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Contents

ANALYSING THE IMPACT OF TECHNOLOGICAL ADVANCEMENT ON THE ECONOMY: AN INPUT – OUTPUT ANALYSIS

Nurul Izzati Sydina[1], Nabilah Mohd Taha[2], and Jamia Aznita Jamal[3]

ABSTRAK

Dalam beberapa dekad kebelakangan ini, Malaysia telah berkembang pesat dari segi teknologi yang telah merevolusikan landskap perniagaan dan kehidupan seharian. Sebagai pemacu utama pertumbuhan dan inovasi, kemajuan teknologi di Malaysia memberi kesan bukan sahaja kepada sektor teknologi tetapi juga industri lain dan ekonomi secara keseluruhan. Artikel ini menggunakan analisis input-output untuk mengkaji saling kebergantungan antara pelbagai sektor dan impak ekonomi yang lebih luas daripada kemajuan teknologi di Malaysia dengan menggunakan model input–output Leontief. Kajian ini menekankan peranan penting sektor teknologi utama, khususnya komponen dan papan elektronik, yang menyumbang kepada 49.3 peratus perubahan output susulan peningkatan eksport sebanyak 25.0 peratus. Analisis ini juga meneroka kepentingan peralatan komunikasi, elektronik pengguna serta industri sokongan seperti perdagangan borong & runcit dan pengangkutan dalam memacu transformasi digital. Dengan mengambil kira rantaian ke belakang dan ke hadapan serta pengganda output, kajian ini menunjukkan kesalinghubungan sektor ini dan impak ekonomi yang meluas. Penemuan menunjukkan bahawa memberi tumpuan kepada sektor teknologi utama adalah penting untuk memupuk inovasi dan pertumbuhan ekonomi.

Kertas kajian ini diakhiri dengan cadangan untuk penyelidikan masa depan, menekankan kepentingan memahami saling kebergantungan antara sektor bagi mempromosikan kemajuan teknologi dan mencapai manfaat ekonomi yang berterusan. Dengan menggunakan ukuran rantaian ke belakang dan ke hadapan serta pengganda output, kajian ini menunjukkan bagaimana kemajuan dalam ICT menjana kesan pengganda yang meluas ke seluruh ekonomi. Dapatan kajian mencadangkan bahawa pengukuhan sektor teras ICT adalah penting untuk memacu inovasi dan pertumbuhan ekonomi yang mampan. Selain itu, cadangan untuk penyelidikan masa hadapan, termasuk keperluan untuk memasukkan set data yang lebih terkini dan meneroka teknologi baharu yang berkembang seperti Kecerdasan Buatan (AI), Rantaian Blok (blockchain) dan Internet Benda (IoT).

Kata kunci: Analisis Input-Output, Sektor Teknologi, Kesan Ekonomi, Saling Kebergantungan Sektor, Pertumbuhan Ekonomi

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ABSTRACT

In recent decades, Malaysia has rapidly advanced technologically, reshaping both business activities and daily life. As a key driver of growth and innovation, technological development in Malaysia affects not only the technology sector but also other industries and the overall economy. This paper applies an input–output analysis to examine sectoral interdependencies and the broader economic impact of technological progress in Malaysia using the Leontief input–output model. The study highlights the significant role of key technological sectors, notably electronic components and boards, which account for 49.3 per cent of output changes following a 25.0 per cent increase in exports. The analysis also identifies the importance of communication equipment, consumer electronics, and supporting industries such as wholesale & retail trade and transport in driving digital transformation. By calculating backward and forward linkages and output multipliers, the research demonstrates the interconnectedness of these sectors and their extensive economic impact. The findings suggest that focusing on key technological sectors is vital for fostering innovation and economic growth.

The paper concludes with a recommendation for future research, emphasising the importance of understanding sectoral interdependencies to promote technological progress and achieve sustained economic benefits. By applying backward and forward linkage measures as well as output multipliers, the paper demonstrates how advancements in ICT generate extensive multiplier effects across the economy. The findings further suggest that strengthening core ICT sectors is essential to drive innovation and sustainable economic growth. Additionally, recommendations for future research include incorporating more recent datasets and exploring emerging technologies such as Artificial Intelligence (AI), Blockchain and the Internet of Things (IoT).

Keywords: Input - Output Analysis, Technological Sectors, Economic Impact, Sectoral Interdependencies, Economic Growth

1. INTRODUCTION

In today's swiftly changing economic landscape, information technology (IT) has emerged as a revolutionary force with significant consequences for many industries. The modern economy relies heavily on the IT sector, which drives productivity, innovation and industry competitiveness. With the advent of digital technologies, Malaysia has experienced a rapid transition to a knowledge-based economy backed by increasing reliance on IT to spur innovation and efficiency across a range of industries, including manufacturing, retail and services. The COVID-19 pandemic has further accelerated this dependence on IT, as businesses and individuals increasingly turn to digital solutions for remote work, online transactions and communication.

The influx of IT into Malaysia has not only transformed the business landscape but has also influenced the daily lives of its people. From e-commerce platforms and digital payment systems to smart city initiatives and telemedicine services, IT has permeated various aspects of Malaysian society, bringing greater convenience, accessibility and

connectivity. The widespread adoption of smartphones and the internet hastened the digital revolution, making IT an integral part of everyday life in Malaysia.

As global connectivity continues to broaden, Malaysia's IT future looks increasingly promising. The collaboration between government agencies, educational institutions, and industry players has created a conducive environment for the development of a vibrant IT ecosystem, attracting both local and foreign investments. In relation to this, Malaysia has launching MyDIGITAL in 2021 - a national initiative which symbolises the aspirations of the Government to transform Malaysia into a digitally-driven, high income nation and a regional leader in the digital economy. With a focus on blockchain, IoT and cybersecurity, the country is poised to lead in IT innovation, in line with MYDIGITAL aspirations to position Malaysia as a regional digital economy leader and to achieve inclusive, responsible and sustainable socioeconomic development.

Given the importance of the IT sector in Malaysia's economic scenario, it is vital to comprehend the specific challenges and opportunities it presents. In this regard, Input–Output (I–O) analysis provides a systematic framework for tracing how advancements in digital technologies generate multiplier effects across industries. Accordingly, the central question of this study is: “What impact do these technological advancements have on various sectors within the Malaysian economy, as observed through input–output linkages and intersectoral effects?”

IT has emerged as a transformative force with far-reaching implications for productivity, innovation and competitiveness. In Malaysia, the rapid digital transition has been accelerated by the widespread adoption of mobile technologies, e-commerce and digital payments, as well as national initiatives such as MyDIGITAL launched in 2021. This transformation positions Malaysia on a path toward becoming a digitally driven, high-income economy and a regional hub for digital innovation.

The COVID-19 pandemic further highlighted the importance of IT, as businesses and households increasingly turned to digital platforms for work, commerce and communication. Initiatives in areas such as blockchain, IoT and cybersecurity continue to shape Malaysia’s technological trajectory. Against this backdrop, it is crucial to understand how ICT development influences the wider economy. Input–output (I–O) analysis provides a structured framework to trace intersectoral linkages and multiplier effects arising from technological change. This study therefore examines the impact of technological advancement on different economic sectors, with particular attention to ICT manufacturing, trade and services.

2. LITERATURE REVIEW

Research on ICT’s economic impact highlights its dual role in driving both direct sectoral growth and indirect spillover effects. Studies such as Hosseinzadeh and Sharify (2018) demonstrate how technological restructuring shapes output growth, while Keček et al. (2016) show that ICT sectors generate substantial multiplier effects in European economies. Recent global studies (e.g., OECD reports on digitalisation, 2022–2023) further emphasise the transformative role of semiconductors and communication technologies in global value chains. However, limited research has examined these dynamics specifically within the Malaysia’s context. By focusing on

Malaysia, this study addresses this gap by integrating international insights with country-specific data.

3. METHODOLOGY

This paper utilised data obtained from the Malaysia Input-Output (I-O) Table 2021 published by the Department of Statistics Malaysia (DOSM). The choice of 2021 as the reference year is justified as it represents the most recent official I–O table available. Nonetheless, the findings should be interpreted within this temporal context and may not fully capture longer-term structural dynamics. The Leontief I-O model (Leontief, 1974) is adopted, as shown below:

$$X = (I - A)^{-1}Y \tag{1}$$

where *X* is the output, *Y* is the final demand, *I* is the identity matrix, A is the input coefficient matrix, and $(I – A)^{-1}$ denotes the Leontief inverse matrix. For the purpose of this study, *Y* refers to exports.

The normalised backward and forward linkages are used to identify key sectors, given its high dependence on both upstream and downstream sectors. Normalised backward linkage formula can be defined as:

$$NBL_j = \frac{\sum_{i=1}^{n} l_{ij}}{\frac{1}{n^2}\sum_{i=1}^{n}\sum_{j=1}^{n} l_{ij}} \tag{2}$$

where, NBLj is the normalised backward linkage of sector j
lij is the ij element of Leontief inverse matrix,
n is the number of sectors

Normalised forward linkage formula can be defined as:

$$NFL_i = \frac{\sum_{j=1}^{n} g_{ij}}{\frac{1}{n}\sum_{i=1}^{n}\sum_{j=1}^{n} g_{ij}} \tag{3}$$

where, NFL_i is the normalised forward linkage of sector i
g_{ij} is the ij element of Gosh inverse matrix
n is the number of sectors

An output multiplier for a sector j is defined as the total value of production in all sectors of the economy that is necessary for all stages of production in order to produce one unit of product j for final use. It can be expressed as:

$$O_j = \sum_i^n l_{ij} \quad (4)$$

where, O_j is the output multiplier of sector j
l_{ij} is the ij element of Leontief inverse matrix
n is the number of sectors

4. RESULT AND DISCUSSION

The contribution of the Information and Communication Technology (ICT) sector to the national economy was 13.6 per cent in 2022, driven primarily by the ICT Manufacturing industry, which recorded a higher double-digit growth of 21.3 per cent as compared to 11.0 per cent in 2021. Electronic components and boards as well as Communication equipment and consumer electronics continued to be the leading contributors to ICT Manufacturing, accounting for 35.7 per cent of the total. The production of ICT products increased by 14.6 per cent (2021: 6.7%) and reached a value of RM263.9 billion in 2022. The growth was driven by favourable performances in ICT Manufacturing industry (24.8%) and ICT Trade (12.0%).

The total supply of ICT products was primarily dominated by domestic production, with a share of 71.7 per cent, followed by imports of ICT products (27.7%). In the meantime, exports accounted for 39.9 per cent of the total use with exports of ICT products climbed to RM444.5 billion in 2022, an increase of 24.9 per cent from 13.1 per cent in the previous year. Exports of ICT products accounted for 32.2 per cent of the total national exports. Meanwhile, imports of ICT products were RM308.8 billion, representing an 18.5 per cent increase, driven by ICT services growth (19.5%). Imports of ICT products accounted for 24.7 per cent of the total imports in 2022. As a result, net exports of ICT products increased significantly, reaching RM135.7 billion in 2022.

Given the importance of ICT in driving the economy, technological progress has a substantial impact on various sectors, with electronic components and IT-related industries playing critical roles. Assuming a 25.0 per cent increase in the demand of exports, the Electronic components and boards sector stands out, experiencing an expected 49.3 per cent output increase, underscoring its vital contribution to technological infrastructure and innovation. Communication equipment and consumer electronics (12.7%) and Computers, peripheral, office equipment and machinery (9.9%) are also important sectors in digital transformation. The Telecommunications & computer and information services sector, with a 5.6 per cent increase in output, is essential for enabling connectivity and data exchange. Additionally, the Wholesale and retail trade, repair of motor vehicles and motorcycles sector (6.3%) supports the sales of IT products to consumers. Transport sectors such as Land transport (0.4%) further contribute by ensuring the distribution of these technological goods (**Table 1**).

Table 1: Output Changes in Selected Sectors Following a Demand Increase by 25.0 per cent

Sector	Expected Output Changes (%)
Electronic Components and Boards	49.3
Communication Equipment and Consumer Electronics	12.7
Computers, Peripheral, Office Equipment and Machinery	9.9
Wholesale & Retail Trade, Repair of Motor Vehicles and Motorcycles	6.3
Telecommunications & Computer and Information Services	5.6
Coke and Refined Petroleum Products	1.7
Electricity and Gas	1.4
Other Fabricated Metal Products	1.3
Monetary Intermediation	1.0
Specialised Construction Activities	0.8
Motor Vehicles, Trailers and Semi-Trailers	0.6
Crude Oil and Natural Gas	0.6
Basic Precious and Other Non-Ferrous Metals	0.6
Electricity Distribution & Control Apparatus, Batteries and Accumulators	0.6
Professional	0.6
Land Transport	0.4
Basic Iron and Steel	0.4
Repair & Installation of Machinery and Equipment	0.4
Printing	0.3
Insurance/ Takaful and Pension Funding	0.2
Warehousing and Support Activities for Transportation	0.2

This analysis shows that technological advancement does not only affect ICT related industries but also demonstrates a complex network of interconnected sectors. Key sectors, such as Electronic components and boards as well as Communication equipment and consumer electronics play a direct role in driving technological innovation. Simultaneously, supportive sectors such as Wholesale trade, financial services, transportation and professional services are essential in facilitating the growth and adoption of new technologies.

The analysis of normalised backward and forward linkages underscores the strategic importance of ICT-related sectors within the Malaysian economy. For instance, the Electronic components and boards sector records a backward linkage of 1.107 and a forward linkage of 1.211, highlighting its dual role as a major consumer of upstream inputs and a critical supplier to downstream industries such as electronics manufacturing, automotive and telecommunications. This suggests that policies aimed at fostering the development of the semiconductor ecosystem could yield broad multiplier effects, stimulating both input demand and enabling technological advancement across other sectors. Similarly, Communication equipment and

consumer electronics demonstrate a backward linkage of 1.108 and a forward linkage of 1.047, reflecting significant dependencies on diverse inputs while simultaneously contributing to the growth of key sectors, including telecommunications and financial services.

Meanwhile, Computers, peripherals, office equipment and machinery exhibit the highest backward linkage of 1.144, indicating that this sector is highly dependent on inputs from a wide range of industries including electrical, plastics, logistics and business services. However, with a forward linkage of 0.741, its role as a supplier remains relatively limited. Overall, these results suggest that ICT sectors, particularly semiconductors and communication equipment, serve as the backbone of Malaysia's digital economy, as reflected in their strong backward and forward linkages. This underlines their importance in national strategies such as MyDIGITAL **(Table 2)**.

Table 2: Normalised Backward & Forward Linkages for Selected Sectors

Sector	Normalised Backward Linkage	Normalised Forward Linkage
Electronic Components and Boards	1.107	1.211
Communication Equipment and Consumer Electronics	1.108	1.047
Computers, Peripheral, Office Equipment and Machinery	1.144	0.741
Wholesale & Retail Trade, Repair of Motor Vehicles and Motorcycles	0.867	1.157
Telecommunications & Computer and Information Services	0.942	0.971
Coke and Refined Petroleum Products	1.061	1.372
Electricity and Gas	0.904	1.491
Other Fabricated Metal Products	0.920	1.382
Monetary Intermediation	0.761	1.353
Specialized Construction Activities	1.102	1.512
Motor Vehicles, Trailers and Semi-Trailers	1.108	1.354
Crude Oil and Natural Gas	0.669	1.355
Basic Precious and Other Non-Ferrous Metals	1.057	1.281
Electricity Distribution & Control Apparatus, Batteries and Accumulators	1.074	0.980
Professional	0.859	1.444
Land Transport	1.079	1.149
Basic Iron and Steel	1.089	0.954
Repair & Installation of Machinery and Equipment	1.122	1.592
Printing	0.986	1.319
Insurance/ Takaful and Pension Funding	0.808	1.040
Warehousing and Support Activities for Transportation	1.106	1.062

Output multipliers provide valuable insights into the economic impact of these sectors. Computers, peripheral, office equipment and machinery, with an output multiplier of 2.032, demonstrate a high level of economic activity spurred by technological advancements. Telecommunications & computer and information services, with an output multiplier of 1.674, reflects its significance in facilitating technology-driven activities. Similarly, Electronic components and boards, along with Communication equipment and consumer electronics, show output multipliers of 1.967 and 1.969, respectively, reflecting their reliance on technology and their importance in economic activity. These multipliers reveal the interconnectedness of technology-driven industries and their substantial influence on various other sectors, demonstrating how technological advancements generate considerable economic benefits across the broader economy **(Table 3).**

Table 3: Output Multipliers for Selected Sectors

Sector	Output Multiplier
Electronic Components and Boards	1.967
Communication Equipment and Consumer Electronics	1.969
Computers, Peripheral, Office Equipment and Machinery	2.032
Wholesale & Retail Trade, Repair of Motor Vehicles and Motorcycles	1.540
Telecommunications & Computer and Information Services	1.674
Coke and Refined Petroleum Products	1.886
Electricity and Gas	1.607
Other Fabricated Metal Products	1.634
Monetary Intermediation	1.352
Specialised Construction Activities	1.959
Motor Vehicles, Trailers and Semi-Trailers	1.968
Crude Oil and Natural Gas	1.189
Basic Precious and Other Non-Ferrous Metals	1.878
Electricity Distribution & Control Apparatus, Batteries and Accumulators	1.908
Professional	1.526
Land Transport	1.917
Basic Iron and Steel	1.935
Repair & Installation of Machinery and Equipment	1.994
Printing	1.752
Insurance/ Takaful and Pension Funding	1.436
Warehousing and Support Activities for Transportation	1.966

The analysis indicates that ICT sectors have strong backward and forward linkages with manufacturing, trade and services. Electronic components and boards demonstrate the highest responsiveness to export demand shocks, with a 49.3 per cent increase in output. Communication equipment and consumer electronics (12.7%) and Computers and peripherals (9.9%) also play key roles in Malaysia's digital economy. Supporting sectors such as Wholesale & retail trade (6.3%) and Telecommunications & information services (5.6%) facilitate distribution and connectivity.

5. POLICY IMPLICATIONS

The findings underscore the strategic role of semiconductors and ICT manufacturing in Malaysia's economy. Policies aimed at strengthening the semiconductor ecosystem, whether through foreign investment or developing domestic suppliers, can generate broad multiplier effects. Strengthening ICT trade and services complements these efforts by enhancing Malaysia's competitiveness. Linking these findings to national strategies such as MyDIGITAL and the National Industrial Master Plan highlights the importance of coordinated industrial and digital policies in achieving inclusive and sustainable economic growth.

6. CONCLUSION

The analysis reveals that key sectors are highly influenced by technological advancement, particularly Electronic components and boards, which output is expected to incline by 49.3 per cent in response to changes in demand, highlighting their crucial role in technological infrastructure and innovation. Communication equipment and consumer electronics also play a pivotal role in Malaysia's digital transformation.

These findings also highlight how key sectors rely on technology to drive growth and underscore the importance of continued focus on these areas to foster innovation and economic development. Beyond these results, the study provides broader policy implications. The strong backward and forward linkages of Electronic components and boards underscore the need for Malaysia to strengthen its semiconductor ecosystem, not only by attracting foreign investment but also by nurturing domestic suppliers to reduce import dependency.

For future research, more comprehensive datasets such as the forthcoming Input–Output Tables or ICT Satellite Accounts should be incorporated to capture structural shifts beyond 2021. Furthermore, sector-specific analyses of emerging technologies such as AI, blockchain and the IoT would provide deeper insights into how digital transformation reshapes Malaysia's economic landscape. Technological advancement significantly influences on Malaysia's economy, with ICT-related sectors at the forefront of this transformation. The study demonstrates the multiplier effects of ICT sectors across industries, highlighting the centrality of semiconductors, communication technologies and supporting services. Policy efforts should focus on enhancing the resilience and competitiveness of these sectors, while preparing for future transformations driven by AI, blockchain and IoT. Future research should incorporate updated datasets such as ICT Satellite Accounts and undertake comparative studies to benchmark Malaysia against regional peers.

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EARLY SIGNALS ON ECONOMIC DIRECTION PRIOR TO GROSS DOMESTIC PRODUCT (GDP)

Mohd Afzainizam Abdullah[1]

ABSTRAK

Krisis ekonomi merupakan gangguan mendadak terhadap kestabilan ekonomi, yang sering dicirikan oleh kemerosotan dalam aktiviti ekonomi, ketidakstabilan kewangan dan impak negatif sosial. Oleh itu, kerajaan Malaysia menghadapi tugas yang mencabar untuk menangani gangguan tersebut dengan segera bagi memastikan kestabilan dalam ekonomi makro. Meramalkan krisis ini dapat membantu mengurangkan kesan negatif melalui intervensi dasar yang tepat pada masanya. Justeru itu, ekonomi dapat dilindungi daripada kemelesetan yang lebih teruk. Petunjuk Ekonomi Malaysia terdiri daripada tiga indeks: Pelopor, Serentak dan Susulan. Indeks Pelopor (IP) mempunyai keupayaan untuk meramalkan pergerakan ekonomi masa depan di Malaysia termasuk krisis ekonomi dan memberi amaran awal dalam tempoh empat hingga enam bulan akan datang. Berdasarkan sejarah ekonomi sebelum ini menunjukkan bahawa IP boleh meramalkan krisis kewangan Asia 1997/ 98 tiga bulan lebih awal, krisis dot-com 2000/ 01 sepuluh bulan lebih awal, krisis subprima dan zon Euro 2008/ 09 dua bulan lebih awal dan krisis kesihatan COVID-19 lima bulan lebih awal.

Kata kunci: Indeks Pelopor, Krisis Ekonomi, Mampan, Isyarat Amaran Awal

ABSTRACT

Economic crises are sudden disruptions in economic stability, often characterised by declines in economic activity, financial instability and negative social consequences. The Malaysian government therefore faces the challenging task of managing such disruptions promptly to safeguard macroeconomic stability. Predicting such crises can help mitigate negative impacts through well-targeted policy interventions implemented at the right time. Consequently, the economy can be protected from more severe recessions. The Malaysian Economic Indicators consist of three indices: Leading, Coincident and Lagging. The Leading Index (LI) has the ability to forecast future economic movements in Malaysia, including economic crises and provides early warnings within the next four to six months. Historical evidence demonstrates that LI anticipated the 1997/ 98 Asian financial crisis three months in advance, the 2000/ 01 dot-com crisis ten months in advance, the 2008/ 09 subprime and Eurozone crises two months in advance and the COVID-19 health crisis five months in advance.

Keywords: Leading Index, Economic Crisis, Sustainable, Early Warning Signals

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1. INTRODUCTION

An economic crisis is a significant and sudden disruption in macroeconomic stability. Economic crises are often characterised by a sharp decline in economic activity, financial instability and adverse social consequences. They may be triggered by various factors and often have profound implications for both national and global economies. One of the key criteria for achieving a sustainable economy is maintaining macroeconomic stability (Jackson, T. 2009). To ensure such stability, the Malaysian Government must address potential disruptions promptly and effectively. Anticipating economic crises is crucial to mitigate adverse impacts through informed policy decisions, thereby safeguarding the economy from severe downturns. In this regard, the LI is adopted in this study as an analytical tool to provide early signals of Malaysia's near-term economic trajectory.

2. LITERATURE REVIEW

Economic crises are generally defined as severe disruptions in economic activity resulting in output contraction, financial instability and breakdowns in credit markets. They often involve a sudden loss of confidence and rapid transmission across sectors (Claessens & Kose, 2013; Kaminsky, Lizondo, & Reinhart, 1998). The literature distinguishes between cyclical recessions and systemic financial crises, with the latter linked to vulnerabilities in credit, banking and capital flows. Early warning systems (EWS) have been developed to detect vulnerabilities before crises materialise. Commonly used indicators include financial measures such as the credit-to-GDP gap, debt service ratios and bank leverage; asset market variables such as equity and real estate prices; macroeconomic measures such as output gaps, unemployment and industrial production; and external variables such as capital flows and international reserves (Drehmann, Borio, & Tsatsaronis, 2011; Drehmann & Juselius, 2014).

Empirical research emphasises that multivariate approaches, which combine multiple signals, are superior to relying on single indicators (Aldasoro, Drehmann, & Borio, 2018). Composite indices, particularly the OECD Composite Leading Indicator (CLI) and the U.S. Conference Board Leading Economic Index (LEI), are widely used to anticipate turning points in economic cycles. These indices aggregate diverse series into a single forward-looking measure, providing effective in signaling cyclical peaks and troughs (OECD, 2005; Stock & Watson, 1993). However, while useful for output cycles, their performance in predicting systemic financial crises is limited. Studies report challenges such as false positives, sensitivity to filtering methods and declining accuracy in the presence of structural change (Estrella & Mishkin, 1998; Frankel, 2011). The literature highlights gaps in integrating financial stability measures into LI frameworks, tailoring indices to emerging economies and evaluating the cost-benefit of policy responses to LI signals. Addressing these gaps, this study develops a hybrid LI that incorporates both cyclical and financial indicators, applies it to Malaysia, and assesses its policy usefulness.

3. METHODOLOGY

Composite Index

The compilation of Malaysia's Economic Indicators involves selecting various economic indicators and categorising them according to their behaviour either "lead" or "coincide" or "lag" or disqualified. These indicators are then aggregated to form a Composite Index. Hence, the Composite Index comprises three sub-indices namely the Leading, Coincident and Lagging Indices.

Leading Index

The Leading Index (LI) serves as a tool to forecast the overall state of the economy in the coming months, providing an early indication of economic trends. A continuous decrease in the LI growth rate is among the earliest signs that an ongoing economic expansion may begin to slow. This indicator comprises elements that, on average, "lead the economy".

The following steps have been used by the Department of Statistics Malaysia (DOSM) in developing the Composite Index for Malaysia in accordance with the *OECD Handbook on Constructing Composite Indicators (2008)*.

Initial Calculation of a Composite Index

Let $Y_{j,t}$ denote the value of the jth component of the composite index (CI) in period t, where $t = 0, 1, 2, \ldots . T$, and let $y_{j,t}$ denote the component's monthly percent change (symmetrical percent change) :

$$y_{j,t} = 200x \frac{(\mathrm{Y}_{j,t} - \mathrm{Y}_{i \cdot t-1})}{(Y + Y_{j,t-1})} \; for \; t = 0, 1, 2, \ldots T \text{ or} \tag{1}$$

For the components that could have zero or negative values are calculated:

$$y_{j,t} = Y_{j,t} - Y_{j,\mathrm{t}-1}$$

Next, calculated the standardisation factor or average absolute value of the monthly symmetrical percent change for each of the j components:

$$S_j = \frac{\Sigma_j |y_{j,t}|}{T} \tag{2}$$

Let w_j denote the weight for each of the j components:

$$w_j = \frac{\beta_j}{\Sigma_j \beta_j}, \; where \; \beta_j = \frac{1}{\mathrm{S}_j} \tag{3}$$

This formula for wj gives equal weight to each component's standardisation change, $z_{j,t}$, defined as $z_{j,t} = \frac{y_{j,t}}{S_j}$. Note that $\Sigma_j w_j = 1$. If a data for a component are not available in the month t, then $\beta_j = 0$ and $w_j = 0$ for that component.
The symmetrical percent change, c_t, in the composite index is defined as:

$$c_t = \frac{\Sigma_j w_j y_{j,t}}{F_k} \text{ for } t = 0,1,2,\dots T \quad (4)$$

Where F_k is an index standardisation factor that is initially assigned a value of 1 for each of the k indexes. [Note that if F_k = 1, then $c_t = \mu + \Sigma_j w_j (y_{j,t} - \mu)$, where $\mu = \Sigma_j w_j \mu_j$. That is, the trend in the index, μ, will be designed equal a weighted average of the trends in the components, μ_j.]

The level of the composite index in period t, NDX_t, is computed as:

$$NDX_0 = 100, \text{ and}$$
$$NDX_t = NDX_{t-1} \frac{(200+C_t)}{200-C_t}, \text{for } t = 0,1,2,\dots T \quad (5)$$

Index Standardisation

This step ensures that the average absolute symmetrical percent change, Z_k, is the same for each of the k composite indexes in a given set. First, from the c_t values computed using formula 4 (with F_k = 1), calculate a Z_k value for each of the composite indexes:

$$Z_k = \frac{(\Sigma_j |c_t|)}{T} \text{ for } t = 0, 1, 2, \dots T \quad (6)$$

Next, compute the index standardisation factor, F_k, for each index by dividing its Z_k value by the Z value of the "primary" index:

$$F_k = \frac{Z_k}{z_{primary}} \quad (7)$$

The set of LI, Coincident Index (CI) and Lagging Index (LG) uses the CI as the primary index, so the F_k values for the LI, CI, LG indexes are:

$$F_{LI} = \frac{Z_{LI}}{Z_{CI}}, F_{LG} = \frac{Z_{LG}}{Z_{CI}}, and\ F_{CI} = 1$$

Then recomputed the c_t and NDX_t values for each index using formula (4) and (5) and the F_k values from formula (7).

Index Rebasing

$$NDX_{t,rebased} = 100 \left(\frac{NDX_t}{BASE}\right) \text{for } t = 0, 1, 2, \dots T \quad (8)$$

Components of Leading and Coincident Indices

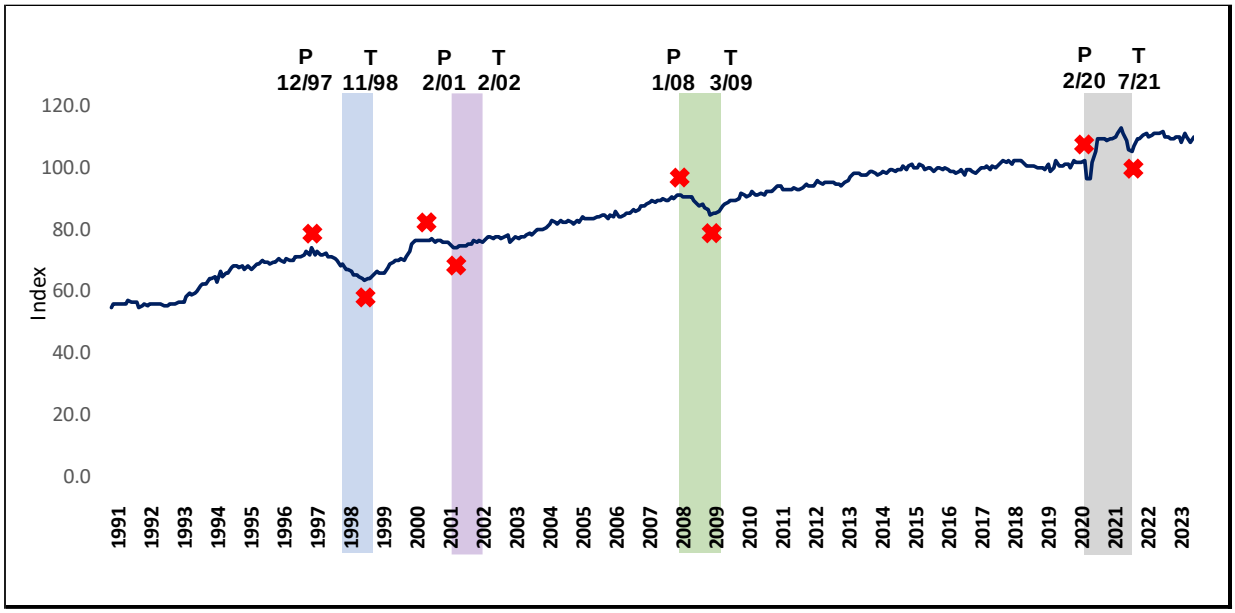
Each economic indicator is selected based on the criteria outlined in the Business Cycle Indicators Handbook, which include conformity to the business cycle, consistent timing, economic significance, statistical adequacy, smoothness and promptness. To construct the Composite Index for the LI and CI, seven (7) components for the LI and six (6) components for the CI were selected as follows:

Components

Leading Index	i.	Real Money Supply, M1
	ii.	Bursa Malaysia Industrial Index
	iii.	Real Imports of Semi-Conductors
	iv.	Real Imports of Other Basic Precious & Other Non-ferrous Metals
	v.	Number of Housing Units Approved
	vi.	Expected Sales Value, Manufacturing
	vii.	Number of New Companies Registered
Coincident Index	i.	Total Employment, Manufacturing
	ii.	Real Salaries & Wages, Manufacturing
	iii.	Industrial Production Index
	iv.	Real Contributions, EPF
	v.	Capacity Utilisation, Manufacturing
	vi.	Volume Index of Retail Trade

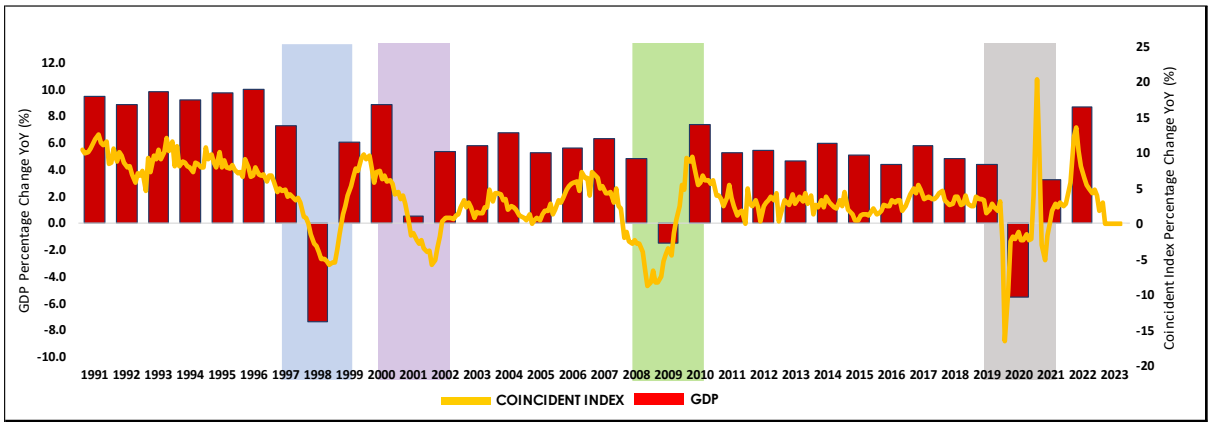
4. RESULT AND DISCUSSION

Figure 1: Leading Index (2015=100), January 1991 to May 2023 and Business Cycle



As shown in Figure 1, the LI provides an early warning signal for each of the economic crises. Based on historical economic behaviour, the LI anticipated the 1997/98 Asian financial crisis three months in advance, the 2000/01 dot-com crisis ten months in advance, and the 2008/09 subprime and Eurozone crises two months in advance as well as COVID-19 health crisis five months in advance. The Gross Domestic Product (GDP) growth for the corresponding year subsequently confirmed these forecasts.

Figure 2: Coincident Index and GDP growth, 1991 to 2022



As seen in Figure 2, the Coincident Index (CI) moves in tandem with current economic performance and serves to validate the turning points identified earlier by the LI**.** The GDP growth during these periods further confirmed the signals provided by both indices.

5. DISCUSSION AND CONCLUSION

Malaysia’s quick action to address economic challenges

1997/ 98

The Malaysian economy experienced a significant downturn during the 1997-1998 Asian Financial Crisis. Malaysia’s GDP, which measures the country's overall economic performance, decreased from 6.1 per cent in the fourth quarter of 1997 to a negative 11.2 per cent in the fourth quarter of 1998. The LI gave an early warning by foreseeing negative growth as early as August 1997 with its downward trend continuing throughout 1998. Meanwhile, the CI peaked at 72.4 points in December 1997, signaling the start of the Malaysian economic slump, which lasted for a full year and reaching trough at 68.1 points in November 1998.

The Asian financial crisis had negative impact on the economic growth of Asian countries including Malaysia. Malaysia responded by establishing the National Economic Action Council (MTEN) on 7 January 1998 to re-stimulate the economy. MTEN subsequently developed the National Economic Recovery Plan, which aimed to stabilise the Ringgit, restore market confidence, maintain financial market stability, strengthen the economic foundation, uphold the equity agenda and revitalise sectors severely impacted by the crisis. Several key institutions were formed as part of these measures, including Syarikat Pengurusan Dana Harta Nasional Bhd (Danaharta),

Syarikat Pengurusan Aset Negara, Danamodal Nasional Bhd (Danamodal) and the Corporate Debt Restructuring Committee (CDRC) (Ibrahim, M. A., 2019). Through these strategic interventions, the crisis was eventually brought under control, allowing Malaysia to recover from the Asian economic recession.

2000/ 01

The 2000–2001 Malaysia economic downturn began in November 2000 and lasted until December 2001, attributed by the slowdown in global economic growth and a sharp decline in the global electronics industry. The LI had provided an early warning by indicating negative growth from the beginning of 2001. Meanwhile, the CI recorded negative growth starting in June 2001, and this downward trend continued throughout the year, suggesting that a recession had occurred. However, due to the concerted measures implemented after the Asian financial crisis which focused on strengthening domestic-driven growth and stimulating internal demand, Malaysia managed to record a positive annual GDP growth of 0.5 per cent in 2001.

2008/09

Another scenario of Malaysia's economic decline was triggered by the infamous housing price bubble in the United States, which subsequently affected Malaysia. Malaysia's GDP fell to minus 5.8 per cent in the first quarter of 2009, down from 7.6 per cent in the first quarter of 2008. In line with the unfolding crisis, the LI provided an early warning one month ahead, peaking in December 2007 at 91.4 points. The downturn began in January 2008, as indicated by the CI, which stood at 87.7 points, and it persisted for more than a year before bottoming out in March 2009 at 79.4 points. Overall, the LI typically forecasts the direction of Malaysia’s economic trajectory four to six months in advance.

The global financial crisis began when one of the world's largest investment banks went bankrupt in September 2008. The Malaysian government implemented proactive and stabilisation measures, including an economic stimulus package aimed at mitigating the impact of the global economic slowdown. These measures encompassed fiscal initiatives, monetary policy easing, and other comprehensive interventions to support the economy.

2020/ 21

The pandemic's mobility restrictions severely affected Malaysia's economy and the economies around the world. As illustrated in Chart 1, the LI for October 2019 revealed an early indicator of peak by hitting 102.3 points, the highest level since 2018. As the impact of COVID-19 pandemic on the Malaysian economy deepened, the LI for March 2020 reached an all-time low at 96.5 points. Given the declining performance of LI from November 2019 to April 2020, the economy was expected to decrease within four to six months from the reference period. In the second quarter of 2020, Malaysia's GDP contracted by 16.9 per cent, the lowest growth rate since the Asian Financial Crisis in 1998. Key industries such as travel and tourism, retail and other services industries were severely affected. Additionally, supply chains and company operations were disrupted, and consumer confidence declined. The prospects of an economic

recovery from the global trade tensions in 2019 were further dampened by the outbreak of COVID-19.
The entire world economy including Malaysia was hit hard during the COVID-19 health crisis. The CI recorded a negative growth of -16.5 per cent following the implementation of the Movement Control Order (MCO) in Malaysia. Nevertheless, in the first quarter of 2021, the government's recovery stimulus with the opening of more than 90 per cent of the economic sectors and social activities, as well as a high vaccination rate has spurred economic growth and the CI recorded a growth of 20.5 per cent.

6. RECOMMENDATION

The potential of the LI to forecast the direction of future economic movement is clearly demonstrated in Malaysia, where it provides advance warnings on average four to six months ahead, in contrast to the CI, which reflects the prevailing economic conditions. This predictive capability underscores the LI's role as an early indicator for anticipating turning points in economic activity. Addressing economic challenges requires a combination of short-term and long-term recovery strategies to realign the economy toward sustainable growth. The implementation of targeted short-term domestic measures, complemented by comprehensive long-term global policies, is expected to enhance production capacity, stimulate domestic demand and reinforce public confidence in the economy.

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EMERGING DATA NEEDS IN DEALING WITH UNCERTAINTY: DOSM OFFICIAL DATA REQUEST

Nur Ain Zainal Abidin[1], Nurul Atiqah Zainal Abidin[2], and Siti Norhudah Nordin[3]

ABSTRAK

Permintaan terhadap data dan statistik rasmi telah meningkat dengan ketara dalam beberapa tahun kebelakangan ini. Data dan statistik yang boleh dipercayai serta tepat pada masanya menjadi semakin penting kerana ia digunakan dalam pelbagai konteks termasuk dalam pembuatan dasar, penyelidikan, perancangan pembangunan dan pemantauan prestasi ekonomi. Oleh itu, peranan pengeluar statistik nasional yang proaktif adalah penting bagi memastikan orang awam menerima maklumat yang tepat, boleh dipercayai dan berguna untuk membuat keputusan yang berinformasi.

Pandemik COVID-19 telah membawa pengalaman yang belum pernah berlaku sebelum ini di seluruh dunia. Pandemik ini telah mendorong lebih ramai pengguna untuk menyedari kepentingan data demi kelangsungan hidup dan menangani krisis. Jabatan Perangkaan Malaysia (DOSM), sebagai organisasi statistik negara, telah memainkan peranan penting dalam proses perancangan pembangunan Malaysia selama tujuh dekad yang lalu. Bagi memahami dan menangani fenomena berkaitan krisis luar biasa akibat COVID-19, kepentingan pertukaran dan perkongsian data merentas pelbagai bidang telah mendapat perhatian masyarakat. Penggubal dasar bergantung kepada data untuk bertindak balas dengan berkesan, menjadikan pengurusan dan perkongsian data termasuk data ad-hoc, sistem pentadbiran dan sumber sedia ada amat penting semasa waktu krisis.

Kajian ini meneliti perubahan corak permintaan data di DOSM sebelum, semasa dan selepas pandemik COVID-19. Analisis deskriptif dijalankan menggunakan rekod permintaan data yang diperoleh melalui sistem National Enterprise Wide Statistical System (NEWSS). Di Malaysia, jumlah permintaan data menunjukkan peningkatan ketara sepanjang tempoh pandemik, terutamanya dari tahun 2019 hingga 2021. Dapatan kajian menunjukkan peningkatan signifikan dalam permintaan data pada tahun 2021, terutamanya daripada kalangan pelajar dan industri-industri tertentu.Trend ini telah mendorong negara dan pihak kerajaan untuk memberi perhatian yang lebih serius terhadap pelbagai isu yang terjejas sambil menekankan keperluan terhadap penyediaan data yang lebih komprehensif, mudah diakses dan relevan dalam situasi krisis.

Kata kunci: Keperluan Data, Permintaan Data, Pertukaran Data, NEWSS, Perkongsian Data, Membuat Keputusan

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ABSTRACT

The demand for official data and statistics has increased substantially in recent years. Reliable and timely data and statistics are more important than ever before, as they are used in various contexts, including policymaking, research, development planning and monitoring economic performance. Therefore, the existence of an active national statistical producers is important to ensure that the public receives information that is accurate, reliable and useful for informed decision-making.

The COVID-19 pandemic has posed the world with an unprecedented experience. It has prompted more users to recognise the importance of data in sustaining life and navigating through crises. The Department of Statistics Malaysia (DOSM), the national statistical organisation, has played an instrumental role in Malaysia's development planning process for the last seven decades. To understand and overcome the phenomenon related to this unprecedented crisis caused by the COVID-19, the importance of data exchange and sharing across various fields has gained significant social attention. Policymakers rely on data to respond effectively, making the management and sharing of data including ad-hoc data, administrative systems and existing sources particularly crucial during times of crisis.

This study examines the changes in data request patterns at DOSM before, during and after the COVID-19 pandemic. Descriptive analysis was conducted using data request records obtained through the National Enterprise Wide Statistical System (NEWSS). In Malaysia, the number of data requests showed a significant increase throughout the pandemic period, particularly from 2019 to 2021. The findings reveal a notable rise in data demand in 2021, especially from students and certain industry sectors. This trend has prompted the government and the nation to pay closer attention to the various affected issues, while also emphasising the need for more comprehensive, easily accessible and relevant data provision during crisis.

Keywords: Data Needs, Data Request, Data Exchange, NEWSS, Data Sharing, Decision Making

1. INTRODUCTION

The COVID-19 pandemic continues to have far-reaching impacts more than two years after the World Health Organization (WHO) first identified the novel coronavirus as the cause of severe pneumonia in early 2020. The crisis has transformed multiple aspects of human life, including social interaction, mobility, communication, economic activity and governance.

One of the most profound lessons from the pandemic is the centrality of data and evidence in policymaking and crisis management. Reliable data are essential not only for monitoring the spread of the virus but also for assessing its socio-economic consequences. According to Straf (2015), official statistics provide accurate, timely and credible information that supports both current and future policy decisions, while safeguarding confidentiality to maintain public trust. Similarly, Hayashi (2020) emphasised that the unprecedented nature of COVID-19 has drawn attention to the importance of data exchange and sharing across multiple sectors.

During the pandemic, the demand for real-time data intensified globally. Bouaziza (2021) highlighted the urgent need for quick access to data and analytics to support informed decision-making in the midst of uncertainty. For instance, Mukherjee (2022) argued that timely prediction models require multidisciplinary teams capable of linking diverse data sources, maintaining analytical systems and producing outputs quickly. In this context, national statistical offices were placed at the forefront of data provision.

In Malaysia, DOSM faced unprecedented data demands from government agencies, businesses, researchers and the general public. Beyond handling routine requests, DOSM also initiated special surveys such as the *Survey on the Effects of COVID-19 on the Economy* and the *Survey on the Effects of COVID-19 on Companies and Business Firms* to capture the crisis' economic and social dimensions. These efforts not only provided timely evidence for national policy responses but also underscored the strategic role of modern statistical systems during crises.

This study is undertaken in response to the rising demand for official statistics during COVID-19. Specifically, it aims to examine DOSM's role in managing large-scale data requests and producing rapid statistical outputs. By documenting DOSM's experience, the study seeks to contribute to broader discussions on the importance of investing in robust national statistical systems and data infrastructures which are crucial for resilience during times of crisis.

2. METHODOLOGY

To examine the patterns of official data requests submitted to DOSM during the COVID-19 crisis, this study utilised data extracted from the National Enterprise Wide Statistics System (NEWSS) portal. The dataset covers the period from January 2019 to July 2022, capturing the profiles of users who submitted data requests. NEWSS serves as an integrated platform that automates interactions between DOSM services and external stakeholders.

A descriptive analysis was conducted to summarise the patterns of data requests and the results were visualised through graphs to facilitate interpretation.

The objectives of this study are:

1. To identify the overall trends in data requests before, during and after the COVID-19 outbreak; and
2. To analyse the characteristics of the requests including the category and organisation of the requester, the subject of the data and the requested time period.

3. RESULT

The data was analysed using descriptive statistics to examine patterns of official data requests from 2019 to July 2022. In 2019, the number of requests peaked in March before declining between April and June. Requests surged again in July and showed a moderate increase in October before gradually declining towards the end of the year. These patterns indicate seasonal fluctuations in demand possibly linked to academic

or organisational reporting cycles. Similar seasonal demand patterns for statistical data have also been observed in other contexts, particularly in relation to academic calendars and fiscal reporting deadlines (OECD, 2020).

During the Movement Control Order (MCO) period in 2020, the number of data requests was generally lower than in 2019. A slight increase was observed in March but requests dropped again in April. The volume then rose sharply in June, fluctuated throughout the year until October and declined towards December. These patterns demonstrate how the MCO disrupted access to official data, causing a temporary decline before triggering a recovery in demand as users increasingly relied on digital and remote channels. In Malaysia, the first MCO began on 18 March 2020 and significantly impacted universities, government operations and businesses which leading to higher reliance on online services and secondary data (DOSM, 2020). Globally, similar disruptions in data availability were reported, as statistical offices faced operational challenges in maintaining surveys and disseminating information during lockdowns (United Nations, 2020).

Figure 1 shows that in 2021, the number of data requests was consistently higher compared to the previous two years. The peak occurred in November 2021 with 374 requests, the highest monthly total across the study period. This surge suggests heightened reliance on official statistics during the later phase of the pandemic when evidence-based decision-making became critical for both policy and research. This trend aligns with reports that organisations worldwide intensified their use of data during the pandemic with studies indicating a marked increase in demand for analytics in health, education and economic planning (Health Catalyst, 2020; Eurostat, 2021). In Malaysia, this trend coincided with the launch of the National COVID-19 Immunisation Programme (February 2021) and the reopening of economic sectors under the National Recovery Plan and both of which required close monitoring through official statistics (JKJAV, 2021). In contrast, data requests in 2022 showed a slower pace, particularly between February and June 2022. This possibly reflecting the easing of restrictions and reduced urgency compared to the earlier crisis period.

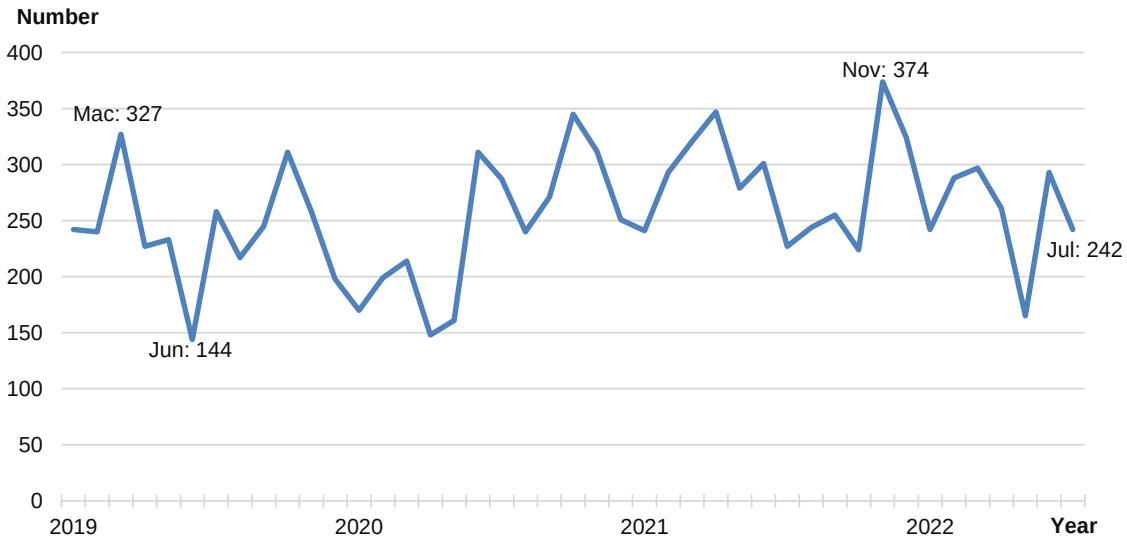
Figure 2 illustrates the distribution of requests by requester category. Students accounted for the largest share of requests between 2019 and July 2022. The surge in student requests during 2020–2021 can be attributed to restrictions under the MCO which limited their ability to collect primary data for academic projects. Similar trends were reported in other countries where remote learning conditions drove higher reliance on secondary datasets (UNESCO, 2021). In Malaysia, the Ministry of Higher Education's directive for online teaching and research activities during 2020–2021 further reinforced students' dependence on secondary data sources (MOHE, 2020).

In terms of subject matter, Population and Demography Statistics recorded the highest number of requests (1,564) followed by Other subjects (320) and Environment & Agriculture (275). Requests related to Prices, Household Income & Expenditure and International Trade accounted for between 200–250 requests each. This trend reflects a global pattern in which demographic and socio-economic indicators became crucial for monitoring the effects of the pandemic on populations and economies (World Bank, 2021). In Malaysia, indicators such as unemployment, consumer prices and trade balance were particularly important for policy responses including stimulus packages

such as PRIHATIN (March 2020) and PEMULIH (June 2021) which relied heavily on timely statistics (MOF, 2021).

Table 1 shows the breakdown by industry. The “Others” industry, which consists of requests that could not be classified under any specific industry, recorded the highest number of submissions between 2019 and July 2022, with Population and Demography Statistics being the most requested subject (1,415 requests). This was followed by International Trade (1,183), Other subjects (209), Environment & Agriculture (189) and Prices, Household Income & Expenditure (187). Overall, most industries recorded their highest levels of data requests in 2021, coinciding with the MCO period when access to in-person data sources was restricted. This pattern aligns with the global acceleration of digital data adoption and the shift towards online information systems observed during the pandemic (Experian, 2021). In Malaysia, DOSM responded to this shift by accelerating digital dissemination initiatives including the DOSM Data Warehouse Platform (StatsDW) and open data releases through DOSM’s official portal and DOSM@Stats mobile application (DOSM, 2021).

Figure 1: Number of Data Requests, 2019 – 2022



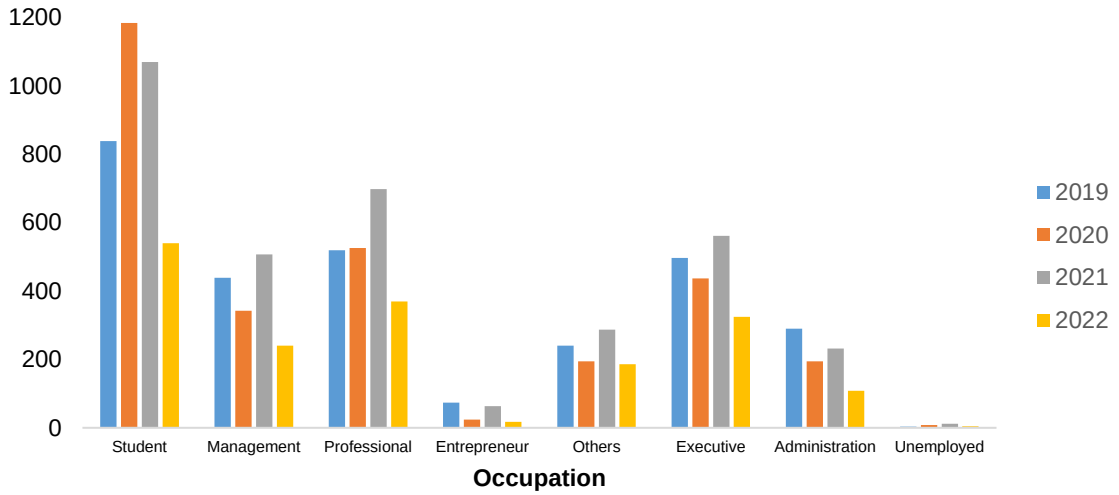


Figure 2: Number of Data Request by User's Occupation, 2019 – 2022

Table 1: Top Five Subjects by Occupation (Student), 2019 – 2022

Occupation	Population & Demography	Others	Environment & Agriculture	Price, Household Income & Expenses	International Trade
Student	1,564	320	275	250	200

Note: For 2022, the data as at July 2022

Table 2: Top Five Subject by Industry (Others), 2019 – 2022

Industry	Population & Demography	International Trade	Others	Environment & Agriculture	Price, Household Income & Expenses
Others	1,415	1,183	209	189	187

Note: For 2022, the data as at July 2022

4. DISCUSSION AND CONCLUSION

The COVID-19 pandemic has highlighted the profound vulnerability of economies and societies to sudden disruptions. Although the precise extent of the economic damage remains difficult to quantify, the findings of this study provide clear evidence of the critical role of official statistics in supporting decision-making during times of crisis. The surge in data requests observed in 2021, particularly from industries and professional sectors reflects the growing reliance on official statistics as organisations sought evidence-based strategies for business continuity, risk management and recovery planning.

The increase in requests from management-level occupations, professionals and executives further underlines the importance of timely and accessible data for decision makers. In the absence of reliable information, responses to uncertainty would have been delayed or misinformed, potentially exacerbating the negative effects of the pandemic. The findings therefore highlight not only the operational relevance of DOSM

but also its strategic role as a trusted provider of official data during national emergencies.

From a policy perspective, the results highlight the need to strengthen national data infrastructures and invest in digital statistical systems such as NEWSS. By enhancing automation, interoperability and user access, DOSM can further improve its capacity to meet surging data demands during future crises. This is particularly relevant within the context of Malaysia's digital transformation agenda where reliable and timely statistics are essential for informed policy formulation and implementation.

From an academic standpoint, this study contributes to the growing literature on the role of official statistics in crisis management by providing empirical evidence from Malaysia. While many studies have examined the epidemiological or economic dimensions of COVID-19, fewer have explored the dynamics of data demand and the institutional capacity required to respond effectively. By documenting user profiles, subject matter demand and temporal patterns, this study deepens understanding of how statistical systems are utilised during emergencies.

Future research could expand the scope of analysis to include variables related to the purpose and outcomes of data requests. Such an approach would provide deeper insights into how data are applied in practice and whether they influence policy, organisational strategies, or academic research. This would not only guide the provision of tailored data services but also strengthen the alignment between user demand and statistical supply.

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