

# Developing an MS-Excel Based Tool for Multi-Regional Economic Assessment Using an Input-Output Approach: Case of the Philippine Regional Transport Infrastructure Development

Krister Ian Daniel Z. ROQUEL <sup>a</sup>

<sup>a</sup> *Civil Engineering, National University, Philippines*

<sup>a</sup> *E-mail: kizroquel@national-u.edu.ph*

**Abstract:** Using an input-output (IO) approach, this study introduces a user-friendly MS Excel-based tool for multi-regional economic assessment. The tool is customized to the Philippine context and disaggregates national IO tables into regional data by utilizing location quotients and an extended Two-Region Logic. It is accessible to local planners and agencies, as it was developed in Excel with Visual Basic for Applications. Projected output, employment, and value-added gains suggest that regions outside Metro Manila, including Central Luzon and Western Visayas, have significant development potential. This is supported by modeling results from transport infrastructure scenarios. A policy integration framework is suggested to direct the process by which results can be incorporated into planning documents. The tool contributes to more inclusive and SDG-aligned development by supporting evidence-based policymaking and enhancing regional capacity for infrastructure planning.

*Keywords:* Economic Impact Assessment, Input-Output Modeling, Visual Basic for Applications, Regional Infrastructure Planning

## 1. INTRODUCTION

Infrastructure development has been found to have a causal impact on economic growth (Calderon & Serven, 2004). Infrastructure has been identified to be a strategic economic growth driver (Babatunde, 2018) which can significantly improve economic growth quality (Du, Zhang, & Han, 2022). Furthermore, infrastructure development necessitates localized strategies and the transformation of cities and human settlements into inclusive, safe, resilient, and sustainable growth centers in order to address the United Nations Sustainable Development Goals (Bartzokas & Cetindamar, 2024).

In developing countries, infrastructure development is one of the biggest challenges (Gurara et al., 2018;). New infrastructure is needed to respond to increasing economic and population growths and urbanization (Tortajada, 2016). This was particularly underscored for less developed countries that were severely lacking in infrastructure (Kodongo & Ojah, 2016; Chakamera & Alagidede, 2018), particularly in remote regions with inadequate access (Munawaroh & Haryanto, 2021). Thus, there is a need to quickly get the infrastructure to meet the demands and needs, as it can inhibit the continued growth.

Critical infrastructures that can contribute to economic growth include those in the transport (Palei, 2015; Donaldson & Hornbeck, 2016; Mohmand, Wang, & Saeed, 2017; Kaur & Kaur, 2018), energy (Calderon, Moral-benitom, & Serven, 2015; Burke, Stern, & Bruns, 2018; Lee, Miguel, & Wolfram, 2020), telecommunication (Llanto, 2002; Mohd, Normaz, & Law, 2012; Timilsina, Stern, & Das, 2021), water and sanitation (Kenny, 2015; Tortajada, 2016), healthcare (Kohli et al., 2017), education (Enya & Ezeali, 2021; Hota, 2023), and finance (Khan et al., 2020; Ray, 2020) sectors.

The tool was intentionally designed to be sector-agnostic, despite the fact that the current study demonstrates the tool using the transport sector as a pilot case. It has the potential to be expanded to evaluate the economic consequences of infrastructure development in other sectors, including energy, education, health, and water. This all-purpose design guarantees that the developed tool remains applicable in a variety of policy and investment scenarios, particularly for regional planners who do not have access to sophisticated modeling platforms.

It is important to note, however, that infrastructure development in these different sectors entail varied investment costs and expected returns. In the Philippines, out of the 197 Infrastructure Flagship Projects of the National Economic and Development Authority (NEDA) as of July 2023 (NEDA, 2023), 24 projects are related to the water sector, while the healthcare and energy sectors have 3 and 1 projects, respectively. All other projects are under the Department of Public Works and Highways and the Department of Transportation, which cover infrastructure projects related to the transport sector, and subsequently, the energy, telecommunication, education, and finance sectors.

With limited resources, it is imperative that the most cost-effective approach to development be taken. Subsequently, there should be clear measures by against which these investment costs will be put. Thus, aside from the usual and specific improvement metrics (e.g., increased travel speeds for transport infrastructure, reduced consumption for energy infrastructure, etc.), it should also be recognized that these different sectors have critical roles in economic operations. Thus, an economic assessment is not only reasonable, but rather necessary.

One of the ways to measure the economic impact of various development programs is the use of the Input-Output (IO) model (Aviso et al., 2015; Roquel, Fillone, & Yu, 2019; Yu et al., 2020; Santos et al., 2022). The IO model is a flexible tool that can be disaggregated in accordance with the focus of the research endeavor (Santos & Haimes, 2004; Yu et al., 2014; Roquel, Fillone, & Yu, 2018; Chan et al., 2020; Yu & Aviso, 2020; Foong et al., 2021). For the Philippines, the IO accounts are only available at the national level. However, infrastructure projects are seldom on a national scale; hence, there is a need to regionalize. Regionalization of the IO model has been applied in various studies (Roquel, Fillone, & Yu, 2017; Amheka et al., 2022; Yu, Solis, & Andiappan, 2023) as applicable to the focus and scope of the study. In these exercises, various software like IMPLAN and R can be used.

There already exists some established methodologies for the disaggregation and regionalization of IO accounts. However, this is usually performed specifically for every research activity. Hence, this process requires a background in the field of economics and some level of understanding of IO modeling. This somehow limits the extent to which the IO model can be used in other fields. Additionally, for large scale research projects, the model may require high device specifications as well as software subscriptions, which may not be accessible to all. In this case, the scale (i.e., 17 Regions) and level of detail (i.e., 240 Industry) needed would entail working with matrix calculations involving extensively large (i.e., 4080x4080) matrices. For such “big data” spreadsheet calculations, tools like Matlab (i.e., licensed software) and R (i.e., programming language) are often utilized. However, this limits the use of IO applications across various fields. Hence, there is a need to utilize resources (i.e., software) that are already available and familiar to the general public (e.g., MS Excel), those that will not require additional training outside the users' respective fields.

The objective of this study is to develop a user-friendly Microsoft (MS) Excel-based tool that can estimate the economic impact of various infrastructure development projects as applicable to any sector within any region. Specifically, the project aims to 1) construct the Multi-regional Economic Assessment Tool (MEAT) using the Visual Basic for Applications (VBA) functionality of MS Excel and 2) conduct an economic impact assessment of various

transport infrastructure development scenarios across different regions.

In this study, a tool was developed to streamline the process of developing the IO model as applied to different research projects. With the use of MS Excel, IO modeling of extensive scale and detail was more manageable and accessible. Additionally, the tool development structure is more flexible in terms of updating as new data becomes available. More importantly, this tool can widen the range of applications of IO modeling in economic impact estimations to supplement infrastructure policy development across different fields of research. The tool can also open opportunities for economic impact estimation of various development programs across different types of infrastructure which may have not yet been extensively explored. Expressing the impacts in monetary terms allows for a more comprehensive assessment of the viability of development programs in terms of the volume and pace of the return of investment.

The development of MEAT is in close alignment with the United Nations Sustainable Development Goals (SDGs), with a particular emphasis on SDG 8 (Decent Work and Economic Growth) and SDG 9 (Industry, Innovation, and Infrastructure). The project contributes to inclusive planning and evidence-based infrastructure development in the Philippines by providing decision-makers with a reliable and accessible economic assessment tool.

The subsequent section reviews pertinent literature, which is succeeded by the research framework in Section 3. The methodology is presented in Section 4, and the results of the transport infrastructure simulations are discussed in Section 5. The study concludes with key insights in Section 7, while Section 6 suggests a framework for policy integration.

## **2. LITERATURE REVIEW**

### **2.1. Infrastructure planning and development**

In the specific sector of infrastructure planning, significant uncertainty is crucial. When decision-makers (i.e., such as legislators, company executives, and government planners) are confronted with a multitude of variables that might impact the course of plans or policies, the scenario is known as deep uncertainty (Kwakkel & Van Der Pas, 2011). Infrastructure planning used to be restricted to direct measurements, which eventually increases the chance of plans failing since other aspects are not considered (Geenhuizen & Thissen, 2016; Marchau, Walker, & van Duin, 2008). New approaches to infrastructure design have been proposed in response to upcoming issues (Swanson et al., 2010; Varum & Melo, 2010), emphasizing the necessity for a more complete examination.

Scenario planning has been developed as a method to address the policy development challenges on various possible infrastructure outcomes (Volkery & Ribeiro, 2009). The new infrastructure planning paradigm broadens the scope of modes, objectives, impacts, and options that are incorporated into planning. This scope is anticipated to become more comprehensive as additional performance indicators and impact measures are taken into account (Litman, 2013). More recently, infrastructure planning has shifted to couple the front-end planning systems with sustainability rating systems for a more holistic approach (Rahat et al., 2022). Ultimately, with various metrics being considered across different sectors, there is also a need to identify a common metric against which these infrastructure project can be assessed, with one being its overall impact to the economy.

### **2.2. Input-Output Model**

Leontief (1936) and Miller and Blair (2009) propose the Leontief IO model, which aims to forecast the input requirements for each product or service by depicting the interaction

between various economic sectors. This is due to the fact that the product of each industry is used as an input for numerous other industries, and in some cases, the industry itself. In order to prevent the emergence of bottlenecks in any given location, the "correct" (i.e., surplus- and shortage-free) level of production for each industry must be one that is in harmony with all of the input requirements of the economy. The IO model presupposes that each industry 1) produces a single homogenous good, 2) employs a fixed input-to-output ratio, and 3) experiences a constant return to scale in its production. This implies that a k-fold adjustment to any input will precisely result in a k-fold adjustment to the output.

Various extensions of the IO model have been developed throughout literature (e.g. energy IO (Anderson, Santos, and Haimés, 2007; Ryerson and Hansen, 2013), environmental IO (Aviso et al., 2015), social accounting IO (Galea et al., 2002; Norris et al., 2002)). IO Modeling has been employed in numerous applications that investigate infrastructure interdependencies and terrorism risks (Santos and Haimés, 2004; Santos, 2006), regional electric power disruptions (Anderson, Santos, and Haimés, 2007), extreme weather events (Crowther, Haimés, and Taub, 2007, Haggerty, Santos, and Haimés, 2008; Baghersad and Zobel, 2015; Aviso et al., 2015), and other scenarios with supply chain disruptions (Pant et al., 2011; Blos and Miyagi, 2015). In all these studies, the IO Model was used to model economic interdependence and forecast economic impacts and overall effects of various future scenarios.

The latest-published IO account of the Philippines is for year 2018. The 2018 IO accounts are available in a 16-, 80-, and 240-sector disaggregation, allowing for detailed modeling across economic subsectors. The Philippines is also split across 17 administrative regions. The National Capital Region (NCR) has the greatest economic productivity, followed by Central Visayas and CALABARZON. The lowest productivity, however, is seen in areas like MIMAROPA and BARMM, showing considerable economic differences. Out of all the regions, Central Visayas lately has the fastest growth rate. In 2023, the Philippines' 17 regions all had positive growth, with Central Visayas seeing the quickest development at 7.3%. Concentrated industries, a thriving service sector, improved infrastructure, and easy access to trained workers are all factors that contribute to high productivity. The Bicol Region, BARMM, and MIMAROPA are among the regions with lower performance. Figure 1 shows the spatial distribution of the economic activity across the country in term of the total economic output.

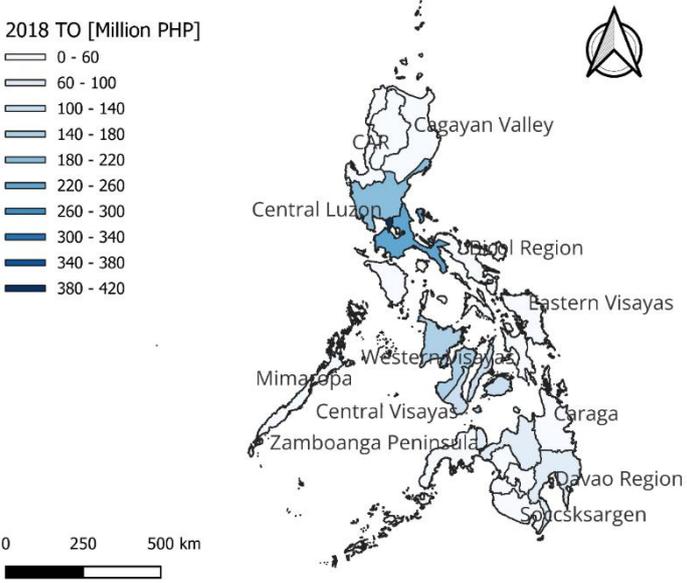


Figure 1. Regional Total Output

### **2.3. VBA Capability of MS Excel**

VBA Capability has been available since MS Excel 5.0 and allows the programmer to program and use a macro, which is essentially just a recording of a series of keystrokes (Ribando, 1998). VBA is more efficient than the processor of the spreadsheet MS Excel when it comes to processing large amounts of data, particularly when it comes to creating matrix functions that mimic database functions (Dydowicz, 2015). Another advantage is that many are already very familiar with MS Excel, hence, adaptation is very easy (Ramadhan, 2020). Additionally, VBA is one of the programming languages that are easy to learn (Hasana & Alifiani, 2019). There are also several resources that extensively cover VBA applications in MS Excel (Chapra, 2003; Bullen, Bovey, & Glenn, 2005).

Use of the VBA capability of MS Excel span across various fields (e.g., decision analysis (Hyde & Maier, 2006;), optimization (Valipour & Montazar, 2012), education (Wulandari et al., 2021), numerical analysis (Thakur, Murthy, & Mandal, 2016), and data visualization (Rouchdi, 2024)). The spreadsheet offers several advantages over other programs, including: ease of use, speedy computation times, a graphical user interface, and the ability to create animated graphs. These advantages give researchers a versatile tool to address issues and swiftly produce scenarios for solving their difficulties. In the early stages of a project, analysis of several solution scenarios may be completed quickly and efficiently, providing decision makers with answers before moving on with a more complex modeling approach using specialist tools (Elfeki & Bahrawi, 2014).

### **2.4. Synthesis**

Deep uncertainty in infrastructure planning makes comprehensive methods necessary. While traditional methods concentrated on direct measurements, more recent approaches prioritize scenario planning, sustainability, and holistic analysis. Complementary viewpoints are provided by System Dynamics Modeling (SDM) and Agent-Based Modeling (ABM), which capture intricate dynamics and stakeholder interactions. As an alternative, Input-Output (IO) modeling has been expanded to include energy, environmental, and social accounting models and efficiently examines relationships across economic sectors. Notably, VBA-enhanced MS Excel is just as versatile as specialist programs like MATLAB, Python, and R, enabling effective data processing and scenario analysis. Even if these substitutes have sophisticated analytics features, VBA is a strong option for infrastructure planning and economic impact analyses due to MS Excel's broad use and intuitive interface.

## **3. RESEARCH FRAMEWORK**

Figure 2 shows the research concept, where the MS Excel Macro capabilities were utilized to manage the computing limitations of the conventional spreadsheet software. Essentially, the established regionalization methodologies were applied (i.e., the national IO accounts will be split into 17 regions, showing both intra- and inter-regional transactions), but the VBA capabilities of MS Excel were utilized to reduce random access memory (RAM) usage. With this, intermediate calculations were no longer performed and stored in spreadsheet cells. Data is only be called from a module as needed. Ultimately, the tool can be run without the need for high device specifications and software that require subscription and/or substantial familiarization.

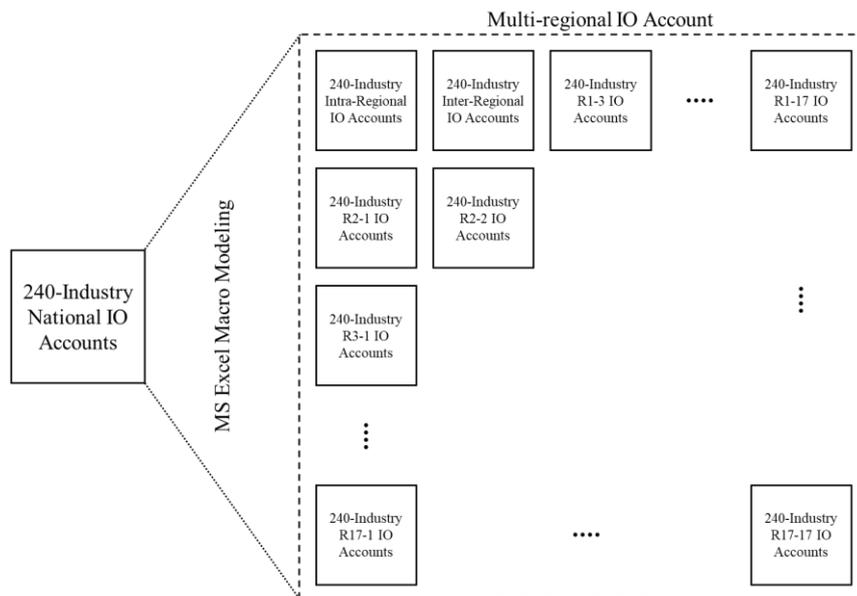


Figure 2. Research Concept

MS Excel was chosen for its widespread adoption in government offices, ease of training, and transparency for end-users, even though open-source tools such as Python or R offer advanced modeling capabilities. Ensuring that regional planners without technical expertise could operate the tool without the need to install or learn programming environments was a critical requirement. Table 1 contrasts the primary attributes of MS Excel with those of other tools that are suitable for this application.

Table 1. Comparison of Excel/VBA vs. Python and R for Use in Government Planning

Factor	MS Excel / VBA	Python / R
Availability	Already installed in most government offices	Needs to be downloaded and installed
Ease of Use	Easy to learn; most users are already familiar	Requires programming skills
User Interface	Clickable buttons, tables, and charts	Code-based; no built-in interface
Training Needed	Minimal training	Requires workshops or prior experience
Transparency	Users can see and edit formulas directly	Depends on how the code is written
Use in LGUs	Commonly used in planning and reporting tools	Rarely used in day-to-day LGU workflows
Cost	Part of MS Office package	Free and open source

### 3.1. Input-Output Model

The flow of inputs and outputs illustrates the extent to which the output of one sector is partially utilized as an input by other sectors to generate their own outputs. Additionally, if sector  $i$  utilizes the output of sector  $k$  as an input and sector  $k$  utilizes the output of sector  $j$ , then sector  $i$ 's production is indirectly reliant on sector  $j$ . Assuming that this is the case for all sectors of the

economy, each sector is subsequently dependent on any other sector, whether directly or indirectly. Intermediate demand is comprised of these transactions between industries. This, in conjunction with the primary inputs (e.g., labor, capital), constitutes the total inputs for each sector. The total outputs are rounded out by final demand categories (e.g., export, consumption), as illustrated in Table 2.

Table 2. The Input-Output Table

	Sector				Final Demand	Total Outputs
Sector	X <sub>11</sub>	X <sub>12</sub>	...	X <sub>1n</sub>	f <sub>1</sub>	X <sub>1</sub>
	X <sub>21</sub>	X <sub>22</sub>	...	X <sub>2n</sub>	f <sub>2</sub>	X <sub>2</sub>
	⋮	⋮		⋮	⋮	⋮
	X <sub>n1</sub>	X <sub>n2</sub>	...	X <sub>nn</sub>	f <sub>n</sub>	X <sub>n</sub>
Primary Inputs	w <sub>1</sub>	w <sub>2</sub>	...	w <sub>n</sub>		w
Total Inputs	x <sub>1</sub>	x <sub>2</sub>	...	x <sub>n</sub>	f	

In the table above,  $x_{ij}$  represents the intermediate consumption from sector  $i$  to sector  $j$ ,  $f_i$  represents the final demand for sector  $i$ ,  $x_i$  represents the total output (or input) of sector  $i$ , and  $w_j$  represents the total use of primary input in sector  $j$ . The following two equations are obtained by denoting  $e$  as the  $n$ -element summation column vector consisting of ones,

$$\mathbf{x} = \mathbf{X}\mathbf{e} + \mathbf{f} \quad (1)$$

$$\mathbf{x}^T = \mathbf{e}^T\mathbf{X} + \mathbf{w}^T \quad (2)$$

Defining the input coefficients as follows,

$$a_{ij} = x_{ij}/x_j \quad \text{or} \quad \mathbf{A} = \mathbf{X}\hat{\mathbf{x}}^{-1} \quad (3)$$

where  $\hat{\mathbf{x}}$  denotes the diagonal matrix with elements of  $\mathbf{x}$  on its main diagonal, Eq. 1 can be rewritten as,

$$\mathbf{x} = \mathbf{A}\mathbf{x} + \mathbf{f} \quad (4)$$

$$\mathbf{x} = (\mathbf{I} - \mathbf{A})^{-1}(\mathbf{f}) = \mathbf{L}\mathbf{f} \quad (5)$$

where  $\mathbf{I}$  is an identity matrix and  $\mathbf{L}$  is the Leontief inverse. This is consistent with the conventional Leontief quantity model. This equation provides the production output required from each sector to meet the demands of both internal and consumer utilization.

The model encapsulates the interdependence of various economic sectors by utilizing a matrix  $\mathbf{A}$  that consists of elements  $a_{ij}$ , which represent the input requirements of sector  $j$  from sector  $i$ , normalized with respect to the total input requirement of sector  $j$ . In addition, the model enables the examination of changes in final demands that are the result of external factors, as well as the system-wide effects on the interconnected network of the economy, in accordance with the linear relationship of matrix equations. Assuming that  $\mathbf{A}$  is fixed and that all prices remain constant, it is evident that a change in the final demand, which is referred to as "demand-pull," has a corresponding effect on the production of each sector, as illustrated below,

$$\Delta\mathbf{x} = \mathbf{L}(\Delta\mathbf{f}) \quad (6)$$

Using a conversion matrix,  $\mathbf{C}$ , with  $n$  rows and  $m$  columns, where  $n$  denotes the original

sectoral disaggregation (i.e. 65) of the matrix to be transformed,  $m$  denotes the intended dimensions of the converted matrix (i.e. 19), and  $c_{ij}$  denotes the value allocations (e.g.  $c_{21}$  with a value of ‘1.00’ for 100% of both  $x_{21,old}$  and  $x_{12,old}$  to go to  $x_{11,new}$ ;  $c_{52}$  and  $c_{53}$  with values of ‘0.30’ and ‘0.70’ for 30% of both  $x_{52,old}$  and  $x_{25,old}$  to go to  $x_{52,new}$  and  $x_{25,new}$ , respectively, while the remaining 70% goes to  $x_{53,new}$  and  $x_{35,new}$ , respectively), sectoral matrix reaggregation can be done as follows,

$$\mathbf{x}_{new} = \mathbf{C}^T(\mathbf{x}_{old}\mathbf{C}) \quad (7)$$

For countries like the Philippines where only national IO accounts are published, a more comprehensive analysis focusing only on a portion of the economy (e.g. region) would require disaggregation at another level. Non-survey techniques, specifically the “Two-Region Logic with more than Two Regions” approach, can be used (Miller and Blair, 2009). This process involves using location quotients, calculated as follows,

$$LQ_i^r = \left( \frac{x_i^r/x^r}{x_i^n/x^n} \right) \quad (8)$$

where  $LQ_i^r$  denotes the location quotient for sector  $i$  in region  $r$ ,  $x_i^r$  denotes the output of sector  $i$  in region  $r$ ,  $x^r$  denotes the total output of all sectors in region  $r$ , and  $x_i^n$  and  $x^n$  denote these at the national level.

Intra-regional input coefficients are estimated as follows,

$$x_{ij}^{rr} = \begin{cases} (LQ_i^r)x_{ij}^n & \text{if } LQ_i^r < 1 \\ x_{ij}^n & \text{if } LQ_i^r \geq 1 \end{cases} \quad (9)$$

where  $x_{ij}^{rr}$  denotes the inputs of sector  $i$  in region  $r$  to sector  $j$  in region  $r$  and  $x_{ij}^n$  denotes the national inputs of sector  $i$  to sector  $j$ . Doing this for all ‘region’s, the diagonal matrices corresponding to intra-regional input coefficients can be estimated. Imports from the “rest of the economy” (RETO) (i.e. aggregation of all other regions except region 1 when estimating  $x_{ij}^{11}$ ) to region  $r$  can be estimated as follows,

$$x_{ij}^{\tilde{r}} = x_{ij}^n - x_{ij}^{rr} \quad (10)$$

The intra-regional inputs for the RETO,  $x_{ij}^{\tilde{r}}$ , can be computed using Eq. (9), but with the calculated location quotient of the RETO. Finally, imports from region  $r$  to the RETO can be estimated as follows,

$$x_{ij}^{r\tilde{r}} = x_{ij}^n - x_{ij}^{\tilde{r}} \quad (11)$$

As an example, Table 3 shows the partitioning of a national economy into three regions. The shaded regions, corresponding to inter-regional inputs, can be filled-in by dividing the imports equally among all other regions. However, the initial allocation of imports may be based on regional GDP values to arrive at a more realistic distribution. Then, knowing the row and column imports, the matrix can be balanced by applying a RAS procedure. However, RAS’s simplicity in application comes with some disadvantages (e.g. lack of economic foundations,

inability to accommodate other sources of data than those in the row and column totals). Thus, in Fofana, Lemelin, and Cockburn (2005), matrix balancing was performed using the cross-entropy (CE) technique.

Table 3. Sample Regionalization

$x^{11}$		$x^{1\bar{1}}$
	$x^{22}$	$x^{2\bar{2}}$
		$x^{3\bar{3}}$
$x^{\bar{1}1}$	$x^{\bar{2}2}$	$x^{\bar{3}3}$

**4. METHODOLOGY**

**4.1. Research Design**

Figure 3 shows the study plan, where the tool development process is shown to use the IO accounts and gross regional domestic product (GRDP) data from 2018. The MEAT was constructed using MS Excel, utilizing the VBA macro capabilities to make the extensive matrix calculations more manageable. The tool was then used to perform economic assessment of regional transportation infrastructure development.

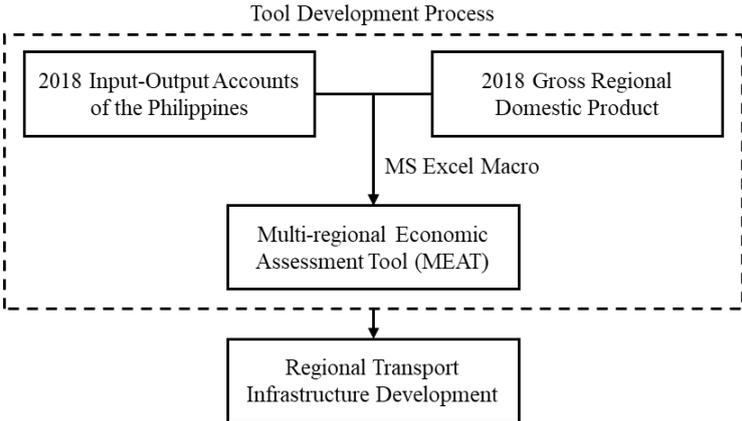


Figure 3. Research Concept

**4.2. Data Collection and Management**

Initial data for the inter-sectoral transactions was taken from the 2018 IO Accounts of the Philippines published by the PSA last December 2021, containing annual comprehensive statistics between all sectors of the economy. Data on the 2018 GRDP was used for the regionalization of the IO accounts. For this research, the 240-Industry dataset was used. However, the 16-Industry dataset was also used to proportion the GRDP data. All computations were maintained in 2018 prices for uniformity of estimates.

The "Two-Region Logic with more than Two Regions" approach was selected due to its capacity to systematically reweight national IO coefficients to reflect regional differences using readily available economic data. In the Philippine context, where complete subnational IO tables are unavailable, this method strikes a balance between practical feasibility and analytical rigor. Alternative methods, such as survey-derived tables or gravity-based allocation, were investigated; however, these necessitated comprehensive inter-regional trade and commodity flow data that were either obsolete or unavailable.

To approximate regional activity profiles, potential biases from incomplete regional data were mitigated by combining GRDP sectoral shares with Location Quotients (LQ). Although this may still oversimplify interregional heterogeneity, the method ensures proportional consistency and captures structural differences. Fallback coefficients were calculated by averaging values from comparable regions or national averages for sectors that exhibited missing or zero values in certain regions.

### 4.3. Economic Assessment

Figure 4 shows the user interface of the tool developed. As shown, the user can set where the initial change will be introduced. Specifically, the user can set within which economic subsector within which region will the spread of change across the economy will come from. The user can also input the initial value of change (i.e., in percentage). Additionally, the user is allowed to select which outputs to display for further flexibility. These include graphs showing the national and regional estimates as well as tabulation of economic impacts across the different economic sectors (i.e., national and regional) and the different regions. The tool also allows to subsequent estimation of other scenarios (e.g., other sectors, other regions).

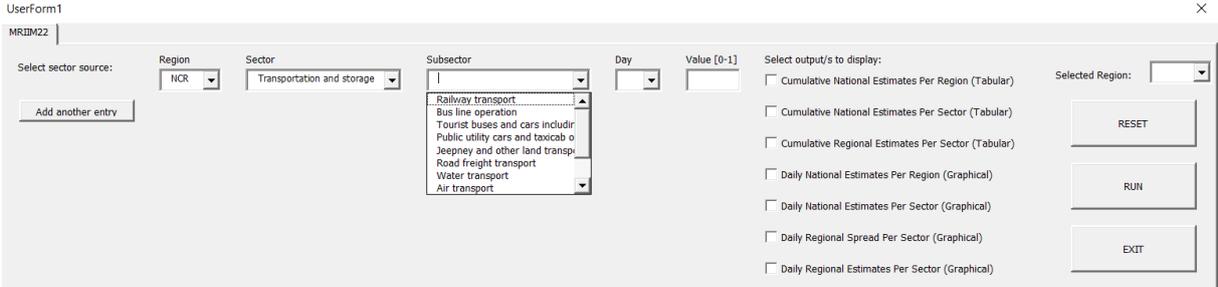


Figure 4. MEAT User Interface

The modular VBA procedures were employed to develop the macro-driven automation, which separated each core function—data entry, matrix balancing, and output generation—into reusable subroutines. This design improves maintainability and allows the tool to be adapted for other infrastructure sectors beyond transport. In order to mitigate user errors, additional usability features were implemented, including data validation routines and reset commands. A user manual is currently in the process of being developed to assist academic users and practitioners in the application of the tool to a variety of regional or sectoral planning requirements.

Figure 5, on the other hand, shows a sample result of using the tool developed, where a 10% change was modeled to originate from the ‘Road freight transport’ sector in the ‘NCR’ region. The change can be modeled from an infrastructure development program in the sector that resulted in a 10% change in the sector’s output. In the given example, it can be in the form of an expansion of the rail freight transport service in the region that resulted in a 10% increase in the overall economic performance of the sector. Alternatively, it can also be from a transport policy implementation (e.g., congestion pricing scheme on other land freight transport options) that resulted in a change in the demand. Whichever from the change resulted, the tool can estimate the spread of the impact across the different sectors and regions.

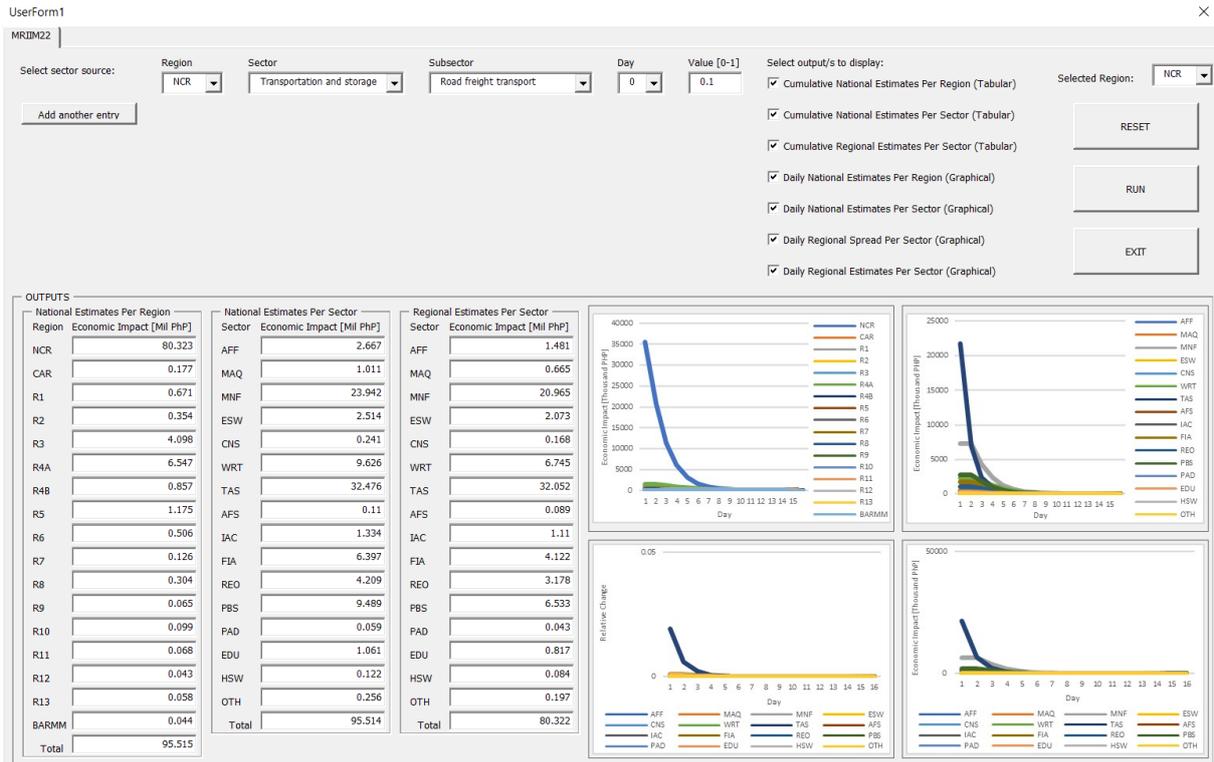


Figure 5. Sample MEAT Output

The tool was designed with scalability in mind, despite the fact that the present simulation utilized regional-level input structures based on available PSA and GRDP data. Users may modify the input matrices as necessary if they have access to local indicators, such as provincial GRDP or municipal investment plans. This feature makes the tool relevant for localized economic planning and assists in the translation of national models into actionable insights at the community level, as it supports application at the LGU level.

At present, the model assumes sectoral presence in all regions. To enhance the accuracy of MEAT in underdeveloped regions, future improvements may include the implementation of user-defined cutoffs. For example, sectors with LQ values below a threshold or zero GRDP contribution may be excluded. These sectors typically demonstrate minimal or volatile economic activity, and their continued inclusion often results in distorted LQ values and unrealistic technical coefficients that artificially exaggerate multiplier effects. Excluding sectors below the threshold thereby enhances numerical stability and guarantees that the estimated impacts pertain solely to industries that actively contribute to the regional economy. In doing so, the multiplier estimates would become more accurate, and the influence of economically insignificant sectors would be reduced through this filtering.

## 5. RESULTS AND DISCUSSIONS

This study simulated two distinct policy scenarios to illustrate MEAT's analytical capabilities. The first is a shock to the transport sector, which is intended to reflect a substantial policy-driven increase in transport services. The transport sector of each region is the subject of a simulated investment in the second scenario. These parameters were chosen for their interpretability, simplicity, and clarity for policymakers, as well as to demonstrate the tool's capacity to identify and differentiate economic ripple effects across regions.

In performing the economic assessment, a 10% change was introduced to the transport

sectors of each region. A summary of the estimated economic impacts can be found in Appendix A. It is worth noting that the change was introduced separately across the different regions to capture the impact of transport infrastructure development within each region. For example, a 10% change in the transport sector in NCR is estimated to result in changes amounting to over P127 million in the ‘Manufacturing’ sector, P41 million in the ‘Wholesale and retail trade’ sector, and around P40 million in the ‘Professional and business services’ sector.

A possible explanation can be on how an improvement in the transport infrastructure can result in increased productivity in the manufacturing sector. Significant spillover advantages are felt by the industrial sector, in particular, because better transportation connection lowers logistics costs, boosts supply chain effectiveness, and eases regional commerce. Urbanized areas with a large concentration of industries may use transportation upgrades to boost their economies, as demonstrated by the P127 million gain in the manufacturing sector in the NCR.

Significant advances are also made in the professional and commercial services sector, especially in metropolitan areas where knowledge-based sectors are more common. This result is consistent with other studies that highlight how transportation accessibility supports increased labor mobility, corporate operations, and service sector expansion.

Additionally, the tool shows how the resulting economic impact spills over outside the source of the initial change (i.e., as evidenced by the difference in the national and regional economic impact estimates in Figure 4). This shows how the tool captures the interconnectivity of the different regions such that a change in one is modeled to also impact the others. Figure 6 shows the spatial distribution of the overall economic impact of a 10% change in the transport sector of each region, where the higher values can be found in the areas of higher economic productivity. This is expected as a constant value of a 10% change will scale accordingly to the current economic activities in the different regions.

One important finding from the data is that the economic impact varies by location, highlighting the disparities in infrastructural development and economic output. Because of their already strong economic foundations, the NCR, CALABARZON, and Central Visayas show high absolute gains, whereas MIMAROPA and BARMM see smaller but still favorable effects.

Although the tool was not benchmarked against a comprehensive regional IO model due to data constraints, its outputs were evaluated against anticipated regional trends and subjected to basic face validation. For instance, regions that are known to have a high concentration of transport and logistics (e.g., NCR, Region III) exhibited higher Type I multipliers, which is in accordance with economic intuition. The model may be validated in the future by comparing it to ex-post investment data or expert elicitation.

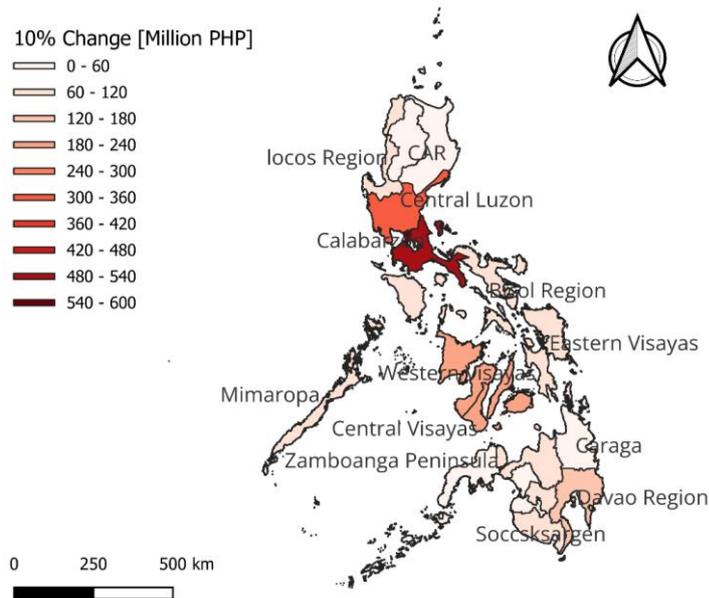


Figure 6. Economic Impact of a 10% Change

Additionally, in terms of transport policy applications, it can be useful to identify in which region is it optimal to invest in the transport sector infrastructure. Figure 7, on the other hand, shows the economic impact of a scaled change in each region, stemming from a P1 M change in the economic productivity of the transport sector in the region. This captures how an investment that results in a P1 M change in an already highly-productive region can amount to less than if the investment is done in a region that is yet to be developed.

As shown, the higher estimates were found for the Cordillera Administrative Region (CAR), Calabarzon, and Northern Mindanao regions, with values of P44.51 million, P40.98 million, and P39.11 million, respectively. This suggests that investing in these areas could result in better returns per peso spent. For policymakers who want to give transportation infrastructure improvements top priority in areas where they would have the biggest proportional economic impact, this is especially pertinent.

Additionally, the cross-regional spillover effects show that infrastructure investments are not isolated. A complicated web of economic interdependencies where an improvement in one region benefits others due to interregional commerce and mobility is suggested by the discrepancy between regional and national impact estimates.

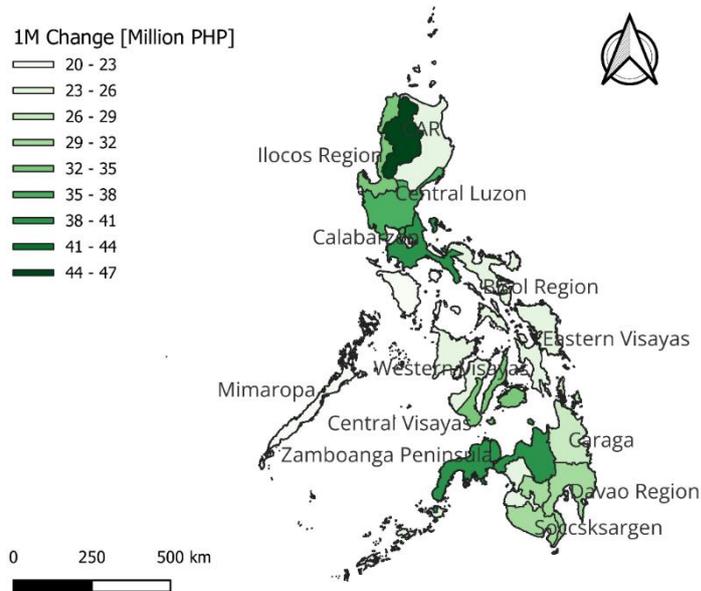


Figure 7. Economic Impact of a P1 M Change

The study's conclusions have important policy ramifications for the Philippines' infrastructure investment optimization. Given the noted economic advantages, government organizations like the Department of Transportation (DOTr) and the National Economic and Development Authority (NEDA) ought to think about giving transportation investments top priority in high-yield areas like Northern Mindanao, CALABARZON, and CAR, where economic returns per peso spent are at their highest.

A more balanced national development strategy might also be achieved by implementing a multi-regional model that takes spillover effects into consideration, avoiding the concentration of economic gains in a small number of urbanized areas. To promote more inclusive economic growth and close the gap between undeveloped and high-performing regions, it is also imperative to strengthen interregional connections. Furthermore, to make sure that major projects result in quantifiable increases in productivity and regional competitiveness, infrastructure decision-making should incorporate economic effect assessments beyond conventional transport indicators, such as trip time reductions.

Although no direct empirical validation was conducted as a result of data limitations, the tool can be validated in future work by applying backtesting, which involves comparing projected outputs to historical GRDP trends in regions where transport investments were completed. A robustness check should also include a sensitivity analysis of key coefficients (e.g., technical coefficients, LQs).

## 6. Framework for Policy Development and Institutional Integration

Economic modeling tools must progress beyond technical assessment and toward institutional usability as infrastructure spending continues to influence regional development strategies. The MEAT, which is based on well-established input-output theory, provides a unique operational pathway that connects technical simulation and practical policy-making. The framework proposed in this section is designed to incorporate MEAT into the current regional planning processes and provides a model for integrating simulation outputs into investment decision-making.

The significance of data-driven tools in addressing both equity and efficiency in regional infrastructure allocation is underscored by the existing literature on policy development (Abdul

Quium, 2019; Iroz-Elardo et al., 2020). Nevertheless, local governments are unable to access a significant number of these tools due to their technical complexity or reliance on proprietary software. MEAT offers a unique contribution by developing a fully transparent, replicable model in Microsoft Excel with VBA that is specifically tailored for the use of local government units (LGUs) and agencies in the Philippine context.

The multi-stage process of the proposed policy integration framework, as illustrated in Figure 8, commences with the encoding of regional infrastructure data (investment levels, GRDP contributions, and sectoral presence via LQ). The MEAT subsequently simulates economic impacts, including output, value added, and employment. Scenario analyses and stakeholder consultations that involve LGUs, NEDA regional offices, and sectoral agencies such as DPWH and DOTR are directly informed by these results.

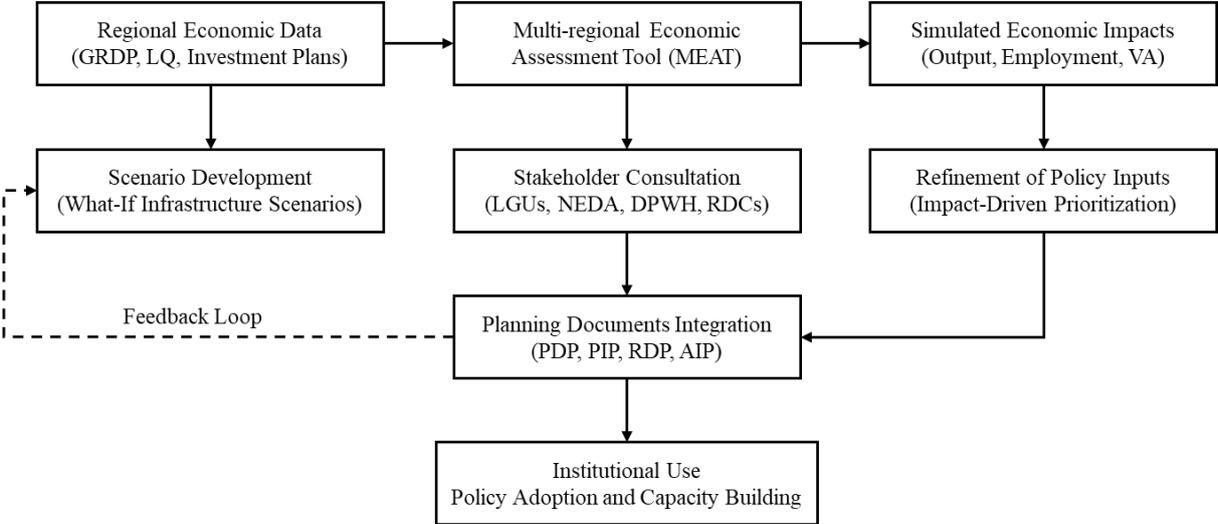


Figure 8. Policy Integration Framework

Policy formulation inputs are generated from these engagements, which enables the refinement of infrastructure prioritization based on real-time, region-specific multiplier effects. Ultimately, these inputs facilitate alignment with national planning instruments, including the Philippine Development Plan (PDP), Public Investment Program (PIP), and Regional Development Plans (RDPs). This method also contributes to the localization of Sustainable Development Goals (SDGs) by facilitating the evaluation of social and economic returns based on evidence.

The research transitions from academic modeling to operational policymaking by incorporating the MEAT tool into this broader policy framework. The tool's adaptability facilitates cross-sectoral application for health, education, and other infrastructure categories, and its design is in accordance with institutional planning workflows. The framework also accommodates potential future expansions, including the integration of social indicators, climate resilience metrics, and fiscal impact modules.

**7. CONCLUSIONS**

Using VBA, this study effectively created an easy-to-use Microsoft Excel-based application to calculate the economic impact of infrastructure development projects in various regions in the Philippines. The tool solves the problem of regionalizing national-level economic accounts by incorporating multi-regional Input-Output (IO) modeling, which permits the methodical evaluation of economic spillovers. Significant regional and sectoral differences in economic

impact are shown by the findings, which also show how the expansion of transportation infrastructure boosts productivity in important industries including manufacturing, wholesale and retail commerce, and professional and business services. Additionally, the findings show that investment in areas with strong relative economic returns, including Northern Mindanao, CALABARZON, and CAR, can result in more effective infrastructure spending while fostering balanced regional growth.

The MEAT is a significant advancement in the democratization of input-output analysis, as it provides a platform-independent, Excel-based model that is appropriate for national, regional, and local economic planning. Its adaptability enables it to be replicated across a variety of sectors and scalable to subnational levels, thereby enabling a more extensive application beyond the initial transport focus. The project's additional objective is to ensure the tool's continued utility by providing MEAT with user documentation and training modules that are publicly accessible. The project's future direction involves the integration of GIS-based spatial data and time-series forecasting to improve the targeting of strategic infrastructure.

In addition, the tool's institutional relevance is emphasized by its alignment with the planning mandates of NEDA, DOTr, DPWH, and local development councils, which enables them to assess the economic implications of their investment portfolios in a cost-effective manner. The tool could be employed in conjunction with investment programming activities, such as the Public Investment Program (PIP) or Regional Development Plans (RDPs), to integrate MEAT into actual planning workflows. Incorporating MEAT into training modules for regional and provincial planners could facilitate scenario simulation prior to project prioritization in capacity-building programs.

## **ACKNOWLEDGMENTS**

This research was funded by National University, Philippines, through its Internally Funded Research Project (IFRP) program. The author gratefully acknowledges the support provided by the Research and Development Office (RDO) in facilitating the study.

## APPENDIX A. Regional Economic Impact Estimate for 10% Change in Transport Sector

Sector	Region																
	NCR	CAR	R1	R2	R3	R4A	R4B	R5	R6	R7	R8	R9	R10	R11	R12	R13	BAR MM
Agriculture, forestry, and fishing	9.008	1.118	4.468	3.9	23.815	30.414	4.892	4.906	14.521	10.215	4.672	4.069	7.166	9.114	4.197	2.705	2.474
Mining and quarrying	4.045	0.386	0.683	0.907	4.951	7.334	1.139	1.144	3.325	2.271	0.639	0.664	1.195	2.003	0.556	0.65	0.473
Manufacturing	127.562	6.122	16.9	14.571	89.432	121.356	17.934	18.135	54.283	50.213	17.453	15.336	27.219	34.837	15.863	10.272	9.168
Electricity, steam, water and waste management	12.615	0.569	1.719	1.34	7.779	10.582	1.78	1.968	3.818	5.139	1.686	0.868	2.627	3.332	1.591	0.981	0.911
Construction	1.024	0.065	0.102	0.082	0.459	0.152	0.097	0.116	0.293	0.363	0.094	0.078	0.157	0.261	0.041	0.068	0.011
Wholesale and retail trade	41.04	2.252	4.781	3.003	15.571	25.429	3.291	3.433	15.827	15.393	3.006	4.118	7.683	10.705	3.383	1.587	1.091
Transportation and storage	195.023	10.17	21.709	19.794	94.152	128.19	25.113	27.947	71.059	58.958	22.099	16.682	32.078	45.764	20.595	15.467	13.413
Accommodation and food service activities	0.544	0.039	0.072	0.039	0.302	0.393	0.074	0.085	0.244	0.227	0.009	0.033	0.107	0.161	0.067	0.049	0.009
Information and communication	6.755	0.417	0.821	0.678	3.509	4.791	0.739	0.809	2.711	2.617	0.805	0.542	1.011	1.578	0.683	0.506	0.31
Financial and insurance activities	25.083	1.55	1.395	0.927	3.112	6.146	1.05	2.098	6.965	9.604	2.082	1.3	2.698	5.532	2.147	2.116	0.497
Real estate and ownership of dwellings	19.335	1.141	1.881	1.03	6.097	11.129	0.835	1.301	5.581	6.958	1.538	1.192	2.621	4.2	1.22	0.857	0.34
Professional and business services	39.75	2.355	1.75	1.098	11.104	7.547	1.088	1.855	9.158	13.789	1.348	1.344	3.44	8.003	2.153	1.224	0.565
Public Administration and Defense	0.26	0.012	0.015	0.011	0.01	0.018	0.009	0.03	0.073	0.059	0.014	0.018	0.035	0.053	0.028	0.023	0.017
Education	4.972	0.334	0.654	0.557	2.234	2.975	0.69	0.784	2.177	1.996	0.637	0.499	0.906	1.426	0.608	0.441	0.363
Human health and social work activities	0.51	0.029	0.059	0.047	0.145	0.176	0.055	0.065	0.195	0.169	0.053	0.046	0.075	0.13	0.05	0.037	0.026
Other services	1.2	0.057	0.131	0.029	0.556	0.642	0.128	0.077	0.444	0.384	0.108	0.046	0.13	0.24	0.05	0.037	0.012
Total	488.726	26.616	57.14	48.013	263.228	357.274	58.914	64.753	190.674	178.355	56.243	46.835	89.148	127.339	53.232	37.02	29.68

## REFERENCES

- Abdul Quium, A. S. M. (2019). Transport corridors for wider socio-economic development. *Sustainability* (Switzerland), 11(19). <https://doi.org/10.3390/su11195248>
- Amheka, A., Nguyen, H.T., Yu, K.D., Noach, R.M., Andiappan, V., Dacanay, V.J., Aviso, K. (2022). Towards a low carbon ASEAN: an environmentally extended MRIO optimization model. *Carbon Balance and Management*, 17 (1) <https://cbmjournal.biomedcentral.com/doi:10.1186/s13021-022-00213-x>
- Anderson, C., Santos, J., & Haimes, Y. (2007). A risk-based input-output methodology for measuring the effects of the August 2003 northeast blackout. *Economic Systems Research*, 19(2), 183-204.
- Aviso, K. B., Amalin, D., Promentilla, M. a. B., Santos, J. R., Yu, K. D. S., & Tan, R. R. (2015). Risk assessment of the economic impacts of climate change on the implementation of mandatory biodiesel blending programs: A fuzzy inoperability input-output modeling (IIM) approach. *Biomass and Bioenergy*, 83, 436-447. <https://doi.org/10.1016/j.biombioe.2015.10.011>
- Babatunde, S. A. (2018). Government spending on infrastructure and economic growth in Nigeria. *Economic Research-Ekonomska Istraživanja*, 31(1), 997-1014. <https://doi.org/10.1080/1331677x.2018.1436453>
- Baghersad, M. & Zobel, C. (2015). Economic impact of production bottlenecks caused by disasters impacting interdependent industry sectors. *International Journal of Production Economics*, 168, 71-80.
- Bartzokas, A. & Cetindamar, D. (2024). How investment in developing countries' infrastructure can be accelerated – and why this is crucial for the SDGs. United Nations University. <https://unu.edu/merit/article/how-investment-in-developing-countries-infrastructure-can-be-accelerated>
- Blos, M. & Miyagi, P. (2015). Modeling the supply chain disruptions: A study based on the supply chain interdependencies. *IFAC Papers Online*, 48(3), 2053-2058.
- Bullen, S., Bovey, R. & Glenn, J. (2005). *Professional Excel Development: The Definitive Guide to Developing Applications Using Microsoft® Excel and VBA®*, The Addison-Wesley Microsoft Technology Series.
- Burke, P. J., Stern, D. I., & Bruns, S. B. (2018). "The Impact of Electricity on Economic Development: A Macroeconomic Perspective." *International Review of Environmental and Resource Economics* 12, 85-127.
- Calderon, C., Moral - benitom, E., & Servén, L. (2015). "Is Infrastructure Capital Productive? A Dynamic Heterogeneous Approach." *Journal of Applied Econometrics* 30, 177-198. doi:10.1002/jae.2373.
- Calderon, C. & Servén, L. (2004). *The Effects of Infrastructure Development on Growth and Income Distribution*. Policy Research Working Paper; No.3400. © World Bank, Washington, D.C.. <http://hdl.handle.net/10986/14136> License: CC BY 3.0 IGO.
- Chakamera, C. & Alagidede, P. (2018). The Nexus between Infrastructure (Quantity and Quality) and Economic Growth in Sub Saharan Africa. *International Review of Applied Economics*, 32(5), 641-72.
- Chan, B. I., Fillone, A., Yu, K. D. S., & Roquel, K. I. D. Z. (2020). Assessing the economic impact of the closure of Ninoy Aquino International Airport caused by Xiamen Air. *Philippine Transportation Journal*, 3(1).
- Chapra, S.C. (2003). *Power Programming with VBA/Excel*, Pearson Education, Upper Saddle River, NJ.

- Crowther, K., Haines, Y., & Taub, G. (2007). Systemic valuation of strategic preparedness through application of the inoperability input-output model with lessons learned from Hurricane Katrina. *Risk Analysis*, 27(5), 1345-1364.
- Donaldson, D., & R. Hornbeck. (2016). "Railroads and American Economic Growth: A "Market Access" Approach." *The Quarterly Journal of Economics* 131, 799–858. doi:10.1093/qje/qjw002. 57/jep.34.1.122.
- Du, X., Zhang, H., & Han, Y. (2022). How Does New Infrastructure Investment Affect Economic Growth Quality? Empirical Evidence from China. *Sustainability*, 14(6), 3511. <https://doi.org/10.3390/su14063511>
- Dydowicz, P. (2015). Creation and use of internal matrix database functions in VBA MS Excel environment for bulk data processing. *Journal of Software and Systems Development*, 2015(2015),1–12. <https://doi.org/10.5171/2016.675401>
- Elfeki, A. & Bahrawi, J. (2014). A fully distributed spreadsheet modeling as a tool for analyzing groundwater level rise problem in Jeddah city. *Arabian Journal of Geosciences*, 8(4).
- Enya, F.O. & Ezeali, B.O. (2021). Public Investment in Infrastructure and Economic Growth in Nigeria (1980-2020). *African Journal of Economics and Sustainable Development* 4(3), 1-22. DOI:10.52589/AJESD-0JM1VBER.
- Fofana, I., Lemelin, A., & Cockburn, J. (2005). Balancing a social accounting matrix: theory and application. Retrieved from: <http://www.pep-net.org/sites/pep-net.org/files/typo3doc/pdf/sambal.pdf>.
- Foong, S., Andiappan, V., Aviso, K., Chemmangattuvalappil, N., Tan, R., Yu, K., & Ng, D. (2021). A criticality index for prioritizing economic sectors for post-crisis recovery in oleo-chemical industry. *Journal of the Taiwan Institute of Chemical Engineers*, 130, 103957. <https://doi.org/10.1016/j.jtice.2021.06.051>
- Galea, S., Ahern, J., Resnick, H., Kilpatrick, D., Bucuvalas, M., Gold, J., & Vlahov, D. (2002). Psychological sequelae of the September 11 terrorist attacks in New York City. *The New England Journal of Medicine*, 346, 982-987.
- Gurara, D., Klyuev, V., Mwase, N., & Presbitero, A. F. (2018). Trends and challenges in infrastructure investment in developing countries. *International Development Policy/Revue Internationale De Politique De Développement*, 10.1. <https://doi.org/10.4000/poldev.2802>
- Haggerty, M., Santos, J., & Haines, Y. (2008). A transportation-based framework for deriving perturbations to the inoperability input-output model. *Journal of Infrastructure Systems*, 14(4), 293-304.
- Hasana, S. N., & Alifiani, A. (2019). Multimedia development using visual basic for application (VBA) to improve students' learning motivation in studying mathematics of economics. *Indonesian Journal of Mathematics Education*, 2(1), 34. <https://doi.org/10.31002/ijome.v2i1.1230>
- Hota, S. P. (2023). Education infrastructure, expenditure, enrollment & economic development in Odisha, India. *International Journal of Educational Development*, 103, 102903. <https://doi.org/10.1016/j.ijedudev.2023.102903>
- Iroz-Elardo, N., Schoner, J., Fox, E. H., Brookes, A., & Frank, L. D. (2020). Active travel and social justice: Addressing disparities and promoting health equity through a novel approach to Regional Transportation Planning. *Social Science and Medicine*, 261. <https://doi.org/10.1016/j.socscimed.2020.113211>
- Kaur, A., & Kaur, R. (2018). Role of social and economic infrastructure in economic development of Punjab. *International Journal of Innovative Knowledge Concepts*, 6(5), 181-188.

- Kenny, C. (2015). Finding Cash for Infrastructure in Addis: Blending, Lending and Guarantees in Finance for Development. CGD Policy Paper 066. Washington DC: Center for Global Development. Retrieved from: <http://www.cgdev.org/publication/finding-cash-infrastructure-addis-blending-lending-and-guaranteesfinance-development>
- Khan, H., Khan, U., Jiang, L. J., & Khan, M. A. (2020). Impact of infrastructure on economic growth in South Asia: Evidence from pooled mean group estimation. *The Electricity Journal*, 33(5), 106735. <https://doi.org/10.1016/j.tej.2020.106735>
- Kodongo, O. & Ojah, K. (2016). Does Infrastructure Really Explain Economic Growth in Sub-Saharan Africa?. *Review of Development Finance*, 6(2), 105–25.
- Kohli, N., Avula, R., Van Den Bold, M., Becker, E., Nisbett, N., Haddad, L., & Menon, P. (2017). What will it take to accelerate improvements in nutrition outcomes in Odisha? Learning from the past. *Global Food Security*, 12, 38–48. <https://doi.org/10.1016/j.gfs.2017.01.007>
- Kwakkel, J. H., & Van Der Pas, J. W. G. (2011). Evaluation of infrastructure planning approaches: An analogy with medicine. *Futures*, 43(9), 934–946. <https://doi.org/10.1016/j.futures.2011.06.003>
- Lee, K., Miguel, E., & Wolfram, C. (2020). “Does Household Electrification Supercharge Economic Development?” *Journal of Economic Perspectives* 34, 122–144. doi:10.12
- Leontief, W. (1936). Quantitative input and output relations in the economic system of the United States. *Review of Economics and Statistics*, 18(3), 105-125.
- Litman, T. (2013). The new transportation planning paradigm. *ITE Journal*. Retrieved April 25, 2016 from: <http://www.vtpi.org/paradigm.pdf>.
- Llanto, G.M. (2002). "Infrastructure Development: Experience and Policy Options for the Future," Discussion Papers DP 2002-26, Philippine Institute for Development Studies.
- Marchau, V., Walker, W., & van Duin, R. (2008). An adaptive approach to implementing innovative urban transport solutions. *Transport policy*, 15(6), 405-412.
- Miller, R. & Blair, P. (2009). *Input-output analysis: Foundations and extensions*. (2nd ed.). New York: Cambridge University Press.
- Mohd, J. M., Normaz, W. I., & Law, S. H. (2012). “A Pooled Mean Group Estimation on ICT Infrastructure and Economic Growth in ASEAN-5 Countries.” *International Journal of Economics and Management* 6 (2): 360–378.
- Mohmand, Y.T., Wang, A., & Saeed, A. (2017). The impact of transportation infrastructure on economic growth: empirical evidence from Pakistan. *Transp. Lett. Int. J. Transp. Res.*, 9 (2), pp. 63-69, doi: 10.1080/19427867.2016.1165463
- Munawaroh, S., & Haryanto, T. (2021). Development of infrastructure and economic growth of Papua Province. *Media Trend*, 16(1), 19–31. <https://doi.org/10.21107/mediatrend.v16i1.7454>
- National Economic and Development Authority. (2023). Infrastructure Flagship Projects. Retrieved from: <https://neda.gov.ph/infrastructure-flagship-projects/>
- Norris, F., Byrne, C., Diaz, E., & Kaniasty, K. (2002). The range, magnitude, and duration of effects of natural and human-caused disasters: A review of empirical literature. National Center for Post-Traumatic Stress Disorder (PTSD) Fact Sheet, White River Junction, VT.
- Palei, T. (2015). Assessing The Impact of Infrastructure on Economic Growth and Global Competitiveness. *Procedia Economics and Finance* 23,168 – 175. [https://doi.org/10.1016/S2212-5671\(15\)00322-6](https://doi.org/10.1016/S2212-5671(15)00322-6)
- Pant, R., Barker, K., Grant, F., & Landers, T. (2011). Interdependent impacts of inoperability at multi-modal transportation container terminals. *Transportation*

- Research Part E: Logistics and Transportation Review, 47(5), 722-737.
- Rahat, R., Ferrer, V., Pradhananga, P., & ElZomor, M. (2022). A Pedagogical Paradigm to Support Infrastructure Projects through Coupling Front-End Planning Techniques with Sustainability Practices. *International Journal of Construction Education and Research*, 19(3), 276–298. <https://doi.org/10.1080/15578771.2022.2096156>
- Ramadhan, F., Rukmi, H.S., Imran, A., Nugraha, C., & Ferdiansyah, R. (2020). Software Design using Visual Basic for Application and Microsoft Excel Programming for Students. *REKA ELKOMIKA: Jurnal Pengabdian kepada Masyarakat* 1(2), 86-97. <https://doi.org/10.26760/rekaelkomika.v1i2.86-97>.
- Ray, S. (2020). Infrastructure Finance and Financial Sector Development. Asian Development Bank. <https://www.adb.org/publications/infrastructure-finance-and-financial-sector-development>
- Ribando, R. (1998). An Excel/Visual Basic for Applications (VBA) programming primer. *Computers in Education Journal* 8(2):38-43
- Roquel, K. I. D., Fillone, A., & Yu, K. D. (2019). Comparative flood-risk assessment of different freight transport development programs. *DLSU Business and Economics Review*, 29(1), 146–164. <https://dlsuiber.com/wp-content/uploads/2019/08/13.pdf>
- Roquel, K.I.D., Fillone, A., & Yu, K. (2017). Transport Infrastructure Development Assessment Using a Multi-Regional Inoperability Input-Output Model. 12th Eastern Asia Society for Transportation Studies Conference. [https://www.researchgate.net/publication/321385968\\_Transport\\_Infrastructure\\_Development\\_Assessment\\_Using\\_a\\_Multi-Regional\\_Inoperability\\_Input-Output\\_Model](https://www.researchgate.net/publication/321385968_Transport_Infrastructure_Development_Assessment_Using_a_Multi-Regional_Inoperability_Input-Output_Model)
- Roquel, K.I.D., Fillone, A., & Yu, K. (2018). Estimating Effects of Fuel Price Hikes on the Transport Sector. *ATRANS Annual Conference*. [https://www.researchgate.net/publication/330134095\\_Estimating\\_Effects\\_of\\_Fuel\\_Price\\_Hikes\\_on\\_the\\_Transport\\_Sector](https://www.researchgate.net/publication/330134095_Estimating_Effects_of_Fuel_Price_Hikes_on_the_Transport_Sector)
- Rouchdi, M. (2024). Efficient KPIs Analysis: Harnessing the Power of Excel and VBA Programming for Data Visualization and Analysis. *Digital Technologies and Applications*. DOI: 10.1007/978-3-031-68675-7\_3.
- Ryerson, M. & Hansen, M. (2013). Capturing the impact of fuel price on jet aircraft operating costs with Leontief technology and econometric models. *Transportation Research Part C: Emerging Technologies*, 33, 282-296.
- Santos, J. & Haines, Y. (2004). Modeling the demand reduction input-output (I-O) inoperability due to terrorism of interconnected infrastructures. *Risk Analysis*, 24(6), 1437-1451.
- Santos, J. (2006). Inoperability input-output modeling of disruptions to interdependent economic systems. *Systems Engineering*, 9(1), 20-34.
- Santos, J. R., & Haines, Y. Y. (2004). Modeling the demand reduction Input - Output (I - O) inoperability due to terrorism of interconnected infrastructures\*. *Risk Analysis*, 24(6), 1437-1451. <https://doi.org/10.1111/j.0272-4332.2004.00540.x>
- Santos, J., Roquel, K. I. D. Z., Lamberte, A., Tan, R. R., Aviso, K. B., Tapia, J. F. D., Solis, C. A., & Yu, K. D. S. (2022). Assessing the economic ripple effects of critical infrastructure failures using the dynamic inoperability input-output model: a case study of the Taal Volcano eruption. *Sustainable and Resilient Infrastructure*, 8(sup1), 68–84. <https://doi.org/10.1080/23789689.2022.2127999>
- Swanson, D., Barg, S., Tyler, S., Venema, H., Tomar, S., Bhadwal, S., & Drexhage, J. (2010). Seven tools for creating adaptive policies. *Technological Forecasting and Social Change*, 77(6), 924-939.
- Thakur, N., Murthy, D., & Mandal, D. (2016). Numerical Analysis of One-Dimensional

- Unsteady State Heat Transfer Through a Plane Wall Using Visual Basic. *International Journal of Scientific and Engineering Research*, 7(12):177.
- Timilsina, G., Stern, D., & Das, D. (2021). How Much Does Physical Infrastructure Contribute to Economic Growth? An Empirical Analysis," Policy Research Working Paper Series 9888, The World Bank.
- Tortajada, C. (2016). Policy dimensions of development and financing of water infrastructure: The cases of China and India. *Environmental Science & Policy*, 64, 177–187. <https://doi.org/10.1016/j.envsci.2016.07.001>
- Valipour, M., & Montazar, A. A. (2012). Optimize of all effective infiltration parameters infurrow irrigation using Visual Basic and genetic algorithm programming. *Australian Journal of Basic and Applied Sciences*, 6(6), 132–137.
- van Geenhuizen, M., & Thissen, W. (2016). A framework for identifying and qualifying uncertainty in policy making: the case of intelligent transport systems. In *Policy analysis of transport networks* (pp. 101-118). Routledge.
- Varum, C. A., & Melo, C. (2010). Directions in scenario planning literature—A review of the past decades. *Futures*, 42(4), 355-369.
- Volkery, A., & Ribeiro, T. (2009). Scenario planning in public policy: Understanding use, impacts and the role of institutional context factors. *Technological Forecasting and Social Change*, 76(9), 1198–1207. <https://doi.org/10.1016/j.techfore.2009.07.009>
- Wulandari, N. P., Wahiduddin, F., Lu'luilmaknun, U., Maulyda, M. A., & Apsari, R. A. (2021). Teaching Macro Excel on Pre-service Mathematics Teachers: Analysis error in solving the syntax manually. *JTAM (Jurnal Teori Dan Aplikasi Matematika)*, 5(1), 70. <https://doi.org/10.31764/jtam.v5i1.3313>
- Yu, K. D. S., & Aviso, K. B. (2020). Modelling the economic impact and ripple effects of disease outbreaks. *Process Integration and Optimization for Sustainability*, 4(2), 183–186. <https://doi.org/10.1007/s41660-020-00113-y>
- Yu, K. D. S., Aviso, K. B., Santos, J. R., & Tan, R. R. (2020). The Economic Impact of Lockdowns: A Persistent Inoperability Input-Output approach. *Economies*, 8(4), 109. <https://doi.org/10.3390/economies8040109>
- Yu, K. D. S., Tan, R. R., Aviso, K. B., Promentilla, M. a. B., & Santos, J. R. (2014). A VULNERABILITY INDEX FOR POST-DISASTER KEY SECTOR PRIORITIZATION. *Economic Systems Research*, 26(1), 81–97. <https://doi.org/10.1080/09535314.2013.872603>
- Yu, K.D.S., Solis, C.A., & Andiappan, V. (2023). A Sector Prioritization Index with Carbon Emission Intensity Considerations. *DLSU Business and Economics Review*, 32(2), 54 – 62.