Corona Squeeze of the Sri Lankan Economy: A Sectoral Outlook\(^1\)

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Abstract

*Given the stark choice between saving lives with no certainty vs. saving livelihood with some certainty, Sri Lanka, like some other countries, opted for the former and acted early. Would this wreak havoc in the Sri Lankan economy? Using a forward-looking econometric methodology that combines estimates from pre-crisis data with calibrated estimates for the Covid-19 impact, this exercise tries to shed some light on what to expect from fifteen major sectors of the Sri Lankan economy. This is not a forecasting exercise. Instead, the methodology that accounts for sectoral interdependence generates not only the direct growth impact on a sector from the ‘Covid-19 sentence’, but it also generates the indirect growth impact propagated by other sectors. It is these indirect effects that prolong the downturn in many sectors. One sector cannot recover fully in isolation. Under the optimistic scenario, if Covid-19 pandemic withers away and normalcy returns before the end of the year (2020), a V-shape or U-shape recovery is likely for all the sectors. Some sectors, however, may take more than two years to fully recover. This is too much of a drag and calls for effective policy interventions to expedite the recovery process. Under the pessimistic scenario where Covid-19 outbreaks linger on, the economy would go into an L-shape drag. The growth numbers by sector indicate that GDP in 2020 alone may contract by about 4.3%. The very objective of these warning lights is not to realize the bad outcome.*

**Keywords:** Forward Looking Methodology, Sectoral Interdependence, Covid-19 Shock, Impulse Response Analysis, Direct and Indirect Impact on Sectors

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Introduction
It was a choice between saving lives vs. saving livelihood under enormous uncertainties. Some countries tried to do both initially and failed. Some countries including Sri Lanka opted to save lives first. Many countries including Sri Lanka, having no other choice, were forced to adopt somewhat blindfold measures to control the spread of the corona virus disease (Covid-19) though at a heavy cost to their economies and the global economy in general. International institutions like the World Bank (2020), International Monetary Fund (2020), and International Labour Organization (2020) have already provided warnings on the economic fallout of the pandemic. It suffices to say that the social and economic despair caused by the pandemic at the global scale is likely to be unprecedented.

In the optimistic scenario the pandemic may wither away completely, before the end of the year, like the SARS episode did in 2003. In the pessimistic scenario the pandemic may linger on for a long time with waves of varying amplitudes and duration. The severity and duration of the economic downturn that Sri Lanka has faced will be known much later only when the official statistics are out. Nevertheless, it is worth assessing what to expect. The objective of this exercise is to provide a quantitative assessment of the growth impact on fifteen major sectors of the Sri Lankan economy under these two scenarios. Such prior analyses and early warnings are of immense value to policy makers in steering the economy away from potential danger zones. At the outset, it should be emphasized, however, that prior indicators should not be assessed against the actual outcomes because the very objective of early warnings prevent the realization of bad outcome.

While section 2 provides a non-technical summary of the methodology, the technical details are relegated to Appendix. A major contribution of this exercise is the methodology. Section 3 highlights some descriptive results from the data. The key results from the impulse response analysis are given in Section 4. In Section 5 some pointers from the impulse response analysis are discussed.

Methodology
This type of analysis requires forward-looking methodologies instead of those that rely only on past data. For the ease of reading, mathematical
details of the methodology, developed within the framework of intervention analysis, are given in Appendix. In less-technical terms, the key aspects of the methodology are the following.

1. The econometric model consists of 15 regression equations, one for each sector. The sectors are all interdependent. The intervention variable is the Covid-19 shock, represented by a binary dummy variable.

2. The sectoral growth interdependence among the 15 sectors is estimated from pre-crisis data. The parameter estimates for the intervention variable are calibrated.

3. In addition to the Covid-19 intervention variable, the model uses two other exogenous variables, export-share weighted GDP of Sri Lanka’s trading partners (FORGDP, for foreign GDP) and visitor arrivals (VISITOR). These two variables are used in estimating the parameters from pre-crisis data and for obtaining sectoral forecasts for calibrating the intervention parameters.

4. The calibration is done by first forecasting each sector value-added growth for the first three quarters of 2020 and then estimating the parameters of the Covid-19 dummy for 2020 Q1 Q2 and Q3 by running another regression for each sector.

5. After obtaining all the parameter estimates (285 in total), the growth effects of the Covid-19 shock are estimated by deriving what are known as impulse responses. These growth effects indicate what to expect from 2020 Q1 onwards for over 16 quarters or four years.

Data
Quarterly value-added data (at constant prices) over the period 2010 Q1-2019 Q4 by major sector and sub-sector are provided online in the Department of Census and Statistics website. Figure 1 shows the 15 major sectors ranked by the average GDP share during 2018-19. For manufacturing sector is the largest with a GDP share of 15.6% and the information & communications sector is the smallest, with a GDP share of 0.7%. In contrast, manufacturing is the smallest sector in Hong Kong that resulted over the years because of industrial hollowing out. Singapore and Taiwan, however, try to sustain the prominence of the manufacturing sector.

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3 All the data series are seasonally adjusted. Seasonal adjustment had to be done carefully because of some data anomalies.
The information and communications sector in Sri Lanka is relatively very small; this sector in Hong Kong accounts for 3.3% of GDP, in Singapore 4.1% and in Taiwan 3.2%. The utilities sector that includes electricity, gas and water supply and waste management is typically a small sector in terms of value added because these services are essential and not run on a commercial basis. In Sri Lanka, the accommodation and food services sector that includes hotels and restaurants is also small with a GDP share of 1.6% whereas in Hong Kong this sector’s contribution to GDP is 3.1%, in Singapore 2.1% and in Taiwan 2.4%. This shows how small Sri Lanka’s tourism sector is.

**Figure 1: GDP Share (%) of Value Added of the 15 Major Sectors during 2018-19**

Source: Central Bank of Sri Lanka

Figure 2 plots the two exogenous variables in the model, (a) FORGDP index and (b) Visitor arrivals. FORGDP is derived from export-share weighted GDP growth rate of Sri Lanka’s trading partners (61 economies including the rest of the world). The sharp drop of the variable in 2009 is a result of the Global Financial Crisis.
For the sake of information, quarterly visitor arrivals are plotted since 1970. Visitor arrivals are highly seasonal with peaks occurring in December and January. What is important to notice is that during the LTTE war period (1983-2009) tourism hovered below 200,000 per quarter and picked up noticeably only after the war ended in 2009. The impact of the Easter bombing on April 21, 2019 is also clearly visible in the graph.

We need to forecast these two variables for the first three quarters of 2020 in order to calibrate the Covid-19 related parameters of the model. Although we can set forecast values for VISITOR growth with some certainty, generating forecasts of FORGDP growth is anybody’s guess. Given the extreme uncertainties that prevail, it would be best to use a non-informative prior (as in the Bayesian analysis) and set a uniform contraction of FORGDP growth for every quarter of 2020. Nevertheless, based on preliminary information coming from other countries we set FORGDP to -1% growth in Q1. For the next two quarters we set -3% growth. These are obviously too conservative numbers.Visitor data for 2020 Q1 were available and shows 18.1% drop over the previous quarter. For 2020 Q2 and Q3 zero visitor arrivals is assumed because of travel restrictions and fear of travel.

**Figure 2. (a) GDP of Sri Lanka’s Trading Partners (FORGDP) and (b) Visitor Arrivals (Quarterly)**

Source: Central Bank of Sri Lanka

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4 Experimenting with other numbers show that the basic conclusions remain unaffected except for inferences on the severity of the downturn.
Results

Regression Estimates
Regression estimates based on data over 2010 Q1-2019 Q4 are shown in Table 1. Estimates highlighted in black are statistically significant at the standard levels. The short sample period may be the reason for insignificance of some other estimates. The key observations from the estimates are the following.

1. Most noteworthy are the estimates for $y^*$ (weighted sum of growth rates of the sectors excluding the sector in the column heading, See Appendix). They are all positive and the sum of the coefficients of $y^*, y^{*-1}, y^{*-2}$ is also positive. This indicates that sectoral interdependence is strong and reinforcing. Mining and quarrying and construction show the strongest dependence on other sectors.

2. The growth of Sri Lanka’s trading partners (FORGDP) is highly conducive to the growth of the manufacturing sector. Although the construction sector coefficient is larger, it is not statistically significant. FORGDP is also important for a number of other sectors.

3. Interestingly, growth of visitor arrivals (VISITOR) seems to benefit many sectors. Visitor expenditure (not available in detail) would have shown a much stronger effect. The sectors that do not pick up any direct effect from visitor arrivals are finance and insurance, public administration, and health. Nevertheless, there is an indirect effect as shown in Figure 3 later. As expected, the sector that is most affected by a drop in visitor arrivals is accommodation and food (hotels and restaurants) followed by transportation, and wholesale and retail trade.

4. Most of the autoregressive coefficients (those of $y(-1)$ and $y(-2)$ are negative. This is because quarterly growth rates tend to fluctuate a lot compared to annual growth rates.
Table 1. Regression Estimates for Sector Value Added Growth

<table>
<thead>
<tr>
<th>Sector</th>
<th>Agri</th>
<th>Mining</th>
<th>Manf</th>
<th>Util</th>
<th>Cons</th>
<th>WRtrd</th>
<th>Trans</th>
<th>Accom</th>
<th>Info</th>
<th>FinIns</th>
<th>BizS</th>
<th>Admn</th>
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<tr>
<td>y(-1)</td>
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<td>-0.54</td>
<td>-0.43</td>
<td>-0.42</td>
<td>-0.47</td>
<td>-0.32</td>
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<td>-0.13</td>
<td>-0.19</td>
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<td>0.03</td>
<td>0.13</td>
<td>-0.19</td>
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<tr>
<td>y(-2)</td>
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<td>-0.12</td>
<td>-0.39</td>
<td>-0.09</td>
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<td>-0.31</td>
<td>-0.14</td>
<td>0.06</td>
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<td>-0.11</td>
<td>0.09</td>
<td>0.17</td>
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<tr>
<td>y*(-2)</td>
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<td>1.57</td>
<td>0.36</td>
<td>0.38</td>
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<td>-0.18</td>
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<td>1.23</td>
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<td>VISITOR</td>
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<td>0.01</td>
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<td>-0.02</td>
<td>0.17</td>
<td>0.51</td>
<td>-0.79</td>
</tr>
</tbody>
</table>


Source: Central Bank of Sri Lanka

Note: Full column headings in Figure 1. y refer to the growth rate of the relevant sector in the column heading, y(-1) and y(-2) are the lags, y* is the weighted sum of growth rates of other sectors with two lags, FORGDP is the export-share weighted growth rate of Sri Lanka’s trading partners, VISITOR is growth rate of visitor arrivals to Sri Lanka. Some regressions include outlier dummies. The estimates highlighted in black are those that are statistically significant at the standard levels. Empty cells indicate a dropped variable because of a negative estimate. Red numbers relate to FORGDP(-1) and VISITOR(-1). Estimation period 2010 Q1-2019 Q4.

Covid-19 Impact: Impulse Response (Growth Effect) Analysis

The key objective of this exercise is to assess sectoral growth outlook under the two scenarios mentioned earlier, optimistic and pessimistic. Figure 3 presents the results under the optimistic scenario where we assume that the Covid-19 outbreak withers away by the end of the third quarter of 2020. The baseline numbers in Figure 3 are in percent; percentage point responses to one percentage point growth shock (Covid-19 shock). These numbers can be multiplied by a desired number to magnify the effect. Multiplying by 10 seems to produce numbers that are more in line with the growth forecasts that we generated to calibrate the parameters. These results are presented in Table 2 under the pessimistic scenario where the Covid-19 pandemic lingers on for a long time.

5 To highlight the shape of the curves the vertical scales in Figure 3 are not standardized.
One important advantage of this analysis is that it can generate not only the direct growth impact of Covid-19 on a sector, but also the indirect impact coming through other sectors. In contrast, the numbers in Table 1 pick up only the direct impact. The results in Figure 3 and Table 2 lead to the following observations.

1. Under the optimistic scenario, if normalcy returns by the end of the third quarter of 2020, a V-shape or U-shape recovery is likely for all the sectors. However, the duration varies from sector to sector. In the absence of effective policy interventions, full recovery even under the optimistic scenario may take more than two years. This is too much of a drag and calls for effective policy interventions to expedite the recovery process.

2. It is the indirect growth effect that drags many sectors into the prolonged downturn. For example, accommodation and food (hotels and restaurants) sector, as expected, is severely affected directly because of travel restrictions. But the indirect effect from other sectors propel a further drag as time go by. A similar situation seems to occur in manufacturing, and transportation and storage sectors as well. Basically, one sector cannot recover fully in isolation.

3. Curiously, the indirect effect seems to be nearly the sole driver of the downturn in finance and insurance, public administration, defence and social security, and health sectors.

4. Numbers in Table 2 are quite suggestive of the growth impact in 2020 (column under ‘one year’). A large contraction in the accommodation and food sector is easy to understand. Why the construction sector indicates a large contraction is difficult to explain. In general, construction sectors in many countries are subject to their own dynamics and this type of model may not capture such dynamics well. The sectors that are least affected appear to be education, agriculture, forestry and fishing, utilities, and public administration, defence and social security. This is not a surprising result given the essential nature of these sectors.

5. GDP growth for 2020 is indicated by the numbers in Table 2 is -4.3%. But this outcome can be changed with effective policy interventions.
6. Under the pessimistic scenario, the economy will go into an L-shape drag as shown by the numbers in Table 2 under columns ‘two years’ and ‘four years’.

Figure 3. Optimistic Scenario: V-shape or U-shape Recovery if COVID-19 Outbreak Withers Away after Three Quarters (Baseline Growth Effects (%) over 16 Quarters)
Agriculture, Forestry & Fishing

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</tr>
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<td>8</td>
<td>0.05</td>
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Mining & Quarrying

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<td>16</td>
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Table 2. Pessimistic Scenario: L-shape Growth Effect (%) if Covid-19 Persists

<table>
<thead>
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<th>Sectors Ranked on One-Year Effect</th>
<th>One Year</th>
<th>Two Years</th>
<th>Four Years</th>
</tr>
</thead>
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<tr>
<td>Construction</td>
<td>-16.0</td>
<td>-20.8</td>
<td>-22.2</td>
</tr>
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<td>Accommodation and Food</td>
<td>-13.6</td>
<td>-18.7</td>
<td>-20.1</td>
</tr>
<tr>
<td>Mining and Quarrying</td>
<td>-10.6</td>
<td>-13.9</td>
<td>-14.6</td>
</tr>
<tr>
<td>Information and Communication</td>
<td>-7.0</td>
<td>-8.5</td>
<td>-8.8</td>
</tr>
<tr>
<td>Other Personal Services</td>
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<td>-8.0</td>
<td>-8.7</td>
</tr>
<tr>
<td>Real estate and Biz services</td>
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<td>-5.4</td>
<td>-5.6</td>
</tr>
<tr>
<td>Wholesale and Retail Trade</td>
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<td>-5.1</td>
<td>-5.5</td>
</tr>
<tr>
<td>Finance and Insurance</td>
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<td>-4.4</td>
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<tr>
<td>Health, Residential Care and Social Work</td>
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<td>-4.6</td>
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<td>Manufacturing</td>
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<td>-3.7</td>
<td>-3.8</td>
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<td>Transport, Postal and Warehousing</td>
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<td>-3.8</td>
<td>-4.1</td>
</tr>
<tr>
<td>Public admin, Defence and Social Security</td>
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<td><strong>GDP</strong></td>
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<td><strong>-5.6</strong></td>
<td><strong>-6.0</strong></td>
</tr>
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</table>

Note: Baseline numbers are multiplied by 10 for a better reflection of the severity of the downturn. Growth effect is the sum of both direct and indirects effects.

Some Pointers for Policy Discussion

In the globalized world, economic shocks are transmitted quickly across borders through direct and indirect channels. Susceptibility of an economy to such shocks depends on the intensity of the global links of the economy (Yifan and Abeysinghe, 2020). Preliminary growth estimates for the second quarter of 2020 coming from some OECD and Asian countries show how severe the economic contraction has been as a result of disruptions to global trade and travel. At the early stages of Covid-19 pandemic Abeysinghe and Yifan (2020) using their multi-country model inferred that the indirect growth impact of the Covid-19 on Sri Lanka would be relatively less severe.
because of narrow international linkages. In a hub and spoke diagram prepared using 2019 data, Qiang et al. (2020) show the linkages between value chain hubs with each other and other economies in the world. Sri Lanka sits in the periphery with very weak links. This may have come as a blessing in disguise during the Covid-19 pandemic because the economic shock of major hubs are not fully transmitted into the Sri Lankan economy. This, however, amounts to the old saying that “a man sitting on the ground does not fall.” In the long run, strong global linkages are immensely helpful not only in lifting the economy off the ground but also in sustaining a higher altitude.

If policy makers were to take a sector specific approach to stimulate the economy, it would be useful to carry out the analysis in Section 4 from another angle. Figure 4 shows the (baseline) growth impact of each sector on all other sectors after four quarters. The sectors are ranked by their growth impact under the Covid-19 environment. Most noteworthy is the positive growth effect that health, residential care and social work, and public administration, defence and social security sectors generate on other sectors. If increase in expenditures in these sectors that were allocated to manage the Covid-19 spread were taken into account, the positive growth impact of these sectors would be much larger.

Accommodation and food services sector generates the largest negative effect on other sectors. Regression estimates of Table 1 also show that this sector has a wide-spread influence on other sectors. But this is also the sector that cannot be revived easily without a resumption of international travel. Prolonged uncertainties of Covid-19 containment across the globe may lead to a substantial shrinkage of business operations of this sector unless local tourists could keep the sector going for a while.

The other sector that depends on external demand is manufacturing; the FORGDP variable is a key determinant of the manufacturing sector performance (Table 1). Extreme contraction of Sri Lanka’s major export markets means a reduced demand for Sri Lanka’s manufactured exports.

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6 The analysis in this exercise was carried out in May/June 2020. At the revision stage of the exercise in early September, Sri Lanka’s 2020Q1 growth rate was reported to be 1.6% contraction and estimates for the second quarter were not available.
Nevertheless, international trade has not come to a halt and the outlook for the manufacturing sector is not as uncertain as that for the tourism sector.

Recovery obstacles of other sectors do not appear to be that daunting. While there is a concerted effort by the government to revive the agricultural sector and some domestic industries, the pace of digitalization of the economy has been slow. Talking about the resilience of the Chinese economy Zhang (2020) notes: “It owes this, in no small measure, to a decade of commitment to heavy investment in technology-driven structural transformation.” Zhang goes on to point out that the expansion of the digital economy of China accounted for 34.8% of GDP and 25% of total employment in 2018. The Covid-19 saga has further accelerated the digitalization process in China. Even in Singapore, Lim et al. (2020) using Mastercard data find a substantial shift in consumer expenditure in online transactions since the beginning of Covid-19 restrictions. Sectors such as finance and insurance that are highly digitalized in Singapore have weathered the Covid-19 impact better (Singstat site). Apart from resilience, digitalization process is productivity enhancing in the long run (Jorgenson, Ho and Stiroh, 2008).

**Figure 4. Growth Impact of Each Sector on all other Sectors after Four Quarters**

Note: The numbers are only the baseline effects
Concluding Remarks
The key findings from the Covid-19 growth impact analysis are summarized in the previous sections and not repeated here. Instead, it is worth drawing attention to a couple of other aspects. First, although a V-shape or U-shape recovery is likely for all the sectors, the question is the duration of the downturn. Expediting the recovery process requires policy interventions. Rich countries have already earmarked huge sums of money for stimulating their economies. In the case of Sri Lanka, already faced with the problem of public debt sustainability, stimulating the economy through fiscal means or otherwise is a question open for discussion.7

Second, it is a common belief that the Corona pandemic is going to create major shifts in the global economic structure. The nature of structural shifts is uncertain at this stage. Therefore, such unknown shifts cannot be modelled easily. Nevertheless, early warning lights through this type of analyses are helpful in designing corrective action and even structural shifts.

Commenting on this exercise both Harsha Aturupane and Indrajit Coomaraswamy raised this question.

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Appendix

General Methodology

The standard workhorse for this type of setting is the vector autoregression (VAR) framework. As is well known, however, the standard VAR models become unwieldy when the number of variables to be modelled increases. This problem is addressed in various ways in structural VAR models. We have adapted the methodology in Abeysinghe (2001), Abeysinghe and Forbes (2005) and Yifan and Abeysinghe (2020). In this section we present the general methodology that can be applied in similar settings. The empirical methodology we adopt is described in the next section.

Let $y_{it}$ be the growth rate (%) of value added ($Y_{it}$) of sector $i$. We can estimate the following equation for each sector separately using pre-crisis data.

$$y_{it} = \phi_0 + \sum_{j=1}^{p} \phi_{jj} y_{it-j} + \sum_{j=0}^{p} \beta_{jj} y_{it-j}^* + \lambda'Z_t + \epsilon_{it}$$

(1)

where $y_{it}^* = \sum_{j=1}^{n-1} w_{jj} y_{jt}$, $j \neq i$ is the weighted sum of the growth rate of the remaining sectors. The weights can be worked out in different ways as discussed in the next section. $Z$ are other relevant exogenous (control) variables for the sector. The equation can be estimated by OLS, but there is an endogeneity problem because of contemporaneous $y_{it}^*$ on the RHS of (1). This is unlikely to be a serious problem as observed in Abeysinghe and Forbes (2005) and Yifan and Abeysinghe (2020) where they have tried both OLS and 2SLS.

After estimating all equations using pre-crisis data, each $y_{it}^*$ can be opened up with estimated $\beta$ s and weights. Ignoring $Z$ variables and if $n=3$ and $p=1$ equation (1) for sector 1 can be expanded as:

$$y_{it} = \phi_0 + \phi_{11} y_{t-1} + \beta_{01} (w_{12} y_{t-2} + w_{13} y_{t-3}) + \beta_{11} (w_{12} y_{t-3} + w_{13} y_{t-4}) + \epsilon_{it}$$

(2)

---

8 McKibbin and Fernando (2020) and Maliszewska, Matto and Mensbrugghe (2020)
In matrix notation the three equations can be written (without the constant term) as

\[
\begin{pmatrix}
1 & -\beta_{11} & -\beta_{12} \\
-\beta_{21} & 1 & -\beta_{22} \\
-\beta_{31} & -\beta_{32} & 1 \\
\end{pmatrix}
\begin{pmatrix}
w_{12t} & w_{13t} & y_{1t} \\
w_{21t} & w_{23t} & y_{2t} \\
w_{31t} & w_{32t} & y_{3t} \\
\end{pmatrix}
= 
\begin{pmatrix}
\phi_1 & \beta_{11} & \beta_{12} \\
\beta_{21} & \phi_2 & \beta_{12} \\
\beta_{31} & \beta_{32} & \phi_3 \\
\end{pmatrix}
\begin{pmatrix}
w_{12t-1} & w_{13t-1} & y_{1t-1} \\
w_{21t-1} & w_{23t-1} & y_{2t-1} \\
w_{31t-1} & w_{32t-1} & y_{3t-1} \\
\end{pmatrix}
+ 
\begin{pmatrix}
\varepsilon_{1t} \\
\varepsilon_{2t} \\
\varepsilon_{2t} \\
\end{pmatrix}
\tag{3}
\]

where the notation “\(\cdot\)” indicates the Hadamard product giving the element-wise product of two matrices.

We have to combine pre-crisis parameter estimates with calibrated parameter values for the COVID-19 effect. COVID-19 is represented by the intervention dummy variable \(X\). The full SVAR model in matrix notation for the \(n\) sectors can be written as

\[
(B_0 \cdot W_t) y_t = \phi_0 + (B_1 \cdot W_{t-1}) y_{t-1} + \ldots + (B_p \cdot W_{t-p}) y_{t-p} + \Gamma_0 X_t + \Gamma_1 X_{t-1} + \ldots + \Gamma_p X_{t-p} + \varepsilon_t 
\tag{4}
\]

where \(B\) are restricted parameter matrices (estimated from pre-crisis data), \(\Gamma\) are diagonal calibrated parameter matrices, and \(W_t\) are smoothly changing weights.

Using the lag operator \(L\) and by fixing \(W_t\) at a desired time point, in shorthand notation \(B^w(L) = (B_0 \cdot W) - (B_1 \cdot W)L - \ldots - (B_p \cdot W)L^p\) and \(\Gamma(L) = \Gamma_0 + \Gamma_1 L + \ldots + \Gamma_p L^p\), (4) can be written as

\[
B^w(L) y_t = \phi_0 + \Gamma(L) X_t + \varepsilon_t 
\tag{5}
\]

or

\[
y_t = \phi_0^* + B^w(L)^{-1} \Gamma(L) X_t + u_t. 
\tag{6}
\]
The required impulse responses or growth effects with respect to $X_t = 1$ are given by the matrices $R(L) = B_w(L)^{-1} \Gamma(L)$.

Note that the model parameters are estimated using changing $W_t$ values and as a result, the effective parameter matrices $(B \cdot W)$ change over time. The impulse responses are computed by fixing $W_t$ at a desired time point. When $X$ is a pulse dummy, we generate the transitory effects. When it is a step dummy, we generate long term effects. The impulse responses can be generated for up to desired number of quarters and accumulate to assess how the Covid-19 impact is going to last under different scenarios.\(^9\)

**Empirical Methodology**
Apart from the value added growth rate (%) of the 15 major sectors, two additional variables are used in the model: FORGDP, export-share weighted the GDP growth rate of Sri Lanka’s trading partners (61 economies including the rest of the world) and VISITOR, growth rate of visitor arrivals to Sri Lanka. In addition, dummy variables to account for data outliers are also considered. Quarterly data that are available online over the period 2010Q1-2019Q4 are used in the estimation of the pre-crisis parameter values.

**Step 1**
We have to work out the weights in equation (1) and thereby the weight matrix in (4) to account for interdependence among the sectors. One possibility is to use input-output tables from various years. For various practical issues we did not follow this approach. Instead, we have worked out the weights directly from sector value-added data.

In the standard VAR framework, all the parameters are estimated from the observations of the $n$ variables in the model. We can adopt a two-step procedure to obtain $B$ and $W$ in (4) separately from these estimates. This method, however, provides a fixed-weight matrix instead of a time-varying one.

For illustration, consider sector 1. The basic equation to estimate the weights is of the form:

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\(^9\) Abeysinghe and Forbes (2005) discuss in detail the advantages of this type of SVAR model compared to the standard VAR framework.
where \( Z \) includes FORGDP, VISITOR and dummy variables to account for data outliers. Some experimentation is needed with these variables in the effort to obtain positive estimates for \( \omega \) coefficients. If all the \( \omega \) estimates are positive, then adjust them to sum to unity. But some \( \omega \) values may turn out to be negative. Since weights cannot be negative, add the largest negative \( \omega \) in absolute terms to all the \( \omega \) coefficients and adjust them to sum to unity. This linear transformation does not change the relative position of the coefficients and the correlation between the original and transformed vectors is one. The adjusted \( \omega \)'s are the weights.

**Step 2**

After obtaining the weights, work out \( y^*_t \) in (1) and re-estimate the equation with two lags:

\[
y^*_t = \phi_0 + \phi_1 y^*_{t-1} + \phi_2 y^*_{t-2} + \beta_0 y^*_t + \beta_1 y^*_{t-1} + \beta_2 y^*_{t-2} + \lambda' Z_t + u_t.
\]

(8)

Residual autocorrelation tests indicate that two lags are sufficient. After estimating the equations for all the sectors \( B \) and \( W \) matrices for (4) can be compiled.

**Step 3**

The most difficult task in the exercise is calibrating the parameter values for the COVID-19 intervention dummy in (4) (\( \Gamma \) matrices). Since we set the lag length to two, we need these estimates to account for the first three quarters of 2020. We have to generate forecasts for each sector in order to calibrate the parameter values. Two exogenous variables in the model are FORGDP and VISITOR. If these variables can be projected to the first three quarters of 2020, we can generate the forecasts for the sectors. Forecast assumptions we made on these two variables are explained in Section 3 and not repeated here.

These two variables alone are not enough to generate forecast growth rates for the sectors. We also have to account for sectoral interdependence. Using the structure in (4) we can obtain the forecasting model from:
\[(B_0 \cdot W)y_t = \phi_0 + (B_1 \cdot W)y_{t-1} + (B_2 \cdot W)y_{t-2} + \Lambda^* FORGDP + \Delta^* VISITOR_t + \epsilon_t
\]

(9)

where \(\Lambda^*\) and \(\Delta^*\) are diagonal matrices. Pre-multiplying (9) by \((B_0 \cdot W)^{-1}\) the forecasting model has the format:

\[y_t = A_0 + A_1 y_{t-1} + A_2 y_{t-2} + \Lambda FORGDP + \Delta VISITOR_t + u_t\]

(10)

After forecasting, sectoral growth rates for the first three quarters of 2020 and appending the data set with these values we run a regression for each sector growth rate in the form:

\[y_{1t} = \phi_0 + \phi_1 y_{1t-1} + ... + \phi_p y_{1t-p} + \gamma_0 X_t + \gamma_1 X_{t-1} + \gamma_2 X_{t-2} + v_t\]

(11)

where \(X_t = 1\) for 2020Q1 and zero otherwise. The estimated \(\gamma\) values provide the calibrated parameter estimates for equation (4).

**Step 4**
After obtaining all the required numbers, use a dedicated software like SAS to generate the impulse responses as described in equation (6).

**References**


