Rapid economy-wide appraisal of airport deconcentration: An Excel-based MRIO sensitivity study for the Philippines

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ABSTRACT

This paper introduces a low-cost, Excel/VBA multi-regional input–output tool designed to stress-test the reallocation of airport slots from Ninoy Aquino International Airport (NAIA) to secondary hubs. An activity-conserving scaling method converts an NAIA reduction in air transport into recipient-specific percentage changes in activity, with conservative adjustments to support activities. Single, dual, and tri-split scenarios are assessed using peso-per-1% shift (national/regional sensitivity) and GRDP-Normalized Shift Intensity (GNSI) (local exposure) metrics. The results suggest that a CRK-led reallocation results in the least national loss, followed by CRK+CEB. Configurations that involve Davao deepen short-term losses, and high GNSI signals local capacity needs. The workflow is transparent, reproducible, and runnable on standard office machines, thereby enhancing evidence-based policymaking, resilient infrastructure planning, sustainable transport design, regional development, and disaster risk reduction. The method is easily adaptable to cold-chain policies, ports, and trucking windows, and it facilitates rapid triage and interagency collaboration during policy windows.

INTRODUCTION

Supply-chain resilience, regional accessibility, and national competitiveness are influenced by air transport (Palei, 2015; Bartulovic et al., 2022; Yoo, van Wee, & Molin, 2024). Airport systems worldwide are confronted with operational risks and capacity constraints that have the potential to disrupt high-value passenger and cargo movements (Voskaki, Budd, & Mason, 2023). Consequently, policymakers require rapid, transparent methods to estimate the economy-wide impacts of airport disruptions and policy changes (Chan et al., 2020; Huang, Ali, & Solangi, 2023). Traditional modeling methods are effective; however, they are data-intensive and slow to mobilize during policy windows (Milne & Watling, 2019). A complementary method is to employ stress-testing techniques that are based on input–output analysis to rapidly acquire decision-relevant signals (Johnson, 2018; Roquel et al., 2022; Mijumbi-Deve et al., 2022). Such scans do not substitute for comprehensive models; rather, they identify the areas in which additional analysis and investment would be most beneficial (Kang, 2019). It is this pragmatic perspective that is advanced in this paper to contribute to inclusive and sustainable industrialization and innovation capacity by lowering the technical and cost barriers to quantitative analysis within public institutions.

The necessity of rapid, replicable assessments is emphasized by the Philippine context. Historically, Metro Manila has been the primary hub for air traffic, while secondary hubs in Central Luzon, Central Visayas, and Davao are increasingly managing domestic and international traffic (Francisco & Lim, 2022). In transport literature, many studies have already investigated the deconcentration of slots, the reinforcement of secondary airports, and the construction of redundancy (Ribeiro et al., 2019; Wang et al., 2023). Decisions have repercussions that extend beyond aviation, affecting tourism, business services, manufacturing logistics, and regional development (Roquel et al., 2019; Papatheodorou, 2021; Putrik et al., 2022). However, non-specialist analysts within government are rarely able to quantify the economy-wide impacts in an accessible way (Zhou, Leng, & Shi, 2022; Wandelt et al., 2024). A method that is user-friendly and translates simple scenario inputs into macroeconomic indicators would reduce the barriers to the use of evidence (Salas & Pennington, 2024). A tool of this nature is especially advantageous due to the archipelagic geography of the nation, as the tool operationalizes sustainable transport decision support and fosters accountable, transparent governance of infrastructure choices.

This paper addresses two needs. First, agencies require a credible method to compare "what-if" airport strategies in terms of national and regional economic effects, rather than just terminal throughput (Garcia & Mavris, 2000). Secondly, agencies need a workflow that is feasible, repeatable, and transparent on conventional office machines (Parkes, 2004; Malubag, Briones, & Abante, 2024). Policy debates often rely on qualitative judgment or limited metrics rather than economy-wide evidence in the absence of such a tool (Reed et al., 2021). The discrepancy is practical rather than

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Date received: 23 September 2025
Dates revised: 20 November 2025
Date accepted: 29 January 2026
DOI: https://doi.org/10.54645/2026191PRZ-49

KEYWORDS

multi-regional input–output, airport slot reallocation, sustainable transport, resilient infrastructure, regional economic resilience

theoretical: analysts must be capable of defining scenarios, conducting them rapidly, and communicating the results in a clear and concise manner (Chirwa & Boikanyo, 2022). Timeliness is crucial due to the limited duration of policy windows. Replicability is crucial because the same approach should be applied to other transportation policies. This paper addresses both requirements.

The paper investigates what-if slot shifts from NAIA (NCR) to CRK (Region III), CEB (Region VII), and DVO (Region XI). These were selected because they serve as the country's three primary secondary gateways with established domestic and international operations. CRK serves as the anchor for Central Luzon's expanding industrial-logistics corridor. CEB is the main hub for the Visayas with robust tourism and service connections. DVO is Mindanao's leading commercial gateway. Together, they are the only airports with adequate activity bases to accommodate significant reallocations from NAIA under plausible policy or disruption scenarios. In the scenario modeling, the shocks are implemented in the context of air transport (PSA-240: 187), with a conservative companion adjustment to 'Support activities for transportation' (PSA-240: 189) to account for terminal and ground handling. Hypothetical percentages are employed to evaluate single-recipient, dual-split, and tri-split patterns in tiered scenarios. Modeling outputs are then assessed based on 1) the peso-per-1% shift, which reports absolute sensitivity, and 2) the GRDP-Normalized Shift Intensity (GNSI), which scales local effects by regional economic size. The results are presented at both the national and regional levels.

Furthermore, accessible, low-friction platforms have been prioritized in recent transport economics tool development, enabling agencies to execute scenarios without the need for specialized teams (Jonkeren, Francke, & Visser, 2019; Polyzos & Tsiotas, 2020). A burgeoning trend involves the utilization of spreadsheet front-ends that perform matrix operations in memory, thereby maintaining the auditability of files and ensuring their responsiveness (Romeo, 2020; Weerasinghe & Bandara, 2023; Suchaina et al., 2023). The adoption of R/Python in line agencies is impeded by installations, permissions, and training, despite its considerable power. Excel is already widely used and trusted. Transparent inputs (i.e., via a UserForm), one-click reproducibility, and zero additional software cost are all achieved by combining Excel and VBA. It also facilitates collaboration by allowing partners to open, inspect, and modify scenarios without the need to set up an environment.

The current study adheres to this paradigm by incorporating a short-run multi-regional input–output (MRIO) engine behind a straightforward scenario table, enabling rapid stress tests that are easily replicable and can be applied to other transport interventions. The investigation develops and documents a MRIO toolkit for Excel/VBA that is both lightweight and intended for non-specialists. The user interface is kept simple, while the model encodes a short-run Leontief system at regional and sectoral detail. Scenario inputs are recorded on a single sheet that denotes the regions and PSA-240 industry codes that are impacted, as well as assigns low, medium, and high percentage changes. VBA loops directly compute the responses in memory, preventing the writing of intermediate values to cells. The tool subsequently generates tables, charts, and maps that are prepared for immediate use. Clarity, speed, and reproducibility are the primary objectives of this architecture. Additionally, the scenario structure facilitates collaboration by virtue of its self-documenting nature.

The main objective is to develop an economic impact assessment tool that is easy to adapt, audit, and adopt. The paper also demonstrates the tool by applying it to airport deconcentration and quantifying national and regional effects under alternative slot-shift patterns using peso-per-1% and GNSI. Finally, it evaluates trade-offs between national aggregates and local intensity, compares single- and split-recipient reallocations, and links indicators to operational options such as ground-handling surge capacity and contingency slots.

The contribution is both practical and methodological. In terms of methodology, the paper illustrates that it is possible to conduct user-friendly MRIO stress testing on a platform that is already familiar, thereby reducing the cost of entry for agencies and partners. In practice, the case application generates ranked, policy-relevant signals that identify where marginal operational changes may produce the greatest economy-wide benefits and the highest local intensity. The indicators facilitate the decision-making process for sequencing: the initial restoration site, the establishment of redundancy, and the phased deconcentration process. The results can be scrutinized and refined iteratively due to the transparency of the workflow. The method is designed to enhance detailed aviation, demand, or capacity models by emphasizing rapid triage. Additionally, it establishes a foundation for future collaborative efforts among institutions. The remainder of the paper presents the framework, methodology, results, discussion, and policy recommendations.

FRAMEWORK

An input–output (IO) model delineates the interconnections among all sectors within an economy by tracing how the output of each industry serves as an input to others, thereby forming a network of both direct and indirect production linkages. Table 1 shows a typical IO table, where each row indicates the destinations of a sector's output, while each column illustrates the composition of inputs that a sector sources from the broader economy. These intermediate transactions, together with final demand components such as household consumption, exports, and government expenditures, establish the total output required from each sector.

Table 1: Input-Output Table

	Sector				Final Demand	Total Outputs
Sector	x_{11}	x_{12}	…	x_{1n}	f_1	x_1
	x_{21}	x_{22}	…	x_{2n}	f_2	x_2
	⋮	⋮		⋮	⋮	⋮
	x_{n1}	x_{n2}	…	x_{nn}	f_n	x_n
Primary Inputs	w_1	w_2	…	w_n		w
Total Inputs	x_1	x_2	…	x_n	f	

By transforming the IO table into input coefficients, representing the quantity each sector requires from all other sectors to produce a single unit of output, the model constructs a technical matrix that encapsulates these established production relationships. Utilizing the Leontief inverse, the model subsequently determines how a perturbation in final demand, such as a decrease or increase in activity within a specific sector, propagates through all industries and regions to generate a comprehensive system-wide output response. In this manner, an IO model offers a transparent and manageable approach to estimate how even minor, localized alterations propagate throughout the wider economy through interconnected supply chains and service networks.

This study uses a short-run Leontief IO system extended to a multi-regional setting serves as the analytical foundation for this study. The technical coefficient matrix A and its Leontief inverse L are the representations of production technology. Scenario shocks are introduced as modifications to final demand, Δf, in specific region-industry cells, resulting in output responses, Δx. The model is deliberately static and demand-pull, with fixed, substitution and price feedbacks that are not considered, and results that are interpreted as sensitivities rather than forecasts. Transparency and speed are prioritized by this decision, which allows policy users to observe the cascading effects of a small, well-defined change in one transport subsector on the interindustry network. The framework, shown in Figure 1, can accommodate numerous transport policies, as only the shock's identity, location, and magnitude vary.

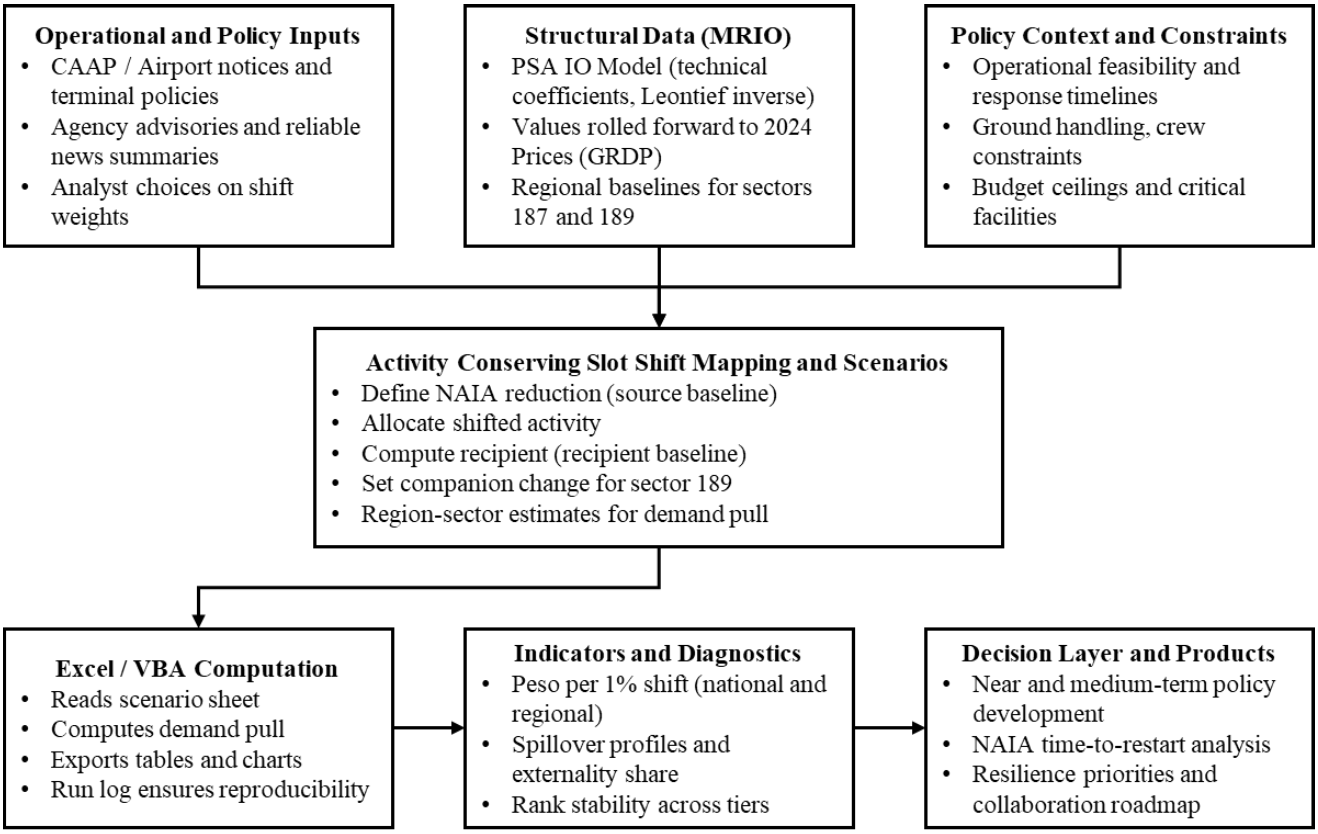


Figure 1: Study Framework

The regional IO structure is based on the PSA 240-industry classification, with 17 regions, resulting in a consistent accounting foundation for cross-regional comparisons. The VBA routines that loop through regions and sectors in memory, compute responses, and write back only the final tables and charts are paired with an Excel front-end. This ensures that the experience is reproducible and prevents the slowdown or instability of large workbooks caused by cell-by-cell matrix math. This separation clarifies roles: the workbook is responsible for documentation and presentation, while the macros are responsible for computation.

Airport deconcentration is characterized in the case application as a series of hypothetical shocks that reduce air transport activity at NAIA and increase it at one or more secondary hubs. A conservative companion adjustment is made to 'Support activities for transportation' to reflect the movement of terminals and ground handling. To enable the model to compare concentrated versus distributed reallocations without relying on operational datasets, the design considers three scenarios: (1) a single recipient, (2) a split between two recipients, and (3) a split among three.

A straightforward "elastic uptake" variant further assumes that recipient airports may only absorb a portion of the shifted activity, thereby capturing practical limits in slots, crews, or facilities. This approach ensures that the mapping from a policy idea to a model input is explicit, transparent, and easy to audit. The user specifies the relative magnitude and location of activity moves, and the tool reveals the economy-wide implications. The framework emphasizes replicability and clarity, enabling rapid sensitivity scans that identify the areas in which further analysis or investment would be most beneficial.

The interpretation of results is governed by two decision indicators. First is the peso-per-1% change metric (i.e., an absolute sensitivity report), which indicates the output loss or gain per percentage point of the applied shock at both the regional and national levels. This determines the maximum amount of pesos that a marginal change can move throughout the entire economy. Second, GNSI scales the regional metric by the region's GRDP to express local intensity as a share of GRDP per 1% shift. It reflects the local scale at which the same marginal change is most significant. The signal of interest is the rank stability of regions and scenarios across tiers, not a single point estimate, as tier doubling approximately doubles effects due to the linear nature of the model. An externality share is one of the optional diagnostics that emphasizes the extent to which the impact is experienced outside of the origin region.

Lastly, the framework establishes a connection between indicators and replicability, as well as policy options. Contingency slots, rapid ground-handling surge, or redundancy in power/IT are the areas where the largest aggregate benefit will be purchased, as indicated by the high national pesos-per-1% values. The recipient regions that are highlighted by high GNSI are those in which small reallocations result in significant local gains, which thereby justifies the implementation of targeted capacity or procedures. External partners can replicate the workflow, modify tiers, or port it to other transport interventions, such as port gate hours, truck-window rules, or cold-chain staging, due to the fact that the entire process is expressed as a documented scenario table and an auditable macro run. In this manner, the framework functions as both a practical stress-testing tool and a platform for policy development collaboration.

MATERIALS AND METHODS

Modeling approach and study design

This study employs a short-run, demand-pull multi-regional input–output (MRIO) model to translate hypothetical changes in airport activity into economy-wide output responses. Production technology is denoted by the technical coefficient matrix, ***A***, and the Leontief inverse, ***L***. Scenario shocks enter as changes in final demand, ***Δf***, and producing output response, ***Δx***, for specific region–industry cells. The horizon is explicitly short-term, as coefficients are fixed, substitution and price feedbacks are not considered, and results are interpreted as sensitivities rather than forecasts. To maintain the validity of ratios and cross-regional comparisons, all monetary values are expressed in constant prices that are consistent with the IO base year. The region × PSA-240 industry cell serves as the unit of analysis, enabling the direct mapping of policy ideas to model inputs.

User-friendly implementation and MRIO foundation

The accounting base is the PSA 240-industry classification, which has been regionalized into 17 regions, resulting in a consistent block structure that is suitable for cross-regional analysis. The model is implemented in Microsoft Excel with VBA to guarantee that the workflow is compatible with standard office computers. A single scenario sheet is used to collect inputs, while VBA loops assemble Δf, compute Δx in memory, and write back only the final tables and figures. The low RAM usage and responsiveness of the system are achieved by not writing intermediate arrays to cells. This allows the same workbook to be repurposed for other transport policies with minimal retraining.

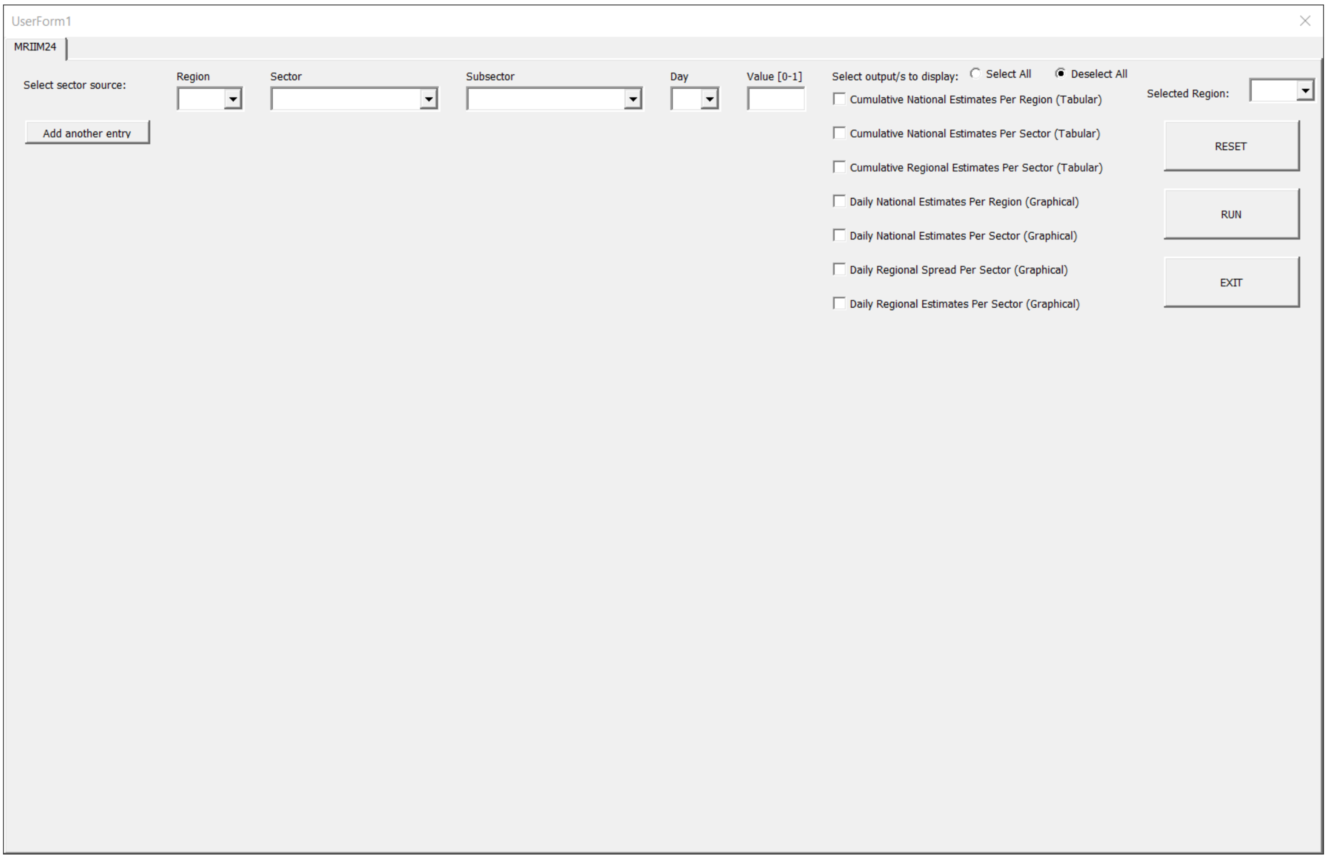


Figure 2: Tool Userform Interface

Slot shifting scenario design

Airport deconcentration is implemented as paired shocks to ‘Air transport’ (PSA-240: 187) with a conservative companion adjustment to ‘Support activities for transportation’ (PSA-240: 189). Tiers are hypothetical shares of flight activity or slots that are reallocated from NAIA (NCR) (i.e., amounting to 5%, 10%, and 15%) to one or more recipient hubs, namely the CRK (Region III), CEB (Region VII), and DVO (Region XI). However, the recipient percentages are not set equal to the NAIA percentage cut; instead, the NAIA reduction is expressed as a share of NAIA's own 187 baseline to yield a shifted activity amount. This amount is then allocated across recipients using explicit weights that sum to one (single-, dual-, or tri-split patterns). The recipient-specific percent change is determined by normalizing to the recipient's baseline and conserving activity. For each recipient region *r* with baseline value B_r in sector 187 and weight w_r (i.e., 1 for single-, ½ for dual-, and 1/3 for tri-split), where B_s is NAIA's baseline from which a source cut will be taken, slot shift t_r will be computed as,

$$t_r = \frac{w_r(t_s B_s)}{B_r} \tag{1}$$

This guarantees that the total shift is conserved across regions, and the percentage uptakes for smaller bases are smaller and those for larger bases are larger when identical numbers of shifted flights or activity units are used. The companion sector 189 in each affected region is scaled as a fraction (e.g., α=1/2) of the actual computed t_r (and $-t_s$ from NAIA) to reflect the movement of ground handling and terminal services in tandem, rather than in a one-to-one ratio.

Table 2 summarizes the Sector GRDPs for the sectors 187 and 189, which were estimated from the PSA 240-industry IO accounts (2018 base) and rolled forward to 2024 using growth rates. To maintain comparability, we updated the 2018 regional baselines using PSA GRDP growth for Transport and Storage (and related sectoral proxies as necessary). The figures were maintained in constant-price terms aligned with the IO base. These baselines are solely intended to scale the slot-shift scenarios, that is, to translate the NAIA reduction into recipient-specific percentage changes under the activity-conserving method outlined in the methodology.

Table 2: Sector GRDPs in Billion P

Sector Number	Sector Name	Region			
		NCR	Region III	Region VII	Region XI
187	Air transport	66.047	38.208	26.453	21.628
189	Support activities for transportation	41.485	23.999	16.616	13.585

Table 3 reports the region-specific percentage changes used in the model for ‘Air transport’ (PSA-240: 187) and the conservative companion for ‘Support activities for transportation’ (PSA-240: 189) under three tiers (Tier 1 = 5%, Tier 2 = 10%, Tier 3 = 15%). Each entry is computed with the activity-conserving scaling previously introduced. The table therefore shows, for every scenario family—single-recipient, dual split (NAIA→CRK & CEB), and tri split (NAIA→CRK, CEB, DVO)—the resulting recipient-specific t_r values alongside the NAIA cut. For each affected region in a scenario, 189 is set to a cautious fraction (1/2) of the actually computed 187 change in that region (and similarly for the NAIA cut), reflecting ground-handling and terminal co-movement without assuming a one-for-one shift. The table thus provides **ready-to-run inputs** for the model: NAIA reductions by tier, recipient-specific increases implied by baseline differences and allocation weights, and the matched 189 adjustments.

Table 3: Slot Shifting Scenario Specifications

Slot Shift	Scenario	Region	Region III			Region VII			Region XI		
		Sector\Tier	1	2	3	1	2	3	1	2	3
Single	A	187	8.64	17.29	25.93						
		189	4.32	8.64	12.96						
	B	187				12.48	24.97	37.45			
		189				6.24	12.48	18.73			
	C	187							15.27	30.54	45.81
		189							7.63	15.27	22.90
Dual	D	187	4.32	8.65	12.97	6.24	12.49	18.73			
		189	2.16	4.32	6.48	3.12	6.24	9.37			
	E	187	4.32	8.65	12.97				7.64	15.27	22.91
		189	2.16	4.32	6.48				3.82	7.64	11.45
	F	187				6.24	12.49	18.73	7.64	15.27	22.91
		189				3.12	6.24	9.37	3.82	7.64	11.45
Tri	G	187	2.88	5.76	8.64	4.16	8.32	12.48	5.09	10.18	15.27
		189	1.44	2.88	4.32	2.08	4.16	6.24	2.55	5.09	7.64

Outputs and computation

The tool first constructs the final-demand change vector, $\Delta \boldsymbol{f}$, from the scenario sheet for each scenario. It then multiplies this vector by the Leontief inverse, $\boldsymbol{L}$, and aggregates the results to regional and national totals. Absolute sensitivity metrics are computed afterwards, expressed in Peso-per-1% shift (PPOPS), namely the Regional PPOPS computed as,

$$\text{Regional PPOPS} = \frac{|\Delta x_r|}{s} \tag{2}$$

where $|\Delta Xr|$ is the total output change in region r and s is the applied shift percent (e.g., 0.05, 0.10, 0.15), and the National PPOPs, defined as,

$$\text{National PPOPS} = \sum_k \frac{|\Delta x_k|}{s} \tag{3}$$

summing across all regions k to capture spillovers. Secondly, the GNSI, computed as,

$$GNSI = \frac{Regional\ PPOPS}{GRDP} \tag{4}$$

scales local sensitivity by economic size by computing the percentage of GRDP that is lost due to a 1% shift. The results are then presented in the form of tables (national/regional Pesos, GNSI, ranks) and maps for spatial interpretation.

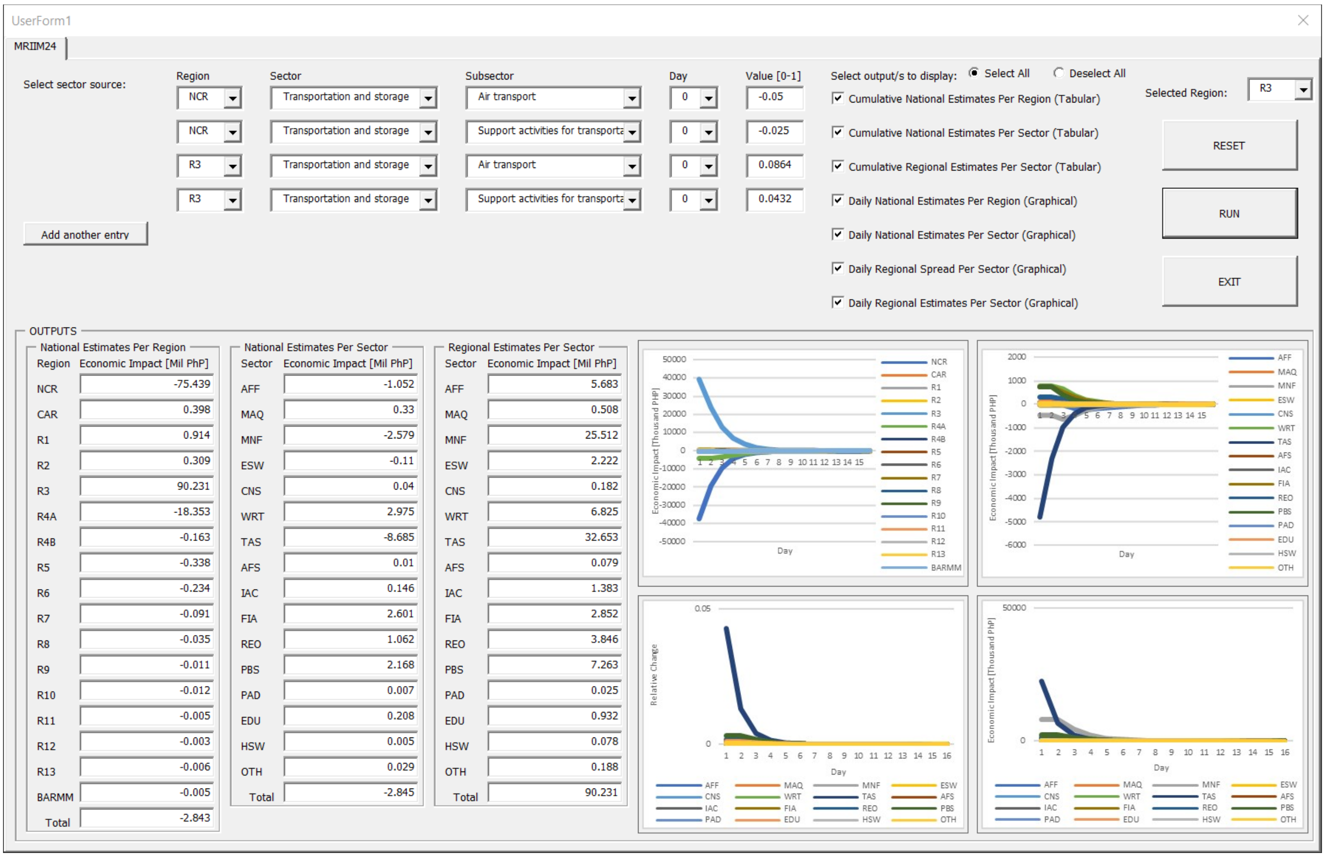
To contextualize these values within operational parameters, the tiers (5–10–15%) can be regarded as plausible ranges for annual slot adjustments during maintenance intervals, runway rehabilitation periods, or contingency reallocation scenarios. NAIA may encounter two to four such disruption periods annually, each of which may result in temporary diversions. Therefore, a 1% adjustment may be interpreted as comparable to a marginal portion of standard annual reallocations among hubs. The peso-per-1% results thus serve not only as sensitivities but also as practical measures of the anticipated economic exposure associated with each operational adjustment event.

Robustness and limits

Robustness is evaluated using the elastic-uptake variant, recipient composition (single, dual, tri splits), and tier sensitivity (5/10/15%). The overestimation of ground-handling effects in recipients is prevented by conservative scaling for 189. Interpretation is constrained by core assumptions of an IO model, which include a short-term horizon, fixed technical coefficients, and the absence of price adjustments or substitutions. The heterogeneity within each IO sector is a recognized limitation. Additionally, with the annual IO baselines, it does not explicitly account for seasonal variations or cost asymmetries among sub-activities. These factors give rise to aggregation bias, which is addressed by considering the results solely as short-term sensitivities. These assumptions are restated in conjunction with the results. Future work may enhance this by integrating seasonal disaggregation or sub-sectoral coefficients as they become accessible. Quality checks encompass the alignment of GRDP with the IO base year, reconciliation of national sums with the regional breakdown, and sign consistency in directly shocked sectors.

RESULTS AND DISCUSSION

The outputs indicate a negative trajectory for NCR and a positive trajectory for Region III (Figure 3). This is consistent with the fact that demand and transactions are shifting with the slots: NCR's losses are primarily concentrated in professional/business services, accommodation and food, retail, and courier/postal, which are closely tied to airport throughput. In contrast, Region III experiences gains in the same aviation-linked services and in logistics support around Clark's catchment. Industrial estates and freeport activities in Region III result in spillovers in manufacturing and wholesale/retail, as time-sensitive cargo and business travel re-anchor around the recipient hub.



Select sector source:

Region	Sector	Subsector	Day	Value [0-1]
NCR	Transportation and storage	Air transport	0	-0.05
NCR	Transportation and storage	Support activities for transporta	0	-0.025
R3	Transportation and storage	Air transport	0	0.0864
R3	Transportation and storage	Support activities for transporta	0	0.0432

Select output/s to display: ● Select All ○ Deselect All

☑ Cumulative National Estimates Per Region (Tabular)
☑ Cumulative National Estimates Per Sector (Tabular)
☑ Cumulative Regional Estimates Per Sector (Tabular)
☑ Daily National Estimates Per Region (Graphical)
☑ Daily National Estimates Per Sector (Graphical)
☑ Daily Regional Spread Per Sector (Graphical)
☑ Daily Regional Estimates Per Sector (Graphical)

Selected Region: R3

OUTPUTS

National Estimates Per Region

Region	Economic Impact [Mil PhP]
NCR	-75.439
CAR	0.398
R1	0.914
R2	0.309
R3	90.231
R4A	-18.353
R4B	-0.163
R5	-0.338
R6	-0.234
R7	-0.091
R8	-0.035
R9	-0.011
R10	-0.012
R11	-0.005
R12	-0.003
R13	-0.006
BARMM	-0.005
Total	-2.843

National Estimates Per Sector

Sector	Economic Impact [Mil PhP]
AFF	-1.052
MAQ	0.33
MNF	-2.579
ESW	-0.11
CNS	0.04
WRT	2.975
TAS	-8.685
AFS	0.01
IAC	0.146
FIA	2.601
REO	1.062
PBS	2.168
PAD	0.007
EDU	0.208
HSW	0.005
OTH	0.029
Total	-2.845

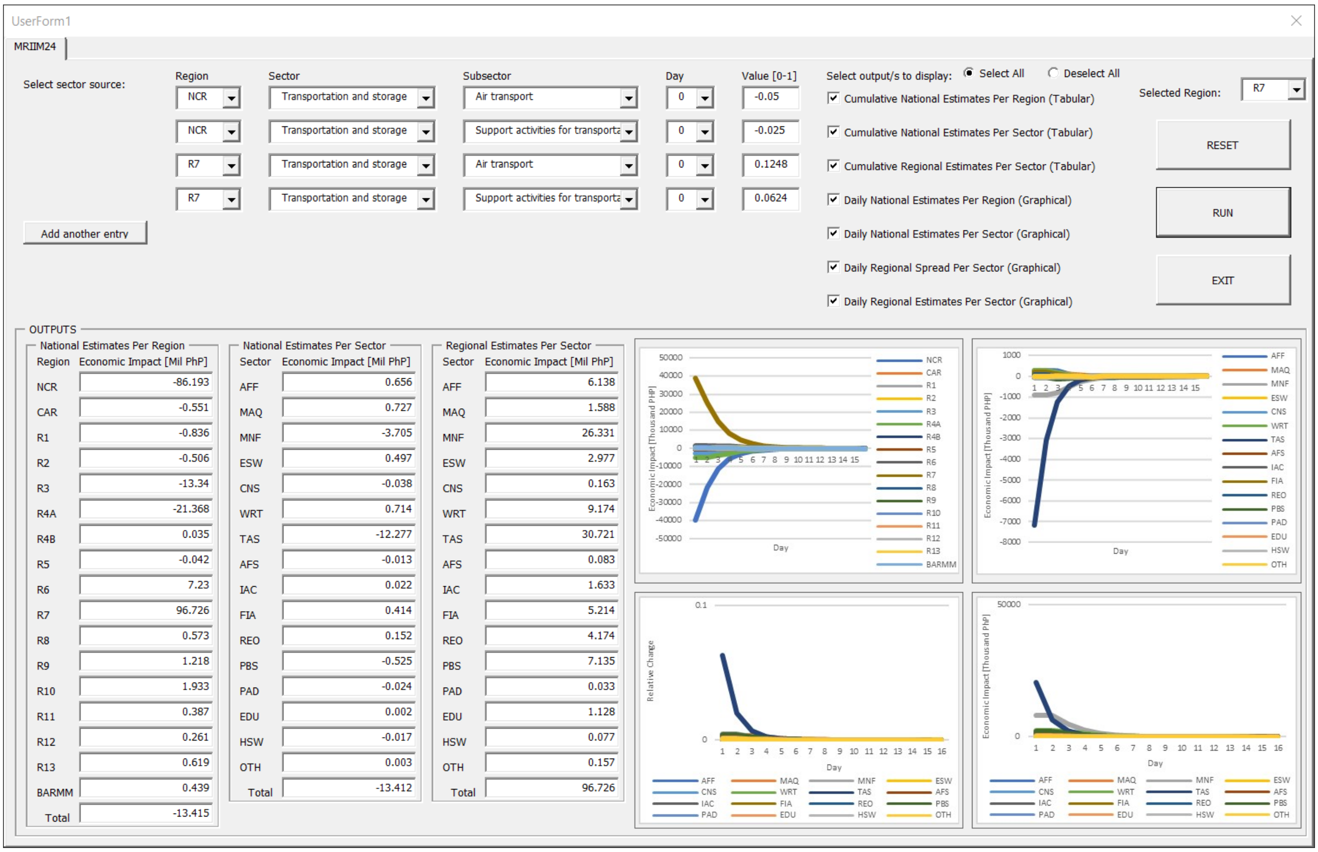
Regional Estimates Per Sector

Sector	Economic Impact [Mil PhP]
AFF	5.683
MAQ	0.508
MNF	25.512
ESW	2.222
CNS	0.182
WRT	6.825
TAS	32.653
AFS	0.079
IAC	1.383
FIA	2.852
REO	3.846
PBS	7.263
PAD	0.025
EDU	0.932
HSW	0.078
OTH	0.188
Total	90.231

Figure 3: NCR-CRK Shift Modeling Results

The model captures approximates frictions (e.g., incomplete uptake, ground-handling limits) via conservative scaling of 189, resulting in a net effect that is smaller than the regional swings at the national level. Secondary effects in adjacent regions (e.g., IV-A and NCR suppliers) appear as a result of their interregional connections to the services demand of Region III. The pattern, when interpreted for policy, indicates that the contingency slotting and ground-handling surge at CRK can significantly mitigate NCR losses in aviation-dependent sectors. Conversely, NCR's contraction underscores the potential for time-to-restart measures and business-continuity arrangements to mitigate short-term impacts.

On the other hand, the results for CEB shift (Figure 4) shows a broad but less compensatory response than CRK. Passenger and cargo activity partially re-anchors around the Visayas hub, resulting in gains in retail, manufacturing, business services, accommodation/food, and the transport–storage complex. Nevertheless, the national balance remains slightly negative due to the difficulty of temporarily replacing high-value corporate and head-office services that are concentrated around NAIA. Through their ongoing dependence on Metro Manila's logistics networks, certain losses also spread to Regions IV-A and III. The pattern implies that local benefits would be strengthened by operational improvements at CEB, particularly in the areas of ground-handling surge and terminal process efficiency, while leakage during temporary reallocations would be restricted by rapid restart readiness in NCR. Cebu redistributes activity more widely across sectors than the CRK case, but it replaces a smaller share of NCR's service-intensive functions. This reflects weaker short-run substitution in finance and corporate services.



Select sector source:

Region	Sector	Subsector	Day	Value [0-1]
NCR	Transportation and storage	Air transport	0	-0.05
NCR	Transportation and storage	Support activities for transporta	0	-0.025
R7	Transportation and storage	Air transport	0	0.1248
R7	Transportation and storage	Support activities for transporta	0	0.0624

Add another entry

Select output/s to display: ● Select All ○ Deselect All

☑ Cumulative National Estimates Per Region (Tabular)
☑ Cumulative National Estimates Per Sector (Tabular)
☑ Cumulative Regional Estimates Per Sector (Tabular)
☑ Daily National Estimates Per Region (Graphical)
☑ Daily National Estimates Per Sector (Graphical)
☑ Daily Regional Spread Per Sector (Graphical)
☑ Daily Regional Estimates Per Sector (Graphical)

Selected Region: R7

RESET

RUN

EXIT

OUTPUTS

National Estimates Per Region

Region	Economic Impact [Mil PhP]
NCR	-86.193
CAR	-0.551
R1	-0.836
R2	-0.506
R3	-13.34
R4A	-21.368
R4B	0.035
R5	-0.042
R6	7.23
R7	96.726
R8	0.573
R9	1.218
R10	1.933
R11	0.387
R12	0.261
R13	0.619
BARMM	0.439
Total	-13.415

National Estimates Per Sector

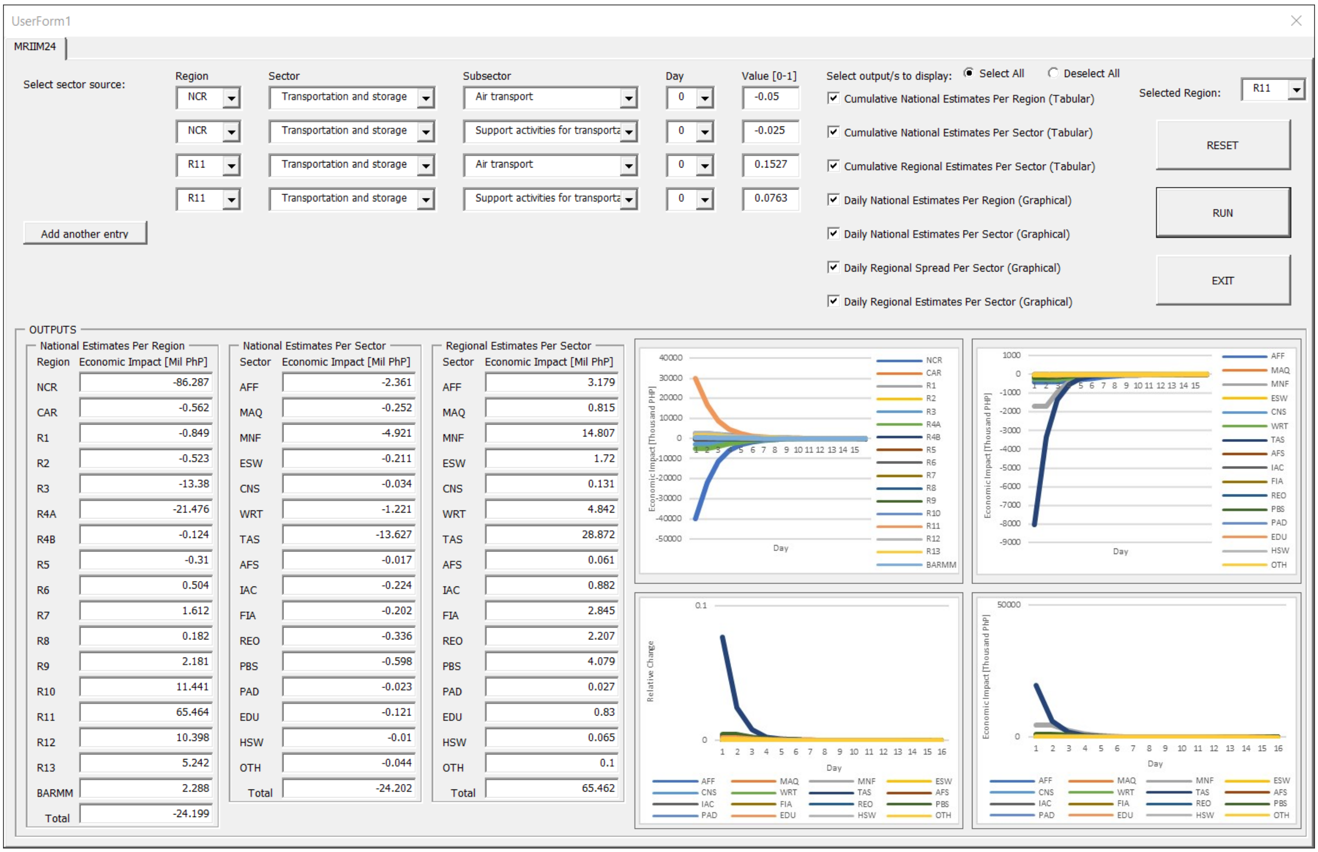
Sector	Economic Impact [Mil PhP]
AFF	0.656
MAQ	0.727
MNF	-3.705
ESW	0.497
CNS	-0.038
WRT	0.714
TAS	-12.277
AFS	-0.013
IAC	0.022
FIA	0.414
REO	0.152
PBS	-0.525
PAD	-0.024
EDU	0.002
HSW	-0.017
OTH	0.003
Total	-13.412

Regional Estimates Per Sector

Sector	Economic Impact [Mil PhP]
AFF	6.138
MAQ	1.588
MNF	26.331
ESW	2.977
CNS	0.163
WRT	9.174
TAS	30.721
AFS	0.083
IAC	1.633
FIA	5.214
REO	4.174
PBS	7.135
PAD	0.033
EDU	1.128
HSW	0.077
OTH	0.157
Total	96.726

Figure 4: NCR-CEB Shift Modeling Results

Still another, the DVO shift (Figure 5) generates substantial local benefits, particularly in the areas of retail, manufacturing, accommodation/food, and business services. Additionally, there are spillover effects that extend to neighboring Mindanao regions, which are connected to agribusiness and regional logistics networks. However, the national outcome remains unfavorable due to the fact that these expansions inadequately replace NAIA-centered high-value services. Consequently, the outcome is indicative of integration disparities rather than uptake size: activity shifts occur, but fewer nationwide linkages are activated. Operationally, the benefits of Mindanao as a whole would be enhanced by improved ground handling, terminal reliability, and crew readiness. Conversely, restart measures in the North Central Region are essential for minimizing losses during diversion periods. The result underscores a sequencing issue: Davao functions less effectively as an immediate replacement hub under the current network structure than it does as a regional growth node.



Select sector source:

Region	Sector	Subsector	Day	Value [0-1]
NCR	Transportation and storage	Air transport	0	-0.05
NCR	Transportation and storage	Support activities for transporta	0	-0.025
R11	Transportation and storage	Air transport	0	0.1527
R11	Transportation and storage	Support activities for transporta	0	0.0763

Select output/s to display: ● Select All ○ Deselect All

☑ Cumulative National Estimates Per Region (Tabular)
☑ Cumulative National Estimates Per Sector (Tabular)
☑ Cumulative Regional Estimates Per Sector (Tabular)
☑ Daily National Estimates Per Region (Graphical)
☑ Daily National Estimates Per Sector (Graphical)
☑ Daily Regional Spread Per Sector (Graphical)
☑ Daily Regional Estimates Per Sector (Graphical)

Selected Region: R11

OUTPUTS

National Estimates Per Region

Region	Economic Impact [Mil PhP]
NCR	-86.287
CAR	-0.562
R1	-0.849
R2	-0.523
R3	-13.38
R4A	-21.476
R4B	-0.124
R5	-0.31
R6	0.504
R7	1.612
R8	0.182
R9	2.181
R10	11.441
R11	65.464
R12	10.398
R13	5.242
BARMM	2.288
Total	-24.199

National Estimates Per Sector

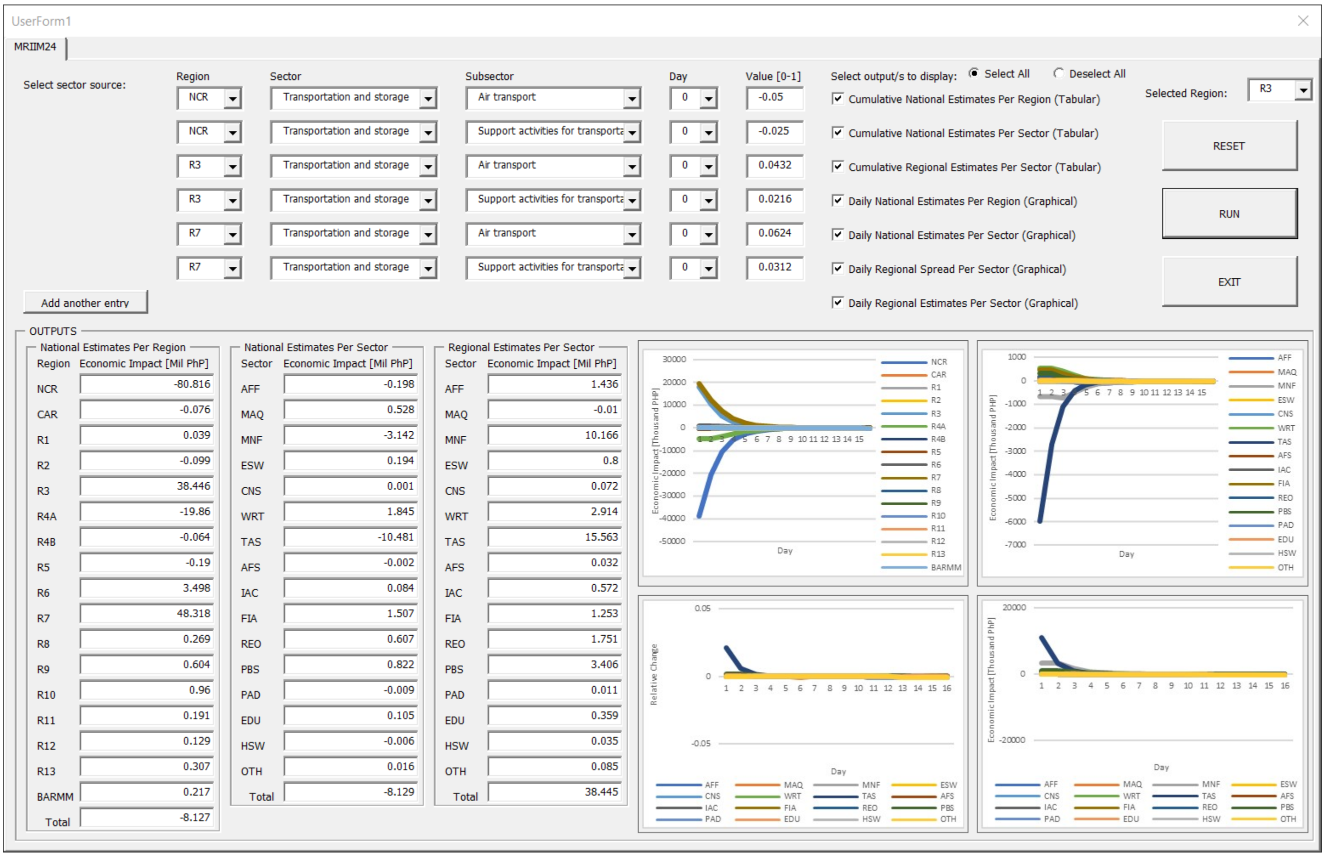
Sector	Economic Impact [Mil PhP]
AFF	-2.361
MAQ	-0.252
MNF	-4.921
ESW	-0.211
CNS	-0.034
WRT	-1.221
TAS	-13.627
AFS	-0.017
IAC	-0.224
FIA	-0.202
REO	-0.336
PBS	-0.598
PAD	-0.023
EDU	-0.121
HSW	-0.01
OTH	-0.044
Total	-24.202

Regional Estimates Per Sector

Sector	Economic Impact [Mil PhP]
AFF	3.179
MAQ	0.815
MNF	14.807
ESW	1.72
CNS	0.131
WRT	4.842
TAS	28.872
AFS	0.061
IAC	0.882
FIA	2.845
REO	2.207
PBS	4.079
PAD	0.027
EDU	0.83
HSW	0.065
OTH	0.1
Total	65.462

Figure 5: NCR-DVO Shift Modeling Results

The dual- and tri-split experiments demonstrate that the location of the reallocated slots is more significant than the number of recipient hubs. The national short-run loss is the smallest among the multi-hub options (≈−P8.13B) when NAIA's reduction is shared by CRK and CEB, as shown in Figure 6. This is significantly closer to the CRK-only benchmark (≈−P2.84B) than any configuration that includes DVO, as summarized in Table 4. In contrast, the national shortfall is exacerbated by any scenario that involves Region XI. The tri-split, CEB+DVO, and CRK+DVO are all worse than the CEB-only case (≈−P13.42B), with negative values of ≈−P23.15B, ≈−P18.77B, and ≈−P13.48B, respectively. This arrangement is in accordance with the MRIO linkages: CRK (Region III) is situated within the Luzon industrial–distribution belt and is closely connected to NCR demand. Consequently, an additional unit of air activity rapidly attracts wholesale/retail, manufacturing, business services, and logistics along existing corridors. CEB (Region VII) also generates substantial gains; however, before it can fully compensate for head-office and professional services losses, it results in more spillovers to NCR and neighboring regions. The system recovers a lesser amount of the lost NCR activity because Davao (Region XI) has a smaller aviation base and weaker immediate ties to the Luzon core. Even large percentage uptakes result in weaker nationwide spillovers.



Select sector source:

Region	Sector	Subsector	Day	Value [0-1]
NCR	Transportation and storage	Air transport	0	-0.05
NCR	Transportation and storage	Support activities for transporta	0	-0.025
R3	Transportation and storage	Air transport	0	0.0432
R3	Transportation and storage	Support activities for transporta	0	0.0216
R7	Transportation and storage	Air transport	0	0.0624
R7	Transportation and storage	Support activities for transporta	0	0.0312

Select output/s to display: ● Select All ○ Deselect All

☑ Cumulative National Estimates Per Region (Tabular)
☑ Cumulative National Estimates Per Sector (Tabular)
☑ Cumulative Regional Estimates Per Sector (Tabular)
☑ Daily National Estimates Per Region (Graphical)
☑ Daily National Estimates Per Sector (Graphical)
☑ Daily Regional Spread Per Sector (Graphical)
☑ Daily Regional Estimates Per Sector (Graphical)

Selected Region: R3

OUTPUTS

National Estimates Per Region

Region	Economic Impact [Mil PhP]
NCR	-80.816
CAR	-0.076
R1	0.039
R2	-0.099
R3	38.446
R4A	-19.86
R4B	-0.064
R5	-0.19
R6	3.498
R7	48.318
R8	0.269
R9	0.604
R10	0.96
R11	0.191
R12	0.129
R13	0.307
BARMM	0.217
Total	-8.127

National Estimates Per Sector

Sector	Economic Impact [Mil PhP]
AFF	-0.198
MAQ	0.528
MNF	-3.142
ESW	0.194
CNS	0.001
WRT	1.845
TAS	-10.481
AFS	-0.002
IAC	0.084
FIA	1.507
REO	0.607
PBS	0.822
PAD	-0.009
EDU	0.105
HSW	-0.006
OTH	0.016
Total	-8.129

Regional Estimates Per Sector

Sector	Economic Impact [Mil PhP]
AFF	1.436
MAQ	-0.01
MNF	10.166
ESW	0.8
CNS	0.072
WRT	2.914
TAS	15.563
AFS	0.032
IAC	0.572
FIA	1.253
REO	1.751
PBS	3.406
PAD	0.011
EDU	0.359
HSW	0.035
OTH	0.085
Total	38.445

Figure 6: Dual-Split Shift to CRK and CEB Modeling Results

These patterns are further reinforced by sector detail. In the CRK-receiving cases, positive impulses cascade into manufacturing, trade, and business services with short routing distances, while the companion shock in support activities (189) reflects terminal and ground-handling co-movement without saturating capacity. Tourism-adjacent services, retail, and light manufacturing are stimulated by CEB-receiving cases; however, finance, head-office, and professional services, which are less mobile in the short term, continue to experience substantial contractions. In DVO-receiving cases, local gains are observed in retail, accommodation/food, and logistics in the vicinity of Davao. However, national recovery is restricted due to the regionalization of upstream supplier networks and the continued orbit of numerous high-value service linkages around NAIA. The conservative scaling of 189 (half the computed air change) further mitigates ground-side effects in regions where terminal ecosystems are still maturing. This elucidates why the national balance is exacerbated rather than alleviated by the inclusion of Davao.

Table 4: Summary of Modeling Results

Scenario	Tier	Regional Estimates				National Estimates
		NCR	Region III	Region VII	Region XI	
A	5%	-75.44	90.23			-2.84
	10%	-150.88	180.46			-5.68
	15%	-226.32	270.69			-8.52
B	5%	-86.19		96.73		-13.42
	10%	-172.38		193.46		-26.84
	15%	-258.57		290.19		-40.26
C	5%	-86.29			65.46	-24.20
	10%	-172.58			130.92	-48.40
	15%	-258.87			196.38	-72.60
D	5%	-80.82	38.45	48.32		-8.13
	10%	-161.64	76.90	96.64		-16.26
	15%	-242.46	115.35	144.96		-24.39
E	5%	-80.86	38.43		32.76	-13.48
	10%	-161.72	76.86		65.52	-26.96
	15%	-242.58	115.29		98.28	-40.44
F	5%	-86.24		49.17	32.95	-18.77
	10%	-172.48		98.34	65.90	-37.54

	15%	-258.72		147.51	98.85	-56.31
G	5%	-83.51	12.92	32.75	21.96	-23.15
	10%	-167.02	25.84	65.50	43.92	-46.30
	15%	-250.53	38.76	98.25	65.88	-69.45

Magnitudes scale roughly in proportion to the shock across tiers (5, 10, 15), but the ranking is consistent: CRK-only remains the least negative; CRK+CEB is the next-best deconcentration; CEB-only follows; and any inclusion of Davao—even the tri-split—pushes the system toward larger national losses. The policy implication is not that Region XI should be disregarded; rather, it suggests a sequence. The logical second recipient should be CEB once gate processes are synchronized, while CRK should lead a near-term, operational reallocation. Davao may be a medium-term candidate if ground-handling depth, business-services ecosystems, and tighter logistics connectivity to national supply chains are met. Additionally, the size and duration of the national loss during any slot adjustments are reduced by time-to-restart measures in NCR, including contingency slots, crew/equipment readiness, and power/IT redundancy.

The peso-per-1% shift metric is a concise way of expressing the amount of economy-wide output that is affected by every one-percentage-point of activity that is reallocated away from NAIA. This metric allows for the comparison of scenarios despite the fact that the recipient baselines may differ. This should be interpreted as a short-term sensitivity: Larger absolute values indicate larger economy-wide losses or gains. Table 5 summarizes the peso-per-1% shift estimates for the most affected sectors in the regions being studied. Across the various scenarios, the disaggregated peso-per-1% shift estimates demonstrate distinct sectoral and regional patterns that clarify how losses and gains are redistributed when NAIA activity is transferred to secondary hubs. In single-recipient scenarios, NCR consistently exhibits sectoral deficits in AFF, MNF, WRT, TAS, and PBS, whereas the designated recipient region reports positive figures in these same sectors. Scenario A (NAIA → CRK) exemplifies this anticipated pattern, while also indicating that Region VII experiences minor negative shocks across multiple sectors. This implies that Cebu remains closely interconnected with NAIA-dependent services and logistics, despite not being a direct beneficiary. Region XI, in contrast, remains largely unaffected across all sectors, indicating its lesser short-term reliance on NAIA. Notably, certain sectors, particularly WRT and PBS, attain net national gains in Scenario A because the increases in Region III marginally surpass the local declines experienced by NCR. Meanwhile, AFF, MNF, and TAS continue to exhibit a negative trend nationwide, signifying that CRK's improvements are insufficient to offset NAIA's decline in these activities primarily focused on production and transportation.

Table 5: Disaggregated Summary of Peso-per-1% Shift Estimates

Scenario	Sector	NCR	Region III	Region VII	Region XI	National
A	AFF	-0.502	1.137	-0.005	0.000	-0.210
	MNF	-3.817	5.102	-0.008	0.000	-0.516
	WRT	-0.675	1.365	-0.002	0.000	0.595
	TAS	-7.709	6.531	0.000	0.000	-1.737
	PBS	-1.060	1.453	-0.001	0.000	0.434
B	AFF	-0.519	-0.562	1.228	0.017	0.131
	MNF	-3.981	-1.036	5.266	0.033	-0.741
	WRT	-1.263	-0.199	1.835	0.007	0.143
	TAS	-7.742	-0.305	6.144	0.002	-2.455
	PBS	-1.357	-0.090	1.427	0.003	-0.105
C	AFF	-0.527	-0.566	0.025	0.636	-0.472
	MNF	-3.986	-1.039	0.135	2.962	-0.982
	WRT	-1.265	-0.200	0.039	0.969	-0.244
	TAS	-7.742	-0.306	0.007	5.776	-2.723
	PBS	-1.358	-0.090	0.034	0.816	-0.119
D	AFF	-0.510	0.287	0.611	0.009	-0.040
	MNF	-3.899	2.033	2.629	0.016	-0.628
	WRT	-0.969	0.583	0.917	0.003	0.369
	TAS	-7.725	3.113	3.072	0.001	-2.096
	PBS	-1.209	0.681	0.713	0.002	0.164
E	AFF	-0.515	0.285	0.010	0.318	-0.341
	MNF	-3.901	2.032	0.064	1.482	-0.748
	WRT	-0.970	0.583	0.019	0.485	0.176
	TAS	-7.725	3.113	0.003	2.890	-2.229

	PBS	-1.209	0.681	0.016	0.408	0.158
F	AFF	-0.523	-0.564	0.626	0.327	-0.170
	MNF	-3.983	-1.037	2.701	1.498	-0.860
	WRT	-1.264	-0.199	0.937	0.488	-0.050
	TAS	-7.742	-0.305	3.076	2.890	-2.588
	PBS	-1.358	-0.090	0.730	0.410	-0.112
G	AFF	-0.516	0.003	0.416	0.218	-0.183
	MNF	-3.928	1.009	1.798	0.999	-0.746
	WRT	-1.068	0.322	0.624	0.325	0.165
	TAS	-7.731	1.973	2.050	1.927	-2.305
	PBS	-1.258	0.424	0.487	0.273	0.070

Scenario B (NAIA → CEB) exhibits a similarly intuitive pattern of losses in NCR and gains in Region VII; however, it is noteworthy that Region XI demonstrates positive effects across all sectors despite not being a designated recipient. This indicates significant spillover effects from Cebu to Mindanao, particularly within the tourism-related, agricultural, and service industries. Region III, by comparison, encounters moderate sectoral declines, illustrating how Cebu's strengthened hub function in this context redirects certain activities from Central Luzon. At the national level, AFF and WRT record net increases in Scenario B, emphasizing the responsiveness of agriculture-related trade and retail sectors to Cebu's enhanced connectivity. MNF, TAS, and PBS, however, continue to exhibit negative trends nationwide, underscoring the challenge of compensating for NAIA-focused high-value manufacturing, logistics, and corporate services through a reallocation limited to Cebu. Scenario C (NAIA → DVO) shows the largest positive local effects in Region XI. However, it consistently yields negative national outcomes across all five sectors, as the cumulative losses in NCR, Region III, and Region VII surpass Davao's gains, indicating Region XI's relatively limited integration into the country's primary manufacturing and service corridors.

In scenarios involving multiple recipients, these dynamics become increasingly complex. Scenario D (CRK + CEB) yields the most balanced results, with Regions III and VII demonstrating improvements and Region XI exhibiting modest positive or near-zero values. Nationally, WRT and PBS transition to a net positive position, indicating that retail and business services are effectively restructured around a dual Luzon-Visayas hub framework, although AFF, MNF, and TAS continue to be negative due to ongoing losses at NAIA. Scenario E (CRK + DVO) exhibits comparable patterns, whereas Scenario F (CEB + DVO) leads to overall national losses across all sectors, suggesting that the exclusion of CRK diminishes the system's capacity to recover lost NCR activity. The tri-split Scenario G distributes gains among all recipients, enabling WRT and PBS to once again record net positive outcomes at the national level, while key sectors such as AFF, MNF, and TAS continue to exhibit negative performance. Collectively, these findings indicate that certain sectors, particularly retail and business services, are more flexible and capable of generating net national gains under specific recipient configurations, whereas manufacturing and transport/storage continue to exhibit persistent negative outcomes at the national level owing to their strong structural connections to NAIA. This sectoral–regional mapping directly responds to the reviewer's request by pinpointing areas of concentrated losses, regions of accumulated gains, those affected by indirect spillovers, and the conditions under which the national system either partially recovers or deteriorates.

Moreover, cumulative estimates for the peso-per-1% shift are summarized in Table 6. The distribution of values is consistent with the previous rankings: the most favorable response per 1% shift (smallest national loss per point) is provided by CRK-only, followed by CRK+CEB and CEB-only. CEB-only yields a larger national loss per 1% shift, and any configuration that involves Davao results in the largest national loss per point shifted. In terms of concept, Region III's robust connections to the Luzon industrial belt and the demand of the NCR translate a marginal air-activity change into broader manufacturing, trade, business-service, and logistics effects. By contrast, Cebu's gains are more tourism- and retail-oriented and flow back toward the NCR. Davao's weaker immediate connections to the Luzon core restrict nationwide offset. The use of peso-per-1% values for prioritization is further bolstered by the fact that they scale roughly proportionally as tiers increase, and the rank order remains consistent. In terms of policy, the metric identifies the areas where each additional percentage point of shift results in the most national benefit (or the least harm) and the areas where complementary actions—such as ground-handling surge, synchronized procedures, and time-to-restart in NCR—will generate the highest near-term returns.

Table 6: Aggregated Summary of Peso-per-1% Shift Estimates

	Regional Estimates				
Scenario	NCR	Region III	Region VII	Region XI	National Estimates
A	-15.088	18.046			-0.568
B	-17.238		19.346		-2.684
C	-17.258			13.092	-4.840
D	-16.164	7.690	9.664		-1.626
E	-16.172	7.686		6.552	-2.696
F	-17.248		9.834	6.590	-3.754
G	-16.702	2.584	6.550	4.392	-4.630

The GNSI, as summarized in Table 7, reframes each scenario as a local stress test. It determines the magnitude of the effect in relation to the size of the local economy by dividing the peso-per-1% response of a region by its GRDP. Interpret this as intensity rather than scale. In single-recipient cases, smaller economies typically exhibit a higher GNSI due to the fact that the same amount of shifted air activity accounts for a greater proportion of local output. This is why Region XI frequently exhibits the highest local intensity, despite its subpar national performance; its air-linked gains or losses account for a greater proportion of its GRDP. Region III is typically mid-range of GNSI. Its larger GRDP dilutes the ratio, but it benefits from strong linkages to the Luzon industrial belt. Region VII is situated between these two scenarios; its diversified services base increases intensity in comparison to large Luzon regions, but it is less intense than in smaller Mindanao economies. The GNSI per recipient decreases when the shift is distributed among two or three recipients, as each absorbs a smaller proportion of activity, despite the occasional improvement in the national balance.

Table 7: GRDP-Normalized Shift Intensity Estimates

	Regional Estimates				
Scenario	NCR	Region III	Region VII	Region XI	National Estimates
A	-0.22844	0.47231			-0.00165
B	-0.26100		0.73133		-0.00778
C	-0.26130			0.60533	-0.01404
D	-0.24473	0.20127	0.36533		-0.00472
E	-0.24486	0.20116		0.30294	-0.00782
F	-0.26115		0.37175	0.30470	-0.01089
G	-0.25288	0.06763	0.24761	0.20307	-0.01343

The absolute pesos narrative is distinct from the policy implications. Targeted capacity and continuity measures (e.g., ground-handling surge, power/IT redundancy, and rapid crew mobilization) are recommended for regions with high GNSI, as they indicate that even a marginal reallocation is significant locally. Regions with a lower GNSI but a strong absolute peso require system-level safeguards to prevent nationwide loss, such as contingency slots, synchronized procedures across hubs, and time-to-restart at NAIA.. It is crucial to note that GNSI does not independently advocate for a recipient; rather, it enhances the national metric by identifying which region is most exposed per unit shift. The indicators collectively indicate a sequencing: prioritize CRK-led reallocations on national grounds, collaborate with CEB to mitigate risk, and consider Davao as a more durable option once local buffers and interregional linkages are strengthened. This is because Davao's elevated GNSI implies substantial local strain from even minor slot movements.

CONCLUSION AND RECOMMENDATIONS

This study introduces a user-friendly Excel/VBA MRIO toolkit that converts narrative policy ideas into auditable, region-specific shocks and decision indicators in a matter of minutes. The workbook design, which involves a scenario sheet at the front and VBA computation in memory, was both practical for non-specialists and maintained transparency from input to output. Using an activity-conserving scaling that converts an NAIA cut into recipient-specific percentages based on each region's air-transport baseline, the tool was applied to a what-if airport deconcentration case in relation to the second and third objectives. The results were summarized with peso-per-1% shift and GNSI. The results indicate that the rankings across tiers are predictable and consistent: CRK-only results in the least negative national outcome; CRK+CEB is the second-best multi-hub option; CEB-only is weaker; and any configuration that involves Davao results in the largest national loss. Consequently, the tool satisfies the fourth objective (compare patterns and trade-offs) by providing consistent, policy-relevant signals with minimal data.

The evidence suggests that location of reallocated slots has a larger effect than the size of the shift when interpreting the peso-per-1% results. A marginal reallocation to Region III (CRK) results in more significant nationwide offsets due to its dense linkages to the Luzon industrial–distribution belt and proximity to NCR demand. This quickly attracts manufacturing, trade, business services, and logistics. Even though Region VII (CEB) delivers tangible regional benefits, particularly in tourism-adjacent services and retail, it is unable to adequately offset NCR's short-term losses in professional services and head-office operations, as CRK does. Under the current linkages, Region XI (DVO) exhibits substantial local gains but weak national offset. Even large percentage uptakes result in limited spillovers to the Luzon core. The magnitudes scale proportionally and the ranking remains stable across tiers (5–10–15%), thereby confirming the reliability of these signals for prioritization.

In addition to the national picture, the GNSI results emphasize the intensity of the local level. This commonly occurs in Region XI, where the same marginal shift represents a greater proportion of GRDP and, as a result, a more significant local "felt" effect, despite the fact that national benefits are modest. Smaller or less diversified economies can experience high GNSI. Region III typically displays mid-range GNSI, as its larger economy dilutes the ratio despite its superior performance in national offsets. Region VII is situated between these two cases. The GNSI per recipient decreases when the shift is distributed among two or three recipients, which is indicative of a lower percentage of local uptakes, despite occasional improvements in national balance. The final objective of connecting indicators to concrete policy choices is achieved through the dual-lens reading of peso-per-1% (national scale) and GNSI (local intensity).

In the near term, the results suggest for any operational reallocation to be CRK-led, with CEB as the logical second recipient. This pairing minimizes national losses while avoiding excessive local strain, as gate processes, ground handling (189), crew readiness, and power/IT redundancy are synchronized. Davao should not be a first-round recipient under current conditions. In order to position Region XI as a medium-term candidate, the following preconditions must be met: stronger business-services ecosystems, deeper terminal/ground capacity, and tighter logistics connections to national supply chains. Time-to-restart measures in NCR—including contingency slots, rapid crew/equipment mobilization, and critical systems redundancy—will reduce national losses during adjustments, irrespective of the recipient mix. Next steps should be taken to address the limitations (short-run fixed coefficients, hypothetical tiers, rolled-forward baselines): validate against observed operational changes, test uptake caps and capacity constraints, explore dynamic recovery and inventory effects, and extend the same Excel workflow to other policies (port gate hours, truck windows, cold-chain). These steps will enhance external validity while maintaining the framework's speed, transparency, and replicability for collaborative policy development.

ACKNOWLEDGMENTS

This work was supported by National University through its internal research funding program. The views expressed here are those of the author and do not necessarily reflect the position or policy of the University. Any remaining errors are the responsibility of the author.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

CONTRIBUTIONS OF INDIVIDUAL AUTHORS

K.I.D.R.: Conceptualization; Methodology; Tool Development; Validation; Formal analysis; Investigation; Resources; Data curation; Writing – original draft; Writing – review & editing; Visualization; Project administration; Funding acquisition

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