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ORIGINAL PAPER

Regional variation in the GDP per capita of colonial Indonesia, 1870–1930

Ulbe Bosma[1,2] · **Bas van Leeuwen**[1]

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Abstract
Since colonial times, substantial regional income disparities have been reported for Indonesia. However, in spite of a wide variety of available data and indicators, so far published data on Indonesian per capita GDP in colonial times are limited to macro-estimates for the entire archipelago or are confined either to Java or to the Outer Islands. In this paper we provide a first attempt to arrive at estimates of diverging income and living standards at a regional level. We implement the Geary and Stark method on a large body of data collected by the colonial government, to estimate GDP for ten macro-regions and five benchmark years between 1870 and 1930. Our findings, corrected for prices, confirm the image arising from the existing literature of major divergences within the Indonesian archipelago in general, and of a higher per capita GDP in most of the Outer Islands (all islands of the Indonesian archipelago except for Java and Madura) compared with Java in particular. This was definitely the case in 1870 and still the case in 1920, but the picture is less clear for 1930, which was the final year before Indonesia's commodity exports started to collapse.

Keywords GDP · Indonesia · Living standards · Wages · Prices

JEL Classification N15 · N35 · N95 · O11 · O40

1 Introduction

1.1 Regional income differences

Spread over 17,508 islands, Indonesia is a highly diverse country, which not for nothing carries "Unity in Diversity" as its national motto. This diversity definitely

✉ Ulbe Bosma
ubo@iisg.nl

[1] International Institute of Social History, Amsterdam, The Netherlands

[2] VU University, Amsterdam, The Netherlands

pertains to economic performance too. Since colonial times, substantial regional income disparities have been reported (Malines van Ginkel 1929; Booth 1988; Maddison 1989; Van Zanden 2003; Leigh and Van der Eng 2009). These regional disparities probably emerged over the course of the nineteenth century, as for the early nineteenth century most wages in Europe as well as in Asia were near subsistence (Van Zanden 2003), thus leaving little room for widespread income differences both among regions and between social classes. The incorporation of colonial Indonesia into the global economy culminated in international trade making up 40 per cent of Indonesia's GDP by the 1920s and has been noted this increased social inequalities (Van Zanden and Marks 2014; De Zwart 2020). Indeed, Booth (1998, p. 89) observes that the "economic stratification […] was pronounced in Indonesia by the early twentieth century, and in spite of the egalitarian rhetoric […], this stratification persisted into the post-1950 period."

The incorporation of Indonesia in the global economy may also have engendered regional inequalities. Considering highly divergent demographic patterns, the impact of colonial policies, and the modes of export production (e.g., smallholder production and plantations), considerable variations in income and living standards throughout the archipelago should not surprise us. But to what extent we can trace them back into colonial times is a largely unexplored field. Most publications about Indonesian per capita GDP in colonial times are either limited to macro-estimates for the entire archipelago or confined to Java or to the Outer Islands (i.e., all islands of the Indonesian archipelago except for Java and Madura). Some studies using other indicators of income variations at the provincial (also called residency) level for the entire archipelago were conducted in colonial times, but more recent studies have focused predominantly on postcolonial Indonesia (e.g., Malines van Ginkel 1929; Van der Eng 2002a). To capture the trend in regional divergence, it is of crucial importance to disaggregate the GDP of colonial Indonesia by region. We will show that this can be done, even though with some drawbacks, by applying the Geary and Stark method.

Even though GDP is thus not available at a regional level, we can distinguish four types of regional studies that do exist for colonial Indonesia. Before presenting our findings upon the Geary and Stark method applied on a large collection of data derived from colonial sources, we will first discuss these four types of existing studies. We start with one of the most well-known fields, which concerns Indonesia's integration in the world economy and its effect on regional well-being (Sect. 1.2), while three more quantitative variables—related to income, stature, and education—are dealt with in Sect. 1.3.

1.2 Integration in the world economy

One of the best-known lines of study concerns Indonesia's interaction with the global economy. In this literature there are many indications that the integration in the world economy in the final years of the nineteenth and early years of the twentieth century impacted differently across Indonesia. This had three reasons:

First, the timing of the beginning of the interaction was different. The eastern Moluccan islands and Java had already been extensively colonized, providing the Dutch East India Company with spices, rice, sugar, and coffee. From 1830 to 1870, a significant share of Java's households was recruited to grow cash crops under the so-called Cultivation System. This island also experienced rapid population growth, resulting in both increasing population pressure and dependency on wage labor in the expanding plantation economy. Forced cultivations also existed in the Moluccas, northern Sulawesi, and West Sumatra, which mostly gave way, however, to free production by local entrepreneurs and smallholders from the 1860s onward. In the early twentieth century smallholders in Sumatra joined the rubber boom, whereas in some of the eastern parts of the archipelago there was a boom in smallholder copra cultivation.

Second, the structure of export commodity production in Java on the one hand and in Sumatra, Borneo [Kalimantan], and Sulawesi on the other was markedly different. In Java plantation agriculture dominated, whereas in these Outer Islands—with the notable exception of the rubber and tobacco plantation belt of East Sumatra—smallholder production as well as mining prevailed (Clemens and Lindblad 1989; Touwen 2000; Van der Eng 1996, pp. 260–265, Table A 1.2.). A crucial difference between Java's export economy and those of the Outer Islands was that, with the exception of East Sumatra, these were smallholder-based, which kept income in the local economies more than in the plantation belts and sites of oil extraction and mineral mining.

Third, both global economic cycles and changing terms of trade impacted differently on different parts of Indonesia, and this pertained in particular to the agricultural crisis of the 1880s. Whereas the 1930s Depression struck both plantation and smallholder sectors throughout the archipelago, the agrarian crisis of the early 1880s struck Java almost exclusively, with almost simultaneous occurrence of severe coffee and sugar diseases as well as a rinderpest. Moreover, before 1900 the Outer Islands accounted for only 30 per cent of Indonesia's exports, and at that time about 60 per cent of Indonesia's exports consisted of sugar and coffee—overwhelmingly produced in Java. Precisely at the time that sugar became Java's most important export commodity, it faced sharply declining market prices (particularly in the period 1884–1902). This can also explain why, after 1870, Indonesia's highly favorable terms of trade fell rapidly to the—still favorable on average—terms of trade of Southeast Asia and turned sharply negative by 1930 (Bassino and Williamson 2017, p. 32, Table 4 and p. 36, Fig. 2). Although from 1900 onward the share of the Outer Islands in Indonesia's exports increased rapidly, it never rose above 50 per cent (Lindblad 1989, p. 17). In sum, the effects of deteriorating terms of trade and price volatility of commodities impacted more severely on Java than on most of the Outer Islands.

Not surprisingly, due to the above-mentioned three factors, the economic history literature dealing with the commodity export sector of Indonesia perceives an economic divergence, with Sumatra and Borneo [Kalimantan] and parts of Sulawesi doing relatively well thanks to palm oil and rubber, while Java's per capita income stagnated because of demographic pressures, with rising income inequality (Touwen 2000; Leigh and Van der Eng 2009; Van Leeuwen and Foldvari 2016, 2017; Bosma 2019).

1.3 Quantitative indicators of regional income

Besides the exposure to the global economy, we have three other indicators of regional divergence. First, rough estimates exist for diverging GDP trends between Java and Madura on the one hand and the so-called Outer Islands on the other in late colonial times (e.g., Polak 1979; Van Zanden 2002).[1] In addition, reports were published in the 1920s about taxation pressure on the populations of Java and the Outer Islands, by Meijer Ranneft and Huender (1926) and Malines van Ginkel (1929), respectively. Since the two reports are very different in terms of data collection and presentation, we cannot compare their findings. Nonetheless, the Meijer Ranneft and Huender report contained alarming facts, particularly with regard to the increasing inequality and precarity of marginal farmers (Meijer Ranneft and Huender 1926). One of the authors, W. Huender, had already observed in 1921 that the people of Java were "taxed to the limit" (quoted in Booth 1980, p. 91). Moreover, the nutritional situation of Java's population seems to have deteriorated over the 1920s (Booth 2012).

Furthermore, available data from the 1960s onward also reveal significant regional income disparities, as Van der Eng has pointed out, which can most likely be traced back to the colonial period. East Nusa Tenggara is positioned at the lower end of incomes, whereas since the early twentieth century oil-rich Kalimantan has been positioned at the higher end (Van der Eng 2002a, 8; Touwen 2001). It should be noted, however, that oil revenues do not stay within a region but flow to the center, which is the reason we exclude oil income in the following sections of this paper. Nonetheless, in terms of Gross Value Added for Agriculture per capita, according to Van der Eng (1993), the Outer Islands exceed that of Java by 8 percent in 1920 and 30 percent in 1930.[2]

Still, regional disparities should not be perceived as a Java–Outer Islands binary. That East Java might have been doing better than the rest of Java, while the dry eastern part of Indonesia (Nusa Tenggara) stagnated, is strongly suggested (Malines van Ginkel 1929). Van Ginkel's data (see Table 3) are particularly interesting because they are partly based upon field research, present both wage data and qualitative evaluations of welfare levels, and show significant regional variation. It is somewhat disappointing that Malines van Ginkel reports only assessments of living standards for the Outer Islands, but the information provided is still valuable. Table 3accords with the observation made by Van der Eng for the 1960s (Van der Eng 2002a)—for example, that the Nusa Tenggara were relatively poor, whereas the residencies of Jambi, Palembang, Benkulen, and Riau were doing well. In these residencies booming smallholder and coffee cultivation may have contributed to higher wages and living standards. However, the levels of the living standards are at variance with the agricultural wages, suggesting relatively good living standards in parts of East Nusa Tenggara, Bali and Lombok, and West Sumatra despite modest agricultural wages.

[1] Jan Luiten van Zanden, Statistical file: Estimates Javanese National Accounts 1815–1939, http://www.cgeh.nl/indonesian-economic-history.

[2] Calculation based on Van der Eng (1993, pp. 259–260, 269–270 Tables A.1.2 and A3).

Table 1 Stature (cm) by date of birth, *Source:* Foldvari et al. (2013); Van Leeuwen and Foldvari (2016)

	1890–1920	1920–1940	1965–1985
West java	160.8	160.1	163.2
Central java	160.4	159.5	162.8
East java	160.1	159.7	162.6
Sumatra's west coast	n.a	159.4	163.0
South sumatra	n.a	159.1	162.7
North sumatra	161.8	160.1	164.1
Kalimantan	n.a	159.5	161.5
Sulawesi	160.1	159.9	162.9
Moluccas	160.6	160.1	n.a
East nusa tenggara	160.6	160.7	n.a
Bali and lombok	n.a	160.7	164.4

Where applicable corrected for shrinking at old age and left truncation (i.e., having a minimum height requirement) of military data. Excludes Europeans

Indeed, this point partly accords with the observation made by Booth (2012): real wages do not always form a useful indicator of living standards.

Second, studies based upon anthropometrics sometimes show the stature (i.e., height) of people, which is often argued to be related to the per capita income of their parents when they were children (e.g., Baten et al. 2010; Foldvari et al. 2013; Van Leeuwen and Foldvari 2016). These studies find that stature on average was higher in the Outer Islands in the period 1920–1940. Yet, at a further disaggregated geographic level there are also differences (Table 1): in addition to North Sumatra, it is mainly the smaller islands of the Outer Islands (East Nusa Tenggara, and Bali and Lombok) that show higher statures in these years, a trend that seems to persist in the 1965–1985 period. On Java it is West Java that shows the highest statures over this period. These data seem to contradict the above-quoted observations that East Java did economically better than Central Java and West Java, as well as that Bali and Lombok were relatively poor. The data on stature also seem to contradict our findings about per capita GDP corrected for prices (Table 9). Yet, considering that these data are obscured by migration patterns, and since they also include non-monetary aspects, such as health, and do not suggest a particularly strong pattern; human heights do not, by themselves, present conclusive evidence.

Besides the above-mentioned indicators, a third category of publications pertains to data on factors of production, such as education enrolment as a proxy for human capital (Table 2).[3] These show a considerably higher enrolment in education for Sumatra than for the rest of Indonesia and seem to correlate with stature. Both were significantly higher in West Java than in Central and East Java. Sumatra's educational

[3] Another human capital related measure concerns age heaping, i.e. the percentage persons able to write their name (e.g. Crayen and Baten 2010). Yet, since they result strongly fluctuate, we will omit them in this paper.

Table 2 Education enrolment ratio, 1910–1930, *Sources:* Enrolment back casted from the census of 1970 (Minnesota Population Center 2019)

	1910	1920	1930
West java	23.1%	29.8%	38.3%
Central java	13.4%	22.5%	34.0%
East java	14.6%	19.2%	27.7%
Sumatra's west coast	25.8%	50.4%	56.1%
South sumatra	28.1%	33.4%	45.5%
North sumatra	24.9%	39.5%	54.4%
Kalimantan	20.7%	27.3%	28.1%
Sulawesi	22.9%	28.0%	33.8%
Other	17.1%	26.1%	32.7%
Coefficient of variation	0.24	0.31	0.27

Table 3 Agricultural day wages and assessment of living standards by residency in 1924

	Residency	Agricultural daily wage in guilder cents	Qualification living standards
Sumatra's West Coast	Benkoelen	75	Very good
	Sumatra's Westkust	50	Good
South Sumatra	Lampongsche Districten	55	Very good
	Palembang	83	Very good
	Djambi	175	Very good
North Sumatra	Tapanoeli	70	Fair
	Atjeh en Onderhoorigheden	65	Modest
	Sumatra's Oostkust	80	Good
	Riouw en Onderhoorigheden	150	Very good
	Bangka en Onderhoorigheden	85	Poor
Kalimantan	Zuid en Oost Borneo	60	Fair
Sulawesi	Celebes en Onderhoorigheden	50	Fair
Moluccas	Manado	75	Poor
	Amboina	70	Poor
East Nusa Tenggara	Timor en Onderhoorigheden	50	Modest
Bali and Lombok	Bali-Lombok	50	Good to very good
Coefficient of Variation		0.46	

Source: For agricultural daily wages, see *Verslag* 1926 *van den Economischen Toestand*, vol. I. Normaal Dagloon voor grondwerk en dergelijken door B.O.W., p. 219. For qualification living standards, see the same report, vol. II

attainment greatly exceeded that of Java. Similarly, we test for correlations between GDP per capita (Table 9) and educational enrolment (Table 2). We find strong

correlations between income and enrolment in 1910 and 1920, primarily driven by high values in the various regions of Sumatra. However, this correlation diminishes over time: whereas Sumatra and West Java remained leading in educational enrolment up to 1930, the 1910s and 1920s witnessed a shift in the ranking of per capita GDP from Sumatra to other Outer Provinces, such as Sulawesi and Kalimantan.

In summary, the three available categories of data (income, stature, and educational enrolment) suggest regional disparities in living standards, stature, and production factors, in which West Java and Sumatra in particular belonged to the most prosperous regions. As such, the assessment of living standards in Table 3, which only include the Outer Islands clearly seem to be in line with the previous tables (Tables 1 and 2), in which we found Sumatra to be high in terms of both stature and educational enrolment up to the 1920s.

Obviously, GDP is a financial indicator, which is not necessarily correlated with nutrition, stature and educational enrolment. From this perspective, Table 3 is of particular interest because it contrasts data on wages (being a financial indicator) with qualitative observations on living standards. Here we see that relatively low nominal wages, such as in West Sumatra, Bali and Lombok, and Sulawesi, do not exclude relatively good living standards. Conversely, conditions on the tin and pepper island of Bangka, for instance, were considered to be poor even though wages were relatively high—not least because food had to be imported, whereas Bali and Lombok produced enough rice to allow them to export part of their crop.

The discrepancy between income measures such as GDP and other indicators is thus far from negligible. If we were to run correlations between the various indicators and other regional indicators discussed above, the coefficient may turn positive or negative depending on the variable and time period.[4] Hence, there is ample reason to attempt a regional approach toward trends in per capita GDP in colonial Indonesia. Our article does not aim to *explain* variations but confines itself predominantly to presenting figures for the development in GDP between ten macro-regions of colonial Indonesia over the sixty years between 1870 and 1930. This approach applies the Geary and Stark method to a large body of data collected by the colonial government (Sect. 2). This results in Sect. 3 in estimates of GDP for ten macro-regions between 1870 and 1930. In Sect. 4 we discuss the results and make some suggestions for further research.

2 Method

2.1 Benchmark years, region division, and Geary and Stark method

Our choice to study the period between 1870 and 1930 coincides with the years in which most of Indonesia's archipelago became incorporated into the global

[4] Indeed, Pim de Zwart's recent article, which focuses on regional variations in income inequalities and which observes considerable disparities in GINI ranging from < 30 to > 60 argues that there is a pattern. Using the colonial residencies, comparable to Indonesia's current provinces as units of analysis, he attributes significant variations in income inequality to the unequal spread of plantation agriculture in particular (De Zwart 2021).

economy, in which the share of Java's exports became less dominant within Indonesia, and in which the archipelago's exports widened from mostly coffee and sugar to new products such as rubber, copra, and oil. This diversification of the colonial economy expectedly created divergent economic trends not only between but also within Java and the Outer Islands, as De Zwart has already demonstrated (De Zwart 2021). Although we can make the divergent trends visible at the residency level, this approach has distinct disadvantages. Aggregating our data within large geographical units of analysis with similar natural conditions and comparable economic trajectories eliminates outliers and compensates for lacunae in data for individual residencies.

For the purpose of this article, we aggregated the units of analysis to ten macro-regions, based upon what is known about their different economic histories, population densities, climates, and/or soil conditions. The regions in Java not only more or less coincide with the late-colonial administrative division under three provinces (*gouvernementen*), but they also represent different economic histories and different cultural zones. East Java emerged as the frontier of sugar and coffee production from the late nineteenth century onward, whereas Central Java saw throughout the nineteenth and early twentieth century large outmigration because of overpopulation and heavy taxation. In West Java, the old rice, pepper, and coffee frontiers declined, but in the course of the nineteenth century a new tea plantation frontier emerged. North Sumatra consists of the plantation and oil frontiers—respectively, the residencies Sumatra's East Coast and Aceh, and Riau—and the tin islands Bangka and Billiton. West Sumatra consists of the residencies on the west coast of this island, where after the abolition of forced cultivations a booming smallholder coffee cultivation emerged. South Sumatra contains the remaining residencies in the southern and southeastern part of the island and served as a frontier for both plantation and smallholder cultivation of export crops, particularly rubber. Kalimantan and Sulawesi are two other macro-regions and were the least colonized until the early twentieth century, but then they became important rubber and copra producers. In addition, Kalimantan emerged as an important oil producer. The northern tail of Sulawesi, Manado, is culturally and historically more connected to the Moluccas, famous for their production of spices but generally known as an impoverished region heavily exploited over a couple of centuries through forced cultivations. Nonetheless, in the late nineteenth century some crucial products grown in this part of the archipelago (spices *inter alia*) were in high demand and may have brought new wealth to the region. The final region, which we have labeled "Other," consists of the dry and generally poor Nusa Tenggara, to which we have added Bali (see Table 4 and Fig. 1).

To estimate GDP for these regions, we follow Geary and Stark (2002; 2015), as well several studies on other countries such as Spain (Diez-Minguela et al 2018) and Sweden (Enflo and Missiaia 2018), who show that, after equating labor productivity times number of laborers with GDP, GDP by sector and region can be calculated as follows:

$$Y_i = \Sigma L_{ij} q_j$$

Table 4 Residencies (Dutch colonial names) by macro-region

Region	Residency
West Java	Bantam, Batavia, Preanger Regentschappen, Cheribon
Central Java	Tegal, Pekalongan, Semarang, Japara, Rembang, Bagelen, Kadoe, Djokjokarta, Soerakarta
East Java	Soerabaija, Pasoeroean, Probolinggo, Bezoeki, Banjoemas, Banjoewangi, Madioen, Kediri, Madoera
Sumatra's West Coast	Sumatra's Westkust, Tapanoeli, Bengkoelen
South Sumatra	Lampongsche districten, Palembang, Djambi
North Sumatra	Sumatra's oostkust, Atjeh en onderhoorigheden, Riouw en onderhoorigheden, Banka, Billiton
Kalimantan	Westerafdeeling van Borneo, Zuider- en oosterafdeeling van Borneo
Sulawesi	Celebes en onderhoorigheden
Moluccas	Manado, Amboina, Ternate
Other	Bali & Lombok, Timor en onderhoorigheden

Papua New Guinea excluded

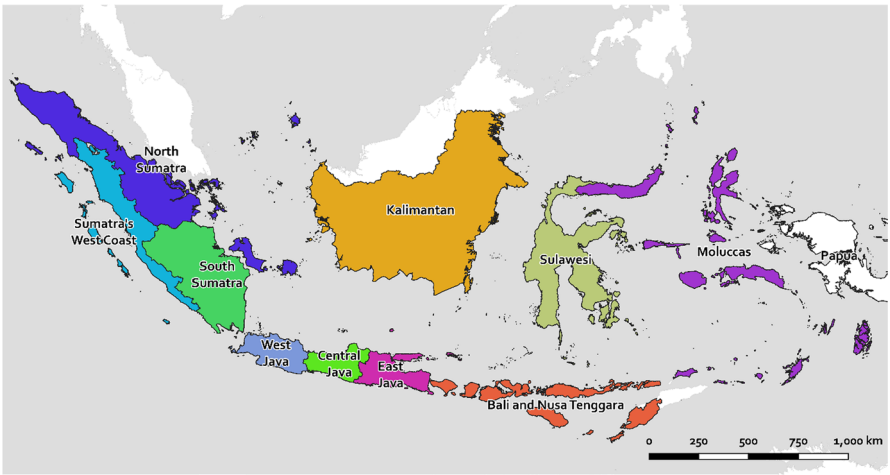

Fig. 1 The ten macro-regions used in this study

where Y_i is GDP in region i, L_{ij} is the labor force in region $_i$ and sector $_j$, and q is labor productivity in sector $_j$. Yet, since labor productivity by sector will, most likely, not apply to all regions, we assume the regional to national wage ratio can function as a proxy for regional labor production disparities. That is:

$$Y_i = \beta \Sigma L_{ij} q_j \frac{w_{ij}}{w_j}$$

Table 5 GDP by sector in 1930 constant prices (mln guilders), *Sources:* Polak (repr. 1979), Maddison (1989), Van der Eng (1992b), and this text

	GDP	Agriculture	Industry	Services
1870	2262	1549	260	453
1890	2653	1805	295	554
1905	3466	2349	403	714
1920	4980	3188	677	1115
1930	6495	3966	1040	1489

where $\frac{w_{ij}}{w_j}$ is the regional to national wage ratio for industry $_j$, and β is a scaler causing the sum of the output of all sectors in a region to be equal to total output in each region.

2.2 Data

The way in which we estimate GDP requires us to first calculate GDP for Indonesia as a whole per sector (agriculture, industry, and services) for each benchmark year (1870, 1890, 1905, 1920 and 1930). Most published datasets are presented in constant 1980s' or 1990s' prices, which cannot straightforwardly be combined with current price wages for the late nineteenth and early twentieth century. This is because, even if we were to assume that price growth does not diverge over regions between 1870 and 1990, price growth as such still affects the shares of economic sectors for each benchmark year (i.e., prices from agriculture, industry, and services move differently over time). Since current price GDP, calculated via the value-added approach, does not yet exist, we followed an alternative route and estimated GDP in constant 1930 (our latest benchmark year) prices. First, we took total current price GDP (expressed as GDE [Gross Domestic Expenditure]) from Van der Eng (2019) for our latest benchmark, 1930. From Van der Eng's (2019) GDE we can derive a total GDP, but we also need GDP for individual sectors. Hence, we rely on Polak (reprinted 1979) to estimate a 1930 share of ten sectors (see Table 12 in Appendix 1) and use those as weight to bring Van der Eng's (1992b) volume indices back in time. Linking this to the Van der Eng (2019) nominal GDP for 1930 gives constant 1930 GDP by sector between 1880 and 1930. By linking to Maddison (1989), we bring it back to 1870 (see Table 5).

In addition to GDP, as a second indicator we require estimates of the labor force by region. For these, we used the quintennial tables that were produced on population and occupations per residency from the Colonial Reports (*Koloniale Verslagen*) from 1873 to 1905 and the Census of the Netherlands Indies of 1930 (Economische Zaken, Volkstelling 1935), which was the first successful census for colonial Indonesia. In the (relatively detailed) quintennial tables, the way in which occupational data were collected and presented varied considerably over the years. We solved this problem by standardizing the occupational and by-employment categories along the lines of the 1930 Census report (Economische Zaken, Volkstelling 1935).

Table 6 Occupational distribution by sector in Indonesia, *Source:* this text

	Agriculture	Industry	Services
1870	86.4%	6.4%	7.2%
1890	85.0%	7.0%	8.0%
1905	84.9%	7.2%	7.9%
1920	84.3%	7.3%	8.4%
1930	84.1%	7.3%	8.7%

These data are slightly different from the data presented by Marks et al. (2020, p. 30) as we start from the total population to avoid that we miss a substantial (particularly female) labour force employed in agriculture and rural crafts. In addition, we included regional data.

1920 averaged between 1905 and 1930

Another serious limitation concerns the lack of inclusiveness of the data, which varies over time and from survey to survey. To improve the data consistency, we first compared our benchmark years with previous and subsequent years to find inconsistencies. After all, if the category of traders, for instance, was substantially higher in 1891 compared with 1890, we may assume the latter is underestimated. In such a case, we corrected the underestimated employment category using either earlier or later surveys.

As the next step we standardized our data by assuming a total labor force made up 57% of the total population, and any missing laborers were placed under the heading of agriculture. By basing ourselves on a total employable population (i.e., the entire population without young children and people unfit for work or who do not need to work) we ensure that we include the important category of women in particular, who were engaged in the cottage industry, but not counted in colonial statistics. In the colonial report of 1905, for instance, a figure is given of a mere 9 percent of all women of Java, whereas other data strongly suggest that cottage handicrafts and peddling were sources of income for at least a third of all households (Bosma 2019, p. 137). The employable population can be deduced from occupational data distributed per age cohort. Although such data are not available for Indonesia for the year 1905, which is more or less halfway 1870–1930, they are for the Philippines that has a comparably rapidly growing population and comparable GDP to that of Indonesia. According to the Census for the Philippines of 1903 (vol. 2, p. 894) about 38% of the population is registered as younger than 15 years and of this cohort over 95% is registered as without occupation. Taking into account that another 5–10 percent of all people of 15 years and older can be assumed as either unable to work because of physical or mental conditions or does not need to work, the figure of 57% suggested in the literature such as Guo (2019) on Fujian (China) appears to applicable to Indonesia as well.

No occupational data are available for the years before 1882 and between 1905 and 1930. For our 1870 benchmark we therefore used the 1882 data. We did correct the absolute number by population totals and increased agriculture share as mentioned below. For 1920, we calculated the mean between 1905 and 1930, also corrected for population totals and missing data on laborers in agriculture. One may

question the reliability of this approach; however, as can be seen in Table 6, diverging trends in occupational structure over the period of this study were limited, thus implying that any potential bias for both 1870 and 1920 must be small.

Indeed, in the resulting trends in occupational structure we find a slight overall rise in industry and services at the expense of agriculture, which is in conformity with the existing literature (Booth 1998; Van der Eng 2007). Looking at the share in agriculture of ca. 85%, this is about as high as China (Guo et al. 2019) and a little higher than British India (Usami 2006).

A third category of data required to estimate regional GDP concerns nominal agricultural and industrial wage data. These were retrieved from the Colonial Reports produced between 1875 and 1918, and in particular from tables providing a wealth of data for different types of factory labor (1881–1924) and more narrowly for the sugar industry (1921–1940). For the year 1905 the volume of Dros and Van Dooren (1992, p. 150) offers additional data. However, with respect to the wages we faced two problems. First, for 1930 the Colonial Report does not provide data on wages, whereas Dros and Van Dooren provide only some scattered data. Fortunately, the report of the Labor Inspection (*Kantoor van Arbeid*) over the year 1926 provides us with wage data for the Outer Islands, which can be used for 1930 since nominal wages remained rather stable between 1923 and 1930. Similarly, the Colonial Report of 1924 (containing data on 1923) provides wages for the rubber industry as well as for the petroleum and the tobacco industry, which are used to fill in the remaining gaps for 1930. Since general coolie wages tend to correlate with unskilled agricultural wages, we used these general coolie wages to interpolate agricultural wages.[5] In those few cases where gaps still remained, we used trend lines to infer the deviation of each residency from the average. For example, if wages in the residency of Madiun are always 69 per cent of the average in preceding years, we assume that this would also be true for 1930. Second, the lack of reliable data on services has been addressed by following the assumption of Geary and Stark (2002), based on Kravis et al. (1978), that these wages are a labor share weighted mean of agricultural and industrial wages (for a comparable, though not identical, method see Enflo and Missiaia 2018).

Table 7 presents the population-weighted nominal agricultural, industrial, and services wages for all macro-regions. Its data suggests that nominal agricultural wages in Indonesia on average were rather stagnant over the period 1870–1930. Yet the table also shows significant regional variation, with nominal wages in Java before the 1930s being lower than in the Outer Provinces. With the notable exception of East Java, most macro-regions in the Outer Provinces experienced higher agricultural growth than Java and Madura, which were more densely populated and more under the sway of the colonial economy. Especially Sumatra experienced higher nominal agricultural wages—as well as higher industrial and service sector wages, for that matter—which might partly be explained by a less developed labor

[5] Wages from the sugar industry were not used, as they deviated from agricultural wages for the years when both were available. This is partly because many *toekangs* (artisans) wages were used in Dros and Van Dooren (1992).

Table 7 Nominal wages by sector, macro-region, and year (guilder cents per day), *Source:* see text

	1870	1890	1905	1920	1930
Agriculture					
West Java	30.2	25.2	28.6	42.6	37.2
Central Java	34.3	25.0	25.7	37.1	46.9
East Java	36.5	34.2	28.5	42.6	43.3
Sumatra's West Coast	50.0	43.8	45.1	61.4	46.7
South Sumatra	46.6	58.9	57.2	67.5	60.6
North Sumatra	77.7	68.7	57.9	65.5	48.3
Kalimantan	60.0	48.8	53.1	70.4	44.5
Sulawesi	50.0	50.0	50.0	75.0	59.0
Moluccas	40.1	46.4	43.0	50.2	43.1
Other	40.1	46.4	43.0	50.2	43.1
Industry					
West Java	65.9	59.5	65.9	93.2	60.2
Central Java	87.1	93.5	63.0	89.0	57.5
East Java	89.9	91.3	75.1	105.0	50.5
Sumatra's West Coast	125.9	105.0	100.1	142.2	76.8
South Sumatra	141.4	155.4	147.0	244.5	84.0
North Sumatra	109.7	119.3	114.0	141.4	71.0
Kalimantan	116.8	122.5	100.5	144.2	75.0
Sulawesi	158.1	173.2	130.0	173.7	52.5
Moluccas	51.4	98.4	89.8	152.7	67.0
Other	51.4	98.4	89.8	152.7	67.0
Services					
West Java	33.1	27.8	31.5	46.1	38.7
Central Java	39.2	31.9	29.7	42.7	48.1
East Java	39.6	38.4	32.0	47.5	43.9
Sumatra's West Coast	52.8	46.2	47.3	65.2	48.3
South Sumatra	54.5	66.1	63.4	78.3	61.9
North Sumatra	96.5	72.7	95.1	70.0	48.3
Kalimantan	63.0	52.4	55.4	73.3	45.5
Sulawesi	52.9	54.3	53.0	79.9	58.6
Moluccas	40.9	51.6	47.0	60.6	45.8
Other	40.4	48.2	44.8	55.0	44.4

market, and hence a relatively low supply of wage laborers coupled with an accelerating demand because of the rapid development of plantations. High nominal agricultural wages for Sulawesi and Kalimantan in 1920 seem to indicate that in these two regions cash crop production was of recent date. Other factors explaining relatively high agricultural wages are booming smallholder cash production of coffee and rubber.

With the exception of the greater Batavia area, wages of all three sectors in Java and Madura appear to have been consistently lower than those in the Outer

Provinces, and in Sumatra and Kalimantan in particular. Indeed, the industrial wages also show clear discrepancies between several residencies. The area of the Priangan regencies, Cirebon, and Banyumas on Java experienced relatively low industrial wages, whereas residencies in the Outer Provinces such as Palembang and Lampung in South Sumatra and Bangka saw relatively high wages. For Bangka this can be explained by the tin mines that were operated by skilled Chinese miners. In summary, the regional wage discrepancies appear to conform with what we know about the development of cash crop production and mining and how these interact with developing labor markets and migration patterns. Massive migration from Java to the Outer Islands in all likelihood ushered in converging wage levels, although it would require further research to establish to what extent migration indeed caused this convergence.

3 Regional real GDP per capita

By combining the equation in Sect. 2 with labor force and nominal wages (see Tables 6 and 7), we can estimate GDP for each region. Since we use current price wages, the implicit assumption is that the price level is the same for each region. On the one hand, this assumption is quite plausible, as diverging price levels probably had only a limited effect on nominal per capita regional income. Indeed, Geary and Stark (2002, pp. 933–934) find that not including prices leads only to a small bias. On the other hand, there is the argument that omitting prices may cause a bias, as price divergences may mitigate regional wage discrepancies (Geary and Stark 2015). Geary and Stark (2015, p. 135) explain this through the fact that while "[v]ariations in regional prices will impact to some degree on the money values of regional wages and outputs (and hence also income and expenditure) and hence regional GDP," the extent to which this occurs depends on levels of market integration and mobility of factor endowments. In the case of Indonesia there is substantial evidence that both wages and rice prices fell from the 1880s to the 1900s (Booth 1988: p. 317), which caused regional price differences. We therefore test for the effect of price data using the main food crop(s) (in this case rice).

Rice prices were published by Creutzberg and Mansvelt (1978), but for our purpose we constructed a much more fine-grained dataset. We undertook a systematic collection of the regional development of rice prices in the digitized newspaper collection of the Netherlands National Library, where we found almost 2900 rice prices covering the entire archipelago for the nineteenth and early twentieth centuries. In addition, we used the reports of the Labor Inspection (*Kantoor* van Arbeid 1926, pp. 21–31) for the Outer Provinces, which also provided us with rice prices. Gaps have been filled by deriving data from residencies with similar price levels and patterns of price fluctuations. Rice prices are standardized, which means they capture the price of second-class white rice. Looking at price levels, we find patterns similar to those in nominal wages, with prices in the Outer Provinces being slightly higher than those on Java between 1870 and 1930. Yet, both in 1890 and 1930, when Java was more severely affected by their respective crises, Javanese price levels dropped further below those in the Outer

Table 8 Prices in Java and Outer Provinces (West Java in 1930 = 100), *Source:* see text

	Java	Outer provinces
1870	100	87
1890	71	78
1905	91	92
1920	279	304
1930/2	97	87

Table 9 Per capita GDP (1930 guilder, corrected for prices), *Source:* see text

	1870	1890	1905	1920	1930
West Java	54	54	70	94	83
Central Java	64	60	64	95	103
East Java	67	75	62	81	118
Sumatra's West Coast	95	75	107	106	104
South Sumatra	72	76	105	114	109
North Sumatra	147	128	158	132	106
Kalimantan	124	87	110	128	126
Sulawesi	105	110	126	136	160
Moluccas	70	100	88	88	116
Other	73	80	70	86	105
Indonesia	72	71	76	94	107
Coefficient of Variation	0.34	0.27	0.32	0.19	0.18
Gini (unweighted)	0.17	0.14	0.17	0.10	0.09
Gini (population weighted)	0.12	0.12	0.13	0.08	0.08
Theil (population weighted)	0.03	0.03	0.04	0.01	0.01

Provinces (Table 8). This implies, as mentioned above, that price divergences in Indonesia indeed slightly mitigated regional wage discrepancies.

Since rice prices thus contributed to per capita income, we will use them in this paper. Indeed, when we combine nominal wages with prices, we find, first, that even though prices had an effect on income, overall differences in GDP per worker caused by prices were small (6 per cent and 9 per cent at maximum in Java and the Outer Provinces, respectively; see Appendix 1, Table 13); second, that the decline in 1890s prices was steeper in Java than in the Outer Islands; and third, that the price levels were generally higher in the Outer Provinces than in Java. This implies that the correction for prices had a more depressing effect for 1930 GDP per capita in the Outer Provinces than it had in Java, an effect that was exacerbated in 1890 and 1930 by Java's price decline (see Table 9 and Appendix 1, Table 13).

Table 9 presents the GDP per capita, corrected for prices, for the ten macro-regions. It shows that whereas in 1870 the GDP per capita was below average for all three regions in Java and well above average in Sumatra, the picture was reversed for East Java in 1930. In fact, this caused Java's overall share in GDP to

Table 10 Share of GDP by region (1930 guilder, corrected for prices), *Source:* see text

	1870	1890	1905	1920	1930
West Java	11.9%	12.6%	15.7%	17.0%	15.2%
Central Java	29.7%	26.4%	26.2%	28.5%	27.2%
East Java	18.9%	25.2%	20.9%	24.6%	25.5%
Sumatra's West Coast	5.6%	4.5%	6.7%	3.9%	3.8%
South Sumatra	2.4%	2.5%	3.3%	2.8%	2.6%
North Sumatra	5.3%	4.6%	7.3%	6.3%	5.6%
Kalimantan	6.4%	5.6%	5.4%	4.2%	4.5%
Sulawesi	7.1%	6.3%	5.9%	6.1%	8.0%
Moluccas	3.1%	4.1%	3.0%	2.7%	3.5%
Other	9.6%	8.2%	5.5%	5.0%	4.2%
Sum	100.0%	100.0%	100.0%	100.0%	100.0%

Table 11 Compound annual growth rate of GDP per capita (1930, prices corrected), *Source:* see text

	1870–1890	1890–1905	1905–1920	1920–1930	1870–1930
West Java	0.0%	1.7%	2.0%	−1.3%	0.7%
Central Java	−0.4%	0.5%	2.7%	0.8%	0.8%
East Java	0.6%	−1.2%	1.9%	3.8%	1.0%
Sumatra's West Coast	−1.2%	2.4%	0.0%	−0.2%	0.2%
South Sumatra	0.3%	2.2%	0.6%	−0.5%	0.7%
North Sumatra	−0.7%	1.4%	−1.2%	−2.2%	−0.5%
Kalimantan	−1.8%	1.6%	1.0%	−0.2%	0.0%
Sulawesi	0.3%	0.9%	0.5%	1.6%	0.7%
Moluccas	1.8%	−0.9%	0.0%	2.8%	0.8%
Other	0.5%	−0.9%	1.4%	2.1%	0.6%
Indonesia	−0.1%	0.4%	1.5%	1.3%	0.7%

steadily increase from 61 per cent in 1870 to 68 per cent in 1930 (Table 10). This was mainly because Java's compound annual growth rate of GDP per capita (with prices corrected) over these sixty years was larger than that of the Outer Islands (Table 11).

4 Conclusions and suggestions for further research

Indonesia is an economically diverse country. This article provides a first attempt to calculate regional GDP. We used a variety of sources, covering more than our five benchmark years, which allowed us to correct for outliers clearly caused by reporting errors by comparing with nearby years and, in rare cases, to fill in gaps in the data with interpolation. Using these data in combination with the method from Geary and Stark (2002; 2015), we arrive at regional per capita GDP, which we corrected

for prices. Below we mention the four most visible trends. First, as pointed out in the introduction, in the mid-nineteenth century, with opening up to the world market, Indonesia must have witnessed rising regional inequality. Our estimates show this peak must have been around 1870–1905, followed by declining coefficients of variation. After World War II we indeed find a declining inequality (Van Leeuwen and Foldvari 2017) thus suggesting an inverted u-shaped curve which started in the nineteenth century and ran until well into the twentieth.

Second, the results further confirm the impression arising from the existing literature that per capita GDP in the Outer Islands was higher on average than in Java. According to Table 9, this was definitely the case in 1870 and still the case in 1920, but the picture is less clear for 1930. This contradicts the finding by Van der Eng that the economies of the Outer Islands grew faster than Java's economy. Part of this discrepancy can be explained by the existence of economic enclaves. Oil in particular was a dominant sector in the Outer Provinces and increased in importance from 4.4% of Indonesian GDP in 1920 to 7.6% in 1930 (Van der Eng 2002b). If it were to be factored into our model, it would increase the per capita GDP growth rate of the Outer Provinces over the period 1870–1930 from ca. 0.4% to ca. 0.8%, which is equal to that of Java over the same period. Similar to the case of the oil sector, the plantation economy of East Sumatra led to a drain of income away from that province, thus lowering income in the Outer Provinces. Conversely, in Java much more money remained in the economy, due to, *inter alia*, land rents.

Third, the declining discrepancy between Java and the Outer Provinces can further be explained by the fact that, when corrected for prices, wages grew faster in Java than in the Outer Islands. Thanks in part to the construction of an extensive database on rice prices, we were able to nuance the assumed lack of GDP per capita growth in Java in comparison with most of the Outer Islands. In fact, the trend is one of a convergence between Java and the Outer Islands, and between Java and Sumatra in particular. Nevertheless, this pattern varied on a more disaggregated level: as Appendix 1 Table 13 shows, both nominal wages and wages corrected for prices must have grown particularly rapidly in in the 1920s in East Java, which experienced a boom in plantation agriculture (Dick 1995), whereas in West Java wages even declined. The same happened with wages in North and South Sumatra, which declined between 1920 and 1930 both in terms of nominal wages and when corrected for prices. Massive labor migration from Java to North and South Sumatra may explain these declines despite the booming plantation economy. The migration to East Java was not less important, but in contrast to North Sumatra there were no wage-depressing effects of indentured labor systems allowing wages to rise as a result of labor shortages. Whereas in 1920, GDP per capita (corrected for prices) in Sumatra and Kalimantan was still well above that of Java, the gap had narrowed by 1930. Another set of explanations for the wage convergence concerns a growth of productivity. Even though Java suffered from deteriorating terms of trade, and declining sugar prices in particular, its sugar industry managed to surmount these adverse conditions by, for instance, introducing new high-yielding cane varieties. East Java in particular was the sugar frontier of the island.

Fourth, we find more pronounced growth divergence among smaller regions. For example, besides the discrepancy in growth between Java and the Outer Provinces, within the latter, it was mostly the Moluccas and Sulawesi that grew faster between 1870 and 1930 than Sumatra. This growth was concentrated mostly in the 1920s when these poorest regions started catching up. Indeed, the Moluccas had low well-being in the start of the 1920s (Table 3). Also, other factors like education increased fastest here (Table 2). This increase, however, was just catching up rather than leaping ahead. Besides catching up, a second example of growth differences among parts of Indonesia concerns agriculture. We see from 1905 to 1930 a decline of Sumatra's and Kalimantan's share in total agriculture in Indonesia and a corresponding rise of it in East and West Java: whereas in 1905 the share of agriculture of Sumatra and Kalimantan in Indonesia's total agriculture had been 24%, it declined to 19.1% in 1920 and 18.4% in 1930 with a corresponding rise of Java in total agriculture. This pattern might have various reasons with one of them being that Sumatra and Kalimantan were more sensitive to agricultural crises.

Our estimates provide just another step in studying Indonesian regional economic differences. Agronomic and technological drivers of economic growth have not been included in our analysis, nor have skill levels been introduced as factors to explain divergences. This was not the aim of our exercise, which was to show that the Geary and Stark method can also be applied to a "peripheral" economy. The Geary and Stark method is not an explanatory model; its value is that it allows for the formulation of new hypotheses to explain per capita GDP convergence or divergence in such an extended territory as Indonesia. Obviously, it is possible to include more benchmark years. But this refining will have its limits since the data are retrieved from government colonial reports, which, particularly in regions where the colonial administration was stretched thinly, may contain quite a few biases, caused not least by lack of data-gathering capacity over such extensive territories. Moreover, in theory, regions of colonial Indonesia where the labor market was not yet developed nominal wages could have been driven up. This may have played a role particularly in Sulawesi. Here, the GDP per laborer is less an indicator of per capita GDP than it is in Java, where the labor market was much more developed. Our data for Java seem to validate Malines van Ginkel's (1929) findings that East Java performed better than the rest of this island in the late 1920s.

Since the average labor productivity thus potentially deviates from marginal labor productivity, the Geary and Stark model may produce biased results. There are however four reasons why this should not be a major problem. First, while such a bias may hold in the short run, over time labor markets tend to adjust to existing obstacles. Second, the extent to which this bias occurred in the case of Indonesia, appears to be limited. For example, looking at consumption per household in 1932, it is suggested that household consumption for landless agricultural laborers and operator/landowners below one hectare were roughly equal and this concerns

the overwhelming majority of Java's rural population. A serious divergence in consumption expenditures are only to be found for operators/landowners with more than one hectare. Within the various categories of non-agricultural labor force similar patterns are found, which suggests that only ca. 16% of total population could afford a substantial above average per household consumption (Van Leeuwen and Foldvari 2017). This reduces the possibility of a strong bias. Third, extending the argument made in point 2, in economies approximating subsistence, such as that in Indonesia, deviations in income must be less since there is not that much income rich persons can extract from the poorer classes. Fourth, it should be noted that the situation in Indonesia is not radically different from that in the most advanced economies of the nineteenth century for which such estimates are made. For example, in a debate on Britain (e.g., Crafts 2005), it is found that the bias caused by non-market wage workers is small (Geary and Stark 2015). A similar finding comes from Enflo and Roses (2015). In summary, even though some bias obviously exists, it is probably not large enough to render a regional GDP analysis invalid. Moreover, further research in local economic structure and development may add much needed information to this debate.

Appendix 1

See Tables 12 and 13.

Table 12 1930 current price sectoral GDP shares, *Source:* Calculated from Polak (repr. 1979)

Sector	Share
Food crops	40.2%
Cash crops	7.3%
Livestock	6.4%
Fisheries	1.0%
Forestry	1.0%
Plantations and mines	10.3%
Manufacturing	10.9%
Transport	1.4%
Trade	6.6%
Housing	5.6%
Government	5.8%
Other services	3.5%
Sum	100.0%

Table 13 Comparison with and without price correction for GDP/capita by region, *Source:* This text

		Java	Outer Provinces
1870	1930 GDP with current price wages	66	85
	1930 GDP with 1930 price wages	63	93
	Differences	6%	−9%
1890	1930 GDP with current price wages	62	96
	1930 GDP with 1930 price wages	63	91
	Differences	−3%	5%
1905	1930 GDP with current price wages	65	104
	1930 GDP with 1930 price wages	65	106
	Differences	1%	−2%
1920	1930 GDP with current price wages	85	120
	1930 GDP with 1930 price wages	88	112
	Differences	−3%	6%
1930	1930 GDP with current price wages	106	110
	1930 GDP with 1930 price wages	102	120
	Differences	4%	−8%

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