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Forecasting the potential output and growth of the manufacturing industry: a case study of Indonesia's manufacturing sector

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Abstract: Indonesia is currently experiencing deindustrialization, characterized by a manufacturing industrial sector growth rate lower than the overall economic growth rate. Therefore, it is necessary to encourage the development of the industrial sector to achieve sustainable development. The scenario for industrial development policy is determined based on an evaluation of the country's economic position in relation to current business cycle conditions. The evaluation is carried out through output gap analysis, which refers to the gap between actual and potential output. The research aim is to analyze output potential estimates and gaps in the Indonesian non-oil and gas processing industry sector. The methodology used in this research includes the HP Filter (Hodrick- Prescott), BP Filter (Band-Pass), and the Production Function Approach. The findings show that Indonesia's non-oil and gas processing industry experienced a slight decline below its potential between 2020 and 2021. Therefore, policymakers must consider this; in the short term, inflationary pressures are caused by a positive output gap, so the government needs to prioritize efforts to control inflation. Meanwhile, medium-term structural reforms must continue to increase potential output, including increasing labor force participation, sustainable investment for capital factors, and improving the quality of human resources and technological expertise for productivity factors. In particular, it is necessary to pay attention to the adoption of new emerging technologies.

Keywords: Indonesia; output gaps; HP filter; BP filter; manufacturing industry

JEL Classification: O4, E1, N15



Introduction

Indonesian economic analysts have expressed various viewpoints regarding indications of deindustrialization in Indonesia. These views are substantiated by the declining proportion of manufacturing sector employees relative to the total workforce since 2002 and the decrease in the proportion of value added by the manufacturing sector in the country's GDP since 2005 (Basri, 2019). These developments led the author to believe that Indonesia's economic growth was no longer solely reliant on natural resources, but also heavily dependent on the manufacturing industry. The main question raised is to what extent this shift has occurred. This inquiry emerged due to statistical data released by the Indonesian Central Statistics

Agency (BPS), which revealed that Indonesia's manufacturing industry's growth rate was lower than the overall economic growth rate (Ministry of Industry Republic of Indonesia, 2019). Consequently, the term "deindustrialization" emerged and has been prevalent for the past decade.

In Indonesia, the term "industry" was commonly used to refer to the non-oil and gas processing industry or manufacturing, similar to many other developing nations. It typically denoted the transformation of raw materials into more valuable products. Nevertheless, "industry" also represented the skills and endeavors of organized individuals who aimed to create something more valuable and beneficial using natural resources and primary products. The process of industrialization, at the core of structural change catalyzed by the Industrial Revolution, consistently augmented production levels and employment, ultimately leading to unprecedented income growth (Hauge & O'sullivan, 2019). Therefore, promoting the development of the industrial sector was considered crucial for attaining sustainable development. The literature on growth and development emphasized a strong correlation between manufacturing output and GDP growth (Pacheco-López, 2014). The debate surrounding the impact of industrialization on economic development has been extensive. Throughout history, all instances of successful economic development and catching up, starting from 1870, experienced growth and wealth accumulation through investments in their respective industries (Szirmai, 2012). Consequently, this resulted in a rise in the quantity and diversity of manufactured goods, generating employment opportunities and enhancing the standard of living.

In the process of economic development, the industrial sector has been recognized as a crucial driver of growth due to its high potential for productivity improvement (Kaldor, 1967). Consequently, by implementing appropriate policies, the industrial sector has the capacity to propel the economy forward, transitioning from a sluggish recovery to a revitalization (Cerna, 2014). It is widely acknowledged that developing nations would face considerable challenges in eradicating extreme poverty without achieving genuine industrialization, which can generate added value (Hall, 2021). The expansion of the industrial sector can be viewed as an extension of the "Total Causality" process, in which supply variables interact with demand. On the one hand, industrial output growth leads to job creation, income generation, and increased demand (Kniivilä, 2004). On the other hand, expanding industrial production fosters productivity growth, enhancing individuals' well-being (Sharpe & Mobasher Fard, 2022). As part of this process, the continuous enhancement of the industrial production base has the potential to increase productivity through the establishment of new economic sectors, the adoption of advanced technologies, the manufacturing of sophisticated goods, and/or the integration into international supply chains that adhered to higher technological standards (Ministry of Finance Republic of Indonesia, 2020).

Industrial expansion is considered one of a nation's most important economic development indicators. It is crucial in formulating industrial policy and national development objectives (Salazar-Xirinachs et al., 2014). The analysis of industrial growth is imperative, aligning with the government's efforts to foster high-quality industrial development through a judicious mix of fiscal and monetary policy. The formulation of industrial policies should consider the business cycles prevalent in the economy, ensuring their effectiveness in achieving their intended objectives. The output gap technique, a fundamental diagnostic procedure, is utilized to determine the economic position in the economic cycle (Mastromarco et al., 2021).

Rodrik (2016) argues that the decrease in manufacturing in low- and middle-income economies was deemed premature for two main reasons. Firstly, these countries underwent deindustrialization at an early stage in history when their income levels were lower. Secondly, this premature reduction resulted in a missed opportunity for economic growth, as the manufacturing sector lost its dynamism. The decline in dynamism within the manufacturing sector raised concerns due to its significant role in technological innovations, generating trade surpluses, stimulating economic growth, enhancing economic productivity, and fostering regional development (Rodrik & Kennedy, 2007; Manyika et al., 2012; UNIDO, 2013; Szirmai & Verspagen, 2015; Schot & Steinmueller, 2018). Therefore, the manufacturing sector acted as an engine of economic growth (Kaldor, 1967; Su & Yao, 2017; Haraguchi et al., 2017) or as an escalator sector to stimulate the economy, especially the undeveloped, to achieve a high level of development (Rodrik, 2013; Rodrik, 2014). Rodrik (2016) suggests that industrialization played a crucial role in shaping contemporary society. Many developed countries experienced significant economic growth during their respective industrialization phases and attained high per capita incomes. However, as manufacturing declined in prominence within the economy, the growth engine lost much of its power, resulting in a lower growth rate (Rowthorn & Ramaswamy, 1997; Wan et al., 2022).

The concept of an output gap encompasses two scenarios within an economy: either there is excess demand or there is underutilized production capacity (idle resources) (Sun, 2020). The output gap is characterized as the difference between the actual output, representing the value of economic output determined by demand during a business cycle—typically measured by Gross Domestic Product (GDP)—and the potential output. On the one hand, actual output reflects the economic output influenced by demand; on the other hand, potential output indicates the optimal production level at which labor and capital inputs are sustainably utilized in the long term, maintaining a stable rate of natural unemployment and inflation. De Masi (1997) states that potential output signifies an economy's maximum output without generating inflationary pressures. Both potential output and the output gap hold significance within the framework of macroeconomic policies. Potential output serves as a gauge of an economy's supply capacity on the supply side, considering factors such as capital stock, labor utilization, and available technology. Over the long run, the efficient utilization of production factors at a given level of

productivity plays a significant role in determining potential output. However, in the short term, aggregate demand can drive production levels above potential long-term output. This scenario exerts pressure in the form of excess demand in both the goods and labor markets, ultimately increasing inflation (Bernanke & Blanchard, 2023).

Determining the output gap enables an assessment of the stage of economic conditions. This determination is then considered when formulating fiscal and monetary policies. If the actual output surpasses the potential output (positive output gap), it signifies that the economy is experiencing a period of prosperity or expansion, resulting in inflationary pressures (Sriyana, 2022). As a result, a contractionary fiscal policy response, such as reducing expenditures, raising taxes, and implementing tight monetary policy, such as increasing interest rates, is necessary. Conversely, when the actual output falls short of the potential output (negative output gap), it indicates an inadequate production capacity utilization. This leads to higher unemployment rates and deflation, indicating an economic recession. In such cases, an expansionary fiscal and monetary policy response is required to boost or create demand (Li et al., 2021).

An accurate evaluation of industrial growth conditions and potential outputs serves as the foundation for measuring and predicting medium- and long-term economic trends (Kniivilä, 2004). Although the issue of output gaps is crucial in the formulation of fiscal and monetary policies, a comprehensive study of this topic in Indonesia is still very limited. This limitation can be understood by considering that both potential outputs and gap outputs are unobserved or latent variables, and their measurements or estimates contain elements of error or uncertainty. If the element of uncertainty or measurement error is relatively large, using potential outputs and gap outputs to craft policy recommendations may be inaccurate. Therefore, the estimation of potential and gap outputs must be carried out using scientific methods and evaluated with a methodology that aligns with the underlying economic theory.

The existing research gap is related to previous research focusing on estimating economic growth using a relatively similar potential output estimation method, based on annual data up to 2013 (Nasution & Hendranata, 2014). To address this gap, our research examines non-oil and gas industries, employing more recent data and utilizing quarterly time frames (high frequency) to enhance the analysis. This approach aims to offer a more thorough understanding of the dynamics involved. This research specifically aims to evaluate the output potential and output gap growth of the Indonesian non-oil and gas industry, along with its position in the business cycle. Various approaches, both univariate and multivariate, are employed, and the selection of the best model is based on its capacity to elucidate the dynamics of inflation in Indonesia over time. The ultimate goal is for the research findings to contribute valuable insights and effective policy recommendations, fostering sustainable economic growth.

Several studies were conducted to estimate potential output and output gaps in Indonesia (Tjahjono et al., 2010; Rinaldi & Saputro, 2017; Syamsuar & Sumitro, 2020). This study prioritizes an approach using the production function model, wherein potential output is calculated based on the production function, establishing a relationship between the output gap and the inflation rate. Furthermore, Mitra et al. (2015) conducted a study to estimate the potential output and output gap in Sweden using several approaches generally divided into two categories: univariate and multivariate. A similar study was also conducted by Araujo et al. (2004), who attempted to estimate potential output and output gap using a series of univariate methods such as the Hodrick-Prescott (HP) filter, Band-Pass (BP) filter, moving average, and others, as well as the production function approach and structural VAR.

Research Method

The research utilized the documentation method as the data collection approach, involving gathering relevant data from selected reports. This study used secondary data acquired from institutions dedicated to publishing data to benefit data users. The study relied on time series data in quarterly intervals, covering the period from the first quarter of 2000 (2000q1) to the fourth quarter of 2021 (2021q4). The data sources included CEIC (an economic database provider), the Central Agency of Statistics (BPS), the Ministry of Industry of the Republic of Indonesia, the Ministry of Finance of the Republic of Indonesia, and the Total Economic Database. Unfortunately, without specific details on the data used in the paper, such as the specific variables or indicators, it is impossible to provide further information about the data sources or the specific data points analyzed in the study.

Table 1 Variable, Dimension, and Sources

Variable	Definition	Unit	Source
Real Gross Domestic Product: Seasonal Adjusted (YSA)	GDP data, whose effects/patterns have been eliminated through specific statistical methods	Billion Rupiah	BPS and CEIC, processed
Real Gross Domestic Product manufacturing sector: Seasonal Adjusted (YMSA)	The economic information regarding the Gross Domestic Product (GDP) is specifically related to the manufacturing sector and is classified into two-digit codes. Certain statistical methods have been employed to eliminate the effects and patterns from the GDP.	Billion Rupiah	BPS and the Ministry of Industry, processed
Real Gross Fixed Capital Formation (I)	During a specific time frame, there has been a rise in the number of capital goods (investment), encompassing building (infrastructure), machinery, equipment, vehicles, and other tools.	Billion Rupiah	BPS

Table 1 Variable, Dimension, and Sources (cont')

Variable	Definition	Unit	Source
Depreciation Rate (δ)	The weighted average percentage of depreciation rate for each component forming the PMTB.	Percent	BPS
Number of Workers (L)	The population within the age range suitable for employment or working	Million People	BPS
Number of Each Sectoral Manufacturing Workers (LM)	The population of individuals within the appropriate working age range who are employed in the manufacturing sector.	Million People	BPS and the Ministry of Industry, processed
Labor income share ($1-\alpha$)	Elasticity of output to labor	Percent	Total Economic Database
Inflation (π)	Measured using consumer price index (CPI)	Percent	BPS

Estimating potential output and output gaps typically involves two primary approaches: the univariate method and the quasi-theoretical method. The univariate method is a statistical approach that focuses solely on statistical properties without considering macroeconomic variables. This process involves the division of time series variables into permanent and cyclical components. Notable examples of univariate methods include the Beveridge-Nelson, Baxter King, HP filter, and BP filter. In contrast, the quasi-theoretical approach constructs models based on economic theory and the interconnections between macroeconomic variables. The production function approach belongs to this category. Technically, the univariate approach is simpler compared to the multivariate approach. However, this does not mean that the results produced with the univariate approach are always inferior to the multivariate approach. For example, a study conducted by Araujo et al. (2004) to estimate the output gap in Brazil, using various univariate and multivariate methods, found that the Beveridge-Nelson decomposition method (an univariate method) performed the best. The study also found that including output gaps as one of the free variables in the Phillips curve equation significantly improved the model's predictive power. In contrast, a study by Álvarez & Gómez-Loscos (2018) to estimate the output gap, which also used several univariate and multivariate approaches, found that the production function approach (a multivariate method) did not significantly improve the accuracy of output gap estimation but imposed additional structural assumptions. Another study conducted by Tjahjono et al. (2010) to estimate potential output and output gaps in Indonesia, using various univariate and multivariate methods, found that the multivariate approach performed better than others. This study employed a multivariate model with an unemployment and capacity utilization approach incorporating relevant empirical relationships between actual GDP, potential GDP, unemployment rate, inflation rate, and manufacturing sector capacity utilization within a small macro-econometric model.

To estimate potential output, this study employs three methods: time series filtering techniques such as the HP Filter and BP Filter and the quasi-theoretical approach using production functions. The utilization of these analytical methods is described as follows: Statistical techniques rely on time series filtering methods to estimate actual output data trends by separating or filtering the data into cyclical and trend components. Well-known methods used in this approach include the HP and BP filters. The main advantage of this method lies in its relative simplicity and transparency. However, since it relies solely on statistical calculations, it may lack a strong connection to economic theory and ignore the relationships between economic variables, making it difficult to explain the dynamics according to economic theory. The HP filter is a commonly used smoothing technique to estimate potential output. It minimizes the difference between actual output and potential output by constraining the rate of change in potential output for the entire observation sample (T). The HP Filter equation can be written as follows (Hodrick & Prescott, 1997):

$$\text{Min} \sum_{t=1}^T (y_t - y_t^*)^2 + \lambda \sum_{t=2}^{T-1} [(y_{t+1}^* - y_t^*) - (y_t^* - y_{t-1}^*)]^2 \quad (1)$$

where y is the actual output (real GDP), y^* is the potential output, and λ is the weighting factor that determines the degree of smoothness of the trend. A smaller value of λ indicates that the potential output closely follows the actual output, while a larger value of λ results in a smoother potential output that deviates further from the actual data. To determine the value of λ , a common practice is to use the equation $\lambda = 100 q^2$, where q represents the periodicity of the data. For example, λ would be set to 100 for annual data, 1600 for quarterly data, and 14400 for monthly data. The parameter λ (where $\lambda \geq 0$) functions as a tuning parameter regulating the magnitude of the penalty. As evident from this criterion, the method is nonparametric, and the selection of λ significantly influences the shapes of the fitted trend and cycle functions. If λ is chosen to be excessively large, the fitted trend approximates linearity, converging to a linear trend as λ approaches infinity. Conversely, if λ is chosen too small, the fitted trend becomes highly flexible, closely mirroring the data and incorporating elements of short-term fluctuations (Phillips & Shi, 2019).

The BP filter is a linear filter that calculates weighted moving averages on both sides of the data, allowing only the components within a specified frequency range (band) to pass through. It separates the time series data into different frequency components, focusing on capturing the medium-frequency cyclical component, often associated with business cycles. The determination of the duration range for the filter depends on the knowledge of the length of the business cycle in a particular country, which may vary or may not be readily available. As a general guideline, the standard practice assumes a lower cycle range of 6 quarters (1.5 years) and an upper cycle range of 32 quarters (8 years). The BP Filter employs decomposition theory to isolate the data into various frequency components (Baxter & King, 1999).

$$X_t = y_t + \widetilde{X}_t \tag{2}$$

In the production function approach and growth accounting, the potential output is connected to input factors. Solow's theory of growth asserts that the output level (economic growth) is influenced by the inputs of capital and labor, which mutually interact under a given level of technology. Technology represents the knowledge and efficiency in producing goods and services. The level of technological progress can be indicated by the Total Factor Productivity (TFP), which reflects the efficiency of each component of the production factors. Higher TFP implies more efficient use of the production factors in generating output. Solow's growth model can be expressed as follows (Solow, 1957):

$$Y_t = A_t \cdot K_t^\alpha \cdot L_t^{1-\alpha} \tag{3}$$

In this context, Y symbolizes the production of goods and services, A represents Total Factor Productivity (TFP), K signifies capital, L denotes labor, and α denotes capital contribution to output. An increase in production efficiency leads to a shift in the production function curve (from point A to B). Technological advancements result in increased output by shifting the production function curve from point B to C. Additionally, an increase in inputs from X_1 to X_2 leads to an increase in output from points C to D, as shown in Figure 1.

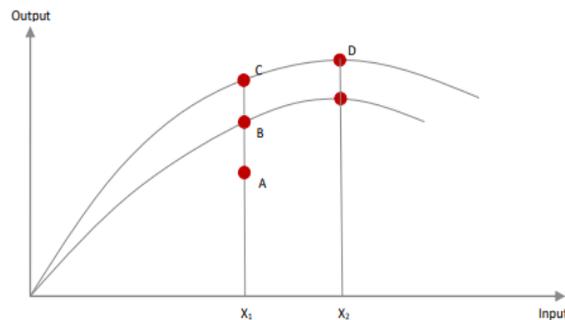


Figure 1. Production function

TFP is not directly observable and is typically derived as a residual in the Solow growth accounting framework, as shown in the following equation:

$$Y' = A' + \alpha K' + \beta L' \tag{4}$$

The symbol (') indicates each component growth, Y' denotes the output growth, K' represents the capital growth, L' represents the workforce growth, A' signifies the technological advances growth, α denotes the elasticity of capital to output, and β signifies the elasticity of labor to output. When estimating potential output using this production function approach, the following stages need to be completed.

The first step involves estimating the initial capital stock using the accelerator model approach. The initial capital stock (χ_t) can be estimated using the accelerator model approach, which takes into account the additional new investment (I_t), the GDP growth rate (g_t), and the depreciation value (δ_t). The formula is as follows:

$$\chi_t = I_t(g_t + \delta_t)/Y_t \quad (5)$$

Capital stock estimation using the perpetual inventory method, the capital stock (K_t) can be calculated using the perpetual inventory method, which involves updating the previous period's capital stock (K_{t-1}) by accounting for depreciation (δ) and adding the additional new investments (I_t). The formula is:

$$K_t = (1 - \delta)K_{t-1} + I_t \quad (6)$$

To obtain the trend component of the labor and TFP variables, a smoothing process was performed. In this paper, the HP filter was used for this purpose.

Calculating TFP, TFP represents the portion of output (Y_t) that cannot be explained by the inputs of capital (K_t) and labor (L_t) according to the production function. It can be calculated using the formula:

$$A_t = Y_t/K_t^\alpha * L_t^{(1-\alpha)} \quad (7)$$

Calculating potential output using aggregate production functions. After obtaining the components of potential capital (K_t^*), potential labor (L_t^*), and potential TFP (A_t^*), the potential output (Y_t^*) can be calculated using the aggregate production function.

$$Y_t^* = A_t^* \cdot K_t^{*\alpha} \cdot L_t^{*1-\alpha} \quad (8)$$

The production function approach has the advantage of being built on economic theory and incorporating key macroeconomic variables. This approach can provide insights into the dynamics of potential output estimates and gaps, drawing from theoretical and empirical explanations. Additionally, it can help identify the factors driving past growth and highlight structural changes in the growth trend. However, it should be noted that this approach still relies on time series filtering techniques, which have their limitations. To calculate the output gap, the estimated potential output (Y_t^*) is compared to the actual output (Y_t) using the following formula:

$$GAPt^* = ((Y_t - Y_t^*)/Y_t^*)/* 100 \quad (9)$$

Where $GAPt^*$ represents the output gap in period t , Y_t is the actual GDP/output level, and Y_t^* is the potential GDP/output level.

To evaluate the potential output estimation method, the Phillips curve model approach is utilized, which examines the relationship between the output gap and the inflation rate's dynamics. The optimal model selection is determined by the extent to which the output gap can explain inflation dynamics, taking into account the inflation rate's fluctuations over different periods (Nasution & Hendranata, 2014). The expression of the Phillips curve model is as follows.

$$\pi_t = \alpha + \sum_{j=1}^4 \beta_j \pi_{t-j} + \sum_{j=0}^4 \beta \lambda_j \gamma \text{gap}_{t-j} + \varepsilon_t \quad (10)$$

Where π is the inflation rate and ygap denotes the output gap.

Results and Discussion

In general, despite varying magnitudes, consistent patterns and directions of movement were observed in the estimates of potential and gap output using the HP filter, BP filter, and production function methods. These estimates of potential growth rates from 2000 to 2021, obtained through three approaches, demonstrate a remarkable level of consistency. The provided dataset further indicates that Indonesia's manufacturing sector has experienced relatively stable growth since the crisis period in the early 2000s until the present, as evidenced by the growth rates. Additionally, the data reveals a minimal difference between the actual and potential growth rates. The illustrations also depict the impacts of the crises in 2008 and during the COVID-19 pandemic in 2020. Figures 2 demonstrate that the actual output trend was slightly below the potential output estimated through the production function (FPYgap) and HP filter (HPYgap) approach, and marginally lower than the potential output estimated using the BP (BPYgap) filter approach.

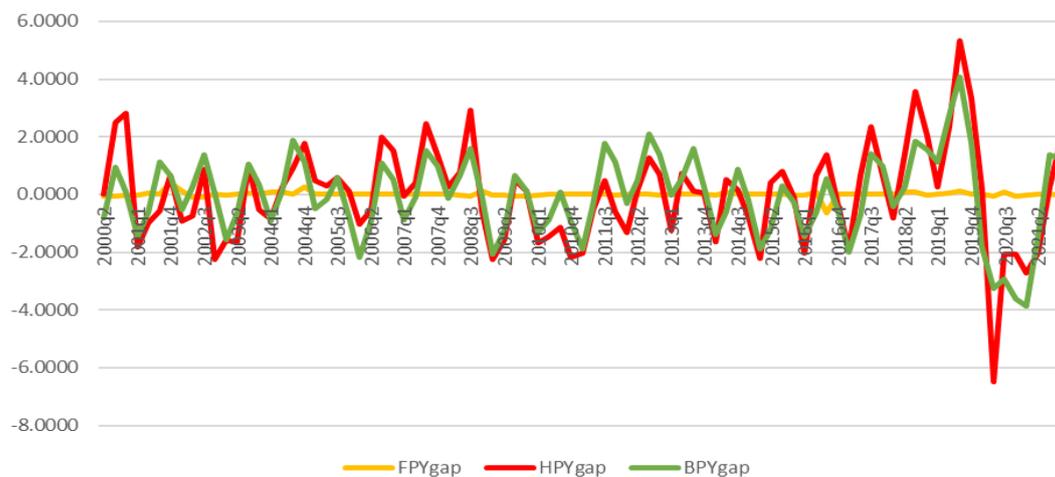


Figure 2 Output Gap 2000q2-2021q4

Figure 2 illustrates the dynamics of Indonesia's industry tides throughout the 2000-2021 period. Consumption growth was crucial in driving the post-crisis economic recovery process during this period. Ikhsan (2005) and Adelowokan (2021), suggest that several factors, including deferred consumption from the crisis period, regional minimum wage hikes, government subsidies, and an expansion of consumer credit, drove the increase in consumption. From 2003 to 2008, the industry's growth tended to surpass its potential level, resulting in a positive output gap. However, at the end of 2008, the global financial crisis unfolded, triggered by the emergence of subprime mortgages, leading to the closure of several major companies in the US (Tori et al., 2023). This situation also impacted Indonesia's industry, causing a slowdown in growth and a return to negative output gap levels in 2008q2 and 2010q1.

Moreover, in Indonesia it is apparent that the industry witnessed a positive output gap between 2011 and 2014, which subsequently turned negative from 2015 onwards. The surge in global demand for commodities, known as the commodity boom, primarily drove the positive output gap during the period of 2011-2015. As a country that produces and exports raw commodities such as coal, Crude Palm Oil (CPO), and metal minerals, Indonesia experienced a significant boost in its economic performance (Rezki et al., 2022). Generally, the high global demand and subsequent price increases during this period resulted in higher incomes for the population, leading to increased demand for goods and services. Additionally, this situation was accompanied by inflationary pressures due to limited economic potential (Liliana et al., 2020).

Between 2016 and 2017, a global economic downturn was characterized by a slowdown in economic growth in developed and developing countries (Kim & Park, 2017). This was accompanied by a significant drop in global commodity prices, which impacted Indonesia's industry and resulted in slower growth. As a result, the actual output of the Indonesian industry fell below its potential level, indicating a negative output gap. Between 2017 and 2019, the output gap approached positive levels again. However, the COVID-19 pandemic in 2020 created additional challenges for the industrial sector, affecting both supply and demand (Kwon, 2020). On the supply side, there were disruptions in global supply chains, while on the demand side, reduced purchasing power hindered the industry. Numerous prospective manufacturing industries were compelled to curtail operations and reduce production, resulting in a significant downturn within the industrial sector in Indonesia.

The estimated growth of Indonesia's non-oil and gas processing industry in 2021 was projected to be 3.8%, higher than the actual growth. This suggests that there is limited potential to increase the industry's output and reach its current potential level. This situation provides valuable information for improving the national economy in the short and medium terms. In the short term, according to the Phillip curve model, a positive output gap worsens inflationary pressure (Del Negro et al., 2020; McLeay & Tenreyro, 2020). Therefore, controlling inflation requires implementing countercyclical fiscal and

monetary policies, such as regulating the money supply and setting the benchmark interest rate, to alleviate the pressure of rising inflation expectations. On the other hand, in the medium term, it is crucial to enhance potential output by increasing labor, investment, and productivity in production capacity. Analyzing efforts to improve production capacity involves decomposing the estimated potential output and output gaps using the production function approach, as explained in the following section.

Table 2 The regression results based on the Phillips Curve model

Variable	HP filter	BP filter	Production Function
C	1.2191**	1.2478**	1.2926**
Ygap	0.0043	-0.2803	1.0546
Ygap(-1)	0.0514	0.6103	1.3379
Ygap(-2)	-0.0486	-0.6006	-0.4847
Ygap(-3)	0.1330	0.6621	-0.7699
Ygap(-4)	0.0049	-0.3402	4.5707*
Inflation(-1)	0.9950**	0.9904**	1.0014**
Inflation(-2)	-0.0437	-0.0364	-0.0460
Inflation(-3)	-0.0123	-0.0061	-0.0302
Inflation(-4)	-0.1415	-0.1532	-0.1471
R ²	0.7940	0.7943	0.8068
Adj R ²	0.7686	0.7689	0.7829
F-statistic	31.2576	31.3136	33.8645
Prob(F-stat)	0.0000	0.0000	0.0000
DW stat	1.8675	1.8691	1.8483

*) significant at $\alpha = 1\%$; **) significant at $\alpha = 5\%$.

The regression outcomes of the Phillips Curve model revealed that all three approaches produced comparable R-squared values and significant results in both t-tests and f-tests when explaining the variations in the inflation rate. This indicates that the three methods were successful in estimating potential output. However, the production function method offered an advantage by explaining the primary factors that drive growth. Additionally, the production function approach was utilized to analyze the impact of labor, capital, and productivity factors on economic performance, encompassing both historical patterns and future trends (Crafts & Woltjer, 2021).

To conduct the decomposition analysis, the Solow growth model was utilized within the production function approach. This allowed for establishing a link between growth and the factors that drive it, such as labor, capital, and TFP (Total Factor Productivity). Consequently, it became possible to estimate the factors contributing to economic growth from 2000 to 2021, both in terms of actual output and potential output, as demonstrated in Tables 3 and 4.

Table 3 Production Factor Components Contribution to The Actual Output

Decomposition	2000-2004	2005-2009	2010-2014	2015-2019	2000-2021
Average Growth (%)	5.15	3.94	4.8	4.54	4.16
Labor (%)	-0.01	-0.01	-0.004	-0.02	-0.002
Capital (%)	4.27	3.52	4.5	4.35	3.82
TFP (%)	0.88	0.44	0.3	0.2	0.34

Based on the information presented in Table 3, the performance of Indonesia's non-oil and gas processing industry was primarily influenced by the role of capital, accounting for 90.4% (3.82 out of 4.16%) of the industry's growth. Total Factor Productivity (TFP) contributed 9.7% (0.34 out of 4.16%), while labor had a minimal contribution of -0.1% (-0.002 out of 4.16%). The significant impact of capital aligns with the observed upward trend in the investment-to-GDP ratio, which has consistently increased since the crisis period. Conversely, the contribution of labor has gradually declined over time.

Table 4 Production Factor Components Contribution to The Total Potential Output

Decomposition	2000-2004	2005-2009	2010-2014	2015-2019	2000-2021
Average Growth (%)	5.67	3.98	4.79	4.54	4.2
Labor (%)	-0.01	0.03	-0.004	-0.02	0.01
Capital (%)	4.73	3.55	4.49	4.35	3.86
TFP (%)	0.95	0.44	0.3	0.2	0.34

Furthermore, the potential output decomposition results provided in Table 4 demonstrated a tendency to display comparable conditions to the actual output decomposition results observed between 2000 and 2021. A closer scrutiny of the analysis period from 2015 to 2021 revealed a scenario in which the actual output declined below the potential output. This occurrence predominantly stemmed from the lower contributions of TFP and capital compared to their potential levels, while the contribution from the workforce slightly exceeded its potential.

As mentioned earlier, the findings from the analysis of economic growth and potential output suggest that the scope for enhancing and optimizing economic potential is becoming increasingly limited. Consequently, there is a pressing need to undertake efforts to boost economic capacity, leading to increased potential output. These efforts primarily revolve around enhancing the supply side, which encompasses labor, capital, and productivity, all of which are integral components of the production function approach.

According to the information presented in Tables 3 and 4, the primary driver of economic growth in Indonesia is primarily attributed to an increase in the accumulation of capital. In contrast, the contributions of both the labor and TFP components have shown a declining trend in recent years. This pattern reflects a situation where there is a growing mastery of technology but relatively low productivity. Anand et al. (2014) suggest that the low TFP contribution can be attributed to various factors, including a low level of R&D,

insufficient infrastructure, and the economy, particularly the processing industry sector, suffering from a dearth of complexity. Additionally, the licensing procedures during the business startup process posed challenges due to their complexity. These findings serve as an early indication that structural reforms should be a key focus for optimizing the sources of national economic growth. Government policies aimed at supporting these structural reforms may involve implementing a combination of measures that target improvements in labor, investment, and productivity factors.

The industry drove the post-crisis economic recovery from 2011 to 2014 but experienced a negative trend from 2015 onwards. From 2011 to 2015, the period witnessed a positive output gap, primarily fueled by a surge in global commodity demand, specifically in the production and exports of coal, CPO, and metal minerals (Admi et al., 2022). During this period, the high global demand and price increases increased incomes and boosted the demand for goods and services. However, this led to inflation due to limited economic potential (Kim & Park, 2017). In 2016-2017, global commodity prices fell, and economic growth in advanced and developing countries slowed, affecting Indonesia's slow-growing industry. Consequently, the output of the Indonesian industry declined (negative output gap). From 2017 to 2019, various approaches indicated a positive output gap (Verico, 2021). However, the COVID-19 pandemic in 2019-2020 severely impacted the industrial sector from both the supply and demand sides (Kwon, 2020). Global supply chain disruptions disrupted the supply, while decreased purchasing power disrupted the demand. As a result, Indonesia's industrial sector contracted as future manufacturing industries reduced utilities and production. According to the Phillip curve model, short-term inflationary pressures can arise from a positive output gap. Therefore, countercyclical fiscal policies and monetary policies controlling the money supply and benchmark interest rates can help manage inflation expectations and control inflation. In the medium term, increasing production capacity through labor, investment, and productivity is crucial. Analyzing production capacity increases by decomposing potential output and output gaps using the production function approach is recommended. The projected growth rate for Indonesia's non-oil and gas processing industry in 2021 is estimated to be 3.8%, which is slightly above the actual growth rate. This limited growth potential of the non-oil and gas processing industry hampers its output expansion. However, this situation can contribute to short and medium-term improvements in the economic fundamentals. The Indonesian government's goal of achieving 6.5%-7% growth in the non-oil and gas processing industry within the next three years (by 2024) seems unlikely due to its significantly lower potential output growth.

In the short term, fiscal and monetary policies were implemented to control inflation and alleviate the pressures of rising prices. In the medium and long term, policy measures were undertaken to promote structural reforms that enhance production factors such as labor, capital, and productivity. Regarding the labor aspect, the growth rate of the workforce continued to decelerate, but there was still potential for improvement. This improvement could be achieved through various means, including prioritizing training a

critical mass of workers in new technologies. Since the private sector's involvement was challenging to rely on, upgrading existing training centers to offer a wider range of programs in new technologies was also considered (Muchdie & Nurrasyidin, 2019). This suggestion is substantiated by the transformative influence of Industry 4.0 on manufacturing processes, which, in turn, affects globalization through alterations in the workforce dynamics and enhanced opportunities for acquiring new skills and knowledge. The World Economic Forum estimates that by 2025, half of the global workforce will need retraining due to embracing new technologies. Studies conducted by Li (2022) indicate that individuals and organizations must dedicate themselves to reskilling and upskilling, making career development a crucial aspect of future workforce planning.

Another suggestion involves allocating funding for newly designed technology training programs tailored specifically for small and medium-sized enterprises (SMEs). These programs should focus on technological entrepreneurship training. Securing financial support for SMEs is crucial, particularly since financial technology plays a vital role in enhancing the financial well-being of SMEs in developing nations and promoting increased financial inclusion for these entities. Both financial technology and enterprises utilizing this technology significantly enhance SME financing efficiency in emerging markets (Lasak, 2023). To address marketing challenges encountered by SMEs, it is recommended to implement entrepreneurship training that leverages technology to improve understanding of product marketing through technological means (Irianto et al., 2023). This training aims to equip participants with an in-depth comprehension of entrepreneurship and digital marketing concepts, enabling them to optimize social media usage for boosting product sales. Another recommendation is to ensure access to institutions providing advanced technical training and to encourage the involvement of foreign companies, particularly in industries like automotive, to expand their training facilities. Empowering foreign companies investing in Indonesia can serve as a means to develop local human resources, wherein these companies can prompt local suppliers to train workers to meet quality standards and influence governments or industry associations to establish training facilities (Golejewska, 2001).

The following recommendation for enhancing the quality of human resources involves exploring the potential of engaging skilled women across various sectors. Another policy approach is to boost the participation of women in the labor force, fostering a more inclusive growth process. A woman's likelihood of becoming a productive member of society with paid employment increases with education, and the improvement is particularly significant for women with higher levels of education. Therefore, concentrating on women's education is vital for the progression of employed women and represents an investment in achieving a higher GDP (Kiani, 2013). Additionally, there is a need to augment funding for apprenticeships, provide on-the-job training opportunities for university students, and capitalize on the growing number of Indonesian graduates in science, technology, engineering, and mathematics (STEM). Apprenticeships can contribute to economic growth while addressing gaps in skill provision (Gambin &

Hogarth, 2017). The application of STEM proves valuable in enhancing students' entrepreneurial skills, motivation for learning, and a range of competencies. Consequently, the implementation of STEM education should be uniformly executed across all levels of educational institutions and in all provinces in Indonesia (Farwati et al., 2021). By implementing these measures, the workforce's potential is expected to be further developed and contribute to technological advancements and overall economic growth.

Regarding capital, the initiatives to maximize its potential were visibly demonstrated by the acceleration of investment growth. Investment is pivotal in fostering economic growth, allowing a nation to acquire the capital and technology essential for its economic development. Generally, there are three approaches to encourage investment: introducing new measures to simplify licensing procedures, mitigating economic inefficiencies, and revising policies, rules, and regulations unfavorable to the market. One of the regulations governing investment is outlined in Law Number 25 of 2007 regarding Capital Investment. This law adheres to the principles of transparency, ease of doing business, and fostering healthy business competition. It also empowers regional governments in handling investment affairs, expecting to expedite the investment licensing process and improve coordination between the central and regional governments (Nurmal, 2023).

Furthermore, streamlining business licensing can attract investment, such as by consolidating business permits through the online single submission (OSS) system (Harahap et al., 2020; Arsawati et al., 2023). Therefore, by enacting laws and integrating systems that support investment, we have successfully created a more favorable and appealing investment climate for investors. These endeavors aim to facilitate investors in making investments, developing essential infrastructure, and providing supportive facilities for industry players. The government should prioritize planning efforts and offer necessary infrastructure, as it cannot solely depend on the private sector to fulfill this role. Additionally, promoting an increase in foreign investment, especially in export-oriented sectors, will help alleviate the burden on the current account balance caused by investments and can be counterbalanced by adding export capacity. By implementing these measures, the potential of capital can be further harnessed, leading to increased investment and economic growth.

To unlock growth through technological transformation, several policy actions were undertaken, including: Resolving gaps in both "hard" and "soft" infrastructure and establishing advanced innovation institutions; Enhancing digital infrastructure at the national level to reduce regional disparities; Creating long-term investment plans for research and development (R&D) and adopting international funding practices for research; Evaluating the necessity of new extension services and intermediate institutions, such as research and technology organizations, to offer technological assistance to businesses; Enhancing institutional capacity to implement policies across

various regions effectively; and Regularly update regulatory frameworks to accommodate the changes introduced by new technologies. By implementing these policy measures, the aim is to foster technological advancements and facilitate sustainable economic growth. The study suggests that technology positively and significantly influences economic growth (Nurdiana et al., 2023). Currently, Indonesia encounters challenges in embracing science, technology, and innovation, as evidenced by its 75th position out of 132 countries in the 2022 Global Innovation Index (GII) (WIPO, 2022). The contribution of science and technology to Indonesia's economic expansion remains relatively low. According to a survey by the International Labour Organization covering 4,000 enterprises across ASEAN, barriers to technology upgrades include high fixed capital costs and a shortage of skilled workers. Nearly half, or 49.6%, of Indonesia's manufacturing sector is concentrated in low-technology fields. Medium-technology sectors comprise 16.2% of the industrial structure, with medium-high and high-technology sectors comprising 31.7%. Nonetheless, ADB's analysis reveals that the share of manufacturing value added in high-technology sectors has quadrupled since 2000 (ADB-Bappenas, 2019). The ADB predicts that by 2040, the adoption of technology in Indonesia could contribute USD 2.8 trillion to its economy. This potential growth can increase Indonesia's gross domestic product (GDP) by 0.55 percentage points annually over the next two decades (Astuti, 2021). Technology and innovation are increasingly prominent in Indonesia's national policy agenda. To boost economic growth, the Indonesian government introduced Making Indonesia 4.0 in April 2018, an initiative program by the Ministry of Industry. The primary objective is to rejuvenate Indonesia's manufacturing sector, preparing it for the challenges and opportunities presented by the Fourth Industrial Revolution. This comprehensive plan encompasses various technologies such as AI, the Internet of Things, robotics, and 3D printing. The integration of these new technologies allows industries to improve productivity through more efficient resource utilization, fostering the development of new products, and facilitating entry into emerging markets (Ministry of Industry Republic of Indonesia, 2018). Indonesia must acknowledge the pivotal role of technology and innovation in attaining economic growth targets and increasing incomes.

Conclusions

The industrial development policy is established by assessing economic conditions, with the evaluation conducted through output gap analysis. This study assesses estimates of output potential and gaps in Indonesia's non-oil and gas processing industry sector. The analysis is based on data from various sources, including CEIC, BPS, the Ministry of Industry of the Republic of Indonesia, the Ministry of Finance of the Republic of Indonesia, and the Total Economic Database, covering the period from 2000 to 2021. Indonesia's manufacturing industry output is estimated using the Production Function Method and the BP filter.

The findings show that Indonesia's manufacturing industry fluctuations occurred from 2010 to 2021. The deindustrialization process observed in Indonesia since 2002 has had a negative trajectory. The deindustrialization in Indonesia was not an inherent result of a

well-established development process, but instead, it was triggered by shocks to the Indonesian economy, exerting a significant impact.

The policy implication should be carried out to facilitate the unlocking of industrial growth by adopting new emerging technologies. The government needs to develop policies to maximize the effects and outcomes of integrating technological advancements in Indonesia. This involves upgrading technology to enhance the efficiency and competitiveness of the sector fueling the country's economic growth, and improving the quality of human resources to ensure their adaptability to future employment requirements.

Author Contributions

Conceptualisation, T.W.P. and G.Y.; Methodology, T.W.P.; Investigation, T.W.P. and E.A.P.; Analysis, T.W.P. and G.Y.; Original draft preparation, T.W.P.; Review and editing, G.Y. and E.A.P.; Visualization, T.W.P.

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Conflicts of Interest

The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

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