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A new sub-national multi-region input–output database for Indonesia

Futu Faturay[a,b], Manfred Lenzen[b] and Kunta Nugraha[a]

[a]Ministry of Finance of the Republic of Indonesia, Jakarta, Indonesia; [b]ISA, School of Physics A28, The University of Sydney, Sydney, Australia

ABSTRACT
As a large archipelago with significant geographical variation and economic diversity, Indonesia requires detailed regional information when subjected to economic modelling. While such information is available, it however has not been integrated and harmonised into a comprehensive input–output database, thus preventing economic, social, and environmental modelling for investigating sub-national regional policy questions. We present the new *IndoLab*, a collaborative research platform for Indonesia, enabling input–output modelling of economic, social, and environmental issues in a cloud-computing environment. Within the IndoLab researchers are for the first time able to generate a time series of regionally and sectorally detailed and comprehensive, sub-national multi-region input–output (MRIO) tables for Indonesia. By integrating a multitude of economic, social, and environmental data into a single standardised processing pipeline and harmonised data repository, the IndoLab is able to generate MRIO tables capturing up to 1148 sectors, and 495 cities and regencies. Researchers can freely choose from this detail to construct tables with customised classifications that suit their own research questions. First results from the IndoLab clearly demonstrate the unique characteristics of regions in terms of their sectors' employment intensity. Thus, the IndoLab has great potential for investigating policy questions that cannot be comprehensively addressed using a single national database.

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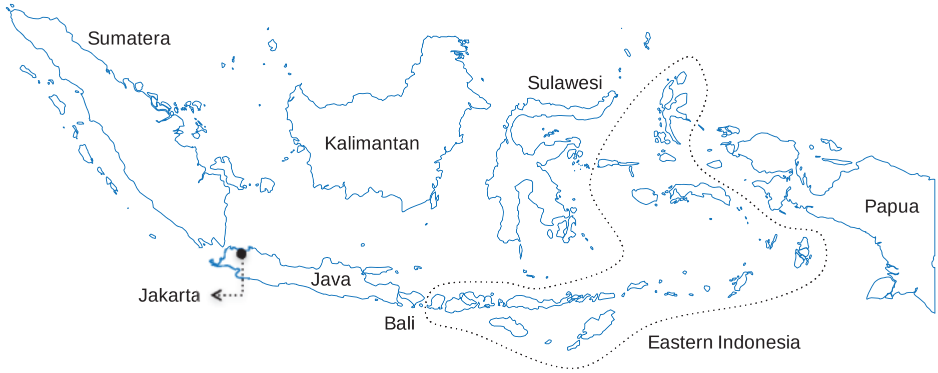
Multi-region input–output tables; Indonesia; virtual laboratories; regionalisation

1. Introduction

Indonesia is an archipelago comprising five main islands (Figure 1) and more than 17,000 small islands (BPS, 2014). In 2014 more than 250 million people lived in 34 provinces, with half of the population on Java Island alone. As a result, almost 60% of economic activity is concentrated in Java (BPS, 2015c), with manufacturing and services as the main sectors, leaving the other parts of Indonesia as the suppliers of agricultural and energy commodities. More generally, Indonesia is a country with comparatively high geographical variation in terms of climate, topography, population density, urban, and transport infrastructure, and therefore features highly diverse production regimes.

CONTACT Futu Faturay futu.faturay@sydney.edu.au

Figure 1. Map of Indonesia.



Given Indonesia's geographical size and economic diversity, it is important that economic, social, and environmental assessments make use of regionally detailed and comprehensive information. However, when examining a particular type of assessment – using input–output methods – studies are usually conducted without any regional specificity, based solely on a national input–output database.[1] Only a small number of studies employ region-specific data, such as analyses of renewable energy and waste treatment options in Kupang City (Amheka et al., 2014), or tollroad investment in Bandung District (Anas et al., 2015). A limited number of attempts have been made at generating a sub-national multi-region input–output (MRIO) system for Indonesia. Hulu and Hewings (1993) created an inter-regional model consisting of 11 sectors and connecting 5 main regions of Indonesia: Sumatera, Java and Bali, Kalimantan, Sulawesi, and Eastern Indonesia. This model was subsequently used for structural analyses (Sonis et al., 1997a; 1997b; Achjar et al., 2006). Resosudarmo et al. (2009a) extended a similar model to 35 sectors, and embedded the resulting information into a Computable General Equilibrium model (Resosudarmo et al., 2009b).

Although this prior MRIO work captured sub-national regions, it did so at a relatively crude level of regional and sectoral detail, with corresponding limitations for economic modelling. In addition, and this is a particular focus of our work, these databases were one-off exercises that did not allow users to customise and update the data to match specific research questions and analytical purposes. At the time of writing, therefore, no detailed, comprehensive and easily accessible sub-national—MRIO database for Indonesia had been available, thus preventing economic and environmental modelling of national and sub-national issues, such as the impact of inter-regional trade, return on investment of social spending among regions, and individual income disparity and taxability.

It is this gap in terms of research capability, and hence knowledge, that our study is aimed at filling. To this end, we follow the concept of the Australian Industrial Ecology Virtual Laboratory (IELab, Lenzen et al., 2014) in introducing the *IndoLab*, a collaborative research platform for Indonesia, enabling input–output modelling of economic, social, and

[1] Lange et al. (1993), Resosudarmo and Thorbecke (1996), Lange (1998), Hamilton (1997), Zuhdi et al. (2014), and Rohman and Bohlin (2014).

environmental activities in a cloud-computing environment. The IndoLab is able to generate a time series of the most comprehensive sub-national MRIO tables[2] for Indonesia. As with the Australian IELab, regional and sectoral detail is flexible and can be chosen by the user, and the IndoLab permits databases with unprecedented detail: up to 1148 economic sectors and 495 regions (down to the city and regency level).

In the following, we will first give a brief review of the Virtual Laboratory concept and technology for sub-national MRIO applications. We then describe our method and data sources for constructing sub-national MRIO tables for Indonesia. We present actual results for the year 2012, including regional employment multipliers derived from our database. We finish by discussing the utility of the new research capability for contemporary policy questions in Indonesia.

2. Methods and data

2.1. MRIO analysis

An input–output table is a matrix that represents the inter-dependency among industries within an economy, and depicts the flows of money and output from suppliers to users. In the beginning of its development era in the 1930s, an input–output table only consisted of a single economic entity. However, during its further development, an input–output became able to capture multiple regions in a single matrix (Leontief, 1953; Leontief and Strout, 1963). Tukker and Dietzenbacher (2013) provide overviews and introductions to the current state of knowledge related to global MRIO frameworks, including EXIOBASE (Tukker, 2013; Tukker et al., 2013), WIOD (Dietzenbacher et al., 2013a; 2013b), Eora (Lenzen et al., 2012a; 2013), OECD (Yamano, 2012; OECD, 2015), and IDE-JETRO (Inomata and Meng, 2013; Meng et al., 2013), but also sub-national MRIO databases, for example for Indonesia (Hulu and Hewings, 1993; Resosudarmo et al., 2009b), Spain (Cazcarro et al., 2013a), Australia (Gallego and Lenzen, 2009), Germany (Többen and Kronenberg, 2011), China (Feng et al., 2012), or the UK (Yu et al., 2010). More recently, international/sub-national nested MRIO databases have been completed, for example for China (Wang et al., 2015) and Canada (Bachmann et al., 2015). MRIO databases have supported research that has impacted policy at high-levels, such as on the UK's carbon footprint (Barrett et al., 2013) and global material resource efficiency and decoupling (Wiedmann et al., 2013).

2.2. Virtual laboratory technology

We build on prior sub-national MRIO work, and apply the construction principles developed in the Australian Industrial Ecology Laboratory (IELab, Lenzen et al., 2014) to creating a new MRIO database (in supply-use format) for Indonesia. The IELab integrates a multitude of economic, social, and environmental data into a single, standardised system, generating time series of MRIO databases at high regional and sectoral

[2] As with the Australian IELab, the IndoLab's MRIO database is actually in Supply-Use Table (SUT) form. For the sake of brevity, we will refer to the multi-region supply-use tables (MR-SUT) simply as 'MRIOs', and treat the entire supply-use block $\begin{bmatrix} 0 & \mathbf{V} \\ \mathbf{U} & 0 \end{bmatrix}$ as a compound transaction matrix $\mathbf{T}$ that can be turned into a coefficients matrix and inverted (see Lenzen and Rueda-Cantuche 2012).

detail. The use of a cloud-computing environment allows multiple users to create customised MRIO tables fit for their particular research aims. This novel approach to MRIO database-making offers many advantages for users: saving the cost of handling data, reducing the time of processing data, and high specificity to the user's specific research question.

As the Australian predecessor, the IndoLab functions in a cloud-computing environment. It contains a web-based user access portal, repositories, and processing functionality for standardising raw data into data feeds that can be understood by a reconciliation engine belonging to either the RAS or quadratic programming families (Geschke et al., 2014). There exist data feeds for assembling the initial estimate, the point of departure of the underdetermined constrained-optimisation task. Data feeds for constraints form the backbone information for 'pinning down' as many areas of the MRIO table as possible. Finally, a particularly useful output of the reconciliation process is a matrix of standard deviations accompanying the MRIO table (Lenzen et al., 2010; 2012b).

2.3. Regionalisation

To construct MRIO tables for Indonesia, we use a technique known as regionalisation (Oosterhaven et al., 1986). This technique is performed when a (set of) regional input–output (or supply-use) table(s) is derived from a national input–output (or supply-use) table (Sargento et al., 2012), to serve as the initial estimate for the constrained-optimisation reconciliation step. To this end the national input–output table needs to be proportionally split using a proxy quantity representing the size of regional economies. In the IndoLab, labour survey data are chosen as the proxy quantity since it is available for all 495 Indonesian cities and regencies, and for 1148 sectors.[3] The actual split of the national I–O table is accomplished through so-called non-survey methods (Bonfiglio and Chelli, 2008). In the IndoLab, users currently have the flexibility to select their preferred regionalisation method from a choice of 11 different non-survey methods, more specifically location quotient and cross-hauling approaches.

In our work we chose a variant of Kronenberg's cross-hauling method developed by Vogt (2011), because this method performed best in terms of representing the entire set of primary data in an overall sense (see the method in Gallego and Lenzen, 2009), using a number of matrix distance measures (Wiebe and Lenzen, 2016).

2.4. Regional and sectoral classification

Within the IndoLab, users are able to choose regional and sectoral subsets of a so-called root classification that acts as a classification 'feedstock'. These subsets form the so-called base-table[4] classification into which the user's MRIO database will be cast. Theoretically, base tables can be expressed in terms of as many individual regions and sectors as the root classification allows, however limits are likely posed by available computer RAM. Typically, a root classification is a consolidation of various classifications from selected high-detail

[3] Value added would have been another proxy quantity candidate, but this was not chosen because data are only available for 185 sectors.

[4] Previously 'mother' table.

data sources[5] into a single classification, so that as many user-specific classifications as possible can be derived from one and the same root.[6] For the root classification in our work, we utilise the 2005 Indonesian Standard Industrial Classification (Klasifikasi Baku Lapangan Usaha Indonesia/KBLI, BPS, 2006) consisting of 1148 economic sectors and the 2010 Cities and Regencies classification (Kabupaten-Kota, KK) covering 495 regions. Employment data expressed in both classifications are available from the 2010 labour survey (Sakernas, BPS, 2016b) published by Indonesian Bureau of Statistics (Badan Pusat Statistik/BPS). This regional and sectoral detail however acts only as a feedstock for a variety of smaller MRIO variants. Generating a full MRIO table using this root detail would produce a matrix sized 1.1 million by 1.1 million elements, requiring 2.3 terabytes of RAM for each time series year and valuation layer. At the time of writing, such amounts of information were beyond existing computer capacity.

Although the IndoLab provides flexibility in choosing regional and sectoral classifications, users must consider the availability of primary data. If, say, data were only available at the provincial regional level, users should not attempt a classification capturing individual cities and regencies, unless they are in possession of additional high-detail data on these regional entities. In such cases, the IndoLab allows users to upload additional information and data sets, with the choice of read protection for a select user group in case of confidentiality. The definition of a classification suited to data sources as well as research aims, therefore, is entirely the user's responsibility.

2.5. Data sources

The IndoLab offers time series of MRIO tables, currently spanning the period 1990–2015. The initial estimate is constructed for 2010, because data availability is best for this year. The selection of the 2010 national supply-use table as the main data source for intermediate transactions determines some attributes of the IndoLab's MRIO tables. First, the currency unit is 1 million 2010 Indonesian Rupiah (IDR), and data from all other years and sources must be adjusted to this unit. Second, final demand has six fixed components: consumption expenditure by households, consumption expenditure by the government, gross fixed capital formation, changes in inventories, export of goods, and export of services. Third, primary inputs have five fixed components: compensation of employees, gross operating surplus, depreciation, taxes less subsidies on production, and taxes less subsidies on products. Fourth, the tables feature six valuations: basic price, wholesale margin, retail margin, transport margin, taxes, and subsidies (Figure 2).

At the time of writing, a number of data sources have been used simultaneously as constraints for the reconciliation step. For the sake of transparency information from these sources is fed into the optimisation process without any scaling, adjustment, or other alteration. As these data sources are conflicting, they require the use of optimisation algorithms such as KRAS (Lenzen et al., 2009) or quadratic programming (van der Ploeg, 1984) that are not affected by the type of convergence problems that afflicts traditional RAS-type methods. Table 1 shows the data used in our work.

[5] In Australia these are input–output product details (1284 sectors) and the Census (2214 regions).
[6] This idea was conceived at the Project Réunion's 2012 meeting at L'Hermitage-les-Bains on Réunion Island.

Figure 2. Structure of IndoLab MRIO tables in supply-use format.

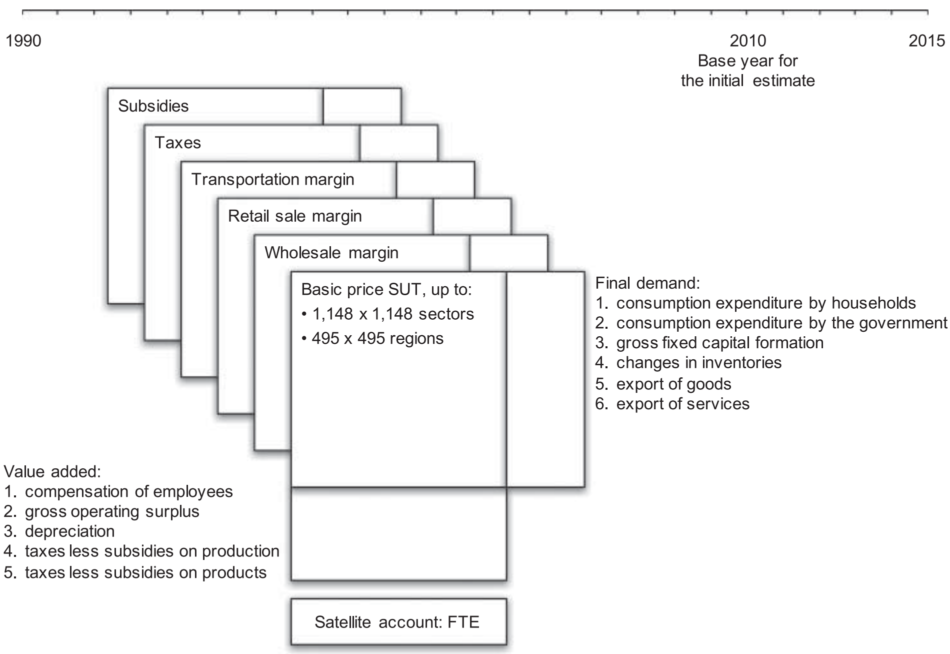


Table 1. Primary data employed for IndoLab constraints.

No	Data	Years	Regions	Sectors	Constraining	Source
1.	National Input–Output Tables					
	a. 66 Sectors	1990, 1995, 2000	1	66	T, y, v	BPS (1994; 1999; 2002b)
	b. 78 Sectors	1990, 1995	1	78	T, y, v	IDE-JETRO (2015)
	c. 76 Sectors	2000, 2005	1	76	T, y, v	IDE-JETRO (2015)
	d. 175 Sectors	2005	1	175	T, y, v	BPS (2008b)
	e. 185 Sectors	2010	1	185	T, y, v	BPS (2015e)
2.	National Accounts					
	a. By sectors	1990–2014	1	43	v	Bank Indonesia (2016a); BPS (2016a)
	b. By expenditure	1990–2014	1	6	y	BPS (2011; 2015a); Bank Indonesia (2016b)
3.	Provincial Accounts					
	a. By sectors	1998–2014	34	17	v	BPS (2002a; 2004; 2009; 2012a; 2015c)
	b. By expenditure	2003–2014	34	6	y	BPS (2008a; 2012b; 2015d)
4.	Cities and Regencies Accounts	2010–2014	495	17	v	BPS (2015b)
5.	Labour Survey					
	a. 1148 Sectors	2007–2010	495	1148	v	(Sakernas) BPS (2016b)
	b. 63 Sectors	2011–2015	495	63	v	(Sakernas) BPS (2016b)
6.	Socio-economic Survey	2010–2015	495	311	y	(Susenas) BPS (2016c)

Note: BPS: Badan Pusat Statistik (Indonesian Bureau of Statistics); T: intermediate demand matrix; y: final demand matrix; v: value-added matrix.

Since the primary data listed above adhere to different classifications, concordance matrices are needed to connect these data to the MRIO structure. These concordance matrices were assembled manually.

3. Results

3.1. Multi-region supply-use structure

Figure 2 shows the structure of the IndoLab's MRIO tables in supply-use format, distinguishing the basic price tables, wholesale margins, retail margins, transportation margins, taxes, and subsidies, all summing up to the purchasers' prices. The IndoLab is able to provide information beyond the monetary input–output transactions. Satellite accounts accompanying the value-added matrix, social, and environmental indicators can be integrated into the MRIO tables. In this paper we present multipliers derived from an employment satellite account expressed in units of full-time equivalents (FTE), complied on the basis of the Labour Survey (Sakernas).

The IndoLab is able to construct time-series MRIO tables, at the time of writing from 1990 to 2015, capturing up to 1148 sectors and 495 regions[7] and consisting of 5 value-added and 6 final-demand categories. For illustrative purposes we present here an MRIO version with the root classification aggregated

- into nine economic sectors: agriculture, forestry and fishery; mining and quarrying; manufacturing; utilities; construction; trade, hotels and restaurants; transportation and communication; finance; and other services,
- and into eight regions: Sumatera, Jakarta, rest of Java, Bali, Kalimantan, Sulawesi, Papua, and the rest of Eastern Indonesia.

The choice of nine sectors for the MRIO table relates to the availability of the cities and regencies data for the year 2012, with the original service sectors aggregated into one.

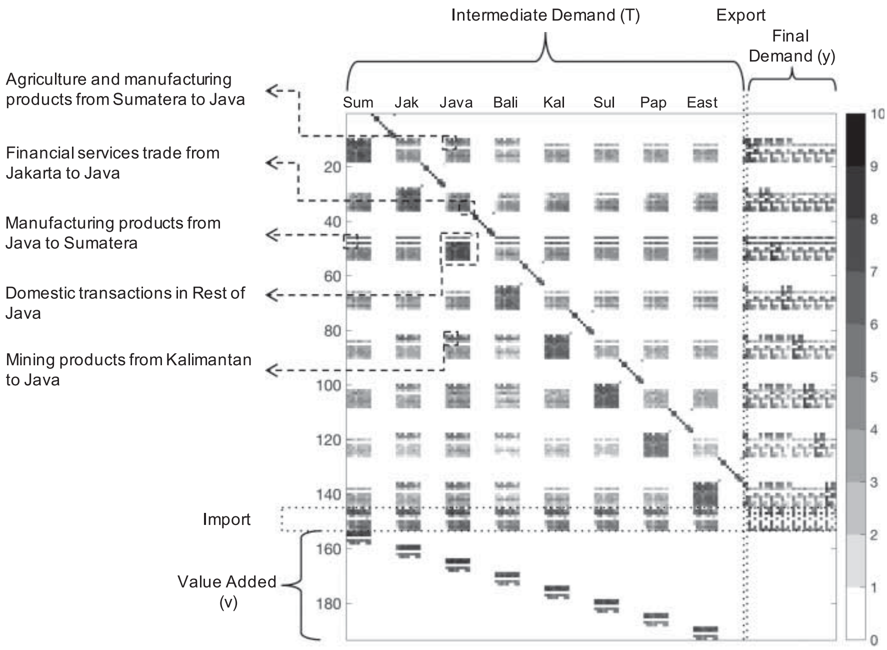
3.2. Database for 2012

The heat map in Figure 3 shows a visualisation of the monetary transaction flows within the Indonesian economy. Such visualisations are useful tools providing immediate understanding about regional attributes, such as regional economic size, inter-regional trade transactions, and sectoral contribution of a region.

The heat map in Figure 3 allows a quick inspection of Indonesian regional economies. The high intra-regional transactions among sectors in Java (excluding Jakarta) show that Java's economy dominates national economic activities. In fact, Java's GDP, workforce, and population amount to 41%, 54%, and 53% of the national totals, respectively (Table 2). Java is the prime location in Indonesia for manufacturing industries (61% of the national manufacturing total). Hi-tech industries such as electronics equipment, vehicles, machinery, and textiles manufacturing are mainly located in West Java, while food and tobacco products are mainly produced in Central Java and East Java. Chemical and metal industries are the leading sectors in Banten, the western part of Java. To support their large manufacturing industries, about 64% of utilities such as electricity, gas, and water supply are situated in Java. Java also dominates the Indonesian trade, hotel, and restaurant sector (48% of the national total), and transportation and communication (41% of the national total).

[7] Not 1148 sectors and 495 regions simultaneously, but for example 1148 sectors and 5 regions, computer RAM permitting.

Figure 3. Heat map of the Indonesian MRIO table in supply-use format for the year 2012.



Note: The cell colours indicate the logarithm of the transaction values scaled in millions of Indonesian Rupiah. A value of 2 represents a transaction value of IDR100m, and a value of −2 represents a transaction value of minus IDR100m. The Indonesian MRIO table can be distinguished as three separate parts: the intermediate demand **T** (MR-SUT) matrix, the final demand **y** matrix, and the value-added **v** matrix. The diagonal blocks of the **T** matrix and the **y** matrix represent intra-transactions of all provinces, while the off-diagonal blocks are the inter-regional trade transactions. The block immediately below the **T** matrix indicates the import **M** matrix, and two vertical columns next to the **T** matrix indicate exports of goods and services. Since primary inputs are not traded, the value-added **v** matrix only contains diagonal blocks.

The heat map also allows a quick evaluation of trade transactions among regions. The Java–Sumatera off-diagonal blocks show that each island relies on the manufacturing products of the other. In particular, Sumatera exports food products such as sugar, cooking oil, and other (semi-) processed agricultural products to Java, for example from its large sugar cane plantations in Lampung and palm plantations in Riau and North Sumatera. On the other hand, Java exports consumer items such as foods and beverages, apparels, cosmetics, vehicles, and household appliances to Sumatera and other part of Indonesia.

Sumatera and Kalimantan boast significant mining sectors, especially for crude petroleum and natural gas representing 75% of the national total. High volumes of mining products from Kalimantan, especially coal, are exported to Java.

Jakarta dominates the national economy with its large financial sector, contributing 47% to the national total. The dark grey highlights of the trade matrix between Jakarta and Java, and Jakarta and other regions confirm that Jakarta's large financial sector sells its products to all regions in Indonesia.

Table 2. Characteristics of Indonesian regions.

No	Region	Gross domestic product[a] (%)	Population[b] (%)	Employees[b] (%)	Human Development Index[b] (average)	Dominant sectors[a]
1.	Sumatera	23.0	21.5	20.4	74.3	Agg (22%), Min (20%)
2.	Jakarta	15.8	4.0	4.3	78.3	Fin (24%), Trade (21%)
3.	Rest of Java	40.9	53.1	54.3	73.5	Man (35%), Trade (19%)
4.	Bali	1.4	1.6	2.0	73.5	Trade (29%), Agg (16%)
5.	Kalimantan	9.7	5.9	6.0	73.4	Min (42%), Man (16%)
6.	Sulawesi	5.4	7.3	6.8	72.5	Agg (26%), Ser (14%)
7.	Papua	1.8	1.6	1.6	68.0	Min (37%), Ser (12%)
8.	Eastern Indonesia	1.9	5.0	4.6	69.4	Agg (27%), Ser (22%)

Source:
[a]BPS (2015c).
[b]BPS (2014).

3.3. *Data conflict and uncertainty*

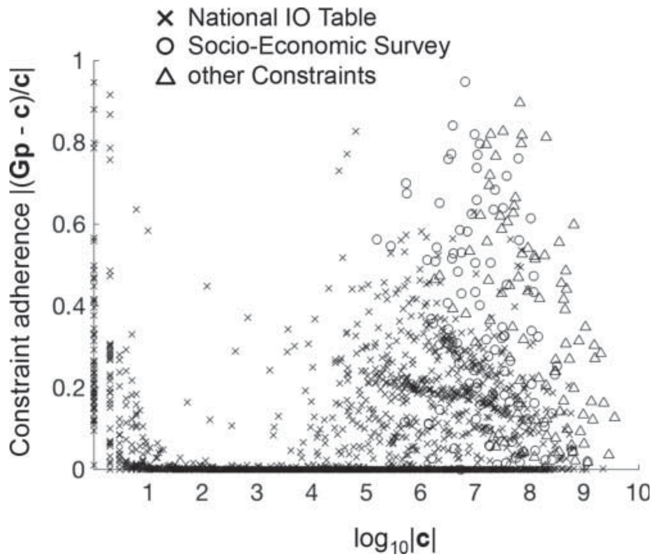
The use of multiple primary data sources as constraints for the reconciliation of the Indonesian MRIO tables involves data conflict. In other words, there is often a mismatch between different sets of primary data, and between primary data and their realisation in the MRIO database. National statistics offices often resolve data conflict manually, for example by choosing one data source over another, which is very time-consuming. We maintain all primary information unmodified, and let the reconciliation engine (e.g. KRAS) find the MRIO table that best adheres to all data points.

The IndoLab is transparent in that it retains the original source data, and lets the user choose which data source they consider most reliable. For example, due to the well-known problem of incomplete representation of high-income classes in income surveys (Sumner and Edward, 2014), household consumption information from the Indonesian socio-economic survey likely underestimates national expenditure. Including these survey data can cause deviations of MRIO elements from any data source that also provides household consumption, as differing pieces of information on the same accounting items distort the reconciliation process (see Figure 1 in Lenzen et al., 2012a). However, as each primary data set comes with accompanying standard deviations, the reconciliation engine chooses a compromise solution between conflicting data points, adhering more to any data that are tagged with relatively low standard deviations. As a consequence, in our optimisation runs, we have assigned a much higher standard deviation to the socio-economic survey data set than to other census-type data sources.

In order to evaluate the performance of the constrained-optimisation reconciliation process of primary data with the MRIO structure, we undertake a diagnostic test (Figure 4). In this test, primary data $\mathbf{c}$ are compared with their realisations $\mathbf{Gp}$ in the MRIO matrix, and relative constraint adherences $|[(\mathbf{Gp})_i - c_i]/c_i|$ are enumerated. Here, $\mathbf{p}$ is a vectorised MRIO table and $\mathbf{G}$ is the constraints address matrix linking primary data and MRIO elements (see p. 8375 in Lenzen et al., 2012a).

The result of this performance test for the Indonesian MRIO table is depicted in Figure 4, showing that adherence tends to improve towards larger primary data items. This circumstance occurs because large MRIO elements undergo relatively few adjustments during reconciliation process (Lenzen et al., 2012a). These adherence characteristics

Figure 4. Relative constraint adherence $|\mathbf{Gp} - \mathbf{c}|/\mathbf{c}$ for constraints imposed on the 2012 Indonesian MRIO table from primary data $\mathbf{c}$ (in Millions of IDR), where the variable $\mathbf{p}$ holds the vectorised MRIO table, and $\mathbf{G}$ is the constraint coefficients matrix that links the MRIO elements $\mathbf{p}$ to the constraints $\mathbf{c}$.

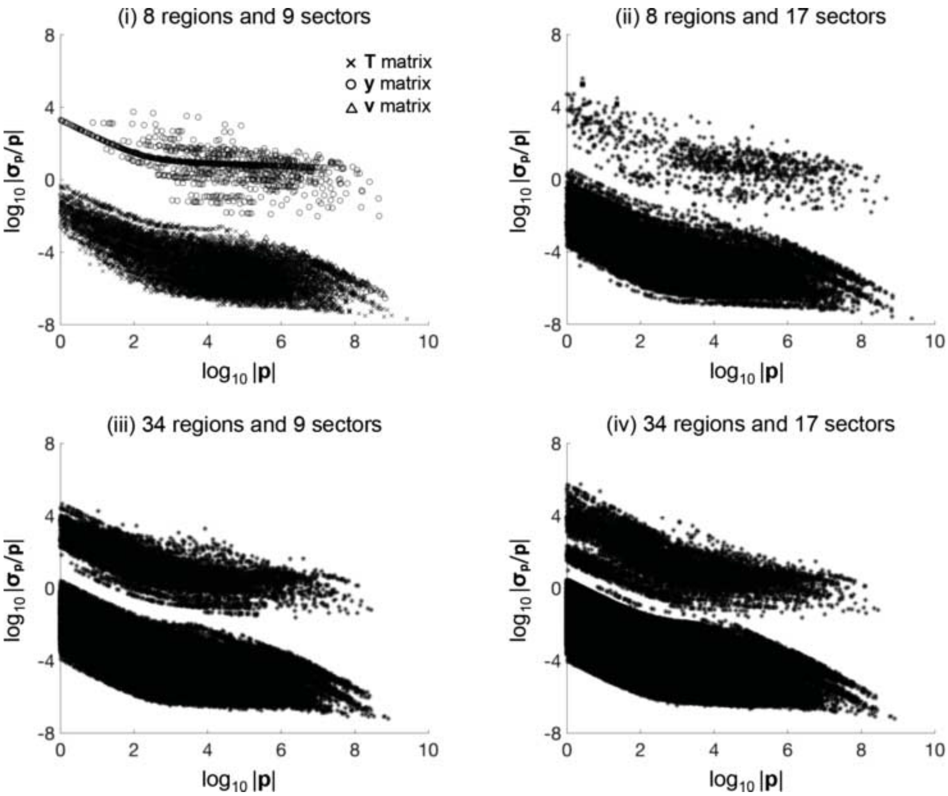


Note: Each constraint point c_i is realised in the MRIO by a value $(\mathbf{Gp})_i$, which is usually different from c_i. *For each data source*, the points follow a distinct 'hockey stick' curve, indicating that large primary data items c_i are represented more accurately in the MRIO table, because they deviate less from constraint realisations $(\mathbf{Gp})_i$. Note also that socio-economic survey data carry more uncertainty than national I–O table data.

are satisfactory, given that Jensen has demonstrated with his concept of holistic accuracy (Jensen, 1980; Jensen and West, 1980) that the accuracy of individual small elements in an I–O table is relatively unimportant for the accuracy of multipliers used for policy analysis.

It is important to equip MRIO tables with estimates of data uncertainty. Standard deviations are a suitable measure for evaluating the magnitude of estimation errors of MRIO entries. We present standard deviations of four 2012 MRIO variations with different regional and sectoral details (Figure 5). As with constraint violations, larger MRIO items are associated with smaller relative standard deviations, because these elements undergo only minor adjustments during the reconciliation. Panel (i) shows an estimate of uncertainty at the broad classification used in this work. We found that the eight-region nine-sector Indonesian MRIO table generated in the IndoLab is characterised by standard deviations of less than 1%, but around 10% for some large elements in the order of 10^8 million Rupiah and above, and more than 100% for some final demand transactions worth 10^7 million Rupiah and less. However, when we increased the number of regions and sectors of MRIO tables, standard deviations of more than 100% occurred more often (panels ii–iv). This result highlights the principle that in order to estimate an MRIO table with sufficiently low uncertainty, primary data must be available that constrain the MRIO elements at the respective level of detail. If the chosen MRIO classification is more detailed than the data, standard deviations increase. Estimating standard deviations thus provides an effective check on table reliability.

Figure 5. Standard deviations for 2012 Indonesian MRIO table variants. The *x*-axis shows the magnitude of MRIO elements p_i, and the *y*-axis shows their relative standard deviation $\sigma_{\mathbf{p},i}/p_i$.

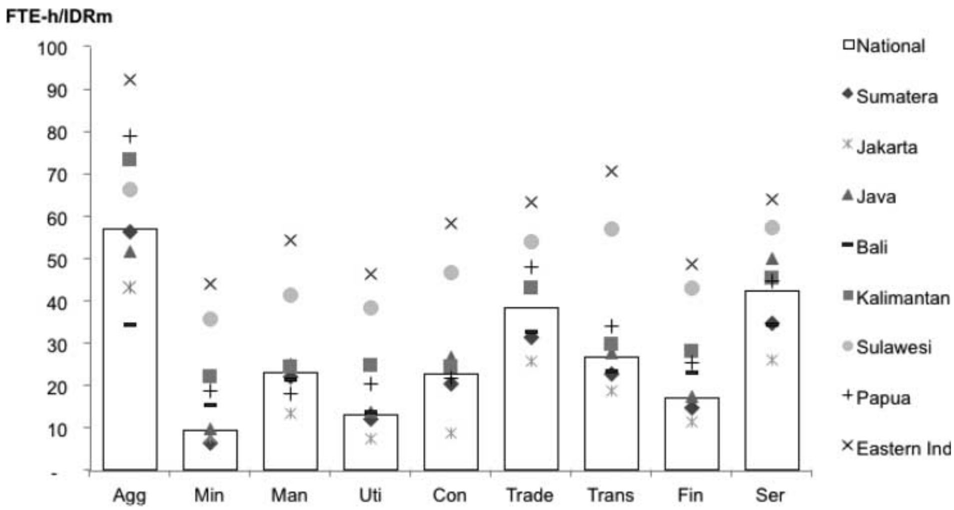


3.4. Utility for policy applications

The input–output approach can be a powerful tool for businesses that can, for example, utilise employment multipliers for determining which investments can provide high labour productivity and can create above-average number of jobs (Domański and Gwosdz, 2010; Gretton, 2013). In addition, governments can use income multipliers in order to formulate individual taxes policies and poverty reduction programmes (World Bank, 2014). Prior studies on Indonesian economic input–output multipliers, however, only relied on national-scale information, for example a study on creative industries by Zuhdi (2015), and on coal utilisation by Winarno and Drebenstedt (2016). As a consequence, valuable information about regional specific-industry characteristics was not being utilised.

To demonstrate the utility of the new Indonesian MRIO database over current single-region national I–O tables for analysing regional economics, we compute regional employment multipliers measuring the impact of one unit of final demand on regional employment expressed in full-time-equivalent hours worked (FTE-h). Information for populating the corresponding satellite account was taken from the 2012 Labour Survey (Sakernas, BPS, 2016b). FTE-hours were calculated by converting the surveyed number of hours worked into annual FTE.

Figure 6. Employment multipliers for the year 2012, in units of FTE-h/IDRm, for eight Indonesian regions: Sumatera, Jakarta, rest of Java, Bali, Kalimantan, Sulawesi, Papua, and the rest of Eastern Indonesia, and nine economic sectors: agriculture, forestry and fishery; mining; manufacturing; utilities; construction; trade, hotels and restaurants; transportation and communication; finance; and other services.



Employment multipliers vary among sectors, as expected (Figure 6). Agriculture, forestry, and fishery features the highest employment multiplier at a national average of 57 FTE-h/IDRm. The second and third largest employment multiplier belongs to the services sector, and the trade, hotel, and restaurant sector, at 42 and 38 FTE-h/IDRm, respectively. These three sectors are the most labour-intensive in the Indonesian economy. The employment multipliers for the mining sector, the utilities sector, and the financial sector are relatively low, at between 9 and 17 FTE-h/IDRm, reflecting their status as capital-intensive sectors. More importantly, we are able to inspect the employment multipliers from a regional point of view. First of all, the regional employment multipliers show a consistent trend across sectors, as expected aligned with the national labour-intensity pattern.

Second, the employment multipliers in Jakarta and Sumatera are lower than national multipliers, for all sectors, indicating that stimulating demand in these regions will likely not result in significant additional employment, compared to other Indonesian regions. We believe that this is due to the relatively high level of human and socio-economic development in Jakarta and Sumatera (see the human development index (HDI) and other data in Table 2), and consequently to the relatively high wages. Highly paid labour means that a fixed amount of additional demand will translate into relatively little employment in terms of FTE-h. In contrast, the employment multipliers in Kalimantan, Sulawesi and Eastern Indonesia, and to a degree also Papua, are higher value than the national averages. Here, the reverse argument applies: Relatively low human and socio-economic development means that wages are low, and hence a fixed amount of additional final demand translates into relatively high FTE employment.

Most importantly, Figure 6 shows that the range of employment multipliers around the national average is sufficiently large to cause regional policy assessments to lead to inaccurate results if a surrogate national I–O table is used for the region. These circumstances underscore the significance of being able to regionalise I–O and satellite data, offered by the IndoLab.

4. Conclusions

We have described the creation of the IndoLab, a collaborative research platform operating on a cloud-computing environment, capable of generating time series of regionally and sectorally highly detailed MRIO databases for Indonesia, with users being able to freely choose the classification of the MRIO tables to suit their particular research aims. This is the first time that such a detailed I–O database exists for Indonesia, able to capture 495 regions of Indonesia down to the city and regency level represented by up to 1148 sectors.

The Indonesian MRIO database has numerous policy applications. For example, Indonesia has implemented significant and massive decentralisation, known in Indonesia as the 'big bang approach to decentralisation' (Bahl and Martinez-Vazquez, 2006). Despite Indonesia's socio-economic diversity and large population, the authorities moved from central to local government within a relatively short period and without major disruption to public services (World Bank, 2003; White and Smoke, 2005; Firman, 2009). This rapid change altered both inter-regional performance and central-local relationships. For example, central duties have shrunk to cover only foreign affairs, defence, security, justice, monetary and fiscal policies, and religious affairs (Law 32 of 2004), leaving substantial responsibility to local governments, such as public works, health, education, culture, agriculture, communication, industry, trade, investment, environment, land, and labour. It is useful, therefore, to utilise the Indonesian MRIO to compare Indonesia's economic structures during pre- and post-decentralisation eras in order to evaluate regional developments. This research-based analysis can provide a credible reference to policy-makers in reformulation of the central and local government duties.

The Indonesian MRIO is also useful as a tool for verifying whether investment in natural-resource-endowed regions outside Java is more successful after the implementation of decentralisation. Referring to Law 28 of 2009, local governments are now allowed to grant investment licenses for exploration of coal and other mineral products, thus providing more flexibility for local governments in directing their own investment towards revenue-maximising activities. The IndoLab's MRIO, therefore, can be used to examine the capacity of local governments to boost particularly profitable regional sectors.

Furthermore, having successfully identified specific employment characteristics of the Indonesian regions, it is of interest to use the Indonesian MRIO for analysing a wide range of other social issues such as corruption and gender inequality, as well as environmental issues such as climate change and deforestation (Hamilton, 1997). As with employment, such social and environmental indicators are likely to vary across regions, thus requiring a regional MRIO for their assessment.

Summarising, the use of the IndoLab's MRIO capability has great potential for solving national and regional research questions that cannot be comprehensively addressed using a single and/or aggregated national database. As an online cloud-based platform, the IndoLab, offers many benefits. Its openness enables interested parties to become involved in collaborative work, and address common research questions. Through its standardised MRIO construction pipeline, it allows researchers to integrate a wide variety of raw data from third-party sources with their own data. These features mean that work in the IndoLab will likely lead to significant cost reduction and accelerated work outcomes in MRIO-related research.

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