Economic geography of electricity consumption: do regional characteristics matter in Indonesia, 1993-2010?

Timotius D. Harsono
Gadjah Mada University, Yogyakarta, Indonesia
National Resilience Institute Republic of Indonesia

Mudrajad Kuncoro
Faculty of Economics & Business
Gadjah Mada University, Yogyakarta, Indonesia

Keywords
Electricity Consumption, GRDP, Discriminant Analysis, Regions, Economic Corridor

Abstract
Indonesia faces unique challenges in developing appropriate electricity policy to deal with its underdeveloped regions. This paper attempts to explore some spatial patterns of electricity consumption in 14 PLN's distributive regions over the period of 1993-2010. Our analysis pioneers the study of Indonesia's electricity consumption and regional development that incorporates 'geography'. Discriminant analysis proves to be useful as the basis to integrate the formulation of regional electricity development policy. The findings suggest that Indonesia needs development policies that incorporate regional variations in terms of population, industrialisation, electricity development and poverty. More importantly, Indonesia can enhance the performance of regions by taking into account the spatial dimension of population, industrialisation, electricity development and poverty. Our findings offer some insights about spatial aspect of the Indonesia's electricity consumption and regional development.

1. Introduction

As the world largest archipelago consisting of more than 17 thousand islands and the fourth most populous country in the world with 241 million inhabitants scattered across 33 provinces, Indonesia faces complexity in developing energy policy that can boost its underdeveloped regions. Geographically, Indonesia has a unique combination of economic potentials with regions and corridors having its own strategic future roles in achieving its 2025 national objective. On 27 of May 2011, the current government launched Master Plan for Acceleration and Expansion of Indonesia Economic Development (MP3EI) by setting six major economic corridors.

The MP3EI has vast projects in scope aiming to turn Indonesia into a developed country with one of the world's largest economies. Aside from insufficient funding for infrastructure development from central and local government, one of the key issues is that the implementation of electricity development policy has not been elaborated in the MP3EI document. Java and Sumatra economic corridors which represent Indonesia's Western Region (*Kawasan Barat Indonesia*, KBI) have played much more dominant economic role than Indonesia's Eastern Region (*Kawasan Timur Indonesia*, KTI). In 2010, KBI contributed about 81.2% of Indonesia's economy while the economy of KTI accounted for only about 18.8% of Gross Domestic Product (GDP). In terms of electricity, the figures are more pronounced: KBI accounted for about 92.77% of national electricity consumption but KTI only enjoyed about 7.23%. Generating electric power capacity growth in Indonesia has lagged behind the pace of electricity demand growth, leading to power shortages and a low electrification ratio. In 2013, around 76% of Indonesia's population had access to electricity. The uneven geographic distribution of electricity consumption, power shortages and relatively low electrification ratio are largely unexplored.

In the context of regional development, Indonesia is an excellent laboratory for studying the electricity consumption due to its unique geographical and demographical conditions. KBI covering Java and Sumatra islands is relatively much more developed when compared with KTI that covers Kalimantan, Sulawesi, Bali-Nusa Tenggara and Maluku-Papua. The disparity between Western and Eastern Indonesia in term of its regional electricity consumption and Gross Regional Domestic Product (GRDP) strongly suggest the importance to explore economic geography of electricity consumption in PLN's (*Perusahaan Listrik Negara*, State Electricity Company) distributive regions which are regrouped into 6 economic corridors. Electricity consumption has played an important role in Indonesia's regional development. Adequate electricity supply to meet the actual demand of industrial and household sectors will support rapid industrialisation and improve electrification ratio in underdeveloped regions. It is evident that electricity is one of the most important modalities to support a sustainable regional development.

Our aim here is to explore the Indonesia's economic geography of electricity consumption. How do regions vary in terms of electricity consumption and income per capita? Some hypotheses that will be tested are: (1) greater population within a region corresponds to greater probability for such region to have a higher consumption of electricity and higher GRDP per capita; (2) higher degree of industrialisation, as reflected by share of manufacturing industrial sectors to GRDP, tends to enhance the probability for those regions to have a higher consumption of electricity and GRDP per capita; (3) greater role of electricity to GRDP within a region tends to induce probability for the respective region to have a higher consumption of electricity and GRDP per capita; (4) higher poverty rate will lead to lower electricity consumption and income per capita.

The outline of this paper can be described as follows. First, it will highlight some literature survey on electricity consumption and regional economic growth. Second, it will describe briefly on the data and methodology. Third, our study will also examine the spatial patterns of the electricity consumption and regional income in the 14 PLN's distributive regions by using discriminant model to show some key factors beyond regional diversity. Finally, concluding remarks and policy implications will be given in the final section.

2. Literature Review

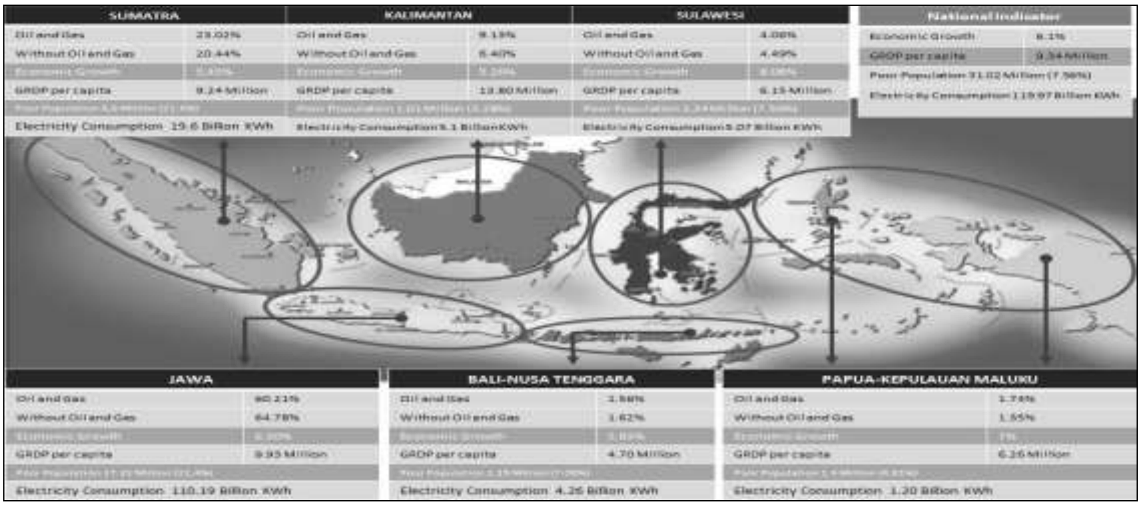
The purpose national electricity policy, based on the Electricity Law No. 30 year 2009, in particular article 2.2, is to secure the availability of sufficient and good quality electric power with affordable price to increase the welfare of all Indonesians (MEMR, 2011). PLN is a state-owned enterprise and mandated by the law to provide electricity service as a single operator. As the main objective of the electricity law is to improve the welfare of people and to support the economic growth, the government has a priority to fulfill electricity demand of households and industrial sector (MEMR, 2010). The policy direction and strategy are incorporated in some official documents, such as Energy Outlook 2008-2010, Annual State Budget and Expenditure Report (*Nota Keuangan* and *RAPBN*) and MP3EI. The general policy in energy sector, including electricity, is mostly supply and price oriented. The electricity price is set by the government involving huge subsidy, which is mostly aimed to control the inflation level. Table 1 shows that electricity and fuel subsidies have largely predominated the Indonesia's government subsidies during 2007-2013.

Item	2007	2008	2009	2010	2011	2012	2013
	Audited	Audited	Audited	Audited	Audited	Revised Budget	Budget
A. Energy	**116,865.90**	**223,013.20**	**94,585.90**	**139,952.90**	**255,608.80**	**202,353.20**	**274,743.00**
1. Fuel Subsidy	83,792.30	139,106.70	45,039.40	82,351.30	165,161.30	137,379.80	193,805.20
2. Electricity subsidy	**33,073.50**	**83,906.50**	**49,546.50**	**57,601.60**	**90,447.50**	**64,973.40**	**80,937.80**
B. Non Energy	**33,348.60**	**52,278.20**	**43,496.30**	**52,754.10**	**39,749.40**	**42,723.10**	**42,475.60**
1. Food subsidy	6,584.30	12,095.90	12,987.00	15,153.80	16,539.30	20,926.30	17,197.90
2. Fertilizer Subsidy	6,260.50	15,181.50	18,329.00	18,410.90	16,344.60	13,958.60	16,228.80
3. Seed Subsidy	479	985.2	1,597.20	2,177.50	96.9	129.5	1,454.20
4. Public Service Obligation	1,025.00	1,729.10	1,339.40	1,373.90	1,833.90	2,151.40	1,521.10
5. Interest Subsidy on Credit	347.5	939.3	1,070.00	823	1,522.90	1,293.90	1,248.50
6. Cooking Oil Subsidy	24.6	103.3	-	-	-	-	-
7. Tax Subsidy	17,113.60	21,018.20	8,173.60	14,815.10	3,411.80	4,263.40	4,825.10
8. Soybean Subsidy	-	225.7	-	-	-	-	-
9. Other Subsidy	1,514.00	-	-	-	-	-	-
Total	**150,214.50**	**275,291.40**	**138,082.20**	**192,707.00**	**295,358.20**	**245,076.30**	**317,218.60**

Source: MoF (2013)

Table 1: Indonesia's government subsidies, 2007-2013 (in billions rupiah)

The consumption of electricity for industry and business sectors is closely related to the quality of economic growth (Figure 1). An adequate primary energy and electricity infrastructure development are definitely required to increase the capacity of electric power supply. So far, the electricity policies and regulations emphasize more on the supply side, rather than driven by the actual demand. In the last few years, the electrification ratio has increased significantly from 62% (2005) to 67.2% (2010). In 2014, electrification ratio is projected to reach 80%. However, the disparities among regions within Indonesia still remain a serious challenge. Jakarta region, as the capital of Indonesia, is the only province with 100% electrification ratio, while the ratio for other provinces is ranging from 30% to 80%. The electrification ratio of many provinces is still as low as 30% to 58%, significantly lower than other developing countries with the similar level of income per capita. In terms of regional economic development, regional inequality tended to increase during the period of 2001-2010 due to between-island and within-island inequality (Kuncoro, 2013a).



Source: Compiled from BPS (2011a, 2011c); MEMR (2010)

Figure 1: National Share of GRDP and Regional Electricity Consumption (% Share of Total Indonesia), 2010

MP3EI is driven by the vision to create a self-sufficient, advanced, just, and prosperous Indonesia. The MP3EI vision is achieved through some strategic initiatives: (1) Encourage a large scale investment realisation in 22 main economic activities; (2) Synchronise national action plan to revitalise the real sector performance; (3) Develop centres of excellence in each economic corridor (CMEA, 2011). SBY's government implements MP3EI as the main strategyies by utilising the basic principles and success for acceleration and expansion of economic development. This masterplan has two key factors, i.e. acceleration and expansion. 'Acceleration' is a strategy that enable Indonesia to accelerate the development of various development programs, especially in boosting value added of its prime economic sectors, increasing infrastructure development and energy supply, as well as the development of human resources, science and technology. The government also pushes for the 'expansion' of Indonesia's economic development so that the positive effects of Indonesia's development can be felt not only at each and every region in Indonesia, but also by all components of the community across Indonesia. Although MP3EI contains the main direction of development for specific economic activities, one of the key issues is that the implementation of electricity development policy has not been elaborated in the MP3EI document.

Most of past studies have applied the Granger causality analysis with ECM techniques to identify the causal relationship between electricity consumption and economic growth. Causality tests between electricity consumption and GDP in Indonesia and Asian countries have been examined earlier by Murry and Nan (1996) using 1970-1990 period, Yoo (2006) using 1971-2002 period, and Harsono and Kuncoro (2013) using 1984-2000 period. The causality test performed by Chen, et al. (2006) using Granger causality test and Error Correction Model (ECM) found a long run relationship moving from electricity consumption to economic growth. These causality analyses have a number of shortcomings, in particular: first, either short-run or long-run directional relationship indicates that so far the policy implementation in electricity sector has been driven by "ad-hoc" approach; second, there is a limited insight on regional policy with respect to low electrification ratio, high incidence of poverty, and non-industrial regions in KTI; third, they neglect regional variations within a country. The role of sub-national region, province, district, and city in affecting the location of economic activity would appear to be more important. Numerous studies from the field of socio-economic restructuring and structural change have emphasised recently the growing importance of regions and their new role as basic economic actors in the configuration of a new spatial pattern of economic development (Rodriguez-Pose, 1998: chap.3).

Unlike majority of previous studies, this study used combination of regional spatial data and discriminant model to identify electricity consumption and regional economic performance for Indonesia. This study will fulfil the gaps, especially studies regarding electricity consumption and regional economic performance for Indonesia using a multivariate discriminant modelling.

3. Methodology

(i) Data

Spatial data mining refers to the process of extracting significant implicit knowledge from large amounts of spatial data. In general, spatial data mining techniques extract patterns of three different types (Koperski and Han, 1995; Megalooikonomou, et al. 2008): *spatial characteristics* (general characteristics and patterns of a spatial-entities set, such as precipitation patterns in meteorological maps), *spatial associations* (implications and associations among spatial features), and *spatial discriminant patterns* (contrasting discriminative characteristics of distinct spatial entity classes). Classification in the context of spatial data is defined as the process of assigning non-spatially related labels to classes of spatial entities. For this purpose, discovering spatial patterns that are discriminative among classes is very useful. Discovering such patterns is the main focus of this paper.

Instead of using only aggregate data of Indonesia as one analysis unit, this study will use pooling data of real GRDP of 33 provinces. The annual data for real GRDP are obtained from Badan Pusat Statistik (BPS) and the annual data for electric power consumption are obtained from PLN. However, electricity consumption data are based on the 14 PLN's distributive regions. To combine those two different data sets, the GRDP data are then regrouped into the 14 PLN's distributive regions. In Indonesia, regions are usually interpreted as provinces and districts (municipalities and cities) based on administrative reason. However, PLN classifies regions based on a set of provinces or just a province. Recently, the SBY regime introduced economic corridors as "regions" consisting of several provinces in the same island or several island forming as a corridor. Table 3 summarizes different concepts of regions in Indonesia. Therefore, our study attempt to test these different concepts of regions by using discriminant analysis. Both set of data are also regrouped into 6 economic corridors in line with the MP3EI, namely Sumatra, Java, Kalimantan, Sulawesi, Bali-Nusa Tenggara, and Papua-Maluku (Table 2). The period of 1993-2010 is determined based on the availability of regional electricity consumption and regional income data. The real GRDP data are expressed in rupiah at constant price 2000 over the period 1993-2010 while the electric power consumption is expressed in unit of Kilowatt hours (KWh). The discriminant analysis is performed by using SPSS 21.0 version.

Provinces			Distributive Regions of PLN	Economic Corridors
1. Nangroe Aceh Darussalam (NAD)			1. NAD Region	1. SUMATRA
2. North Sumatra			2. North Sumatra Region	
3. West Sumatra	4. Riau	5. Riau Islands	3. West Sumatra and Riau Region	
6. South Sumatra	7. Jambi	8. Bangka Belitung Islands	4. South Sumatra Region	
9. Bengkulu	10. Lampung			
11. West Java	12. Jakarta Special District (DKI)	13. Banten	5. West Java and DKI Region	2. JAVA
14. Central Java	15. Yogyakarta Special District (DIY)		6. Central Java and DIY Region	
16. East Java			7. East Java Region	
17. Bali	18. West Nusa Tenggara	19. East Nusa Tenggara	8. Bali, West and East Nusa Tenggara Region	3. BALI - NUSA TENGGARA
20. West Kalimantan			9. West Kalimantan Region	4. KALIMANTAN
21. Central Kalimantan	22. South Kalimantan	23. East Kalimantan(*)	10. Central, South, and East Kalimantan Region	
24. North Sulawesi	25. Central Sulawesi	26. Gorontalo	11. Suluttenggo Region	5. SULAWESI
27. South Sulawesi	28. West Sulawesi	29. South-East Sulawesi	12. Sulselrabar Region	
30. Maluku	31. North Maluku		13. Maluku Region	6. PAPUA - MALUKU
32. Papua	33. West Papua		14. Papua Region	

Notes: (*): Based on the Law No. 20/2012, a part of East Kalimantan Province was declared in 2012 as the 34th province of Indonesia named as North Kalimantan province.

Source: PLN (2011); BPS (2011); CMEA (2011: 51, 74, 96, 120)

Table 2. Provinces, PLN distributive regions, and economic corridors

For each economic corridor, the SBY regime set its MP3EI's theme and provincial coverage. Sumatra economic corridor which connects its main economic centres from Banda Aceh (in NAD province), Medan, Pakanbaru, Jambi, Palembang, and Bandar Lampung is set as a centre for production and processing of natural resources as the nation's energy reserves. Java's economic corridors connecting its main economic centres from Banten, Jakarta, Bandung, Semarang, Yogyakarta, to Surabaya is set as a driver for national industry and services provision.

Major economic centres of Kalimantan corridor involving Pontianak, Palangkaraya, Banjarmasin and Samarinda is designed for a center for production and processing of national mining and energy reserves. Sulawesi corridor is expected to be production and processing centre of agricultural, agriculture, fisheries, oil and gas, and mining national, and become the forefront in serving markets of East Asia, Australia, Oceania, and America via its major centres (Makassar, Mamuju, Kendari, Palu, Gorontalo, Manado). Major economic centres of Bali-Nusa Tenggara corridor are Denpasar, Lombok, Kupang. Papua-Maluku corridor have been designed to be the centres for development of food, fisheries, energy and national mining that connects its main economic centres from Ambon, Sofifie, Sorong, Manokwari, Timika, Jayapura and Merauke.

Table 3 shows the economic indicators and characteristic of electricity consumption in each economic corridor that indicate the occurance of regional variations. The highest electricity consumption per capita is in Java (874.70 Kwh/capita), followed by Sumatra (388.64

Kwh/capita), Kalimantan (372.13 Kwh/capita), Bali-Nusa Tenggara (325.90 Kwh/capita), Sulawesi (313.12 Kwh/capita), and Papua- Maluku (195.93 Kwh/ capita).

Corridors	Population		GRDP		GRDP Per Capita	Electricity Consumption Per Capita
	%	Millions	%	Rp Millions	Rp Millions	KwH
Sumatra	22.43	50.63	21.07	467.82	9.24	388.64
Java	55.78	125.97	61.05	1355.44	10.76	874.70
Kalimantan	6.11	13.78	8.57	190.16	13.80	372.13
Sulawesi	7.17	16.21	4.81	106.82	6.59	313.12
Bali-Nusa Tenggara	5.78	13.07	2.77	61.43	4.70	325.90
Papua-Kepulauan Maluku	2.73	6.16	1.73	38.50	6.25	195.93
Indonesia	100.0*	225.82*	100.0*	2220.18*	9.84**	644.46**

* = total
** = average

Sources: Calculated from BPS (2011); PLN (2011)

Table 3: Electricity Consumption and Economic Indicator of Indonesia's Six Economic Corridors (2010)

Java is one of the smallest corridor in terms of size of island among others but it has the highest concentration of 55.78% of total population, followed by Sumatra with 22.43% of total population. Java and Sumatra regions represent the KBI with 30.63% of the total area and 78.21% of the total population of Indonesia. In terms of GRDP, KBI contributes 82.12% of the national GDP. In contrast, the other four corridors within KTI, i.e. Kalimantan, Sulawesi, Bali-Nusa Tenggara, and Papua-Maluku, only account for 6.11%, 7.17%, 5.78%, and 2.73% of the total Indonesia's population respectively. In terms of income per capita, Kalimantan with Rp13.8 millions per capita has the highest income per capita among all other regions, followed by Java (Rp10.76 million per capita), Sumatra (Rp9.24 million per capita), Sulawesi (Rp6.59 million capita), Papua-Maluku (Rp6.25 million per capita), and Bali-Nusa Tenggara (Rp4.7 million per capita).

KBI region with only representing 30.63% of the national territory has a portion of 78.21% of national population and 82.12% of GDP. In contrast, KTI region, representing 69.37% of the national territory, has only a portion of 21.79% population and contributes only 17.88% of national GDP. The imbalanced population concentration and economic activities between KBI and KTI regions have created serious disparity across regions, between and within islands in the Indonesia's economic development (Kuncoro, 2013, 2012).

KBI with only representing 30.63% of the national territory has a portion of 78.21% of national population and 82.12% of GDP. In contrast, KTI, representing 69.37% of the national territory, has only a portion of 21.79% population and contributing only 17.88% of national GDP (Table 3). The imbalanced population concentration and economic activities between KBI and KTI regions have created serious disparity across regions, between and within islands in the Indonesia's economic development (Kuncoro, 2013, 2012).

(ii) Discriminant Model

One of major issues in economic geography (Fujita, et al., 1999; Krugman, 1995; Kuncoro, 2012b, 2013a) is related to *where* the economic activities take place and *why do* electricity demand and supply are concentrated geographically in some regions. More specifically, we will use discriminant analysis to address the following issues. Discriminant analysis is widely applied to serve the dual objectives of discrimination and classification. Group separation is achieved by means of a discriminant function, while identification of future individual is handled through a classification rule (Krzanowski and Marriott, 1995: 1).

Unlike regression analysis, the objective in discriminant analysis is to find a linear combination of the predictors that minimise the probability of misclassifying individuals or objects into their respective groups (Dillon and Goldstein, 1984: 360-3). Discriminant analysis is a statistical technique for classifying individuals or objects into mutually exclusive groups on the basis of a set of predictors. The overall test of relationship between predictors and groups in the discriminant analysis is the same as the test of the main effect in multivariate analysis of variance (MANOVA), where all discriminant functions are combined and grouping variables are considered simultaneously (Tabachnick and Fidell, (1996). Therefore, MANOVA allows us to look at how groups differ, while discriminant analysis allows us to predict what factors discriminate between two or more groups. Detecting spatial sub-regions that are discriminative among different classes using multivariate discriminant models have been applied extensively in regional information system with three dimensional image data (Megalooikonomou et al. 2008), industrial districts in Indonesia (e.g. Kuncoro, 2013b), grain marketing system in USA (Baldwin et al. 1984), and distinguishing between breeds of Nigerian sheep (Yunusa et al. 2013).

The discriminant function analysis was performed to show what predictors are the key factors in explaining four regional groups (Table 5). The 14 regions in Indonesia can be divided into four groups based on GRDP per capita and Regional Electricity Consumption (REC) per capita. The former reflects to what extent a region performs; while the latter indicates regional performance in terms of electricity consumption per person. Regional groups that treated as dependent variables are: low electricity consumption and low income (D_1), low electricity consumption but high income (D_2), high electricity consumption but low income (D_3), and high electricity consumption and high income (D_4). These groups are slightly different with previous studies that use provincial economic growth and GRDP per capita (Hill, 1989; Kuncoro, 2004, 2012a, 2013a). The discriminant analysis was performed to explain what are the key determinants beyond 4 regional groups. Modelling using discriminant approach is suitable given the data available. As has been explained in section 3.i, this study attempts to explore spatial discriminant patterns by contrasting discriminative characteristics of distinct spatial entity classes using some predictors: (a) *Population* (POP), (b) *Industrialisation* (IND), (c) *Electricity* (ELEC) and (d) *Poverty* (POV). Our discriminant function is based on the following equation:

$$D_i = d_{i1}\,POP + d_{i2}\,IND + d_{i3}\,ELEC + d_{i4}\,POV$$

Each predictor is selected based on relevant theories and previous studies. The following will elaborate some key reasons and hypotheses for each predictor.

Region	REC per Capita	GDRP per Capita	Regional Group*
NAD	155	10,133,324	2
North Sumatra	326	6,494,123	3
West Sumatra & Riau	273	11,717,338	2
South Sumatra	170	4,842,236	1
East Java	403	6,625,057	3
Central Java & DIY	272	4,034,242	1
West Java & DKI	938	11,607,327	4
West Kalimantan	170	5,156,765	1
Central, South & East Kalimantan	285	15,044,808	4
Suluttenggo	160	4,650,988	1
Sulselrabar	184	4,207,715	1
Bali, West and East Nusa Tenggara	195	3,619,958	1
Maluku	152	9,121,890	2
Papua	150	9,471,248	2
Average	274	7,623,358	

* 1= low electricity consumption and low income; 2= low electricity consumption and high income; 3= high electricity consumption and low income; 4= high electricity consumption and high income.

Sources: Calculated from PLN (2011) and BPS (2011)

Table 5: REC and GDRP in PLN's Distributive Regions, 1993-2010

Population (POP). Krugman (1991: 23-4) argued that more populous locations will attract concentrations of manufacturing production, assuming that those locations offer a sufficiently larger local market than others, and that fixed costs are large enough relative to transport costs. We use the total population of 14 regions (POP) as a proxy for market size. This variable has also been used to show the effect of generically named external economies of urbanisation (Costa-Compi and Viladecans-Marsal, 1999: 2090). We will test the hypothesis whether a greater population within a region corresponds to greater probability for such region to have a higher consumption of electricity and higher GRDP per capita.

Industrialisation (IND). The study of Adams and Pigliaru (1999) in Western European countries suggest that industrial output growth is positively associated with overall productivity growth. Those regions are still characterized by large differences in terms of sectoral specialisation, productivity levels, and growth. These differences appear to play a crucial role in determining the overall growth rate of regional economies. Therefore, we will examine to what extent higher degree of industrialisation, as reflected by share of manufacturing industrial sectors to GRDP, tend to enhance the probability for those regions to have a higher consumption of electricity and GRDP per capita.

Electricity (ELEC). Figure 2 shows the disparity between eastern and western Indonesia in terms of electrification ratio. The eastern part of Indonesia, especially Papua, West Nusa Tenggara (NTB), East Nusa Tenggara (NTT), South-East Sulawesi (Sulteng), South East Sulawesi (Sultra), and Gorontalo have relatively very low electrification ratio. It shows that those regions in eastern Indonesia with low electrification ratio also have low GRDP per capita. The regional investment for electricity sector has significant contribution towards economic performance of regions. The use of electricity may adversely affect economic growth while increase in electricity may contribute the economic growth (Altinay and Karagol, 2005; Shiu and Lam, 2004). Thus, we will test the hypothesis whether a greater role of electricity to GRDP within a region tend to induce probability for the respective region to have a higher consumption of electricity and GRDP per capita.

Poverty (POV). Figure 3 shows the spatial pattern of poverty in Indonesia. Kuncoro (2013a) found that high incidence of poverty is concentrated geographically in the Indonesian eastern regions. The pattern is found in the KTI provinces, in particular Papua, West Papua, Maluku, NTT, NTB, Gorontalo, Central Sulawesi, which have poverty rate about 15-31.24%, higher than the national average which is 13.33%. By contrast, the western regions of Indonesia generally have lower poverty rate than the national average. Therefore, we will test the hypothesis whether higher poverty rate will lead to lower electricity consumption and income per capita.

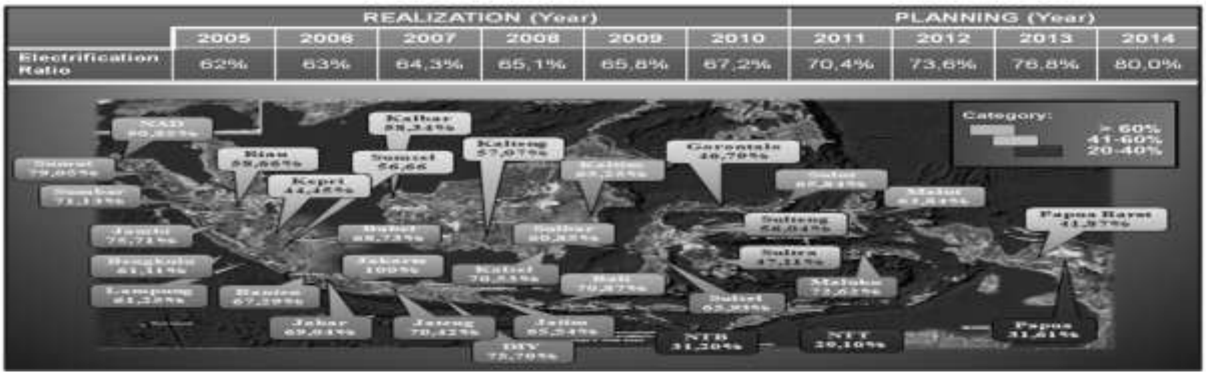


Figure 2: Electrification Ratio by Province, Indonesia 2005-2014

4. Findings and Discussions

Overall, our discriminant model allocates correctly more than 92.5% of the original group cases. Table 6 provides a classification summary for the model, which incorrectly allocates only 11 regions to low electricity and GRDP, 3 regions to high GRDP and low electricity, and 5 regions to high electricity and GRDP. In terms of high electricity and GRDP, the model allocates perfectly 36 cases. As a result, the correctly predicted group membership is 100% for high electricity consumption and GRDP, 86.1% high electricity consumption and low GRDP, 95.8% to high GRDP and low electricity consumption and 89.8% for low electricity and GRDP.

Source: Compiled from BPS (2011a, 2011c)

Figure 3: Poverty Map by Province in Indonesia, 2010 (%)

The results of a direct discriminant function analysis using four predictors suggest that population plays a key role as the best predictor in discriminating 14 regions by electricity consumption and GRDP per capita (Table 6). The coefficient for this variable shows a positive sign. This implies that the higher the number of population in a region the more likely that electricity consumption and GRDP per capita will increase. The findings supports Krugman's study (1991: 23-4) arguing that more populous locations will attract concentrations of manufacturing production, and hence, induce electricity consumption and income per capita.

The coefficient of electricity per GRDP shows a positive sign (Table 7). This implies that the higher the number of electricity per GRDP in a region, the higher the electricity consumption and GRDP per capita. The finding is consistent with some previous studies (Altinay and Karagol, 2005; Shiu and Lam, 2004) that increase in electricity contributed to the economic growth. The coefficient of industry per GRDP shows a positive sign. This implies that the higher the number of industry per GRDP in a region, the higher the electricity consumption and GRDP per capita. Our analysis shows that the industrial output growth is positively associated with overall productivity growth, and hence, increase the GRDP per capita. Our finding supports the study of Adams and Pigliaru (1999: 213-221) in Western European countries.

			Predicted Group Membership				
		Classification	Low Electricy and GRDP	High GRDP and Low Electricy	High Electricy and Low GRDP	High Electricy and GRDP	Total
Original	Count	Low Electricy and GRDP	97	0	1	10	108
		High GRDP and Low Electricy	0	69	3	0	72
		High Electricity and Low GRDP	0	5	31	0	36
		High Electricy and GRDP	0	0	0	36	36
	%	Low Electricy and GRDP	89,8	,0	,9	9,3	100,0
		High GRDP and Low Electricy	,0	95,8	4,2	,0	100,0
		High Electricy and Low GRDP	,0	13,9	86,1	,0	100,0
		High Electricy and GRDP	,0	,0	,0	100,0	100,0

a. 92,5% of original grouped cases correctly classified.

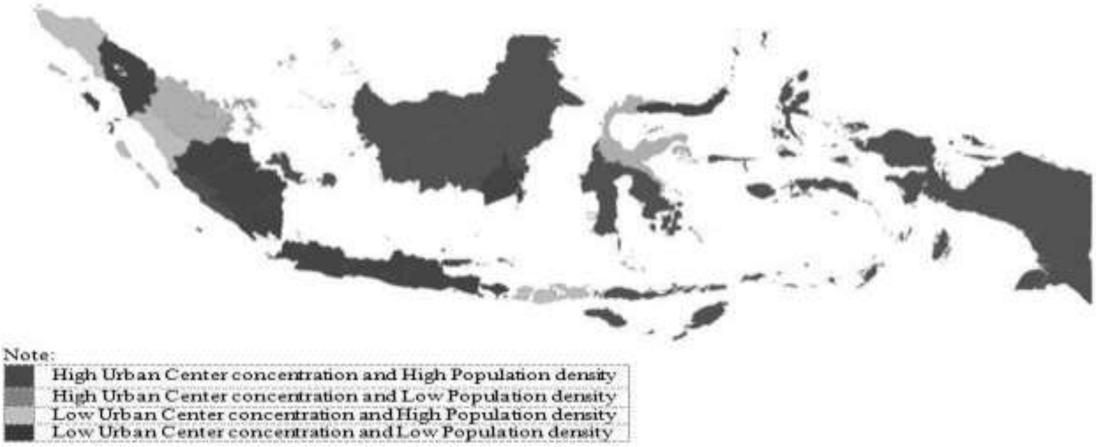
Table 6: Classification Results

	Function		
	1	2	3
Poverty Rate	-,133*	,132	,013
Industry per GRDP	,147	-,732*	,530
Electricy per GRDP	,160	-,520*	,300
Sulawesi Corridor	,086	,437*	,120
Population	,166	-,402*	,324
Java Corridor	,101	-,344*	,302
Bali NTT Corridor	,054	,276*	,076
Kalimantan Corridor	,143	-,149	-,323*
Sumatra Corridor	-,140	-,053	,199*

Table 7: Structure Matrix

As shown by Figure 4, there was a positive association between industrial density and population density across regions in Indonesia The positive coefficient of population density and income per capita shows that both scale of economies and large market size explain regional localisation over time that attract industries especially Large and Medium Enterprises (LME). Our study is in line with Kuncoro and Putro (2013) that found industrial and population density are the two key predictors in geografic concentration of economic activities in Indonesia.

The coefficient of poverty in a region shows a negative sign. This implies that the higher the poverty rate in the region, the the more likely that electricity consumption and GRDP per capita will be low. In the core and periphery model, core regions usually have high electricity and GRDP per capita, while the periphery regions tend to have low electricity and GRDP per capita. Fujita et al. (1999: 61-77) argued that manufacturing will shift overtime to the peripheral regions; otherwise, a core-periphery pattern is an equilibrium, and hence, the concentration of manufacturing will be self-sustained. Our findings highlights that periphery regions have higher poverty rate than those of core regions.



Source: Calculated from BPS (2011)

Figure 4: Employment Distribution by Main Islands and Urban Centers in Indonesia, 2010

Table 8 shows the Chi-square for each discriminant function. From discriminant function 1 through 3, 2 through 3, and 3, the Chi-square indicates a highly reliable relationship between groups and predictors. These findings indicates the first and the second discriminant functions are reliable with 99% level of confidence.

Test of Function(s)	Wilks' Lambda	Chi-square	df	Sig.
1 through 3	,029	869,810	27	,000
2 through 3	,319	278,992	16	,000
3	,660	101,487	7	,000

Table 8: Wilks' lambda and Chi-Square

5. Conclusions

Our analysis is a pioneering study of Indonesia's electricity consumption and regional economic development that incorporates 'geography' in the problem of underdevelopment. As the regional implementation of electricity development policy has not been elaborated in the MP3EI document, this paper has attempted to explore some spatial patterns of electricity consumption. Our findings showed four groups of regions as follows: regions with high electricity consumption and high income (West Java & DKI, Central-South & East Kalimantan), high electricity consumption but low income (East Java, North Sumatra), high electricity consumption but low income (NAD, West Sumatra & Riau, Maluku, Papua), both low electricity consumption and income (South Sumatra, Central Java & DIY, West Kalimantan, Suluttenggo, South-East Sulawesi, Bali, NTB & NTT).

Our findings also showed to what extent these four groups are distinctive by applying discriminant analysis based on some key predictors. Based on the key predictors, those are population, industrialisation, electricity development, and poverty, we found that the best predictor varied markedly across regions and corridors. The positive coefficient of population supports Krugman's study (1991: 23-4) arguing that more populous locations tend to attract concentrations of manufacturing production, and hence, induce electricity consumption and income per capita. The positive coefficient of electricity per GRDP implies that the higher the number of electricity per GRDP in a region, the higher the electricity consumption and GRDP per capita, and hence, is consistent with some previous studies (Altinay and Karagol, 2005; Shiu and Lam, 2004) arguing that increase in electricity contributed to the economic growth. In other words, our study is also in line with Kuncoro and Putro's finding (2013) whereas industrial and population density are the two key predictors that determine the characteristic of electricity consumption. Our finding also highlights that periphery regions have higher poverty rate than those of core regions.

The discriminant analysis is proven to be useful as the basis to integrate the formulation of electricity as well as regional development policy. The findings show that Indonesia needs electricity and regional development policies that incorporate regional variations in term of population, industrialisation, electricity development, and poverty. Our findings showed that regional characteristics and diversity do matter in the Indonesia's economic corridors and regions. Our findings may complement Porter's (2003) study which revealed that the performance of regional economies in the US varies in terms wages, wage growth, employment growth, and patenting. In Indonesia, by contrast, the performance of regional economies and electricity consumption varies markedly in terms of population, industrialisation, electricity development, and poverty.

National development priorities and implementation of MP3EI need to be followed by concrete actions to improve the coherence between various level of governments (central, provinces, municipalities, cities), businesses, academicians, and civil society. Therefore, the study recommends an inclusive development strategy, combining electricity and regional development, needs to be implemented more seriously. Major objective of this strategy is to reach out and uplift the whole society (development for all). Our findings offer some insights about spatial aspect of the Indonesia's electricity consumption and regional development. More importantly, Indonesia can enhance the performance of regions by taking into account the spatial dimension of population, industrialisation, electricity development, and poverty.

Acknowledgement

We appreciate the Academy of Business & Retail Management that accepted this paper in the International Conference of Restructuring of the Global Economy, in Cambridge, UK, 23-24 June 2014. Our thank also goes to Adrian Nalendra Perwira for editing this paper.

References

Adams, J. and Pigliaru, F., 1999. Economic growth and change: national and regional patterns of convergence and divergence. *Economia Politica*, 3: 509-511.

Altinay, G. and Karagol, E., 2005. Electricity consumption and economic growth: evidence from Turkey. *Energy Economics*, 27: 849-856.

Badan Pusat Statistik (BPS), 2011a. Produk Domestik Regional Bruto atas dasar harga konstan 2000 menurut provinsi, 2004-2010 [Regional gross domestic products based on constant price 2000 by provinces, 2004-2010], Retrieved July 25, 2012, from http://www.bps.go.id/tab_sub/view.php?kat=2&Table=1&daftar=1&id_subyek=52&notab=2.

Baldwin, E.D., Thraen, C.S., and Larson, D.W. 1984. A discriminant analysis of grain market structure in selected states of the South and Cornbelt. *Southern Journal of Agricultural Economics*, December: 117-125.

BPS, 2011b. Penduduk Indonesia menurut provinsi 1971, 1980, 1990, 1995, 2000 and 2010 [Indonesia population based by provinces 1971, 1980, 1990, 1995, 2000 and 2010]. Retrieved January 24, 2013, from http://www.bps.go.id/tab_sub/view.php?kat=1&Table=1&daftar=1&id_subyek=12&notab=1.

BPS, 2011c. *Data Sosial Ekonomi [Economic Social Data]*, 3 August, Jakarta: BPS.

Chen, S. T., Kuo, H. I., and Chen, C. C., 2006. The relationship between GDP and electricity consumption in 10 Asian countries. *Energy Policy*, 35: 2611-2621.

Coordinating Minister of Economic Affairs (CMEA), 2011. *Masterplan for Acceleration and Expansion of Indonesia Economic Development 2011-2025*. Jakarta: Coordinating Ministry for Economic Affairs, Republic of Indonesia.

Costa-Campi, M. T. and Elisabet Viladecans-Marsal, E., 1999. The district effect and the competitiveness of manufacturing companies in local productive systems. *Urban Studies*, 36: 2090.

Dillon, William R. and Goldstein, 1984. *Multivariate Analysis Methods and Application.* New York: John Wiley & Sons Inc.

Fujita, M, Krugman, P, and Venables, A.J., 1999. *The Spatial Economy: Cities, Regions and International Trade*. Cambridge, MA.: MIT Press.

Granger, C. W. J., 1969. Investigating Causal Relation by Econometric Models and Cross-Spectral Methods. *Econometrica*, 37(3): 424-438.

Granger, C. W. J. and Newbold, P., 1974. Spurious regressions in econometrics. *Journal of Econometrics*, 2: 111-120.

Harsono, T. D. and Kuncoro, M., 2013. Electricity consumption and economic growth**:** a causality evidence from six economic corridors of Indonesia, 1984-2010, *International Journal of Business, Economics and Law*, 2: 33-55.

Hill, H., 1989. *Unity and Diversity: Regional Economic Development in Indonesia Since 1980*. Singapore: Oxford University Press.

Koperski, K., and Han, J. 1995. Discovery of spatial association rules in geographic information databases. *4th international symposium on large spatial databases* (SSD'95). Portland, Maine.

Krugman, P., 1995. *Development, Geography, and Economic Theory*. Cambridge and London: The MIT Press.

Krugman, P., 1991. *Geography and Trade*. Cambridge MA: MIT Press.

Kuncoro, M., 2004. *Otonomi dan Pembangunan Daerah [Regional Autonomy and Development]*. Jakarta: Erlangga.

Kuncoro, M., 2012a. *Perencanaan Daerah: Bagaimana Membangun Ekonomi Lokal, Kota, dan Kawasan [Regional Planning: How to Develop Local Economy, Cities and Zones]*. Jakarta: Salemba Empat.

Kuncoro, M., 2012b. *Ekonomika Aglomerasi: Dinamika dan Dimensi Spasial Kluster Industri Indonesia [Economics of Agglomeration: Dynamics and Spatial Dimension of Indonesia's Industrial Clusters]*. Yogyakarta: UPP STIM YKPN.

Kuncoro, M., 2013a. Economic geography of Indonesia: can MP3EI reduce inter-regional inequality? *South East Asia Journal of Contemporary Business,Economics, and Law*,2(2):17-33.

Kuncoro, M., 2013b. Economic geography of small and cottage industrial clusters in Java Island Indonesia. *Global Advanced Research Journal of Geography and Regional Planning*, 2(1): 006-018.

Kuncoro, M. and Putro, S., 2013c. *Economic geography of Indonesia's manufacturing industry.* Faculty of Economics and Business Working Paper. Yogyakarta: Universitas Gadjah Mada.

Krzanowski, W.J. and Marriott, F.H., 1995. *Multivariate Analysis Part 2 Classification, Covariance Strutures And Repeated Measurements.* London: Hodder Arnold.

Megalooikonomou, V., Kontos, D., Pokrajac, D., Lazarevic, A. and Obradovic, Z. (2008). An adaptive partitioning approach for mining discriminant regions in 3D image data, *J Intell Inf Syst*, 31:217–242.

MEMR, 2010. Statistik listrik [Statistic of electricity]. Retrieved 10 August 10, 2010, from http://www.esdm.go.id/publikasi/statistik/cat_view/58-publikasi/240-statistik/354-statistiklistrik.html.

MEMR, 2011. Undang-Undang Nomor 30 Tahun 2009 tentang Ketenagalistrikan [Law No. 30 Year 2009 on Electricity], Retrieved September 12, 2011, from http://www.esdm.go.id/regulasi/uu/cat_view/64-regulasi/75-undang-undang/314-tahun-2009.html.

Ministry of Finance (MoF), 2013. *Budget Statistics 2007-2013*. Jakarta: MoF.

Murry, D. A., & Nan, G. D., 1996. A definition of the Gross Domestic Product–electrification interrelationship. *The Journal of Energy and Development*, 19(2), 275-283.

Perusahaan Listrik Negara (PLN), 2010. *Statistik PLN (1984-2010) [PLN by Statistics (1984-2010)]*. Jakarta: PLN.

Porter, M.E., 2003. The Performance of Regions. *Regional Studies*, 37.6 & 7: 549-578.

Rodriguez-Pose, A., 1998. *The Dynamics of Regional Growth in Europe: Social and Political Factors.* Oxford: Clarendon Press.

Shiu, A. and Lam, P.L., 2004. Electricity Consumption and Economic Growth in China. *Energy Policy*, 32(1), 47-54.

Yoo, S. H., 2006. Electricity consumption and economic growth: evidence from Korea. *Energy Policy*, 33: 1627-1632.

Tabachnick, B. G., & Fidell, L. S., 1996. *Using Multivariate Statistics* (3rd ed.). New York: Harper Collins.

Yunusa, A.J., Salako, A.E., and Oladejo, O. A. 2013. Morphometric characterization of Nigerian indigenous sheep using multifactorial discriminant analysis. *International Journal of Biodiversity and Conservation,* 5(10), pp. 661-665, Retrieved July 1, 2014, from http://www.academicjournals.org/IJBC.