Lee Kuan Yew School of Public Policy

Asia Competitiveness Institute

ACI Policy Research Paper #03-2020

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May 2020

Please cite this article as:

Abeysinghe, Tilak and Kway Guan Tan "The Economic Fallout of Corona Pandemic on Singapore: For How Long?", Policy Research Paper #03-2020*, Asia Competitiveness Institute Policy Research Paper Series (May 2020).*

The Economic Fallout of Corona Pandemic on Singapore: For How Long?

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May 12, 2020

Abstract

Impending global economic impact of the COVID-19 pandemic is believed to be unprecedented. The severity and duration of the downturn will be made clear when the official data are released some months down the road. Nevertheless, early assessments provide useful warning lights for policy purposes. In this exercise we offer a methodology for such an assessment within the framework of intervention analysis. The exercise combines estimates from pre-crisis data with calibrated estimates for the intervention effect. The analysis is carried out in a structural vector autoregression framework to account for sectoral interdependence. As a result, it can generate direct and indirect impacts on sectoral growth from the intervention variable, COVID-19.

Under the scenario that COVID-19 effect withers away after three quarters as a result of effective policy interventions a V-shape or U-shape recovery within about six quarters is likely for all the sectors in Singapore except for construction, which is subject to its own dynamics. What is noteworthy is that no sector is spared because of the indirect growth impact. The direct impact is more dominant on accommodation & food services and transportation & storage resulting from restricted visitor arrivals. In the less likely scenario where the COVID-19 effect lingers on more than one year then it would be a wild guess as to how severe the downturn is going to be across all the sectors.

This is part of a series of ACI research projects on COVID-19 impact. Chan Koh Hoe, Paul Cheung, Xie Taojun and Zhang Xuyao provided valuable comments. Authors are fully responsible for the opinions expressed in the paper. Contact emails: tilakabey@nus.edu.sg; spptan@nus.edu.sg.

1. Introduction

With no discernible end to the corona pandemic, impending economic downturn and despair has become the talk of the day. The World Bank, in a number of COVID-19 related studies draws attention to the possibility of a massive increase in poverty levels globally (WB, 2020). The International Labour Organization, in a study released on April 7, 2020 projects devastating losses of working hours and employment globally and calls for swift policy actions and open trade regimes (ILO, 2020). The international Monetary Fund projects a 3% contraction of world GDP with advanced economies projected to take the brunt with 6.1% contraction in 2020. The IMF assesses that this would be the worst economic downturn since the Great Depression (IMF, 2020). Nouriel Roubini, who in 2006 predicted the 2007/08 housing bubble crash in the US, argues that risk factors that were looming even before the COVID-19 outbreak are now intensified and "threaten to fuel a perfect storm that sweeps the entire global economy into a decade of despair." (Project Syndicate, 2020).

How about the Singapore economy? IMF projects a 3.5% contraction of the Singapore economy. Although the downturn in 2020 is a certainty, its severity is highly uncertain and changes by the day as new information unfolds. Nevertheless, it would be bit easier to provide an assessment of the duration of the downturn under different scenarios. The objective of this exercise is to provide such an assessment for different sectors of the Singapore economy.

Although the required data are not yet available, we can carry out this exercise within the framework of intervention analysis as explained in the next two sections. In this framework the intervention variable (COVID-19 in the present case) is represented by a binary dummy variable. There are two key elements to this analysis. First, we have to account for sectoral interdependence. Second, in the absence of required data, we have to work out a sensible way to calibrate the parameter values for the intervention model. The latter is a challenge that requires a forward-looking methodology, not a methodology that relies solely on past data. A major contribution of this exercise, apart from the sectoral analysis, is the methodology. Those who want to skip these technical details may move to Section 4 directly where the key results are summarized.

2. General Methodology

The standard workhorse for this type of setting is the vector autoregression (VAR) framework.[1] 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 adapt the methodology in Abeysinghe (2001) and Abeysinghe and Forbes (2005). 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.

$$y_{it} = \phi_{0i} + \sum_{j=1}^{p} \phi_{ji} y_{it-j} + \sum_{j=0}^{p} \beta_{ji} y^{*}_{it-j} + \lambda' Z_t + \varepsilon_{it} \tag{1}$$

where $y^{*}_{it} = \sum_{j=1}^{n-1} w_{ijt} y_{jt}$, $j \neq i$ 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) 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 βs and weights . Ignoring *Z* variables and if *n*=3 and *p*=1 equation (1) for sector 1 can be expanded as:

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

In matrix notation the three equations can be written (without the constant term) as

$$\begin{pmatrix} 1 & -\beta_{01} & -\beta_{01} \\ -\beta_{02} & 1 & -\beta_{02} \\ -\beta_{03} & -\beta_{03} & 1 \end{pmatrix} . \begin{pmatrix} 1 & w_{12t} & w_{13t} \\ w_{21t} & 1 & w_{23t} \\ w_{31t} & w_{32t} & 1 \end{pmatrix} \begin{pmatrix} y_{1t} \\ y_{2t} \\ y_{3t} \end{pmatrix} =$$

[1] McKibbin and Fernando (2020) and Maliszewska, Matto and Mensbrugghe (2020) have used the CGE framework to assess the global growth impact of COVID-19 outbreak.

$$\begin{pmatrix} \phi_{11} & \beta_{11} & \beta_{11} \\ \beta_{12} & \phi_{22} & \beta_{12} \\ \beta_{13} & \beta_{13} & \phi_{33} \end{pmatrix} \cdot \begin{pmatrix} 1 & w_{12t-1} & w_{13t-1} \\ w_{21t-1} & 1 & w_{23t-1} \\ w_{31t-1} & w_{32t-1} & 1 \end{pmatrix} \begin{pmatrix} y_{1t-1} \\ y_{2t-1} \\ y_{3t-1} \end{pmatrix} + \begin{pmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{2t} \end{pmatrix} \qquad (3)$$

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

$$(B_0 \cdot W_t) y_t = \phi_0 + (B_1 \cdot W_{t-1}) y_{t-1} + ... + (B_p \cdot W_{t-p}) y_{t-p} + \Gamma_0 X_t + \Gamma_1 X_{t-1} + ... + \Gamma_p X_{t-p} + \varepsilon_t \qquad (4)$$

where B are restricted parameter matrices (estimated from pre-crisis data), Γ 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 $B^w(L) = (B_0 \cdot W) - (B_1 \cdot W)L - ... - (B_p \cdot W)L^p$ and $\Gamma(L) = \Gamma_0 + \Gamma_1 L + ... + \Gamma_p L^p$, (4) can be written as

$$B^w(L) y_t = \phi_0 + \Gamma(L) X_t + \varepsilon_t \qquad (5)$$

or $$y_t = \phi_0^* + B^w(L)^{-1} \Gamma(L) X_t + u_t \,. \qquad (6)$$

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 $(B \cdot W)$ are changing 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 cab 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.[2]

[2] Abeysinghe and Forbes (2005) discuss in detail the advantages of this type of SVAR model compared to the standard VAR framework.

3. Empirical Methodology

In Singapore there are 11 sectors in national income accounts. Among these 'other goods industries' accounts for a very small fraction of GDP; we ignore this sector. The remaining 10 sectors constitute: manufacturing, construction, utilities, wholesale & retail trade, transportation & storage, accommodation & food services, information & communications, finance & insurance, business services, other services industries. Two additional variables used in the model are FORGDP, export-share weighted GDP growth rate of Singapore's trading partners (61 economies including the rest of the world) and VISITOR, growth rate of visitor arrivals to Singapore. In addition, dummy variables to account for different recessionary episodes caused by events like the Asian financial crisis, SARS outbreak and the global financial crisis are also considered. We use quarterly data over the period 1978-2019 or 1985-2019 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. One major practical problem in this regard is the averaging of highly disaggregated input-output coefficients to obtain the above 10 sectors. Ideally the averages must be weighted averages. For example, to obtain the weight for the manufacturing sector, the electronics sub-sector should be assigned a bigger weight than the chemicals sub-sector. In the absence of required data simple averaging is the only option available. This may not be appropriate. For this reason, we adopt a different method to work 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 (manufacturing sector in our case). The basic equation to estimate the weights is of the form:

$$y_{1t} = \phi_0 + \phi_1 y_{1t-1} + \phi_2 y_{1t-2} + \omega_2 y_{2t} + \omega_3 y_{3t} + ... + \omega_{10} y_{10t} + \lambda' Z_t + u_t \quad (7)$$

where Z includes FORGDP, VISITOR and dummy variables to account for events like SARS and global financial crisis. Some experimentation is needed with these variables in the effort to obtain positive estimates for ω coefficients. If all the ω estimates are positive, then adjust them to sum to unity. But some ω values may turn out to be negative; largely due to the collinearity problem. Scatter plots of these variables with negative coefficients show basically no relationship. Since weights cannot be negative, add the largest negative ω in absolute terms to all the ω 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 ω's are the weights.[3]

Step 2

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

$$y_{1t} = \phi_0 + \phi_1 y_{1t-1} + \phi_2 y_{1t-2} + \beta_0 y_{1t}^* + \beta_1 y_{1t-1}^* + \beta_2 y_{1t-2}^* + \lambda' Z_t + u_t . \tag{8}$$

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) (Γ matrices). Since we set the lag length to two, we need these estimates to account for the first three quarters of 2020. For Singapore some preliminary growth rates for 2020Q1 are available. With these in hand 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.

Although we can set forecast values for VISITOR with some certainty, generating forecasts of FORGDP is anybody's guess. Visitor data for 2020Q1 are available and shows a 48% drop over the previous quarter. For 2020Q2 it is very safe to assume zero visitor arrivals because of travel restrictions. As for the third quarter, even if the travel restrictions are lifted, it is very unlikely that tourism will pick up because of the fear-persistence. Therefore, even for 2020Q3 zero visitor arrivals is assumed.

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[3] We tried constrained estimation of (7) with the restrictions $\omega_j \geq 0$ and $\sum \omega_j = 1$. Although there is some correspondence of the estimates under the two methods, constrained estimation tends to produce more zero weights.

FORGDP is a key determinant of Singapore's economic growth. 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 in every quarter of 2020. Nevertheless, based on the preliminary estimate for Singapore's manufacturing sector growth rate we set FORGDP to zero growth in 2020Q1 and -2% for the next two quarters.[4]

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:

$$(B_0 \cdot W)y_t = \phi_0 + (B_1 \cdot W)y_{t-1} + (B_2 \cdot W)y_{t-2} + \Lambda^* FORGDP + \Delta^* VISITOR_t + \varepsilon_t \tag{9}$$

where Λ^* and Δ^* are diagonal matrices. Pre-multiplying (9) by $(B_0 \cdot W)^{-1}$ the forecasting model has the format:[5]

$$y_t = A_0 + A_1 y_{t-1} + A_2 y_{t-2} + \Lambda FORGDP + \Delta VISITOR_t + u_t \tag{10}$$

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:

$$y_{1t} = \phi_0 + \phi_1 y_{1t-1} + ... + \phi_2 y_{1t-p} + \gamma_0 X_t + \gamma_1 X_{t-1} + \gamma_2 X_{t-2} + v_t \tag{11}$$

where $X_t = 1$ for 2020Q1 and zero otherwise. The estimated γ 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).

[4] We tried a couple of alternative scenarios by setting FORGDP in every quarter of 2020 to -1% and -3%. But these affect the severity of the downturn and not the key findings of the exercise.

[5] One may question why not use the model for forecasting directly. It is, however, not that simple because we need additional models to forecast variables like FORGDP and VISITOR.

4. Results

The basic regression estimates for each sector value-added growth rate are given in Table 1. It is worth highlighting some observations from the table. First, sectoral interdependence is clear from the coefficients of y* (weighted sum of value-added growth of the remaining sectors). The results are not this clear-cut if we used a regression like (7) to estimate interdependence.

Second, the construction sector has its own dynamics; apart from its own lags, the other variables in the model do not show a statistically significant link with the sector. This is understandable because construction activities often come to play as counter-recessionary measures.

Third, as expected, performance of many sectors is strongly linked to FORGDP with manufacturing and finance & insurance services showing the strongest links.

Fourth, interestingly visitor arrivals correlate with most of the sectors in Singapore though the link is not as strong as that of FORGDP.[6] The most directly affected sectors by the drop in visitor arrivals are accommodation & food services and transportation & storage. During the SARS episode visitor arrivals dropped by 61% in the second quarter of 2003 and the above two sectors contracted by 24% and 11% respectively. Even the manufacturing sector contracted by 5%. The service sector is in general affected by the fluctuations in visitor arrivals.

Table 1. Regression estimates for sector value added growth

	Manuf	Const	Utilt	W&R sale	Trans &strg	Accmd &food	Info &com	Fin &ins	BizS	OtherS
y(-1)	**-0.319**	**0.229**	-0.114	**-0.181**	**0.142**	**0.134**	0.039	**-0.155**	0.007	-0.238
y(-2)	**-0.269**	**0.303**	-0.044	-0.080	0.021	0.045	**0.209**	-0.121	**-0.562**	-0.006
y*	**1.370**	0.327	**0.317**	**0.661**	**0.240**	**0.334**	**0.264**	**0.563**	**0.404**	**0.254**
y*(-1)	0.548	-0.054	0.127	**0.372**	0.048	0.191	0.031	-0.196	0.052	0.320
y*(-2)	0.023	0.161	0.198	0.080	0.079	-0.025	0.122	-0.134	**0.442**	-0.043
FORGDP	**2.294**	0.342	**0.456**	**1.180**	**0.688**	0.082	-	**1.958**	0.230	-
VISITOR	0.053	-	-	0.022	**0.099**	**0.256**	0.046	-	0.074	0.016
Constant	-2.719	-0.616	-0.112	-0.749	-0.214	-0.495	1.227	0.060	0.811	0.858

Note: Highlighted are the estimates that are statistically significant at the standard levels. Empty cells indicate a dropped variable because of a negative estimate. y refers to the growth rate of the relevant sector, y* is the weighted sum of growth rates of other sectors, FORGDP is export-share weighted growth rate of Singapore's trading partners, VISITOR is growth rate of visitor arrivals to Singapore.

[6] Visitor expenditure, instead of visitor arrivals, would be a better indicator. There is a paucity of data for a long time series of visitor expenditure.

The main focus of the study is the impulse response analysis or assessing the time profile of the growth effect of the COVID-19 outbreak. For this we consider two scenarios: (i) COVID-19 effect withers away after three quarters, (ii) COVID-19 effect persists longer. The former is what is likely to happen with effective global policy actions including successful management of the Corona spread and the latter is what is likely to happen in the absence of effective policy interventions.

Figure 1 presents the impulse responses (growth effects) pertaining to the first scenario and Table 2 shows the results under the second scenario by letting the COVID-19 effect persists over two years. The base numbers generated are in percent; percentage point responses to a one percentage point growth shock. These base numbers can be multiplied by a suitable number to magnify the effect. Comparing with the forecast numbers we generated from model (10) we find that multiplying the base numbers by 10 provides some indication of the severity of the growth effect (see also point 4 below). Therefore, the results in Table 2 are after multiplying the base numbers by 10. Furthermore, the direct effect shows how a sector is affected directly by the COVID-19 shock and the indirect effect shows how a sector is affected through the other sectors.[7]

Some key findings from the impulse response analysis are the following.

1. Under the scenario where the COVID-19 effect withers away after three quarters, there is likely to be a V-shape or U-shape recovery within one to two years for all the sectors except for construction. It is a bit difficult to shed much light on the construction sector from this analysis because the sector is subject to its own dynamics.

2. The severity of the downturn depends on how Singapore's trading partners are going to be affected by the COVID-19 outbreak. Unlike the SARS episode which affected growth primarily through the drop in visitor arrivals, COVID-19 involves a double whammy, FORGDP and VISITOR. Although our assumptions on VISITOR are reasonable, how FORGDP is going to behave is a wild guess.

3. For eight sectors the indirect effect generated by the other sectors is stronger than the direct effect. For transportation & storage and accommodation & food services it is the direct impact

[7] This type direct and indirect impact is not possible with a single equation regression.

of COVID-19 that dominates. These are the sectors that have to bear the brunt of the drop in visitor arrivals.

4. Under the less likely scenario where the COVID-19 effect persists at a constant level then negative growth also persists and settles to constant values. Table 2 shows the impact after one year and two years. These numbers indicate that GDP contraction in 2020 is about 5.3%. For a contrast, as a result of the global financial crisis GDP contracted on an annual basis by 7.8% in 2009Q1. If the COVID-19 effect persists for another year GDP contraction in 2021 would be about 6.2%. Such a long persistence is speculative and depends on how unsuccessful the countries are going to be in controlling the Corona spread and on disruptions it creates.

Figure 1. Growth effect if COVID-19 outbreak withers away after three quarters (Baseline impulse responses over 12 quarters)

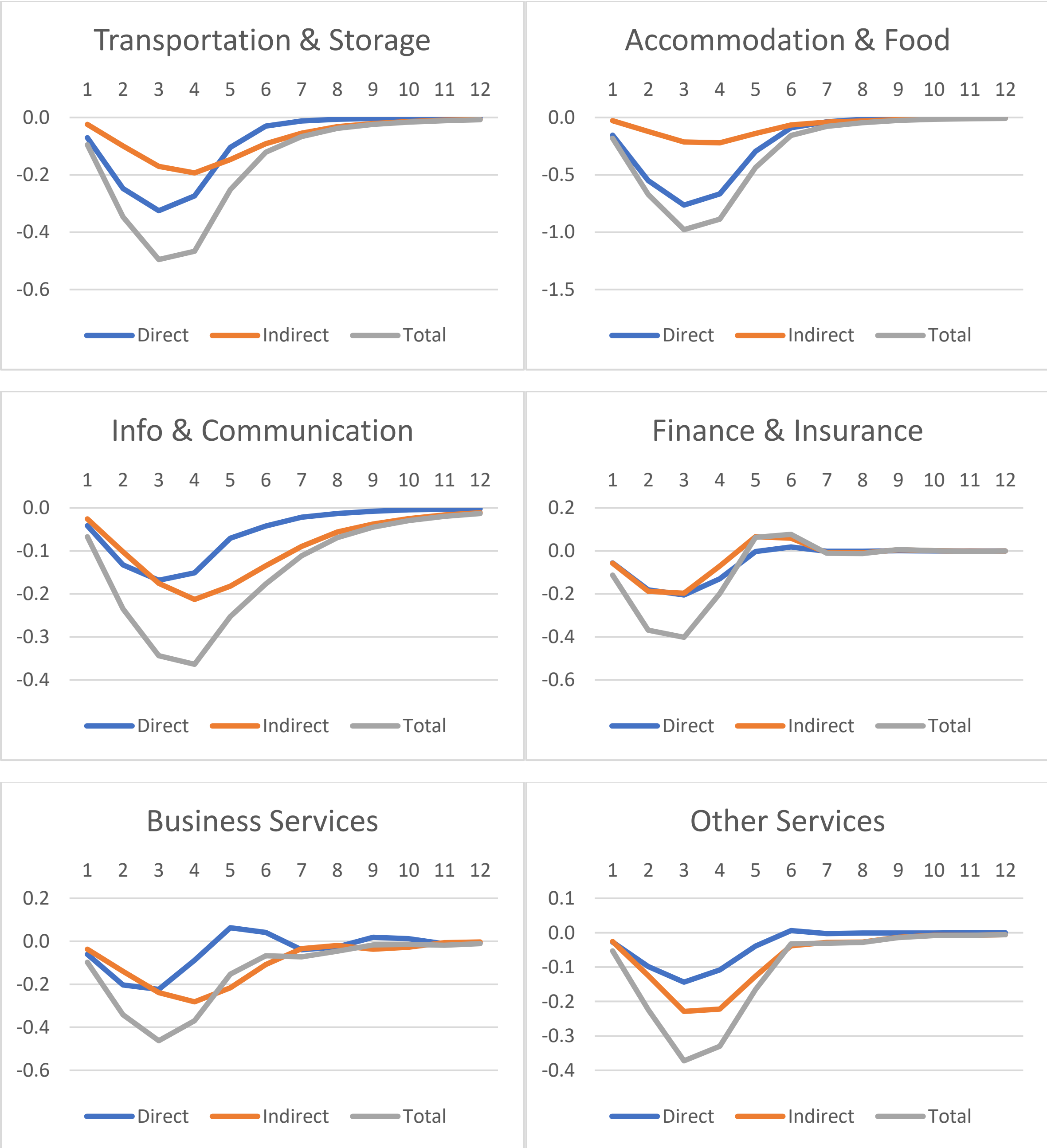
Transportation & Storage
1 2 3 4 5 6 7 8 9 10 11 12
0.0
-0.2
-0.4
-0.6
Direct Indirect Total
Accommodation & Food
1 2 3 4 5 6 7 8 9 10 11 12
0.0
-0.5
-1.0
-1.5
Direct Indirect Total
Info & Communication
1 2 3 4 5 6 7 8 9 10 11 12
0.0
-0.1
-0.2
-0.3
-0.4
Direct Indirect Total
Finance & Insurance
1 2 3 4 5 6 7 8 9 10 11 12
0.2
0.0
-0.2
-0.4
-0.6
Direct Indirect Total
Business Services
1 2 3 4 5 6 7 8 9 10 11 12
0.2
0.0
-0.2
-0.4
-0.6
Direct Indirect Total
Other Services
1 2 3 4 5 6 7 8 9 10 11 12
0.1
0.0
-0.1
-0.2
-0.3
-0.4
Direct Indirect Total

Table 2. Persisitent growth impact of COVID-19 (% change)

	After	Direct	Indirect	Total
Manufacturing	One year	-2.63	-6.37	-8.99
	Two years	-2.81	-7.04	-9.85
Construction	One year	-2.08	-2.47	-4.54
	Two years	-2.68	-4.27	-6.95
Utilities	One year	-1.14	-2.49	-3.63
	Two years	-1.17	-3.14	-4.31
Wholesale & Retail Trade	One year	-2.83	-4.92	-7.75
	Two years	-2.90	-5.60	-8.50
Transportation & Storage	One year	-3.44	-2.17	-5.62
	Two years	-3.58	-2.79	-6.36
Accommodation & Food Services	One year	-8.22	-2.49	-10.70
	Two years	-8.61	-2.94	-11.55
Information & Communications	One year	-1.92	-2.38	-4.31
	Two years	-2.17	-3.40	-5.56
Finance & Insurance	One year	-1.84	-1.27	-3.11
	Two years	-1.86	-1.31	-3.17
Business Services	One year	-1.49	-3.18	-4.67
	Two years	-1.65	-3.74	-5.39
Other Services Industries	One year	-1.35	-2.48	-3.83
	Two years	-1.38	-2.78	-4.16

Note: Baseline numbers are multiplied by 10 for a better reflection of the severity of the downturn.

5. Conclusion

There are two key aspects to this study. One is the methodology to assess the economic impact of events like COVID-19 well before the required data become available. Second is the analysis of the economic impact of COVID-19 on different sectors of the Singapore economy. The analysis is carried out within the framework of structural vector autoregression and intervention analysis. The key analytical tool is impulse response analysis that helps in assessing the severity and duration of the economic downturn across sectors under different scenarios. As a byproduct, the model can also be used for forecasting under different assumptions on the future behaviour of the exogenous variables. It should be emphasised that the objective of this type of analysis is to privide early assessments and warnings that would be helpful for policy makers. Policy interventions change the trajectoreis of the variables and, therefore, it is futile to judge the results by the actual outcomes.

The most noteworthy findings of the exercise are summarised in the previous section and hence they are not repeated here. Instead, it is worth emphasising an area where further improvement to the methodolgy is needed. This is the computation of the weight matrix to obtain the weighted sum of growth rates of the remaining sectors of the economy. We used a fixed weight method but in Section 2 we have indicated that the weights shoud vary over time as the economy evolves. Such a weight matrix can be developed from input-output tables that are available at different time points. Some experimentation is required to assess the operationaity of this method.

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