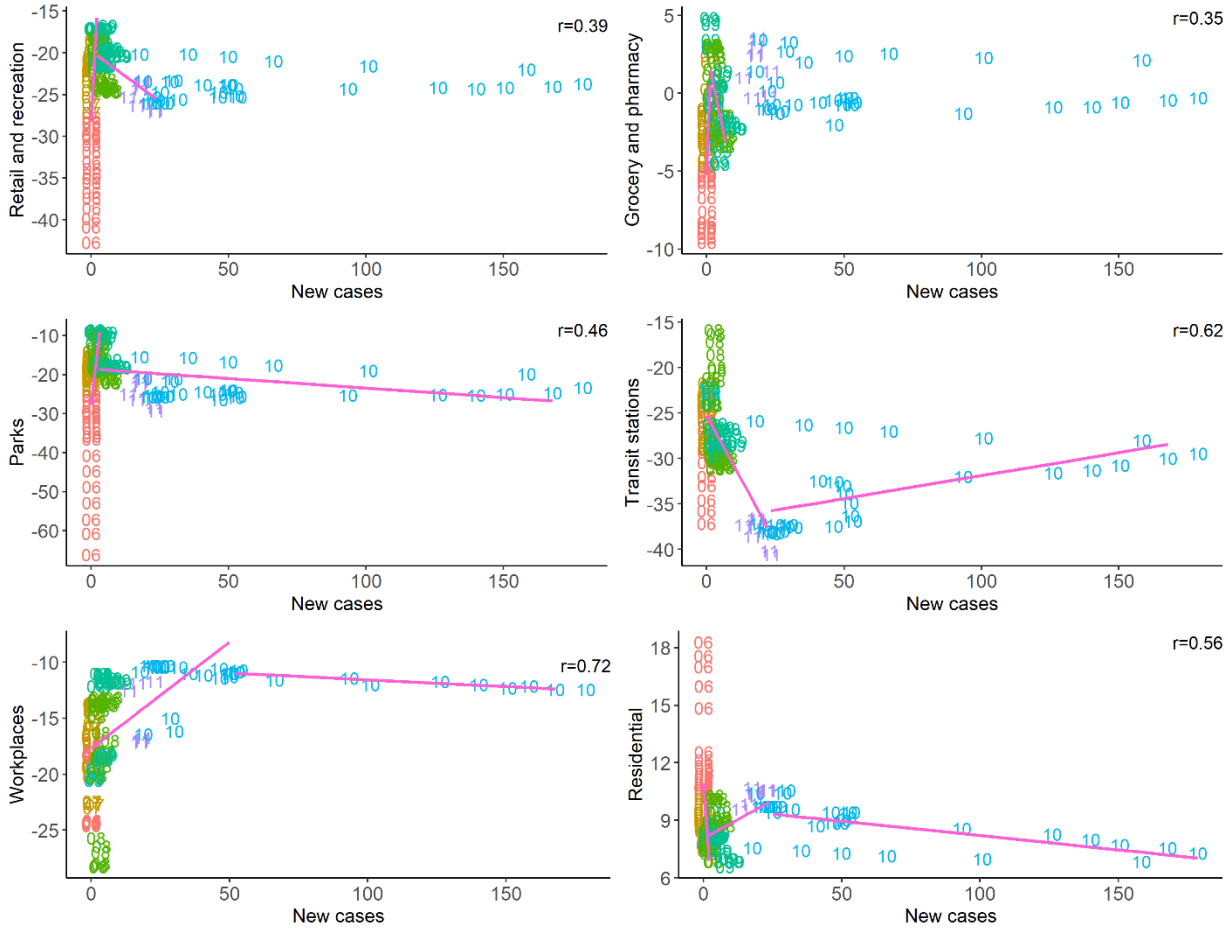
Figure A8: Non-linear correlation plots of 7d MA of mobility changes in Penang versus new cases in Malaysia during RMCO (10 June – 8 November 2020)



Note: Coloured texts in each plot refer to the respective months in 2020, i.e. 06 refers to June, 07 refers to July and so on.

Source: Authors' calculations, derived from Google community mobility data

Figure A9: Non-linear correlation plots of 7d MA of mobility changes in Penang versus new cases in neighbouring states during RMCO (10 June – 8 November 2020)

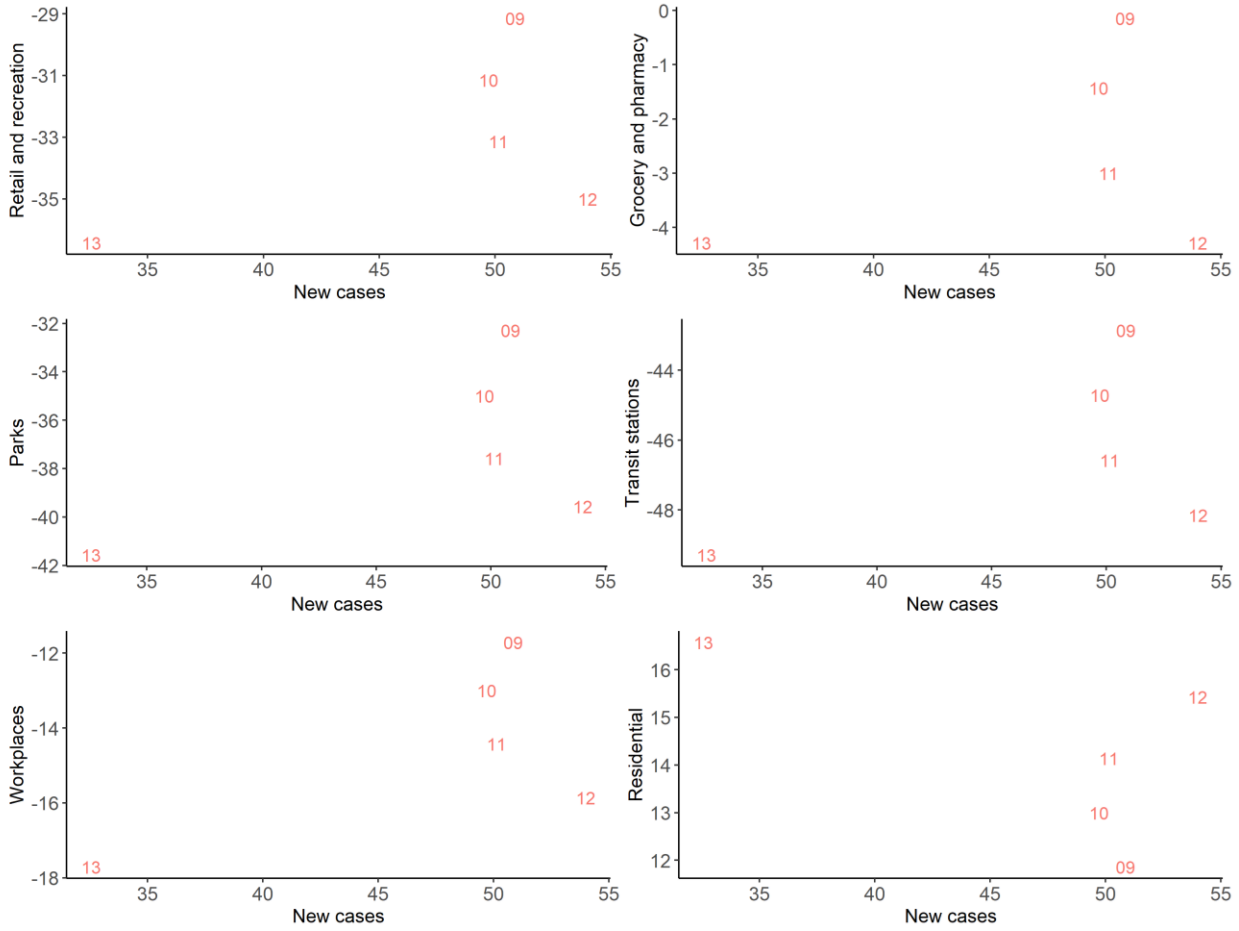


Note:

1. Coloured texts in each plot refer to the respective months in 2020, i.e. 06 refers to June, 07 refers to July and so on.
2. Segments of plot without a straight line indicate insignificant correlation coefficients.

Source: Authors' calculations, derived from Google community mobility data

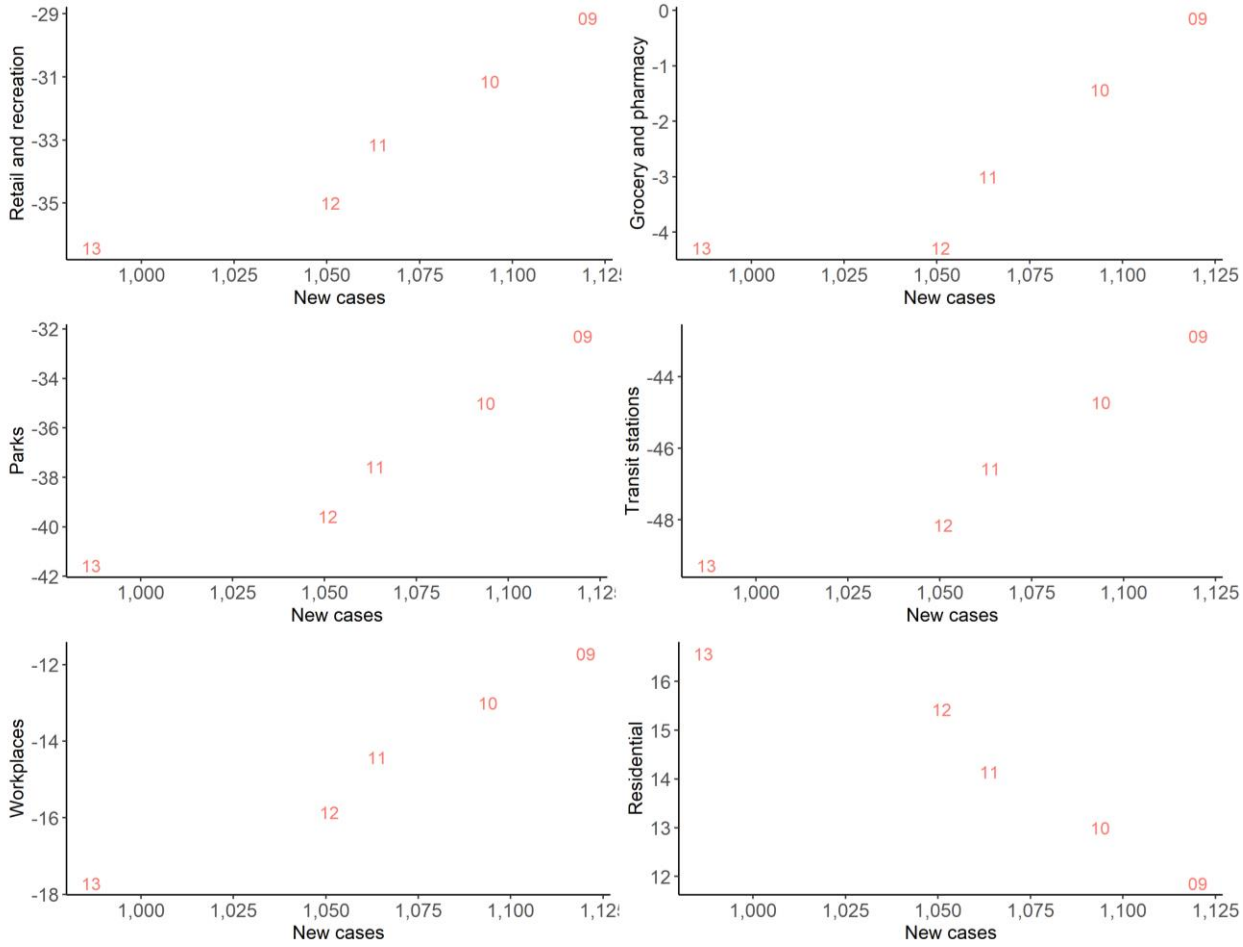
Figure A10: Scatter plots of 7d MA of mobility changes versus new cases in Penang during targeted MCO (9–13 November 2020)



Note: Coloured texts in each plot refer to the days in November 2020, i.e. 09 refers to 9/11, 10 refers to 10/11 and so on.

Source: Authors' calculations, derived from Google community mobility data

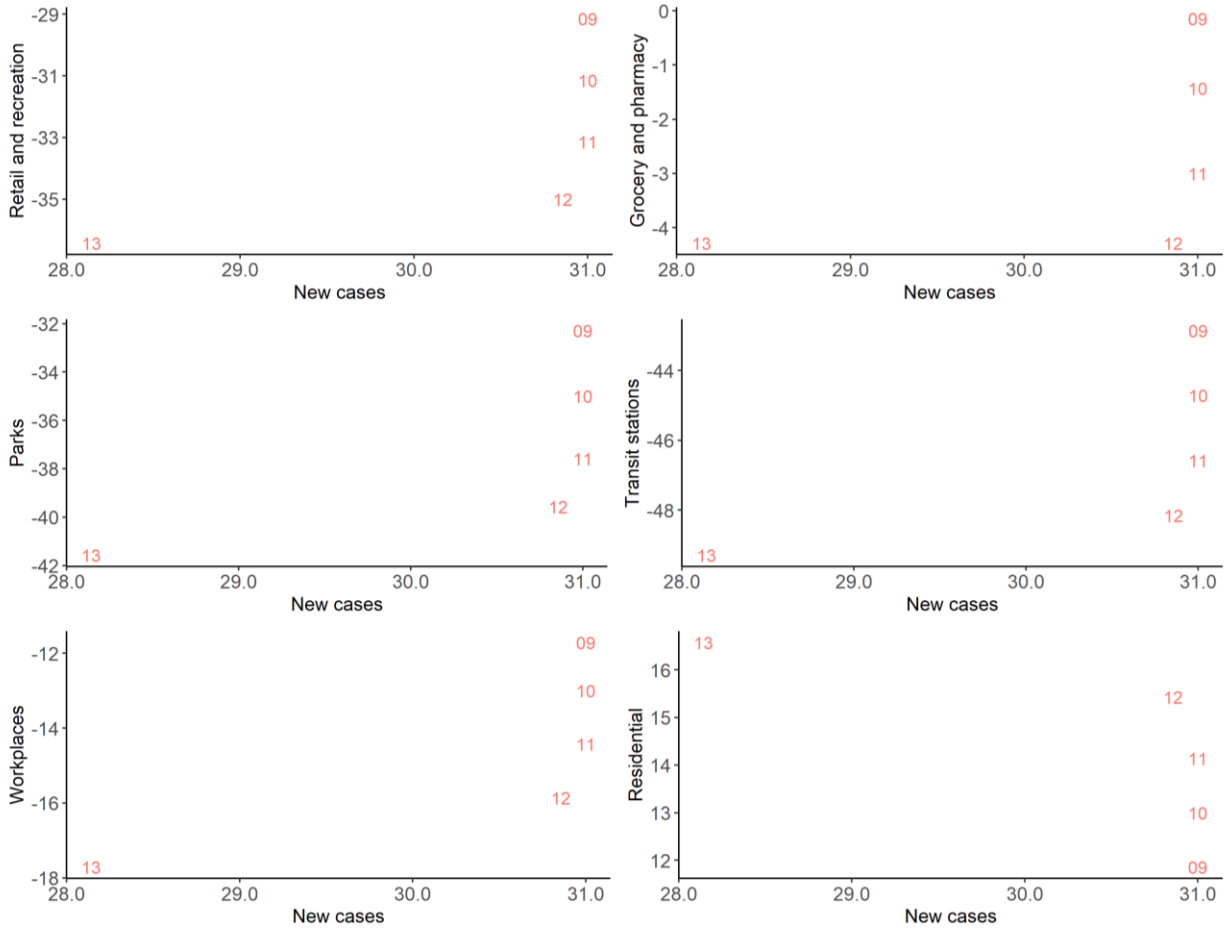
Figure A11: Scatter plots of 7d MA of mobility changes in Penang versus new cases in Malaysia during targeted MCO (9–13 November 2020)



Note: Coloured texts in each plot refer to the days in November 2020, i.e. 09 refers to 9/11, 10 refers to 10/11 and so on.

Source: Authors' calculations, derived from Google community mobility data

Figure A12: Scatter plots of 7d MA of mobility changes in Penang versus new cases in neighbouring states during targeted MCO (9–13 November 2020)



Note: Coloured texts in each plot refer to the days in November 2020, i.e. 09 refers to 9/11, 10 refers to 10/11 and so on.

Source: Authors' calculations, derived from Google community mobility data

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