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Article

Efficiency of labor allocation: An observation in Indonesian Standard Industrial Classification (ISIC)

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Abstract: This study aims to analyze the efficiency and elasticity of the large and medium manufacturing industry sector in Indonesia from 2012 to 2020. The analysis focuses on the 24 subsectors within the 2-digit Indonesian Standard Industrial Classification (ISIC) principal groups 10 to 33. The efficiency level of the manufacturing industry sector was analyzed using the Cobb-Douglas production function model with linear logarithmic transformation. During the period 2012–2020, the production efficiency of the 24 ISIC 2-digit subsectors increased by an average of 445%, or 4 times higher than before. The ISIC 2-digit subsector (24 subsectors) had output elasticity values smaller than one ($E_L < 1$) or inelastic 45 times. This indicates that the marginal value added of labor was lower than the average value added of labor. Therefore, the additional allocation of labor in large and medium industries tends to reduce the average value added of labor. The computer industry, electronic and optical goods computer, electronic and optical goods had the highest efficiency index in order, according to the data. This can be achieved by focusing on industries such as ISIC 17 (paper and paper goods industry), ISIC 31 (furniture industry), and ISIC 29 (motor vehicle, trailer and semi-trailer industry). To improve the efficiency of labor allocation, it is necessary to optimize the use of labor resources, increase productivity, and remain competitive in the market. To improve efficiency and elasticity, it is recommended to implement a robust workforce planning strategy that aligns labor resources with production needs. Additionally, matching the skills and abilities of the workforce with job roles is crucial. Finally, identifying tasks that can be automated using technology can also increase efficiency.

Keywords: efficiency and elasticity; ISIC subsectors; labor allocation; Cobb-Douglas function

1. Introduction

Indonesia has a thriving manufacturing industry, with a variety of large and medium-sized processing industries. This industry has grown significantly over the years, contributing to the country's economic growth and development [1]. With a population of over 260 million people, Indonesia offers a vast domestic market for manufacturers to enter.

Industrialization in Indonesia has yielded significant results. The manufacturing sector has emerged as the leading contributor to the country's economic growth, not only through added value, employment, and foreign exchange but also by facilitating the cultural transformation of the nation towards modernization and supporting the formation of national competitiveness [2].

In general, the manufacturing industry has long been in the main position in the Indonesian economy, although this sector has also been eroded due to Covid-19 which has occurred since the end of the first quarter of 2020. During the period 2017–2022, the contribution of manufacturing value added to Gross Domestic Product (GDP) was highest in 2017 at 21.22%, then experienced the lowest position in 2022 at 20.17%. This figure is the highest contribution to GDP compared to other employment business sectors. The growth rate of the number of manufacturing industries was the lowest in 2020 at −2.08% and the highest in 2022 at 6.28%. However, during the 2017–2022 period the growth rate was still positive, averaging 3.32% per year. The average proportion of employment during the 2017–2022 period averaged 14.25%. This figure is the largest proportion of employment compared to other employment business sectors [3]. The sizable position of the processing industry in Indonesia is an indicator that there is a transformation from the agrarian sector. Until recently, the manufacturing sector in Indonesia was still associated with the utilization of labor and thus still oriented towards a labor-intensive production system. However, with advances in technology and automation, the manufacturing process has undergone a significant transformation towards greater capital intensity and automation.

The evolution of the manufacturing (processing) industry is certainly an important thing to study and analyze in order to get a picture that can be used as a basis for policy making. One aspect of manufacturing that can be analyzed is the contribution to value added and the allocation or absorption of labor. The relationship between the contribution in value-added output and the allocation of labor in the manufacturing industry can be seen from the level of efficiency in the use of labor inputs. Langemeier [4] states that labor efficiency refers to labor productivity, which is the amount of output that can be produced per unit of labor input. In other words, labor efficiency measures how well a firm utilizes its labor force to achieve its objectives.

The efficiency of labor allocation in the manufacturing industry is worth studying because labor is an input factor in producing value-added production. This study focuses on the large and medium manufacturing industry sector, specifically the 24 types of manufacturing sub-industries within the Indonesian Standard Industrial Classification (ISIC) 2 digits (principal groups 10 to 33). This study aims to assess the efficiency of the large and medium manufacturing industry in Indonesia, as classified by the Indonesian Standard Industrial Classification (ISIC) with 2 digits (principal group 10 to 33), which includes 24 sub-industries.

2. Theoretical review

2.1. Efficiency

Efficiency is the relationship between resource inputs (costs, such as labor, capital, or equipment) and outputs (results or outcomes) [5]. Nababan [6] states that efficiency is a parameter for measuring company performance in the production process. Coelli et al. [7] identified three types of efficiency: technical efficiency, allocative efficiency, and overall efficiency. Management can control productive efficiency, which is composed of technical efficiency and allocative efficiency. Technical efficiency refers to an economic unit's ability to produce the maximum output using a specific set of inputs and technology. Allocative efficiency refers to an economic unit's ability to balance the value of the marginal product with the marginal cost of producing that output [8,9].

One way to measure efficiency is to calculate the costs incurred by an organization to produce a product or service. If production costs are low, then this is an indication of efficiency in the use of resources [10]. Another way is to measure the output of a particular production process or line on a per-employee or per-hour basis. This ratio shows how much each employee contributes to the production process, and whether the system is optimized [11]. According to Banton [12] efficiency can be measured and can be expressed as a ratio or percentage. Efficiency can be measured using the following formula:

$$\text{Efficiency} = \text{Output} \div \text{Input}$$

2.2. Labor efficiency

Labor efficiency is crucial for organizational success. This data allows organizations to identify areas for improvement and make informed decisions regarding resource allocation. To measure workforce efficiency, organizations must collect data on various aspects of their workforce, such as employee attendance rates and productivity [13]. Labor efficiency refers to how effectively workers complete tasks and achieve goals within a given time period. It measures the amount of work done by an individual or team in relation to the resources used to complete the task. The goal of labor efficiency is to maximize output while minimizing resource usage.

Labor efficiency refers to labor productivity, which is the amount of output that can be produced per unit of labor input [14]. In other words, labor efficiency measures how well a company utilizes its workforce to achieve its goals. Labor efficiency refers to labor productivity, which is the amount of output that can be produced per unit of labor input [15]. There are various ways to measure labor efficiency, including:

(1) Labor productivity: This is a measure of the amount of output produced per unit of labor input. It is calculated by dividing total output by the total number of hours worked [16,17].

(2) Employee utilization rate: This is a measure of the percentage of time that employees spend on productive tasks. It is calculated by dividing the total hours worked on productive tasks by the total working hours available [17–19].

(3) Employee turnover rate: This is a measure of the rate at which employees leave the company. A high employee turnover rate can negatively impact labor efficiency by reducing the number of experienced workers available to perform tasks [20].

3. Research method

3.1. Data

The data coverage is the manufacturing industry, which consists of large and medium-size industries according to the 2-digit ISIC classification, which is composed of 24 subsectors, as shown in **Table 1** below.

Table 1. Division of large and medium manufacturing based on ISIC 2 digits [21].

ISIC code	Division of manufacturing	ISIC code	Division of manufacturing
10	Food products	22	Rubber and plastic products
11	Beverages	23	Other non-metallic mineral products
12	Tobacco products	24	Basic metals
13	Textiles	25	Fabricated metal products except machinery and equipment
14	Wearing apparels	26	Computers, electronic and optical products
15	Leather and related products and footwear	27	Electrical equipment
16	Wood and products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials, bamboo, rattan, and the like	28	Machinery and equipment
17	Paper and paper products	29	Motor vehicles, trailers, and semi-trailers
18	Printing and reproduction of recorded media	30	Other transport equipment
19	Coke and refined petroleum products	31	Furniture
20	Chemicals and chemical products	32	Other manufacturing
21	Pharmaceuticals, medicinal chemicals, and botanical products	33	Repair and installation of machinery and equipment

The data used in this study are data of Indonesia's large and medium industries related to the number of labors and output value for the period 2012 to 2020. The research data comes from the Indonesian Central Board of Statistics (BPS), as shown by **Tables 2** and **3**.

Table 2. Total labor of large and medium industries by ISIC 2-digits sub-sector (person) year of 2012–2020 [21].

Subsectors	2012	2013	2014	2015	2016	2017	2018	2019	2020
ISIC 10	884,602	901,550	877,791	858,170	1,119,579	1,042,575	1,005,612	1,014,886	989,066
ISIC 11	46,691	51,628	52,681	59,973	97,428	94,080	93,392	94,412	83,397
ISIC 12	324,614	362,933	356,117	346,082	299,470	323,380	290,871	297,722	287,889
ISIC 13	482,349	477,985	546,946	513,743	540,663	650,212	629,298	581,235	519,299
ISIC 14	600,109	571,458	636,684	684,023	917,477	856,636	763,314	797,947	695,920
ISIC 15	256,500	266,918	279,064	313,949	399,776	425,376	391,200	483,543	444,256
ISIC 16	225,456	229,819	228,201	243,072	306,609	286,442	257,783	258,103	243,589
ISIC 17	129,359	136,114	180,712	133,199	161,922	170,233	145,478	150,614	140,241
ISIC 18	52,147	51,334	50,505	54,561	88,210	83,753	63,873	79,933	70,342
ISIC 19	6574	6470	6352	7283	19,946	23,791	31,123	18,596	23,760
ISIC 20	185,066	203,413	193,261	193,629	234,362	233,765	221,738	233,245	242,461
ISIC 21	63,529	61,179	58,024	58,348	90,577	88,218	94,087	85,880	86,194
ISIC 22	353,624	365,958	390,555	443,250	459,017	499,789	442,841	454,384	440,403
ISIC 23	193,136	182,420	177,082	186,423	207,201	224,120	209,636	211,917	191,999
ISIC 24	60,430	73,258	73,255	68,864	144,659	124,335	139,841	133,919	156,394
ISIC 25	161,861	173,210	160,849	156,134	169,112	199,993	173,062	171,080	181,324
ISIC 26	158,706	150,564	144,895	154,349	151,128	187,446	148,109	142,152	130,589
ISIC 27	115,488	118,963	125,090	104,065	147,441	149,015	154,970	158,498	134,255

Table 2. (*Continued*).

Subsectors	2012	2013	2014	2015	2016	2017	2018	2019	2020
ISIC 28	56,905	58,679	61,720	70,584	77,247	106,291	93,950	86,288	87,118
ISIC 29	118,643	138,179	140,107	147,553	203,549	234,455	248,614	247,570	257,067
ISIC 30	85,349	86,350	89,992	103,057	138,082	142,655	106,337	133,177	104,291
ISIC 31	190,127	165,307	171,789	167,436	182,612	211,664	184,358	182,936	160,378
ISIC 32	160,019	153,603	159,864	166,089	192,033	217,537	208,447	194,885	205,646
ISIC 33	17,555	17,620	18,995	13,465	42,823	39,193	25,251	28,199	26,489

Table 3. Value added of large and medium industries by ISIC 2-digits sub-sector (billion rupiah) year of 2012–2020 [21].

Subsectors	2012	2013	2014	2015	2016	2017	2018	2019	2020
ISIC 10	217,449	290,952	320,961	348,956	554,435	523,651	574,602	601,981	603,438
ISIC 11	10,314	15,772	20,263	26,632	21,030	33,985	36,433	40,938	40,429
ISIC 12	66,302	97,965	106,276	133,471	2736	103,235	126,230	150,292	147,403
ISIC 13	47,286	78,816	84,061	86,025	84,970	117,522	128,906	141,104	121,812
ISIC 14	43,745	54,613	49,092	60,456	113,886	157,163	171,206	175,264	115,468
ISIC 15	25,891	28,021	33,879	59,662	65,614	86,661	96,554	102,869	81,725
ISIC 16	19,481	21,637	21,562	39,472	43,946	58,996	51,834	44,033	36,006
ISIC 17	55,261	58,626	58,478	54,069	55,978	92,681	152,594	133,860	123,020
ISIC 18	6736	8943	11,658	13,107	91,115	33,982	35,990	25,286	28,369
ISIC 19	1637	3447	2552	3862	54,706	49,169	70,204	108,390	120,154
ISIC 20	124,391	180,903	208,292	21,9047	187,576	280,526	263,550	255,210	281,325
ISIC 21	13,077	11,285	14,601	15,344	32,337	88,965	68,589	61,864	62,482
ISIC 22	57,428	86,766	134,977	134,499	150,706	139,706	152,730	146,002	115,009
ISIC 23	44,707	45,981	78,104	106,716	88,489	192,577	136,506	124,314	105,162
ISIC 24	37,885	61,747	64,538	79,050	85,273	115,005	148,190	196,550	194,797
ISIC 25	41,588	40,116	40,901	35,026	65,886	53,705	61,323	72,790	67148
ISIC 26	27,855	40,024	38,505	63,279	78,165	56,653	56,714	62,682	50,951
ISIC 27	48,572	75,089	70,205	70,613	114,291	248,235	256,090	225,587	154,769
ISIC 28	19,409	23,400	33,271	48,858	28,518	87,483	95,004	70,988	59,863
ISIC 29	123,139	127,234	145,236	197,518	116,048	246,353	247,128	243,363	197,591
ISIC 30	55,184	50,363	57,131	49,600	117,273	57,844	79,785	93,517	60,681
ISIC 31	8058	11,039	21,648	21,445	14,748	27,016	29,867	30,550	26,850
ISIC 32	8928	11,175	15,405	21,985	28,930	22,512	28,043	26,549	33,862
ISIC 33	2367	2613	3112	5101	8962	13746	10,659	11,947	12,654

3.2. Model of analysis

To analyze the efficiency of labor allocation in large and medium industries, we use short-term Cobb-Douglas production function analysis, as proposed by Gasperz [22]. The conditions that must be met in this analysis are: (1) total output cannot be negative ($Q > 0$), so the intercept coefficient (constant) must be positive ($\alpha > 0$). (2) the input factor's marginal product and the input's output elasticity coefficient ($\beta > 0$)

must be positive. The production function assumes that all other input factors are fixed, and there is only one variable input, which is the amount of labor.

Therefore, the short-term Cobb-Douglas production function is expressed as $Q_{it} = \alpha L_{it}^{\beta}$. In logarithmic linear form, it is expressed as $\mathrm{Ln}Q_{it} = \mathrm{Ln}\alpha + \beta \mathrm{Ln}L_{it} + u$.

In year t, the total output value (in Rupiah) of large and medium industry sector i, denoted by Q, is calculated as the product of the number of labor inputs, denoted by L, and the output elasticity of L, denoted by β. The efficiency index, denoted by α, is a constant/intercept value that reflects the efficiency of labor allocation. A higher value of α indicates higher efficiency.

4. Results and discussion

Using OLS (Ordinary Least Square) estimation from the data in **Tables 2** and **3**, a linear-logarithmic regression equation is obtained for each ISIC sub-sector. Then, index of labor allocation in the Cobb-Douglass production function model can be represented by the constant value (α). In addition, to obtain the efficiency index of labor allocation, the linear-logarithmic regression equation is regressed to the Cobb-Douglass production model by using anti-Ln with base number e = 2.71828 [22].

The index based on the Cobb-Douglass production function for each subsector is presented in **Table 4**.

Table 4. Efficiency index for ISIC subsectors based on Cobb-Douglass production function, year of 2012–2020.

Sub sectors	Constant (α)	LnL	Efficiency index	Sub sectors	Constant (α)	LnL	Efficiency index
ISIC 10	−33.382	3.363***	3.180×10^{-15}	ISIC 22	−18.338	2.317***	1.086×10^{-8}
ISIC 11	−3.544	1.222***	2.890×10^{-2}	ISIC 23	−40.861	4.289**	1.796×10^{-18}
ISIC 12	−21.823	2.607	3.330×10^{-10}	ISIC 24	−3.075	1.261***	4.619×10^{-2}
ISIC 13	−18.2146	2.246**	1.229×10^{-8}	ISIC 25	−11.198	1.829	1.370×10^{-5}
ISIC 14	−27.041	2.853***	1.804×10^{-12}	ISIC 26	11.487	-0.055	9.744×10^{4}
ISIC 15	−16.313	2.135***	8.229×10^{-8}	ISIC 27	−32.331	3.731***	9.096×10^{-15}
ISIC 16	−28.356	3.121***	4.843×10^{-13}	ISIC 28	−16.245	2.399***	8.808×10^{-8}
ISIC 17	9.308	0.166	1.103×10^{4}	ISIC 29	3.200	0.731**	2.453×10^{1}
ISIC 18	−25.756	3.223***	6.521×10^{-12}	ISIC 30	−0.399	0.987*	6.710×10^{1}
ISIC 19	−14.37	2.541***	5.744×10^{-7}	ISIC 31	6.207	3.303	4.962×10^{2}
ISIC 20	−10.453	1.852**	2.886×10^{-5}	ISIC 32	−23.783	2.781***	4.690×10^{-11}
ISIC 21	−30.477	3.637***	5.808×10^{-14}	ISIC 33	−5.151	1.381*	5.794×10^{-3}

Dependent variable: LnQ; ***) sign. α = 0.01, **) sign. α = 0.05, *) sign. α = 0.10.

From **Table 4**, an example of the analysis, for the ISIC 10 subsector, the regression equation is $\mathrm{Ln}Q = -33.382 + 3.363\ \mathrm{Ln}L$, for the ISIC 11 subsector it is $\mathrm{Ln}Q = -3.544 + 1.222\ \mathrm{Ln}L$, and so on. This equation is then transformed into the original Cobb-Douglass function model:

$$\text{ISIC 10: } Q = e^{-33.382} L^{1.222} = (2.71828)^{-33.382} L^{3.363}$$

$$Q = (3.180 \times 10^{-15}) L^{3.363}$$

$$\text{ISIC 11: } Q = e^{-3.544} L^{0.824} = (2.71828)^{-3.544} L^{1.222}$$

$$Q = (2.890 \times 10^{-2}) L^{1.222}$$

The efficiency index of labor input for the ISIC 10 subsector is indicated by the coefficient α = 3.180× 10^{-15}, and for the ISIC 11 subsector, it is indicated by the coefficient α = 2.890× 10^{-2}. **Table 4** shows the efficiency indices for the other subsectors, which can be obtained using the same calculation method. All coefficients of the efficiency index and elasticity index are positive, as assumed in the estimation of the Cobb-Douglass function [22]. The table shows that the computer, electronic, and optical equipment industry (ISIC 26) has the highest sub-sector efficiency index, followed by the paper and paper products industry (ISIC 17), the furniture industry (ISIC 31), and the motor vehicles, trailers, and semi-trailers industry (ISIC 29).

Then the output elasticity of labor (E_L) is shown by the variable coefficient LnL. For ISIC 10, the value of E_L = 3.363 means that an increase in labor allocation by 1% can increase value added by 3.363%. The same interpretation can be done for the E_L of other sub-sectors. There are 20 ISIC sub-sectors (83%) that have output elasticity values greater than one (E_L > 1). This indicates that 83% of ISIC sub-sectors have a marginal value added of labor higher than the average value added of labor, so that additional labor allocation in large and medium industries tends to increase the average value added of labor. As for the other ISIC sub-sectors (17%), namely ISIC sub-sectors 17, 26, 29, and 30 have an E_L value < 1, which means that the addition of labor allocation in large and medium industries tends to reduce the average value added of labor.

Issues that can affect production efficiency in industry include the use of automation techniques, just-in-time manufacturing, global supply chains, and lean manufacturing to reduce labor usage. Acemoglu and Restrepo [23] suggest that automation can replace labor in tasks it previously performed, leading to a shift in the content of production tasks towards labor due to displacement effects. Automation reduces the share of labor in value added and can decrease the demand for labor, despite increasing productivity. However, the creation of new tasks where labor has a comparative advantage can offset the effects of automation. Aghion et al. [24] suggest that automated machinery and robotics are widely used in manufacturing, which can reduce the need for manual labor and increase efficiency. This technology can increase productivity by handling repetitive tasks quickly and accurately. According to Javadian Kootanaee [25], just-in-time manufacturing practices can minimize inventory and reduce the need for excessive labor to manage and store materials, including raw materials and finished goods. Additionally, industrial efficiency is affected by the global supply chain. According to Shih [26] manufacturing often relies on global supply chains, which can help obtain materials and components from regions with labor and production cost advantages. Lean manufacturing has been widely applied to improve production efficiency. Tortorella et al. [27] said that lean manufacturing principles can minimize waste and optimize production processes. This approach can result in more efficient use of labor and resources.

Jongwanich et al. [28] and Younus [29] explain that technological advancement can increase the elasticity of industrial output. The adoption of advanced technology and automation can significantly increase the output elasticity of labor. When machines and technology are used to augment human labor, workers become more productive, resulting in higher output per unit of labor. Ras et al. [30] argued that improving labor skills can increase output elasticity. Trained and skilled workers are usually more efficient and can perform tasks more effectively, resulting in higher productivity. Furthermore, employee engagement in the company organization can also play a role in increasing productivity. Moletsane et al. [31], Saxena and Srivastava [32] explain that engaged and motivated employees are often more productive. Building a positive work culture, recognizing and rewarding employees, and encouraging a sense of ownership can all contribute to higher output elasticity.

Labor output elasticity can occur due to capital-intensive factors where industries predominantly use technology in the production process. Capital-intensive industries rely heavily on machinery and technology, which can reduce the impact of labor input on overall output [33]. While capital-intensive systems often lead to increased efficiency and precision, they can also reduce the elasticity of labor output, making the industry less responsive to changes in the amount of labor employed. A decrease in the elasticity of labor output in an industry indicates that the industry becomes less responsive to changes in the amount of labor input, meaning that the industry becomes less efficient in converting labor into output. Manjappa and Mahesa's [34] study in India concluded that capital-intensive industries seem to do better than labor-intensive industries. Therefore, the need to adopt new technologies and attract Foreign Direct Investment (FDI) is crucial for productivity improvement in labor-intensive industries. Khan and Thimmaiah [35] found that capital-intensive manufacturing industries can increase total factor productivity growth, while labor-intensive manufacturing industries show negative total factor productivity growth due to a lack of technological change. This highlights the importance of organizing manufacturing industries efficiently.

5. Conclusion and recommendation

From 2012 to 2020, the output elasticity values of all 24 2-digit ISIC subsectors were inelastic. This indicates that the marginal value added of labor was lower than the average value added of labor during this period. As a result, the additional allocation of labor in large and medium industries tended to decrease the average value added of labor. The highest efficiency indexes are found in the following ISIC sub-sectors, in order: 26 (computer, electronic, and optical goods industry); 17 (paper and paper goods industry); 31 (furniture industry); and 29 (motor vehicle, trailer, and semi-trailer industry).

Future research should investigate labor allocation efficiency related to: (1) the labor skills and abilities related to the availability of real sectors, (2) tasks that can be automated with technology, and (3) the elimination of waste and optimization of labor allocation.

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