ECONOMIC, ENERGY AND CO_2 INTENSITY VALUATION IN INDONESIA'S MANUFACTURING INDUSTRY[1]

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Abstract

The analysis on manufacturing sector mostly focuses on economic valuation such as output, value added, and employment, but few studies attempt simultaneously to analyze economic, energy consumption and carbon dioxide emissions (CO_2). We applied the graph theory to select the dominant industries based on selected criteria. We found that food industry became a dominant industry. However, none industry was dominant for the all criteria. This implied that pro growth is not always similar with pro environment, even the two criteria can be conflicted one and another. We argue that different characteristics of industry need to be considered in evaluating industry performance. Finally, in terms of policy intervention, we suggest government to construct intensity indicator and to develop broad policy framework in enhancing energy efficiency.

Abstrak

Analisis sektor industri manufaktur lebih banyak fokus pada evaluasi aspek ekonomi, seperti output, nilai tambah, dan kesempatan kerja, namun tidak banyak studi yang secara simultan mencoba untuk mengombinasikan aspek konsumsi energi dan emisi gas karbon dioksida (CO_2) di dalam analisis. Kami mengaplikasikan teori grafik (graph theory) untuk memilih industri dominan berdasarkan pada beberapa kriteria tersebut. Kami menemukan bahwa industri makanan menjadi industri dominan. Namun, tidak ada satupun industri yang mendominasi semua kriteria. Hasil ini menunjukkan bahwa pro-pertumbuhan tidaklah harus sama dengan pro-lingkungan hidup, bahkan kedua kriteria tersebut dapat saling bertentangan satu dengan lainnya. Kami berargumentasi bahwa perbedaan dalam hal karakteristik industri menjadi penting diperhatikan dalam menilai kinerja industri. Akhirnya, dalam konteks intervensi kebijakan, kami menyarankan pemerintah perlu menyiapkan indikator intensitas dan membangun kerangka kebijakan yang lebih menyeluruh untuk memacu efisiensi energi.

Keywords: *manufacturing, output, employment, value added, energy, CO_2 emissions*

I. INTRODUCTION

In many literatures, analysis on industrial sector mostly focuses on economic valuation such as output, value added, export and labor absorption. However, following the Gleneagles Summit the Group of Eight (G8) in 2005, industrial sector also needs to developed clean, clever, and competitive energy (3C) in the future (IEA, 2007). In the world's level about 30% of energy consumption and 36% of carbon dioxide (CO_2) emission are attributed to manufacturing industries (IEA, 2007). Similarly, United Nations Industrial Development Organization/UNIDO also greatly

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tends to decrease. This is because of changing in relative fuel prices, shifting in industry structure and process, and implementing environmental legislature to promote clean energy. As a result, there is a decline in CO_2 intensity of fossil fuel use or total final energy used grow much higher than CO_2 emissions. However, industry sector depends on electricity and many of electricity generators supplied by fossil fuel. Finally, most of countries experienced decreasing in energy intensity (ratio of final energy use per unit of value added).

In Japan factories and other workplaces with certain level of annual energy consumption above the threshold need to have energy managers and to prepare and submit regularly reports on energy use (IEA, 2008a). Further Ministry of Economy, Trade and Industry (METI) of Japan conducts on-site inspection on how success factories improving energy efficiency. The Japanese government also assists small and medium enterprises (SMEs) to improve energy efficiency and to reduce CO_2 emissions through energy-efficient equipment and government loan. Finally, there is also possible interaction between SMEs and large companies on greenhouse gas emissions credit trading to implement potential energy-conservation projects (IEA, 2008a).

In Indonesia, energy efficiency has become an intermediate target to improve industrial competitiveness, especially for companies that relatively more energy intensive. Further, discussion on declining in Indonesia industrial competitiveness lead to three failures conclusion namely failure to develop supplier and support industries, to diversify its manufacturing based, and to achieve technological deepening of its manufacturing sector (Dhanani, 2000). The last arguments directly and indirectly lead to the important of energy efficiency. However there are many challenges to increase energy efficiency through technology. According to Energy Policy Review of Indonesia (IEA, 2008b), get price right is important to improve energy efficiency. Energy subsidies become disincentive for improving efficiency performance standard in many industry sectors in Indonesia (IEA, 2008). In terms of institutional setting, IEA (2008) also suggested that it is important to integrate many agencies

Table 1. Indonesia in the Global Production 2004

Production	Production	Rank in the world
Methanol (Mt)	1	12
DRI (direct reduced iron or sponge iron) Mt/yr	1.5	13
Cement (Mt/ yr)*	37	12
Paper and paperboard (Mt)	7.22	12
Chemical and mechanical wood pulp (Mt)	5.21	12
Primary copper (Mt/year)	0.21	18

Note: *Year 2005

Source: IEA (2007)

Table 2. Comparing Energy Intensity in Some Sectors

Products	Indonesia	Comparable SE Asian	Best practice
Steel: Electric arc furnaces	700 kWh/t	604 kWh/t (India)	500 kWh/t (Japan)
Low-quality ceramics	16.6 GJ/t	12.9 GJ/t (Vietnam)	-
Tyres	8100 kcal/kg	7000 kcal/kg (Thaiwland)	-
Cement	800 kcal/kg clinker	-	773 kcal/kg clinker
Glass	12.4 GJ/ton	-	10.2 GJ/ton

Source: IEA (2008) Table 5.3

concerns on millennium development goals / MDGs point 7, namely ensure environmental protection. One of the activities under the UNIDO program is Industrial Energy Efficiency and Climate Change. International Energy Agency (IEA, 2007) also has developed new approach in developing 3C and the new energy use indicators based on physical production e.g. energy use per tonne of product. However, IEA (2007) said that data availability and reliability are still the major challenge.

At the global production level, as seen from Table 1, for some manufacturing products, Indonesia is on the top 20. As the world's largest producer, Indonesia needs to promote industrial efficiency in terms of energy use. This is not only benefits the consumers but also improve industrial competitiveness in the global market. As seen from Table 2, energy intensity in some sectors is higher than other Southeast Asian countries and the best practice level.

At the national level, industrial sector is important not only in terms of its contribution on output, labor absorption, energy consumption, but also in terms of CO_2 emissions. For example, non-oil and gas manufacturing industry has the highest contribution to gross domestic product (GDP). Between 2005 and 2009, it shared to GDP slightly decreased from 22.42% to about more than 22.57% (Ministry of Industry, 2010). Further, according to BPS (2010) on August 2010, share of employment in industrial sector was about 12.7%. This is the fourth largest after agricultural, trading and social services sector. In terms of final energy consumption, industrial sector consumed about 41% of total energy consumption in 2008 that was the highest compare to other sectors (Ministry of Energy and Mineral Resources, 2009). Finally, in terms of CO_2 emissions, share of industrial sector was in the top rank that is about 30% (Sambodo, 2010).

Following concern on sustainable development, and the important of Indonesian's manufacturing sector, this paper has three objectives. **First**, this paper aims to demonstrate how graph theory can be applied in selecting dominant industry. **Second**, to conduct multi criteria analysis in mapping manufacturing sector based on economic, energy and CO_2 emissions intensity valuation. **Third**, to investigate what kind of policy interventions can be implemented for creating green manufacturing industry. However, due to data limitation, this paper is preliminary works in investigating industrial mapping. In the future more update data and detail analysis are needed. We organized this paper into five sections. Section II reviews policies on green manufacturing industry. Section III describes methodology used. Section IV provides results and analysis. Section V contains a discussion of policy implications, with concluding remarks in Section VI.

II. POLICIES REVIEW

Improving energy efficiency has positive impact on energy security, environmental protection and sustainable development (IEA, 2007). Improvement in energy efficiency can be achieved by two ways namely through policies and structural changes (IEA, 2008a). Further, this leads to decouple energy use from economic growth (IEA, 2008a). Energy saving from adoption of best practice of commercial technologies in manufacturing industry can be classified into some ways such as motor systems, combine heat and power, steam systems, process integration, increased recycling, and energy recovery (IEA, 2007). According to IEA (2007), manufacturing can improve its energy efficiency by 18% to 26%, while reducing the sector's CO_2 emissions by 19 to 32% based on the proven technology. The motor system has the highest contribution in terms of energy and carbon saving. Further, type of energy also determine level of efficiency, for example coal is less efficient that other energy sources because of ash content and the need for further gasification (IEA, 2007).

Following a study from IEA (2007) between 1990 and 2004 in a group of 19 IEA members, there are three major findings.[1] First, most of energy consumption in manufacturing is used to produce raw material such as paper and pulp, chemical, non-metallic mineral, and primary metal. Second, while consumption of natural gas tends to increase, consumption of oil and coal

[1] Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, UK and US

that involve in energy efficiency and conservation (EE&C) activities. Further, it is also important to obtain and to develop energy efficiency indicators for policy assessment (IEA, 2008).

The government of Indonesia has implemented some policies on EE&C such as the Presidential Instruction No. 10/2005 on the Instruction on Central and Regional Government to Implement EE&C, the Ministerial Regulation No. 31 on the Procedure for EE&C Implementation, and the Energy Law No. 30/2007, Article 25, focuses on Energy Conservation and Indonesia's 2003-2020 National Energy Policy (IEA, 2008b).

According to the Indonesia's Energy Law No. 30/2007, there are two objectives of energy conservation: sustainability of energy resources and improving energy efficiency. Government will give incentives and disincentives to consumers or producers that can implement energy saving or develop energy saving technology. Further, there is no keyword on electricity conservation in the Electricity Law No. 30/2009. However, the Government Regulation No. 70/2009 on Energy Conservation, energy conservation can be implemented through several ways, such as efficient process or procedure, and efficient technology. Further, for any energy utilization that is equal or larger than 6,000 ton of barrel oil equivalent per year, it is a must to do energy conservation through implementing energy management. Thus, internal energy auditors need to be prepared and external accredited auditors will evaluate the program. Some incentives such as tax, tariff, interest rate, and cost sharing will be provided by government. On the other hand disincentives such as warning, public notice on media, penalty, and reduction on energy supply will be applied.

Government interventions, through taxes and subsidies can remedy market failure and enhance private sector to do adjustment on energy efficiency and to reduce CO_2 emissions. For example, Japanese government allocates subsidies to assist firms in developing energy efficient facilities that also can reduce CO_2 emissions. Further, the subsidy is also given to assist development of energy saving technologies. On the other hand, the Japanese government imposes tax on petroleum, petroleum gas, natural gas and coal, after that government uses the collected taxes for energy conservation and new energy programs.

In conclusion, in order to create clean or green manufacturing industry, there are two ways that can be implemented such as technology or technical aspect and institutional or policy aspect. Technical aspect can be applied directly at firm level, but how deep and robust the technical aspect can be implemented depend on policy environment. The policy environment covers four main areas such as: (i) monitoring energy use at firm level; (ii) implementing incentives and disincentive mechanism such as through tax, subsidy, loan or credit policy; (iii) enhancing partnership and collaboration among companies; (iv) enhancing coordination among many government and non-government agencies.

III. METHODOLOGY

3.1 Data

The analysis focuses on large and medium manufacturing industry. By definition manufacturing industry refers to economic activity that change input material to half finish or finished products, while industrial sector includes mining, manufacturing, electricity, gas, and water, and construction. Thus manufacturing industry is part of industrial sector. By definition large firm has more than 100 persons engaged, while in medium scale the number of workers between 20 and 99 persons.

Data mainly obtained from two sources. First, economic data collected from International Yearbook of Industrial Statistics - United Nations Industrial Development Organization (UNIDO) that covers output, value added, and employment. Second, energy data obtained from the Indonesian energy balance that published by BPS-Statistics Indonesia. Indonesia energy balance provides information on energy consumption for large and medium company, but it covers only six major industries: (1) food, (2) textile, (3) wood, (4) chemical, (5) metal, and (6) others.

Period of analysis is started from 1996 and 2003. This period cover the period prior to the Asian economic crisis and post the economic crisis. Further, the latest collection of UNIDO that the authors have is year 2006 that covered the data until 2003. There is a missing data in analysis especially in year 1997 such as for output and value added of tobacco, wearing apparel, dressing, dyeing of fur, tanning, dressing of leather, manufacture of luggage, handbags, saddler, harness, and footwear. Further, we also obtained the same data of energy consumption for other industry in year 2002 and 2003. This indicates that the Indonesian government needs to improve data quality in the future.

3.2 Techniques of Analysis

We analyzed three types of intensity. First is ratio of energy consumption with respect to output. This measures how much energy is needed to produce one unit of output. Second is ratio of energy consumption with respect to value added. Third is ratio of CO_2 emissions with respect to output. We convert energy consumption at industrial level to CO_2 emissions by using IPCC (2006) default emissions factor, for example we used the unit $kgCO_2/PJ$ for coal, petroleum, and gas. Following the IPCC (2006), we used the default value 101.2, 72, and 63.1 for coal, petroleum and gas respectively.

We conclude that the lower intensity is the better industry performance. Further, we also calculate annual growth for output, value added and labor. Next, we deflated the output and value added with gross domestic product (GDP) deflator based on year 2000 constant prices. It is important to deflate the price because in 1998, Indonesia has high inflation rate that was about 75% by using GDP deflator. Thus we need to measure output and value added indicators in real term. We give high value for industries that have the higher growth. Thus we had six indicators in selecting industry as follows (Table 3).

3.3 General Form

We applied graph theory to select industry base on each criteria. Dominance graph can help decision makers to pick up dominant industry base on specific criteria. Suppose a given directed graph can be written as follows:

$G = (V, E)$, where G refer to graph, V is vertices or node, and E is edge or arc. Because we have six industry, thus $V = \{1, 2, 3, 4, 5, 6\}$, thus set of edges can be obtained as follows:

$E = \{(1,2), (1,3), ...\}$ or we will have about $2^6 = 64$ combinations. One important concept in graph theory is the adjacency matrix. Because we have 6 industries, thus the adjacency matrix (M) can be represented as 6 x 6 or in general form M $= m \times n$. Matrix M can be written as follows: $M = (m_{ij})$ where,

$m_{ij} = 1$ if $(i,j) \in E$

$m_{ij} = 0$ otherwise

The adjacency matrix has the following properties:

(i) Element is either 0 or 1

(ii) All diagonal elements are 0

Dominance graph

Dominance graph theory can be applied to investigate such as tournament competition when we need to decide the winner of the game.

Table 3. Criteria Analysis

Criteria		Indicators	Performance valuation
1. Energy	C1	Based on intensity (energy consumption/output) measure in TJ/billion Rp	The lower the better
	C2	Base on intensity (energy consumption/value added) measure in TJ/billion Rp	The lower the better
2. CO_2 emissions	C3	Base on intensity (CO_2 emissions/value added) measure in $kgCO_2$/billion Rp	The lower the better
3. Economic	C4	Based on average employment growth	The higher the better
	C5	Based on average output growth	The higher the better
	C6	Based on average value added growth	The higher the better

Dominance graph $G = (V, E)$ is defined to be the directed graph such that either the edge $(i,j) \in E$ or $(j,i) \in E$ exists between any two nodes i,j $(i \neq)$. In this dominance graph we interprets the edge (i,j) as "industry *i* has better performance than *j*".

Theorem:

In the dominance graph there always exists at least one node from which there exists 1 relation or 2 relation (path consisting of one or two edges) to any other nodes in the corresponding graph. Thus, the steps in selecting criteria can be summarized as follows:

1. Constructing adjacency matrix: M (we give value 1 if industry *i* has better performance than industry *j*, while we give value 0 if industry *i* has lower performance than industry *j*)
2. Constructing multiplicative matrix: M x M $= M^2$
3. Obtaining $M + M^2$
4. Calculating row sums in $M + M^2$
5. We define the most preferred industry corresponds to the node with maximum total number of 1 relation or 2 relation to any other nodes.

IV. DATA ANALYSIS

Energy use in industrial sector can be divided into two parts, such as electricity and non electricity sources. Non-electricity sources consist of coal, petroleum and gas. Some industries also use non fossil fuel, but in general, the total amount is still relatively low. As seen from Table 4, on average electricity consumption in wood, textile, and metal industry is relatively higher than other industries, but share of electricity consumption in textile industry tends to decrease. Table 4, also provides intuitive information on degree of substitution between electricity and non electricity. If we assume that energy to generating machines and electrical equipments can come from electricity and non electricity, by measuring standard deviation we can conclude that manufacture of wood and textile have more higher degree of flexibility in using energy mix. Flexibility in energy switching can help industry to deal with unexpected increase in energy price. Flexibility in energy mix can be done by modifying the energy system at the firm level.

Table 5 shows the ratio energy consumption with respect to number of employee. We can

Table 4. Ratio of Electricity Consumption to Energy Nonelectricity

Year	Manufacture of Food	Manufacture of Textile	Manufacture of Wood	Manufacture of Chemical	Basic Metal Industry	Other Manufactures	Total
1996	0.209	0.334	0.330	0.287	0.335	0.096	0.173
1997	0.111	0.247	0.122	0.222	0.212	0.124	0.165
1998	0.195	0.316	0.241	0.248	0.429	0.131	0.203
1999	0.288	0.471	0.260	0.272	0.534	0.143	0.253
2000	0.426	0.643	1.554*	0.376	0.417	0.184	0.312
2001	0.232	0.348	0.270	0.291	0.315	0.116	0.179
2002	0.241	0.276	0.246	0.212	0.283	0.163	0.203
2003	0.254	0.224	0.254	0.187	0.273	0.252	0.244
2004	0.567	0.772	0.562	0.468	0.418	0.183	0.385
2005	0.421	0.303	0.336	0.460	0.453	0.100	0.178
Average	0.294	0.393	0.417	0.302	0.367	0.149	0.230
Std.Deviation	0.136	0.181	0.415	0.100	0.098	0.048	0.071

Note: *Unusual information come from the original data, where coal consumption in wood industry was about 22,716 terajoule in 1999, but in 2000 it decreased to about 2,474 terajoule. In 2001, it was 2,487 terajoule and in 1998 it was 2,215 terajoule. Thus it seems that data in 1999 needs to be checked.

Source: Author's calculation

conclude that the high the ratio indicates the industry is relative more energy intensive. As seen from Table 5, chemical, metal and other manufacture are more energy intensity compare to wood, textile, and food industry. High energy intensive industry has more risk on rising in energy price. Flexibility in applying energy switching technology can help energy intensive industry to maintain its competitiveness. However, information from Table 4 confirms that high flexibility in energy mix is mostly occurred in low energy intensive. This may indicates low energy intensive companies face with more competitive environment in the market. Then the companies need to set more flexible energy mixed. Alternatively, most of low energy intensive is labor intensive. Government's regulation on minimum wage that always increases every year pushes the firms to apply more flexible approach in energy mix. Finally, high quality supply of electricity is important to maintain product quality. Thus, companies need to develop alternative supply of energy that generate by its own sources and low energy intensive companies have cost effective ways to do energy mix in generating steam power process.

As seen from Table 6, during period 1996-2003, total employment in medium and large industry increased about 0.41% on average, even most of industry such as textile, wood, chemical, and basic metal had negative growth. On the other hand, food and other manufacture industries have important role in terms of creating new job opportunity. Real output shows higher growth than employment rate at about 4.25%. Other manufacture, basic metal, and food industry elevated total industrial growth. Surprisingly, with negative growth of employment, output growth in basic metal industries grew very high, but in terms of value added it shows negative growth. We need to be careful in analyzing data from basic metal. Finally Table 6 confirms that the performance of food and other industries are better than the total industries performance. By considering the economic crisis 1997/98 and recovery time, we also can conclude that food and other industries can recover faster from the crisis or alternatively

Table 5. Intensity (Energy Consumption/Labor) Measure in TJ/person

Year	Manufacture of Food	Manufacture of Textile	Manufacture of Wood	Manufacture of Chemical	Basic Metal Industry	Other Manufactures	Total
1996	0.073	0.077	0.064	0.322	0.119	0.347	0.158
1997	0.088	0.072	0.060	0.311	0.122	0.173	0.110
1998	0.093	0.083	0.074	0.426	0.272	0.292	0.166
1999	0.103	0.101	0.121	0.498	0.354	0.318	0.191
2000	0.100	0.096	0.050	0.530	0.432	0.454	0.221
2001	0.095	0.074	0.064	0.322	0.356	0.450	0.206
2002	0.149	0.083	0.063	0.311	0.494	0.337	0.198
2003	0.136	0.104	0.068	0.315	0.557	0.236	0.174
Average	0.105	0.086	0.070	0.379	0.338	0.326	0.178

Source: Author's calculation

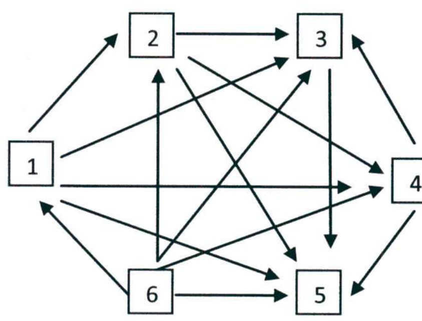
we may argue that economic crisis was not significantly affect those industries.

Representative directed graph and corresponding adjacency matrix (M) from Table

Table 7. Average Annual Growth 1996 – 2003 (in percentage)

Variable	Manufacture of Food	Manufacture of Textile	Manufacture of Wood	Manufacture of Chemical	Basic Metal Industry	Other Manufactures	Total
1. Employment	1.417	-1.259	-2.528	-1.323	-3.393	2.327	0.41
2. Output*	4.823	-0.069	-0.385	1.680	9.433**	11.345	4.25
3. Value added*	8.626	2.275	1.172	4.968	-8.047	13.165	6.43

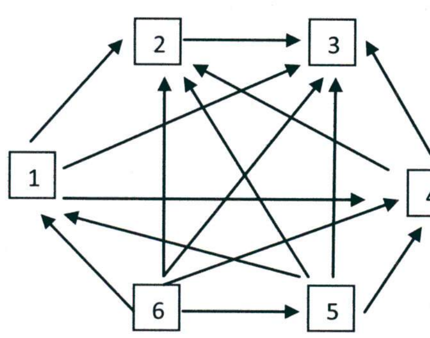
Note: ***growth** is measured at constant price 2000; **data shows that there was a dramatic increase in fabricated metal production between 2001 and 2002. The output grew from Rp11,811 billion to about Rp101,280 billion. On the other hand, value added for the same time period increase from Rp4,526 billion to about Rp5,453 billion



$$M = \begin{bmatrix} 0 & 1 & 1 & 1 & 1 & 0 \\ 0 & 0 & 1 & 1 & 1 & 1 \\ 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 1 & 1 & 1 & 1 & 0 \end{bmatrix}$$

Figure 1. Directed graph for employment

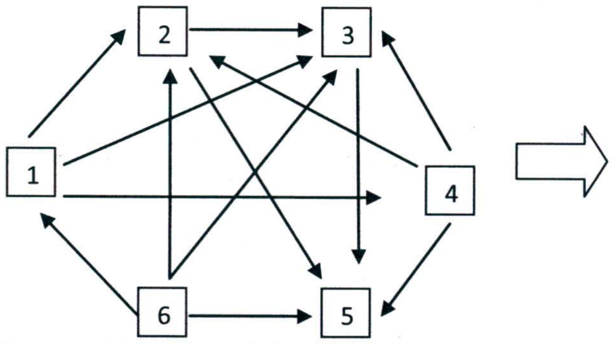
Note: we can read the graph as follows: (1) food has higher growth that (2) textile, (3) wood, (4) chemical, and (5) metal; (2) textile has higher growth than (3) wood, (4) chemical, and (5) metal; (3) wood has higher growth than (5) metal; etc. *M* is adjacency matrix



$$M = \begin{bmatrix} 0 & 1 & 1 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 & 0 & 0 \\ 1 & 1 & 1 & 1 & 0 & 0 \\ 1 & 1 & 1 & 1 & 1 & 0 \end{bmatrix}$$

Figure 2. Directed graph for otput

Note: we can read the graph as follows: (1) food has higher growth that (2) textile, (3) wood, and (4) chemical; (2) textile has higher growth than (3); (4) chemical has higher growth than (2) textile, and (3) wood; etc. *M* is adjacency matrix



$$M = \begin{bmatrix} 0 & 1 & 1 & 1 & 1 & 0 \\ 1 & 0 & 0 & 1 & 0 & 1 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 1 & 1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 1 & 1 & 1 & 1 & 0 \end{bmatrix}$$

Figure 3. Directed graph for value added

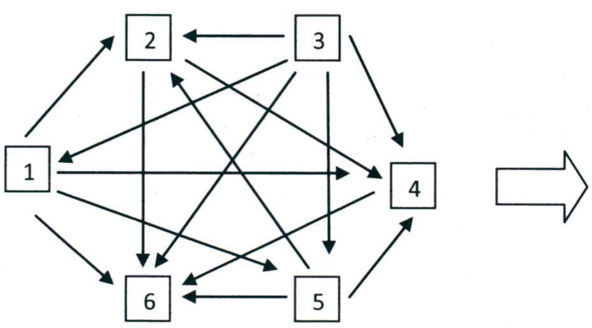
Note: we can read the graph as follows: (1) food has higher growth that (2) textile, (3) wood, (4) chemical and (5) metal; (2) textile has higher growth than (3) and (5) metal; (3) wood has higher growth than (5) metal; etc. M is adjacency matrix

Table 8. Energy Intensity I (Energy Consumption/Output) Measure in TJ/billion Rp

7 can be summarized in Figure 1, 2 and 3 as follows:

Year	Manufacture of Food	Manufacture of Textile	Manufacture of Wood	Manufacture of Chemical	Basic Metal Industry	Other Manufactures	Total
1996	0.49	0.95	0.50	1.05	0.39	1.98	1.08
1997	NA	NA	0.49	0.95	0.46	NA	NA
1998	0.68	1.01	0.61	1.41	1.03	2.14	1.25
1999	0.74	1.19	0.99	1.61	1.44	2.48	1.48
2000	0.68	1.28	0.33	1.70	1.48	2.62	1.53
2001	0.55	1.10	0.45	0.95	1.27	2.86	1.43
2002	0.92	1.09	0.43	0.87	0.69	1.95	1.19
2003	0.83	1.30	0.47	1.00	1.70	1.36	1.13
Average	0.70	1.13	0.53	1.19	1.06	2.20	1.30

We used the average value from Table 8 as basic information in generating directed graph in Figure 4. As seen from Table 8, wood manufacturing has the lowest intensity. This



$$M = \begin{bmatrix} 0 & 1 & 0 & 1 & 1 & 1 \\ 0 & 0 & 0 & 1 & 0 & 1 \\ 1 & 1 & 0 & 1 & 1 & 1 \\ 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 1 & 0 & 1 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

Figure 4. Directed graph for energy intensity I

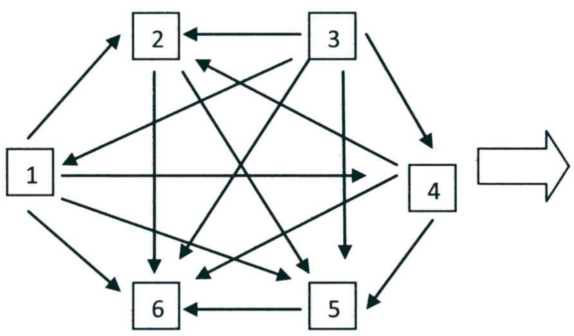
Note: we can read the graph as follows: (1) food has higher lower intensity than (2) textile, (4) chemical and (5) metal; (2) textile has lower intensity than (4) chemical and (6) other; (3) wood has lower intensity than (1) food, (2) textile, (4) chemical, (5) metal, and (6) other; etc. M is adjacency matrix

Table 9. Energy intensity II (Energy Consumption/Value Added) Measure in TJ/Billion Rp

means wood manufacturing has directed graph to all the nodes as seen from Figure 4.

Year	Manufacture of Food	Manufacture of Textile	Manufacture of Wood	Manufacture of Chemical	Basic Metal Industry	Other Manufactures	Total
1996	1.73	3.28	1.41	3.01	0.78	5.46	3.14
1997	NA	NA	1.28	2.75	1.41	NA	NA
1998	1.92	3.08	1.74	3.96	3.62	5.98	3.63
1999	2.11	3.50	2.62	4.19	4.32	6.15	4.03
2000	2.05	3.62	1.00	4.38	4.70	6.67	4.26
2001	1.69	3.56	1.16	2.90	4.03	7.05	4.02
2002	2.66	3.15	1.13	2.55	5.92	5.04	3.65
2003	1.99	3.68	1.16	2.29	6.24	3.42	2.91
Average	2.02	3.41	1.44	3.25	3.88	5.68	3.66

As seen from Table 9, on average between 1996 and 2003, wood manufacturing has the lowest intensity, while other manufacturing has the highest intensity. As seen from Figure 5, there is no directed line out from other manufacture.



$$M = \begin{bmatrix} 0 & 1 & 0 & 1 & 1 & 1 \\ 0 & 0 & 0 & 0 & 1 & 1 \\ 1 & 1 & 0 & 1 & 1 & 1 \\ 0 & 1 & 0 & 0 & 1 & 1 \\ 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

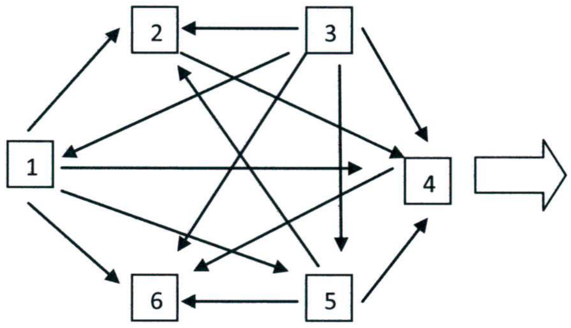
Figure 5. Directed graph for energy intensity II

Note: we can read the graph as follows: (1) food has higher lower intensity than (2) textile, (4) chemical and (5) metal; (2) textile has lower intensity than (5) metal and (6) other; (3) wood has lower intensity than (1) food, (2) textile, (4) chemical, (5) metal, and (6) other; etc. M is adjacency matrix

Table 10. Energy Intensity III (CO_2 Emissions/Value Added) Measure in $ktCO_2$/Billion Rp

Year	Manufacture of Food	Manufacture of Textile	Manufacture of Wood	Manufacture of Chemical	Basic Metal Industry	Other Manufactures	Total
1996	0.109	0.189	0.082	0.178	0.039	0.370	0.200
1997	-	-	0.088	0.171	0.088	-	-
1998	0.123	0.179	0.110	0.232	0.171	0.446	0.240
1999	0.125	0.182	0.175	0.238	0.188	0.463	0.259
2000	0.110	0.169	0.031	0.232	0.221	0.491	0.266
2001	0.105	0.203	0.072	0.160	0.201	0.546	0.279
2002	0.165	0.190	0.072	0.153	0.339	0.359	0.242
2003	0.121	0.232	0.071	0.140	0.355	0.212	0.179
Average	0.123	0.192	0.088	0.188	**0.200**	**0.412**	**0.238**

As seen from Table 10, energy intensity in terms of CO_2 emissions with respect to value added shows wood manufacture has the lowest intensity. We can represent energy intensity III into the following directed graph.



$$M = \begin{bmatrix} 0 & 1 & 0 & 1 & 1 & 1 \\ 0 & 0 & 0 & 1 & 0 & 1 \\ 1 & 1 & 0 & 1 & 1 & 1 \\ 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 1 & 0 & 1 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

Figure 6. Directed graph for energy intensity III

Note: we can read the graph as follows: (1) food has higher lower intensity than (2) textile, (4) chemical and (5) metal; (2) textile has lower intensity than (4) chemical and (6) other; (3) wood has lower intensity than (1) food, (2) textile, (4) chemical, (5) metal, and (6) other; etc. M is adjacency matrix

As seen from Table 11, food manufacturing has the highest total score or we can argue that food industry is a dominant industry. This is happened because food industry has more balance scored for all the criteria. Further, in terms of energy criteria and CO_2 intensity, manufactured of wood is a dominant industry, while in terms of economic criteria other manufacture is a dominant industry. We argue that characteristic of manufacturing industry affect this result. For example, in the case of high energy intensive industries such as chemical, metal and other manufacture is less dominant in terms of energy valuation, but it is dominant in terms of economic valuation. Similarly, for low energy intensive industry, such as food and wood is dominant in energy and CO_2 valuations. Because industry with relatively good performance in energy and CO_2 emissions such as wood industry has low economic performance, this indicates a possibility for conflicting results among the criteria. Further, even for the same index in economic performance such as food and textile manufacturing industry, we obtained huge difference in economic performance. Alternatively we can argue that we cannot obtain industry that dominant for all the criteria.

Table 11. *Dominant Graph Results*

	Industry	C1	C2	C3	C4	C5	C6	Total
1.	Manufacture of Food	10	10	10	11	6	11	58
2.	Manufacture of Textile	3	3	3	12	1	15	37
3.	Manufacture of Wood	15	15	15	6	0	1	52
4.	Manufacture of Chemical	1	6	1	3	3	7	21
5.	Basic Metal Industry	6	0	6	0	10	0	22
6.	Other Manufactures	0	0	0	16	15	16	47

Energy (C1–C2); CO_2 (C3); Economic (C4–C6)

Note: C1 Based on energy consumption/output, measure in TJ/billion Rp; C2 Base on energy consumption/value added, measure in TJ/billion Rp; C3 Base on CO_2 emissions/value added, measure in kgCO2/billion Rp; C4 Based on average employment growth; C5 Based on average output growth; C6 Based on average value added growth; total = sum{C1:C6}

V. POLICY DISCUSSION

Application of graph theory analysis with 6 (six) criteria provided useful information in industrial mapping. We can classify industry performance into three groups such as high, average and low. In terms of energy and CO_2 emissions intensity, we observed that textile, chemical, basic metal, and other manufactures have relatively low score. This means government can intensively evaluate energy efficiency in those industries. Incentives and disincentives can be applied to enhance energy use and clean energy utilization. Constructing benchmarking analysis can help government to determine degree of policy interventions at firms' level. For example, firms with energy use and CO_2 emissions above the average need to be measured first.

According to United Nations Environmental Program (UNEP)'s green economy report on the title, *Towards a Green Economy: Pathways to Sustainable Development and Poverty eradication*, a green economy as one that results in improved human well being and social equity, while significantly reducing environmental risks and ecological scarcity'. The question is can we obtain the three objectives simultaneously. Industrial level analysis showed that we can promote industry with high growth of output or value added and employment, but those industries have high energy intensity and CO_2 emissions. This indicates that we set criteria on environmental risk and ecological scarcity into challenge.

Good indicators in economic performance do not always exist with low energy and CO_2 intensity and *vice versa*. For example, other manufactures and textile show clearly this argument. Thus one size fits all policy may not work effectively to obtain green industry that can support green economy. Alternatively, industrial policy needs to be set comprehensively as policy packages that cover three main criteria such as energy use, CO_2 emissions and economic performance.

VI. CONCLUSIONS

There have been shifted in economic paradigm from conventional way of thought to sustainable development. Industrial sector is not only as an engine of growth but also a major source of energy consumer and CO_2 emissions. Thus industrial sector needs to pursue clean, clever, and competitive energy in the future. Improving energy efficiency will come with three benefits simultaneously such as enhancing energy security, environmental protection and sustainable development. Implementing a high energy performance or energy monitoring policy in manufacturing industry with high energy intensity, can help to reduce CO_2 emissions. This paper aims to demonstrate the power of graph theory in helping decision makers in selecting dominant industry. We also conducted multi criteria analysis in mapping manufacturing sector based on economic, energy and CO_2 emissions intensity valuation.

The results showed that although food industry is a dominant industry, no industry can be a dominant player for all the criteria. This is because the characteristics of industry are matter. The study also indicated that there is a possibility for conflicting results among the criteria. Similarly we can argue that pro growth does not mean pro environment. We can argue that there is a lack in technological deepening especially in high energy intensive industries. Thus we cannot apply the same standard to compare industrial performance. Alternatively, government needs to develop the industrial performance benchmarking for different type and scale of industry. Finally we argue that policy environment is the key to boost energy efficiency at the firm level.

This study has two limitations. First, we could not apply more detail analysis for specific industry due to data limitation. Second, poor data information can affect the final result. Thus we suggest government to improve data quality at the firm level.

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