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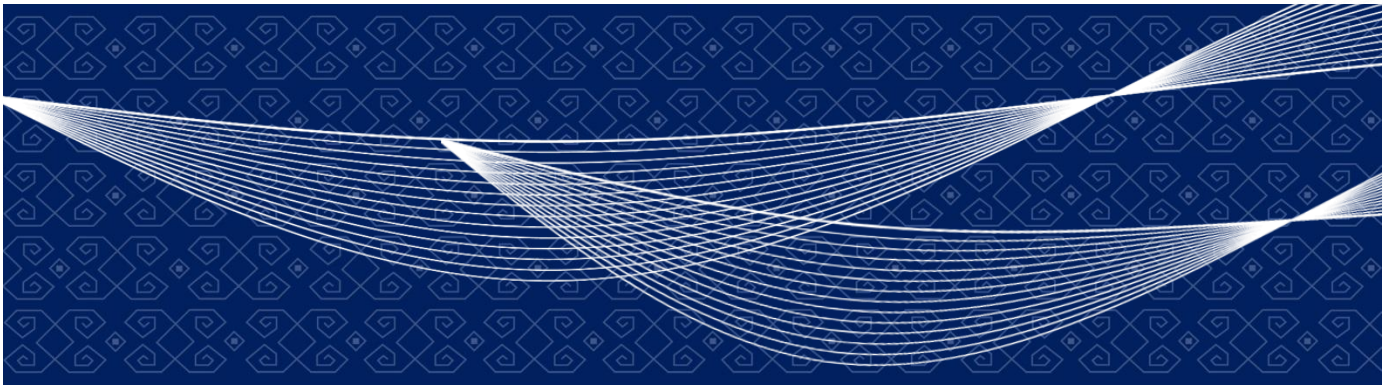

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WORKING PAPER

REVIVING THE MANUFACTURING INDUSTRY THROUGH SERVICIFICATION STRATEGY: EVIDENCE FROM INDONESIAN MICRODATA

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Abstract

This study investigates the role of servicification within Indonesia's manufacturing sector, focusing on its impact on productivity, global value chain (GVC) participation, and regional diversity in servicification practices. Empirical results indicate that servicification is positively correlated with firm productivity, with a 10% increase in service intensity linked to approximately a 1% productivity boost. The study further explores the differential impact of servicification across regions, technological classifications, and firm sizes. It reveals that in regions such as Java and Sumatra, high-value-added sectors benefit more from service integration, while the Eastern of Indonesia (EoI)'s reliance on primary manufacturing highlights challenges due to skill gaps and resource constraints. Also, based on regional survey data, they reveal how the integration of services—such as logistics, R&D, and customer support—into manufacturing operations can drive productivity and increase the sector's competitiveness. This analysis provides policy recommendations to optimize servicification, enhance GVC participation, and support the transition to a service-oriented manufacturing landscape.

Keywords: Servicification, Manufacturing Sector, Productivity, Global Value Chains, Digitalization

JEL Classification: L60, L25

1. Introduction

Global economies are increasingly shifting towards services. Nowadays, services comprise approximately two-thirds of global economic activity. In high-income countries, services have consistently represented over two-thirds of gross domestic product (GDP) in the last two decades, albeit with a gradual rise. Meanwhile, low- and middle-income countries are experiencing a rapid shift towards services, with the share of services being more than fifty percent of the GDP (World Bank, 2023).

Furthermore, the move towards service is also reflected in the rise of foreign direct investment (FDI) and trade, particularly in Asia. More recently, FDI in services accounted for 53.1% of total FDI in Asia (ADBI report, 2019). Trade in services has also increased rapidly in recent decades with the increase of exports of commercial services from $515 billion in 2005 to $1,325 billion in 2017, clearly outpacing the growth of merchandise exports. One reason for the strong growth in services is the fact that manufacturing is increasingly relying on services. More and more services are entering the manufacturing process as intermediate goods. As production is organized in regional and GVCs, services are increasingly being traded. Yet, services still represent only 17.2% of total exports (merchandise and services), implying a high untapped potential (ADBI report, 2019).

The fact that this shift is occurring even as manufacturing has yet to fully develop has prompted some to call the deindustrialization "premature" (Rodrik, 2016). The deindustrialization phenomenon of global economies, based on the notion that the manufacturing industry is a source of growth, has incorrectly raised concerns about the role of services. Without a boost in acceleration and technological advancements, manufacturing has reached its peak and no longer serves as a main driver of economic growth. Yet, the role of services in driving economic growth and creating jobs is growing and frequently overlooked (ADBI report, 2019).

Services are closely linked with manufacturing activities. The recent trends in OECD countries indicate a growing utilization of services by manufacturing industries in both upstreaming and downstream processes. This increase in the use, production, and sales of services in manufacturing sectors are described as the "servicification" of manufacturing (Thangavelu et al., 2018; Lodefalk, 2017; OCED, 2014). Servicification is also known as the fragmentation of manufacturing production into tasks, such as research, marketing, and logistics.

Servicification is crucial for the manufacturing industries for multiple reasons. First, as "enablers" of the global value chains (GVCs), services are increasingly used in developing countries to participate, connect, and benefit from the global economy (Lodefalk, 2017). Secondly, services are recognized as "linkages" or glues" of GVCs, which facilitate the global production of manufacturing products by connecting services such as information and communication services (ICT), transportation, and logistics (Gereffi & Fernandez-Stark, 2011). Thirdly, the servicification of manufacturing is also seen as a renewal of industrialization in OECD countries, which adds value to manufacturing firms with more service workforces (Boddin & Henze, 2014); Kizu et al, 2016). Moreover, servicification enables manufacturing firms of OECD countries to upgrade from low-end fabrication tasks to high-end service jobs, which upgrades their positions in GVCs (Lodefalk, 2017). Last but not least, servicification also improves the performance of manufacturing firms with higher productivity (Thangavelu et al., 2018), more diversified exporting varieties (Kelle et al., 2013), better access to foreign market (Lodefalk, 2017), and larger profits (Mastrogiacomo et al., 2017).

While the service sector plays a prominent role in a global context, it can be varied at the country level. Many factors can affect service optimization as a new potential source of economic growth. Addressing service and how it is interlinked with manufacturing activities is important for policymakers and henceforth, growth strategy. A rapid transition toward services also makes it crucial to gain a better understanding of this sector and the opportunities it offers.

However, despite the prominent role of the service sector as a source of economic growth, studies related to this sector are still relatively new, limited, and often overlooked by academics and policymakers. The growth of this sector has considerable potential and limitations that can still be researched further. However, to the best of our knowledge, empirical evidence on servicification is still scarce for many economies in the world, especially in the context of Indonesia as a developing economy.

Given the background, this study responds to this situation and attempts to provide more evidence on servicification and GVCs' participation in manufacturing activities especially in developing countries using Indonesia as a case study. This study also aims to examine the trends and role of servicification in supporting Indonesia's economic growth. In particular, the objectives of this study are as follows: (1) examine the impact of servicification of manufacturing activities on firm productivity; (2) examine the impact of servicification and GVC participation on GVC participation (3) examine the impact of servicification and digitalization on firm productivity. Other than that, this research provides the impact of servicification on Indonesia's manufacturing industry development at a national level. This study also examines the challenge and potential aspects of developing the service in manufacturing activities in the regional context as well as the policy implications that vary across regions.

This study contributes in several ways. First, we provide evidence on the servicification of manufacturing activities and GVC participation, especially in developing countries using Indonesia as a case study. Our study is among the first to assess the impact of servicification and GVC participation on productivity in the latest data. We expand the body of literature on the impact of servicification in Indonesian manufacturing (Rafitrandi & Narjoko, 2023) by providing a broader understanding of how servicification and GVC participation impacted productivity and the labor market. Lastly, our study provides the differential impact of servicification across manufacturing sectors, firm size, technology categories (high- and low-technology industries), and regional context.

2. Literature Review

2.1 Benchmarking with other countries

There have been notable shifts in global manufacturing export shares over the past 25 years. The left chart of Figure 1 shows that OECD and G20 countries have maintained significant shares in global manufacturing exports, with the OECD's and G20'2 share remaining stable at around 18-19%. The ASEAN region, however, has shown notable growth, increasing its share from about 5% to nearly 10%. China stands out with a dramatic rise, increasing its share from below 10% in 1995 to over 20% in 2020. Meanwhile, Japan and South Korea have seen relatively stable shares, with Japan's slightly declining to below 5% and Korea's maintaining steady growth to about 5%.

The dynamic shifts in the global manufacturing landscape, especially in ASEAN countries, underscore the successful industrialization efforts of these

emerging economies. As seen in the right chart of Figure 1, Vietnam along with India has shown significant growth, with Vietnam's from nearly negligible to around 2.5% and India's share rising from around 1% to approximately 2.5%. Thailand and Malaysia have maintained relatively stable shares, around 2-3%, reflecting steady contributions to global manufacturing exports. Indonesia has also seen gradual growth, increasing its share from below 1% to about 2%, indicating steady industrial development. The Philippines, however, has experienced minimal change, maintaining a share below 1%, suggesting slower progress in enhancing its manufacturing export capabilities.

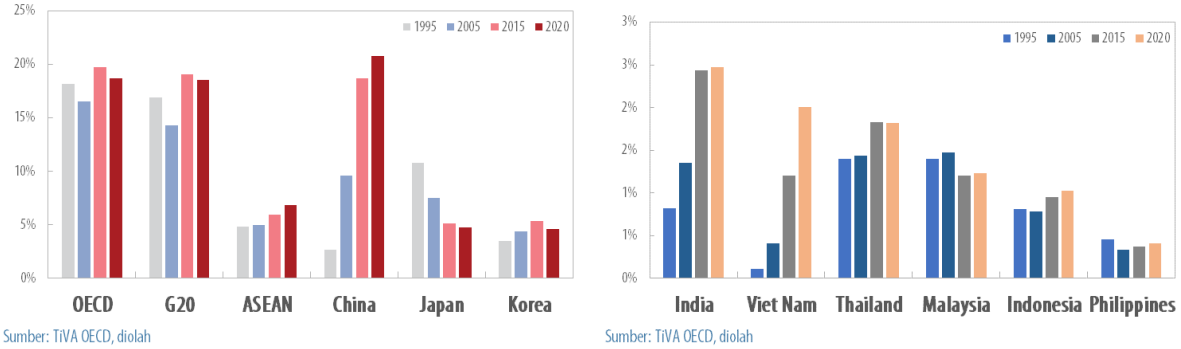


Figure 1 Comparison of Participation in World Manufacturing Exports, 1995-2020

These changes underscore both the opportunities and challenges that policymakers and industry leaders face in improving their countries' competitive positions in the global market. The rise of China and ASEAN countries, particularly Vietnam and Indonesia, emphasizes the shifting dynamics and the necessity of adapting to the evolving industrial landscape.

With intensifying international competition, Indonesia’s manufacturing industry is under increasing pressure to undergo structural transformation and upgrading. Traditional competitive advantages are weakening, and the simple production methods of the past no longer meet the demands of global market integration. Therefore, accelerating the transformation and upgrading of Indonesia’s manufacturing sector has become imperative.

Service-oriented manufacturing, which integrates products and services, offers a pathway to innovative, cost-effective, and high-quality development, helping firms establish new competitive advantages (Abudureheman et al., 2023). Advanced manufacturing countries like the United States and Germany have already embraced this trend, highlighting its significance in global manufacturing. In Asia, the Chinese government, with its “Made in 2025” plan, emphasizes the development of service-oriented manufacturing. Implementing such strategies would drive specialization and enhance Indonesia’s position in the global value chain, supporting the manufacturing sector's modernization and growth.

The concept of servicification, which refers to the integration of services into manufacturing processes, has been increasingly recognized as a significant factor in enhancing export performance and productivity in various economies. According to a study by the Asian Development Bank, servicification plays a crucial role in the global economy by contributing to output, employment, and value-added trade, particularly in Asia where services are increasingly intertwined with manufacturing activities (Mercer-Blackman and Ablaza, 2018). Similarly, research on Turkey highlights that while servicification can enhance firm performance and trade capabilities, there are inefficiencies in service markets that can hinder productivity (Haven and Marel, 2018). In India, the integration of services into manufacturing has been shown to promote exports, leveraging the country's strong services sector to

enhance manufacturing firms' competitiveness in international markets (Pattnayak and Chada, 2022). These findings underscore the multifaceted role of services in modern economies, where they not only support manufacturing processes but also drive export growth and economic development through global value chains (Taguchi and Lar, 2024).

Indonesia's manufacturing sector has been gradually integrating services, but it lags behind some of its peers. As seen in Figure 2, In the last ten years, services have contributed around 23% to Indonesia's manufacturing export value-added, which is lower compared to Malaysia and Thailand, where services account for approximately 30%. India, Vietnam, and the Philippines have experienced a consistent rise in their servicification levels, gradually approaching those of Indonesia, with services now contributing approximately 24-27% to manufacturing exports. China, as an emerging global manufacturing powerhouse, demonstrates the potential benefits of extensive servicification, with services contributing approximately 34.3% to manufacturing value-added in 2020. This significant integration of services has bolstered China's competitiveness and resilience in the global value chain.

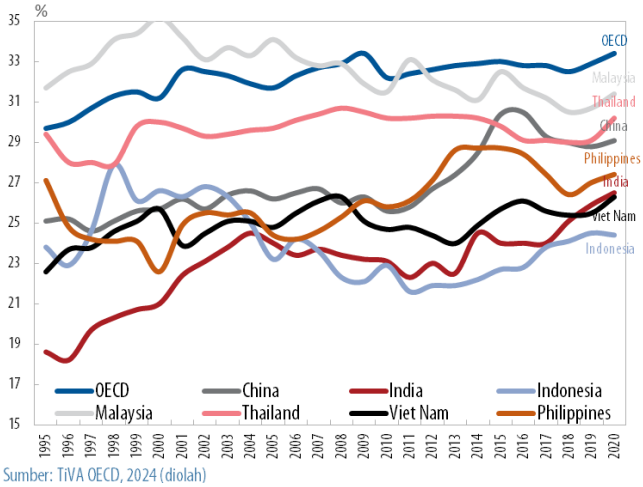


Figure 2 Comparison of Services Value Added Share in Manufacture Gross Exports: Indonesia vs Peer Countries

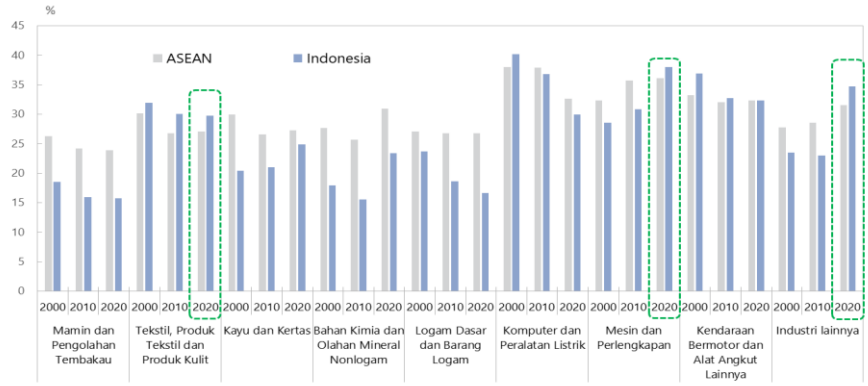
In Malaysia and Thailand, strong service ecosystems support manufacturing. Firms in these countries frequently engage in service activities such as logistics, design, and marketing, which enhance their competitiveness in global markets. For example, Malaysian electronics and automotive sectors benefit from extensive R&D and after-sales services. Similarly, Thailand's automotive industry utilizes advanced logistics and design services to optimize production and distribution.

Vietnam is rapidly improving its service integration, particularly in the electronics sector, with manufacturers increasingly relying on local IT and logistics services to enhance efficiency and global supply chain participation. China, as an advanced manufacturing hub, showcases extensive integration of services across various sectors, especially in electronics and automotive. Chinese firms leverage robust R&D capabilities, logistics, and design services to drive innovation and improve global competitiveness.

A comparative analysis of the value-added share of services in Indonesia's manufacturing sectors from 2000 to 2020 shows mixed results. Figure 3 indicates that in sectors such as textiles and motor vehicles, Indonesia's value-added share of

services is higher than the ASEAN average, particularly by 2020. This suggests some level of integration of services within these industries.

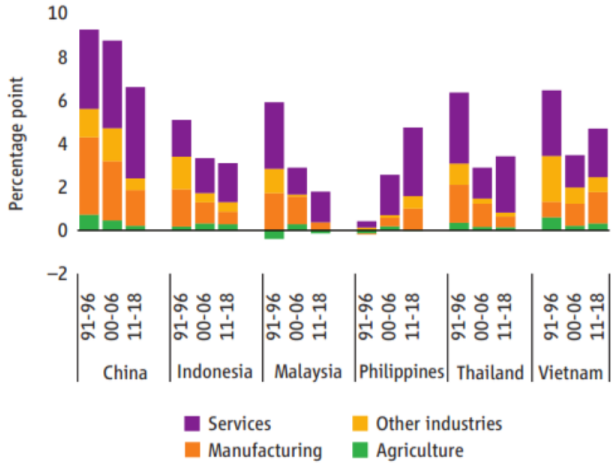
However, the chart also highlights that sectors like chemicals, non-metallic minerals, and electrical equipment have a lower value-added share of services compared to ASEAN averages. This indicates that Indonesia has yet to fully capitalize on the potential productivity gains that could be achieved through greater service integration, particularly in high-technology industries. Indonesia needs to focus on improving service integration across all sectors to enhance manufacturing competitiveness (Javorcik et al, 2012).



Sumber : Tiva, OECD

Figure 3 Comparison of Services Value Added Share by Manufactur's Sectors Gross Exports: Indonesia vs ASEAN

Over the past two decades, there has been a sharp increase in the service contributions to aggregate productivity. Service are key contributor to aggregate productivity growth. In Figure 4, service contributes to 1.68%, 1.55%, and 1.78% of aggregate labor productivity growth in Indonesia during 1991-1996, 2000-2006, and 2011-2018, respectively. Productivity in certain services (i.e., business services, finance, and communication) is higher than in manufacturing (World Bank Report, 2023).



Source: GGDC/UNU-WIDER Economic Transformation Database (Kruse et al., 2022)

Figure 4 Sectoral Contribution to Labor Productivity Growth

Share of services in employment and value-added increased significantly in recent years. Figure 5 below represents the share of value-added and employment in service and manufacturing sector. From this figure, service sector has created higher value-added and employment compared to manufacturing sector. Although services

responsible for increasing value-added and employment, the value-added tends to stagnate with a significant increase in employment

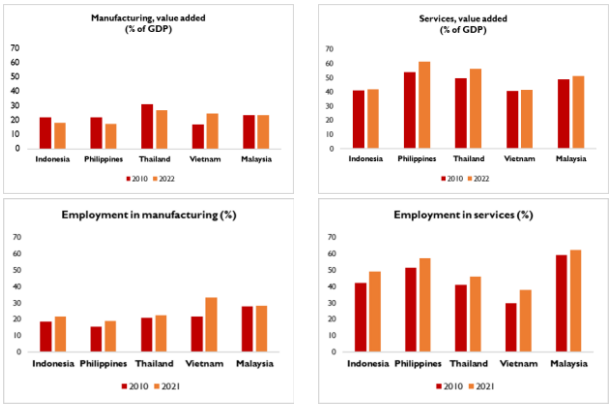


Figure 5 Share of Service and Manufacturing: Value-added and Employment

2.2 Servicification in Indonesia's manufacturing industries

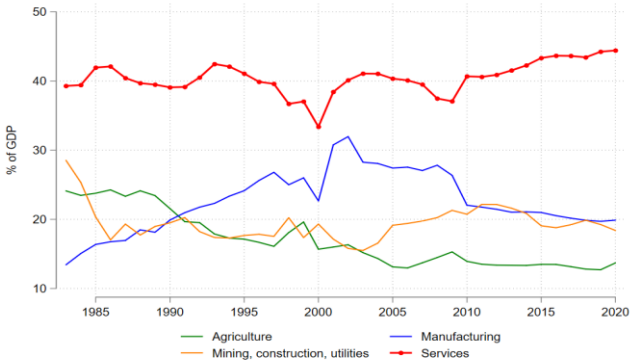


Figure 6 Sectoral value added (% of GDP)
Source: Author calculations based on Badan Pusat Statistik – Indonesia data

The Indonesian manufacturing sector has played a crucial role in propelling economic growth. However, the economic landscape in Indonesia demands a multi-pronged approach to sustainable growth. While manufacturing remains significant, fostering innovation in other sectors is equally paramount. Yet, the role of services in driving economic growth and creating jobs is growing, often overlooked as a key driver of future growth. From Figure 6, we can see that the services sector has the highest share of value-added to GDP compared to other sectors. The service sector has also been experiencing an increasing trend for the last decade.

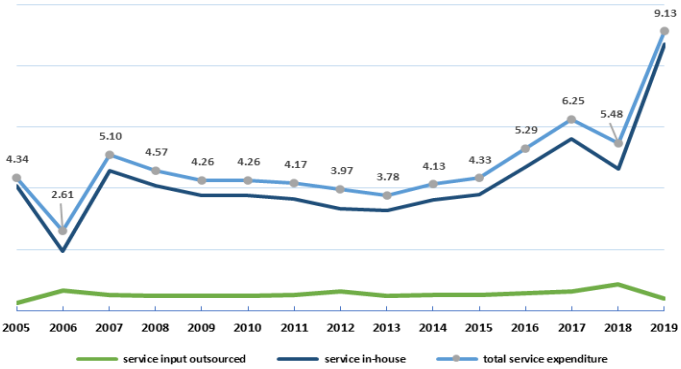


Figure 7 Servicification of Indonesian Manufacturing by expenditure/input (2005 – 2019, % share)

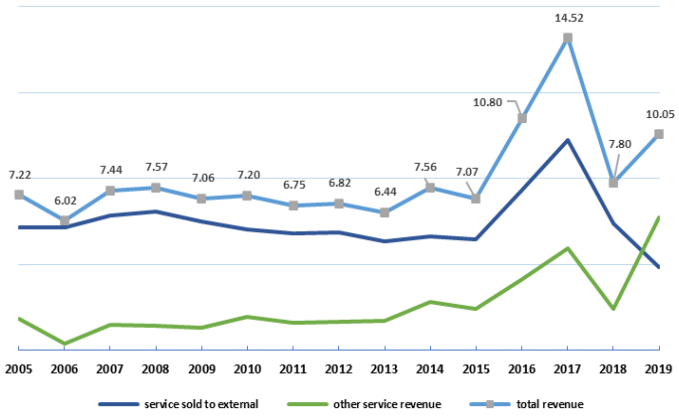


Figure 8 Servicification of Indonesian Manufacturing by revenue/output (2005 – 2019, % share)

Figures 7 and 8 reveal the current state of servicification in Indonesia's manufacturing sector. The services value-added chart provides useful insights into the economic linkages between manufacturing and services. However, it is unable to capture the dynamics of service inputs at the firm level. Therefore, to capture the servicification, we construct a firm-level indicator named service input intensity or service expenditure of manufacturing firms using the SIBS dataset.

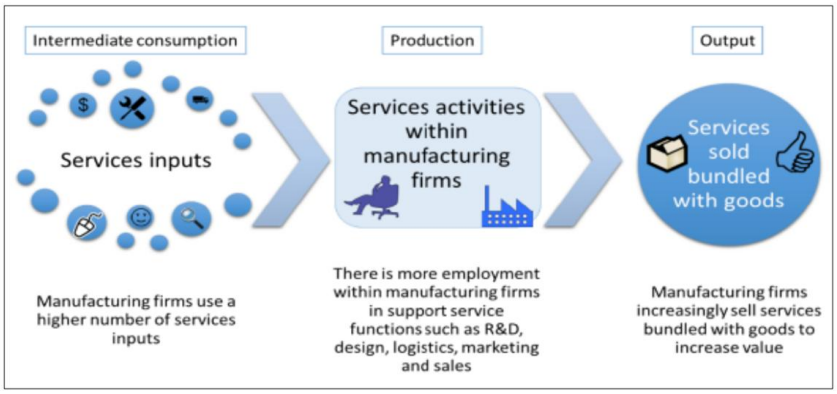
As shown in Figure 7, service input intensity is measured by dividing service expenditures by the total expenditures. The average share of service expenditure in Indonesia's manufacturing is increasing overall. This upward trend is mostly contributed by firms' in-house service. On the other hand, service input from external sources (or outsourced) is decreasing, particularly in 2019. This implies that Indonesian firms incorporate more services into their production activities.

Moreover, the distinctive advantage of the SIBS dataset is that we can construct servicification from a supply-side perspective, emphasizing service revenue/output. Therefore, we measure service output intensity by dividing service revenue by total revenue. The service revenue variable represents the offering of services by manufacturing firms as their additional business portfolio. In Figure 8, the service output intensity of Indonesia's manufacturing sector generally exceeds its service input and is primarily driven by services sold to external, known as *maklon* services[1]. In 2019, other service revenue (unprocessed goods, non-manufacturing services, and sale of scrap waste) also made a significant contribution.

2.3 Concept and literature review

Servicification reflects an increasing tendency of manufacturing firms to engage in services activities (Chun et al., 2021). Services are used by manufacturing firms to create value. This sector can create value at any stage in the value chain and both as inputs and outputs. Moreover, the difference between services and manufacturing is becoming increasingly blurred. Advances in technology have allowed some services to acquire characteristics that were previously unique to manufacturing (Mercer-Blackman & Ablaza, 2018).

[1] Maklon here refers to manufacturing activity where an Indonesian company or factory produces a product at the request of a client generally from foreign countries or domestic.



Source: Miroudot & Cadestin (2017)

Figure 9 The Various Dimenstion of Servicification

The terms of servicification in manufacturing refers to the growing reliance of manufacturing firms on services, whether as inputs, as activities within firms, or as output sold bundled with goods (Figure 9). First, production is becoming more intensive in service inputs (Low, 2013). Second, manufacturing jobs are becoming more service-oriented as reflected by the increase of workers performing service-related activities (Miroudot and Cadastion, 2017). Third, services are increasingly being embedded in, or bundled with, goods to create more value. In general, servicification represents a multidimensional phenomenon within the manufacturing industry.

Figure 10 Services in Production Value Chain

Services can be seen as part of broader category of services inputs that are not only functions to enable value chain but also important inputs in key stages of production. Any value chain starts with some R&D, design, and engineering activities that are service inputs when outsourced. At the end of the value chain are also found other services such as marketing and distribution. Firms producing goods are increasingly selling them together with services. For instance, machines are exported with installation, engineering, maintenance, and repair services.

Several recent studies highlight the importance of the servicification of manufacturing, which increases firms' productivity, exports through improvement of firms' performance, and service linkages to GVCs. For instance, services in manufacturing promote GVC participation of Indian firms. Manufacturing firms using service inputs in production are more likely to participate in GVC (Reddy et al., 2023). Manufacturing firms use services such as R&D to overcome barriers to entry and then use marketing and distribution services to maintain a presence in the export market. Thus, service in manufacturing firms promotes their export performance (Pattnayak & Chadha, 2022). The rising trend of service in manufacturing in Asian countries, particularly the increasing foreign services, has crucial implications for service trade and FDI liberalization (Thangavelu et al., 2018).

There is also a strong linkage between services and manufacturing firm productivity (Chen et al., 2023; Hoekman & Shepherd, 2017). This effect differs significantly across service sectors and manufacturing technology categories. Firms that use service inputs more intensively experienced less reduction in employment (Bamieh et al., 2020). The exporting firm becomes even more productive by learning from exporting and persists in producing a competitive good for foreign markets (Pattnayak and Thangavelu, 2014). Internationally oriented high-tech firms report higher productivity gains from R&D than domestic high-tech firms (Bhattacharya et al., 2021).

Given the important role of service in manufacturing, multiple studies have taken to assess their role in Indonesia's manufacturing industries context. Service sector reform is a major potential source of gains in economic performance, including manufacturing productivity and the firms' coordination. Service sector reform, particularly in the form of reduced restrictions on FDI has a positive impact on the productivity of manufacturing firms in Indonesia. The impact accounts for eight percent of the observed increase in Indonesian manufacturing firms' productivity (Duggan et al., 2013). Moreover, services exist in Indonesian manufacturing firms. However, it is still relatively small or greatly varies across industries at best (Rafitrandi & Narjoko, 2023). Service in manufacturing is strong only in several industries such as textile-garment, electronics, and transport.

3. Data and methodology

3.1 Data and variables

This study uses several firm-level datasets from various resources. First, we utilize the annual firm-level data from the Manufacturing Survey of Large and Medium-sized Firms in Indonesia (*Statistik Industri,* known as SI) established by the Indonesian Statistical Agency (BPS). The SI data covers a long-span annual period and provides firms with detailed data, such as services based on the firms' expenditure and revenue, input, output, and firms' characteristics. In addition, the SI dataset also provides detailed servicification data based on the firms' expenditures and revenue. We use SI panel data from 2005 to 2015 period.

Second, we employ the World Bank Enterprise survey data (WBES). This data covers various firms' specific variables from many countries. However, WBES data has limitations in that it is not carried out consistently every year for each country. We use data from the WEBS dataset for Indonesia, the Philippines, and Vietnam for the years 2009, 2015, and 2023, selected based on the availability of comparable data.

In terms of our main outcomes, we construct the servicification measures based on expenditure and revenue referring to Rafitrandi & Narjoko (2023), Guo et al. (2023), Pattnayak & Chadha (2022), Reddy et al. (2022), Chen & Zhang (2021), Nordwal (2016), Hoekman & Shepherd (2015). Tables 1 and 2 show the variable definition of each servicification proxies.

Table 1 Servicification based on Expenditure

Variable	Definition
exp_s	Share of total service expenditure
irdvcu	Share of R&D expenditure
iisvcu	Share of service input outsourced/bought from external parties
irrvcu	Share of royalty/intellectual property right (IPR) to external parties
iotvcu	Share of other non-production expenditure

Variable	Definition
	(Include: representation cost, royalty, management fee, promotion/ advertising, water, postage, facsimile, telephone, travel expenses, prevention of environment pollution, R&D, human resource development)

Table 2 Servicification based on revenue

Variable	Definition
rev_s	Share of total service revenue
yisvcu	Share of revenue from services output produced & sold to external parties
yrnvcu	Share of revenue from other services not-related to production activities sold to external parties

Next, we define the GVC participation of a firm using a binary variable, which equals 1 if a firm engages in both exporting and importing activities (Antras, 2021; Baldwin & Lopez-Gonzalez, 2015; Dovis & Zaki, 2020; Reddy et al., 2022; World Bank, 2020). Productivity is measured by labor productivity (i.e., output per labor and value-added per labor) and TFP. We estimate TFP using Levinshon-Petrin (LP) methods. Labor market dynamics is measured by employment in services, the average income of production labor, and an average income of service labor. Lastly, we include several firm's characteristics, including capital intensity, financial access, firm size, foreign ownership, and export orientation. We define the industry sector using a 2-digit ISIC classification.

3.2 Empirical strategy

We implement a two-stage method. First, we estimate total factor productivity (TFP) following the approach of Amiti and Konings (2007) to estimate firm-level TFP based on the Cobb-Douglas production function. The estimation of TFP requires a semi-parametric approach developed by Levinshon and Petrin (2003). Second, we estimate the derived TFP with servicification and other firm characteristics variables.

In the second stage, our primary focuses are presented in three folds. In the first framework of the empirical strategy, we want to examine whether servicification affects the development of Indonesia's manufacturing sector, focusing on productivity at the firm level. Second, we want to investigate the impact of servicification on the participation of Indonesia's manufacturing firms in GVCs. Three, we want to assess the extent of digitalization and servicification on firm productivity.

Framework 1

We employ Dynamic Panel Data techniques to assess the impact of servicification on productivity at the firm level data. We use a definition of servicification from the revenue and expenditure side and encompass the channels of servicification. In particular, we use the following empirical strategy:

$$Y_{it} = \alpha + \beta_1 SVC_{it} + \gamma X_{it} + \delta_j + \delta_t + \epsilon_{it} \quad (1)$$

where Y is Total Factor Productivity estimated using Levinshon-Petrin (LP) method, SVC_{it} is servicification and its channels, X_{it} is the firms' characteristics (capital intensity, firm size, foreign ownership, and financial access), i indicates firm, j indicates sector, t indicates year of observations, and ϵ_{it} is an idiosyncratic error. We run the regression above on a longitudinal panel of firms i over year t.

Since we have panel data for the estimation, the study also considers comparing OLS, FE, and Generalized Method of Moments (GMM) methods. For

robustness check, we run for each definition of servicification. For heterogeneity analysis, we run estimation based on size, technology classification, and regional analysis.

To address endogeneity, we employ the GMM approach, which has gained widespread use in empirical research due to its ability to generate instruments for endogenous variables through internal data transformation (Arellano and Bond, 1991; Roodman, 2009). However, a significant challenge lies in identifying valid instruments for servicification variables to effectively address endogeneity issues.

We estimate equation (1) using the *two-step system-GMM* method, incorporating the lagged value of productivity on the right-hand side. This approach is based on the assumption that productivity in the previous year determines the current productivity level, making the model a dynamic panel. As part of the estimation process, system-GMM subtracts the average of all future available observations of a given variable, enhancing the efficiency and consistency of the results (Roodman, 2009).

In our model, we treat lagged productivity, the share of service inputs, and the share of service outputs as endogenous variables and use their lagged values as instrument variables. All other variables are assumed to be strictly exogenous. This specification ensures robust estimation results.

Framework 2

We employ probit model regressions to assess the impact of servicification of manufacturing activities on GVC participation. The selection of the probit model is driven by the binary nature of the dependent variable, GVC. In particular, we use the following empirical strategy:

$$Pr\,(GVC_{it}) = \Phi(\,\beta Servicification_{i,t-1} + Z + \gamma_t + \delta_j + \epsilon_{it}$$

where Φ is the standard normal cumulative distribution. Servicification is the main variable of interest. Z is a vector of control variables, which includes TFP, capital intensity, labor skill intensity, and dummy variables (foreign ownership, financial access, and firm size). We also account for time γ_t and industry-fixed effects δ_j in the model. We run the regression above on a longitudinal panel of firms i over year t. Furthermore, we lag the explanatory variables in the model to control for the endogeneity issues.

Framework 3

To assess the impact of digitalization and servicification on firm productivity, we run the model with the following specifications:

$$tfp_{it} = \beta_0 + \sum_{k=1}^{3} \beta_k . D_{it} + \sum_{m=k}^{M} \beta_m . X_{it} + D_{ind} + D_c + \mu_{it}$$

where tfp_{it} is total factor productivity of firm i at time t. D_{it} is a dummy variable for digital adoption. X_{it} is vector of covariates, which includes sales, age, and dummy variables (foreign ownership, R&D, export orientation, and foreign-technology). We also account for time D_c and industry-fixed effects D_{ind} in the model. We run the regression above on a longitudinal panel of firms i over year t.

Table 3. Variable Details

No	Category	Variable
1	Dependent variable	▪ GVC = dummy variable (1 if firm exports and imports) ▪ TFP = Log of TFP measuring by Levinshon-Petrin method
2	Servicification variable	▪ Servicification by expenditure = s_exp, s_iis, s_npe ▪ Servicification by revenue = s_rev, s_yis, s_yrn
3	Explanatory variable	▪ Capital intensity = log of capital per total labor ▪ Labor skill intensity = log of wage per total labor (average wage of firm) ▪ Firm size = dummy variable (1 is large firm if firm have more than 99 labor, 0 is medium firm) ▪ Foreign ownership = dummy variable (1 if foreign firm, 0 if domestic firm) ▪ Export = dummy variable (1 if exporter, 0 if domestic) ▪ Financial access = dummy variable (1 if firms have financial access) ▪ Technology = category variable (1 = high-tech, 2 = medium-tech, 3 = low-tech)

4. Result and Analysis

4.1 The current state of Indonesia's servicification

To shed light on the current state of Indonesia's servicification, we explore how it interconnects with industrial sector, firm productivity, labor skill intensity, and productivity and relates to regional characteristics across the country.

4.1.1 Sectoral linkages

Figure 11 shows that the extent of servicification in Indonesian manufacturing, measured by service expenditure, is about 6.17 percent on average of the total expenditure for production. This level is modest compared to typical standards for developing countries. In comparison, Pattnayak and Chadha (2022) reported a higher rate of servicification in Indian manufacturing, with service inputs accounting for an average of 10.19 percent of total expenditure, indicating a greater reliance on services in India's manufacturing sector than in Indonesia. From this figure, we can see that the high- and medium-tech industries, except for beverages, dominate sectors with higher service inputs, primarily through in-house service activities. This suggests a strong reliance on internal resources to manage service activities, supporting their operational needs and potentially enhancing control over quality and efficiency.

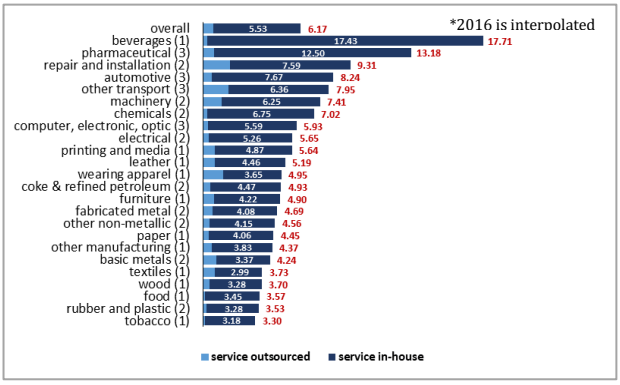


Figure 12 Servicification of Indonesian Manufacturing by subsector expenditure (2005 – 2019)

Figure 13 illustrates that service revenue is notably higher than service expenditure, with an overall average of 10.68 percent. A significant portion of this revenue is generated through services sold externally (known as *maklon*). High service revenue shares are particularly evident in sectors like repair and installation, wearing apparel, and printing and media, which derive substantial income from services sold externally. Interestingly, some low-tech industries also generate considerable revenue from service activities, suggesting that service integration could be a strategic approach to enhance their performance and diversify revenue sources. This trend highlights servicification as a valuable revenue channel, offering low-tech industries opportunities for growth beyond traditional manufacturing outputs.

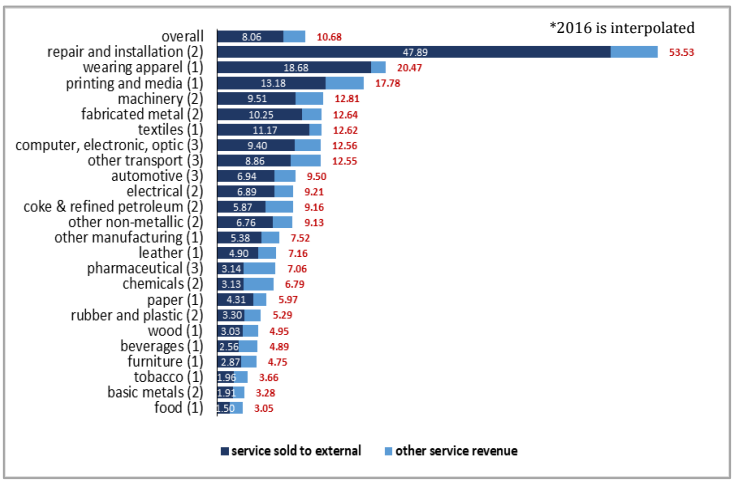


Figure 13 Servicification of Indonesian Manufacturing by subsector revenue (2005 – 2019)

4.1.2 Link to Firm Productivity

We analyze the link between servicification and firm productivity, using TFP and labor productivity as proxies. Figure 14 shows that most industry sectors with higher levels of service input tend to achieve greater TFP, except for beverage (11) and repair & installation (33) sectors. This indicates that a greater service input can be beneficial for enhancing manufacturing firms' productivity. Additionally, Figure 15 depicts that Industry sectors that are more deeply integrated into service activities exhibit higher labor productivity. This suggests the presence of more skilled labor, which leads to greater productivity gains.

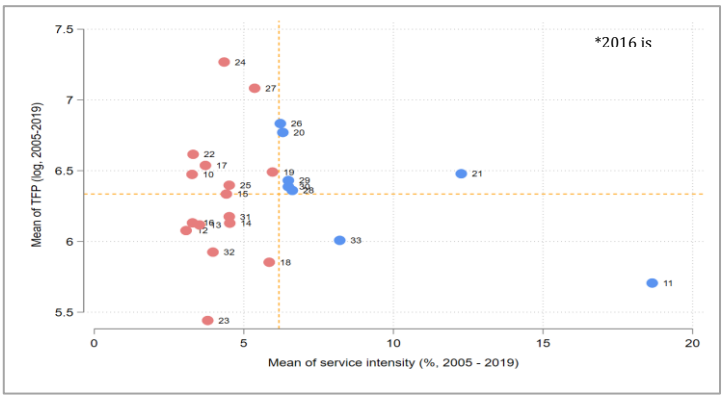


Figure 14 TFP and Service Input Intensity

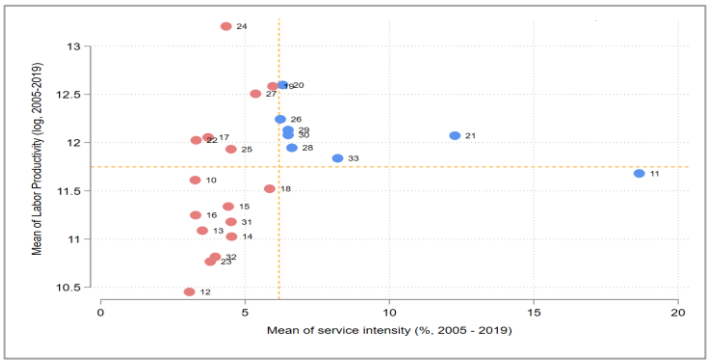


Figure 15 Labor Productivity and Service Input Intensity

4.1.3 Link to Labor Dynamics

Figure 16 shows a positive correlation between service input intensity and labor skill intensity in Indonesian manufacturing. Sectors with higher service input, particularly in medium- and high-tech industries, tend to require more skilled labor. This pattern indicates that deeper service integration could enhance labor skills, especially in industries that demand higher technical expertise.

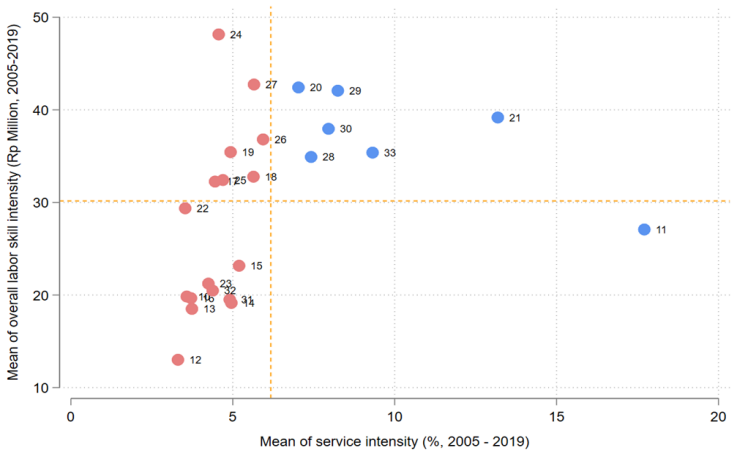


Figure 16 Labor Skill Intensity and Service Input Intensity

Moreover, Figure 17 emphasizes the link between service input and labor skill intensity in Indonesian manufacturing sectors. While production labor dominates the workforce, it is generally lower-skilled and has lower average wages. In contrast, service labor has fewer in number, but has higher-skilled, earning over 1.5 times the average wages of production labor. This wage gaps underscores the value of skilled service labor in sectors with greater service input intensity. Labor skill intensity, measured by average wages, reflects human capital quality—suggesting that firms with higher average wages employ more skilled labor, which, in turn, is expected to boost productivity. Thus, deeper service integration supports a shift toward a skilled labor and emphasize servicification's role in boosting firm productivity in the manufacturing sector.

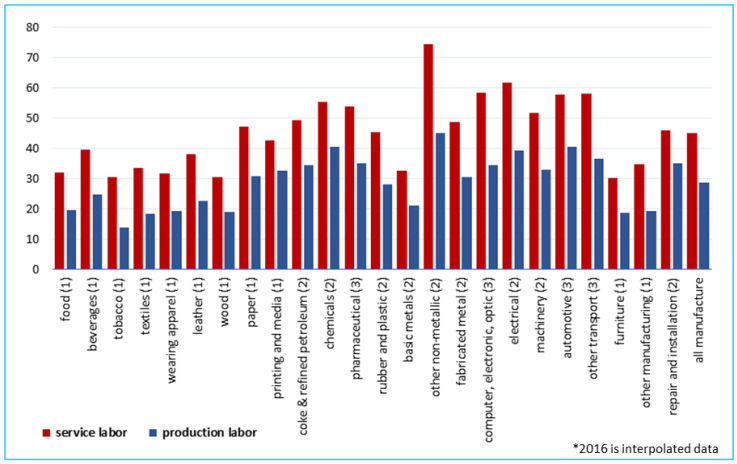


Figure 17 Labor skill intensity of Indonesian manufacturers from 2005 to 2019 (million Rupiah)

4.1.4 Link to GVC Participation

Figure 18 below shows a correlation between service input intensity and GVC participation in Indonesian manufacturing sectors from 2005 to 2019. Industries with higher service input are more involved in GVC, albeit this level remains slightly above the average. However, GVC participation among Indonesian manufacturers is relatively low with an average of less than 5%. This rate is lower than India's manufacturing sector, which has an average of 12% of GVC participation (Reddy, 2022).

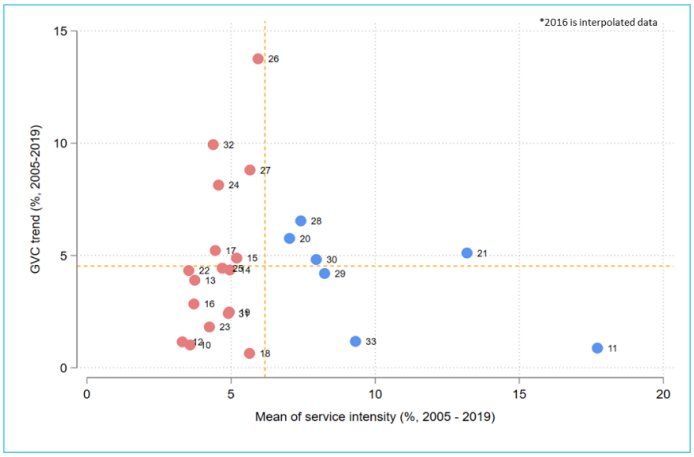


Figure 18 GVC Participation and Service Input Intensity

4.2 Empirical estimation

We conduct an empirical analysis using two survey datasets. First, we utilize SIBS data to assess the impact of servicification on firm-level productivity. Second, we use WBES data to examine the effects of digitalization and servicification on productivity.

4.2.1 Using SIBS data

We divide our baseline estimation into two servicification approaches, based on expenditure and revenue. These results are estimated using fixed effects, fixed effects with lagged regressor, and the Generalized Method of Moments (GMM) to address the endogeneity issue. The estimation includes year-fixed effects to control

for any unobserved time-varying shocks and industry-fixed effects to account for unobserved factors that might affect productivity across different sectors.

4.2.1.1 Servicification impact on firm productivity

As shown in Table 4, servicification is positively associated to firm productivity, indicating that an increase in service input intensity boosts firm productivity levels. This result suggests a 10% increase in service input intensity leads to approximately a 1% rise in productivity. This impact is more pronounced for outsourced services, implying that sourcing services from external suppliers allows firms to reallocate internal resources toward core manufacturing activities, thereby enhancing productivity.

The estimation results in Table 5 reveal that service output intensity (measured as the share of service revenue) has a positive and significant impact on productivity, suggesting that revenues generated from services help firms increase productivity. This finding holds for both channels of service revenue. Additionally, capital intensity positively affects productivity. Financial access also shows positive and significant effects on productivity, which implies firms that access external financing are more productive than those without. Export orientation is also associated with higher productivity, suggesting that firms with export orientation achieve higher productivity due to the competition pressure of the global market.

To address endogeneity, we implement the System GMM approach. We use the lagged value of productivity as the instrument variable based on the assumption that prior productivity levels influence current productivity. Two standard post-estimation tests show our econometric specification is appropriate under the GMM model. First, we check the Arellano-Bond test; the estimation suffers serial autocorrelation if the *p-value* of AR (2) is smaller than 0.05. Second, we investigate if the lagged instruments are jointly valid; the estimate satisfies this condition if the *p-value* of the Hansen test is greater than 0.05. Lastly, we check instruments provide sufficient variation to identify the model parameters; the instruments are likely relevant and the model is identified if the *p-value* of the Kleibergen-Paap is less than 0.05.

The results, shown in columns (9) to (12) of Table 4 and columns (7) to (9) of Table 5, suggest that both GMM estimations satisfy all three tests. As mentioned earlier, we include the two-year lagged value of productivity as the regressor and find that productivity in the previous year is strongly and positively correlated with the current-period productivity. This result demonstrates the dynamic nature of our model. Overall, the results from the GMM estimation provide consistent and efficient evidence that both service input and output have a significant positive impact on firm productivity. These findings suggest that servicification may serve as a strategy to enhance firm productivity in the manufacturing sector.

4.2.1.2 Servicification impact on GVC participation

Table 6 outlines the effects of servicification on firm participation in GVCs using a probit model. Column (1) displays the relationship between servicification and GVC without accounting for firm-specific effects. In Column (2), control variables are incorporated, while Columns (3) and (4) add industry and time-fixed effects. Columns (5) to (7) present results for servicification and its channels on GVC participation including all control variables, industry, and time-fixed effect.

The findings in Table 6 indicate a positive and significant relationship between servicification and GVC participation. The results show that an increase in firm expenditure on services is associated with a 4% - 5% higher probability of participating in GVCs. Additionally, TFP has a positive and significant impact of TFP

on GVC participation, highlighting that more productive firms are more inclined toward GVC participation. The coefficient of labor skill intensity is also positive and significant across all specifications, suggesting that firms with higher levels of skill are more engaged in GVC. Furthermore, larger firms and foreign ownership are positively associated with greater GVC integration, suggesting that these firms are better positioned to engage in GVCs. Lastly, firms with higher capital and financial access are more likely to participate in GVCs.

This section further examines the impact of servicification on GVC participation by disentangling three main transmission channels: in-house service expenditure, royalty expenditure, and outsourced service expenditure. In Columns (5) and (6), we observe a positive and significant impact of service in-house and royalty expenditure on GVC participation. The results indicate that the firm services in-house and royalty expenditure, indicating that this servicification facilitates smoother interaction between key market players, which is crucial in promoting GVC participation among Indonesian manufacturing firms. Moreover, the results for the control variables align with the main findings, confirming that larger, foreign-owned, more productive firms with higher skilled labor, greater capital intensity, and financial access show higher rates of GVC participation.

4.2.1.3 Heterogeneity analysis

Size classification

Our sample includes a diverse range of firms across different size categories. To account for this variation, SIBS data classifies firms as medium or large based on their workforce size. Firms with more than 99 employees are identified as large firms. Table 7 presents the estimation results by firm size. We find that servicification has a positive impact on firms' productivity. Notably, the effect of servicification is significantly stronger for medium-sized firms than for large firms. These findings suggest that servicification plays a vital role in enhancing productivity for medium-sized firms and holds the potential to accelerate their size.

Technology classification

The technology underlying production processes varies across industries. As highlighted previously in Figures 10 and 11, servicification on the expenditure side is more prominent in technology-intensive industries – except for the beverages sector – where these industries demonstrate higher service expenditure compared to low-tech industries. However, from the revenue side, servicification is more pronounced in low-technology industries. We examine the impact of servicification on GVC for firms within technology-intensive and low-technology industries.

Results reported in Table 8 highlight the positive and significant impact of servicification on firm productivity for both low- and high-technology industries. This underscores the importance of integrating servicification to drive productivity gains, especially in low-tech industries, which account for 68.46% of the total observations in Indonesia's manufacturing sector. The magnitude of service input effects is greater than that of service output, confirming that firms with higher service expenditure tend to be more productive and that service inputs are essential to enhancing productivity within Indonesia's manufacturing sector.

Regional specific

We also analyze the regional-specific effects of servicification on manufacturing firm productivity. As seen in Table 9, 82% of manufacturers are in the Java-Bali region. Servicification shows a positive and significant impact on productivity in both regions, although the influence varies. Firms outside Java-Bali

benefit more from incorporating services into their revenue streams, as evidenced by the greater impact of service output intensity in these areas. Conversely, service input integration has the largest effect on productivity among manufacturers within the Java-Bali region. These findings suggest that regional context plays a role in how servicification contributes to productivity in different parts of Indonesia.

4.2.2 Case Study: Promoting Servicification through Digitalization

Our primary findings from this paper indicate a positive relationship between the level of servicification and both productivity and company engagement in GVCs (to some extent). This positive effect is evident in both the use of services as inputs (measured by service expenditure) and the provision of services as outputs (measured by service revenue). As the global economy grows more complex and volatile, manufacturers are increasingly recognizing the importance of moving beyond a pure product-based approach and adopting integrated product-service systems (Resta et al., 2017).

Digitalization plays a pivotal role in driving servicification within the manufacturing sector, enabling companies to integrate services into their offerings seamlessly. Digitalization offers tools and technologies that can streamline service integration, improve efficiency, and ultimately lead to better productivity outcomes (Haven and Marel, 2018). Through digital adoption, manufacturers can enhance operational efficiency, improve customer interactions, and develop data-driven insights that allow them to tailor products and services to meet specific customer needs (Peña et al., 2019; Resta et al., 2017).

Several studies confirm that digitalization drives servicification and firm performance by enhancing efficiency, service integration, and productivity. However, these benefits are maximized when firms invest in complementary technologies and align strategies accordingly. For instance, Wang and Thangavelu (2024) examines the impact of digitalization on the servicification of China's manufacturing sector, analyzing how digital technologies integrate services into manufacturing processes. It finds that digitalization significantly promotes servicification by enhancing production efficiency, improving product quality, and enabling customized services. The study concludes that digitalization is a key driver in transforming traditional manufacturing into a more service-oriented industry in China.

Similarly, Davies et al (2023) finds that service capabilities positively mediate the relationship between digital capabilities and firm performance, with the effect being stronger for customer-supporting services than product-supporting services. The research highlights the importance of integrating digital and service capabilities to enhance firm performance, particularly in the context of servicification.

While ICT has been shown to have a significant impact on productivity (Syverson, 2011; Draca et al., 2006), the effects are nuanced. For example, DeStefano et al. (2018) find that, in the UK, ICT contributes to company growth in sales and employment but does not directly increase productivity. The positive impact of general-purpose technologies like digital tools becomes most apparent when firms also invest in complementary technologies, as highlighted by Brynjolfsson et al. (2017, 2020) and Syverson (2017).

In Indonesia, firm-level indicators reveal that digital adoption in the manufacturing sector lags behind benchmark countries. According to data from recent surveys, the majority of Indonesian manufacturing firms—88.9% in 2023—have internet access. However, this figure falls short compared to countries like Vietnam, where 99.4% of firms are connected (Figure 20). Similarly, indicators such as website ownership and the use of digital payments for transactions, though

improving among Indonesian manufacturing firms in 2023, still trail behind peers like the Philippines and Vietnam ((Figure 21 and 22). This digitalization gap, however, should be viewed as an opportunity. By further embracing digital technologies, Indonesia can leverage this momentum to boost its level of servicification and drive optimal growth in the manufacturing sector.

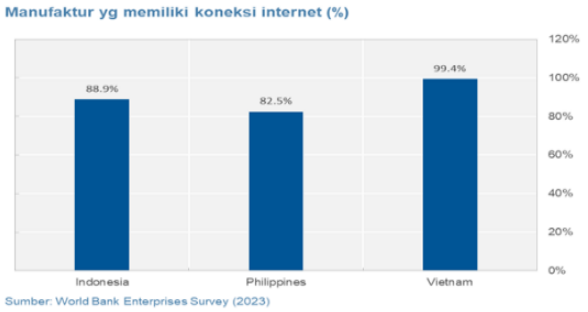


Figure 20 Comparison of the Share of Manufacturing Firms with Internet Connectivity: Indonesia vs. Peers

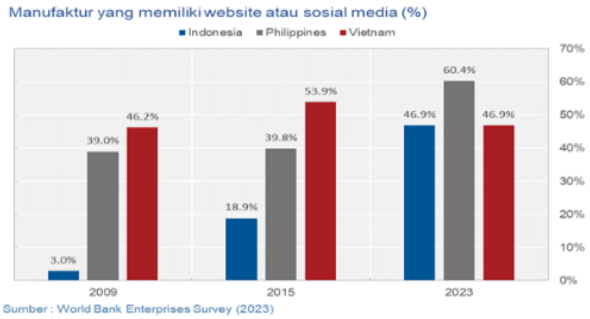


Figure 21 Comparison of the Share of Manufacturing Firms with Websites or Social Media: Indonesia vs. Peers

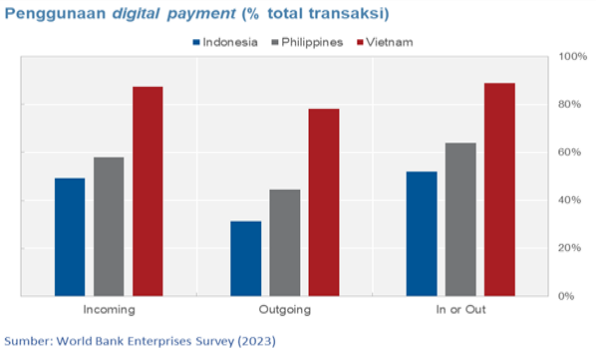


Figure 22 Comparison of the Share of Digital Payment Usage Among Total Manufacturing Firms: Indonesia vs. Peers

To understand the mechanisms through which digitalization can enhance servicification, we conduct a regression analysis of Total Factor Productivity (TFP) on various digitalization channels that serve as proxies for servicification. These channels include internet usage, website/social media adoption, and the utilization of digital payments, which reflect different aspects of digital integration within firms. In addition, we account for country-specific and industry-level factors to ensure that the analysis isolates the impact of digitalization on servicification from other confounding influences. This approach allows us to identify the specific pathways through which digitalization contributes to productivity improvements via servicification.

The analysis uses data from the WEBS dataset for Indonesia, the Philippines, and Vietnam for the years 2009, 2015, and 2023, selected based on the availability of comparable data. The use of internet connectivity, websites/social media, and digital payments is employed as proxies for digitalization, which is closely linked to the level of servicification. Meanwhile, TFP (Total Factor Productivity) is used as a proxy for firm productivity. The statistical summary of the data is presented in the table 10. Estimations are conducted exclusively for companies in the manufacturing industry.

Our findings from the regression analysis of various digitalization channel variables on TFP demonstrate a positive impact, particularly for digital payment variables. As can be seen from summary of the findings in Table 11, the OLS results in column (1) indicate a statistically significant positive relationship between the adoption of digital payments exceeding 30% and TFP, with a coefficient of 0.09 ($p < 0.1$). Quantile regressions at the 25th, 50th, and 75th percentiles (columns 2-4) confirm consistent positive and significant effects across different segments of the productivity distribution, with coefficients ranging from 0.08 to 0.11 ($p < 0.1$).

To further explore how digitalization impacts TFP—whether through new processes or new products—we regress the digitalization channel variables on process innovation and product innovation variables. For process innovation, the OLS estimation in column (5) shows a statistically significant positive effect, with a coefficient of 0.09 ($p < 0.05$). The Probit model in column (6) reinforces this finding, reporting a stronger marginal effect of 0.68 ($p < 0.01$), indicating a robust relationship between digitalization and the likelihood of adopting new processes. Similarly, for product innovation, the OLS results in column (7) suggest a positive and significant effect, with a coefficient of 0.05 ($p < 0.1$). The Probit model in column (8) corroborates this, with a higher marginal effect of 0.43 ($p < 0.05$).

Overall, the results highlight that digitalization, particularly digital payment adoption, consistently exerts a positive and statistically significant impact on TFP, primarily through its influence on process innovation.

4.3 Regional Analysis

4.3.1 Sumatera region

4.3.1.1 Current State of Servicification in Sumatera Region

Sumatra, Indonesia's second-largest economic region after Java, hosts a diverse and growing manufacturing sector, bolstered by its strategic location near major global trade hubs such as Singapore and Malaysia. Key industries in Sumatra’s manufacturing sector include electronics, machinery, chemicals, and pharmaceuticals, each increasingly reliant on services that support production and distribution. Services like logistics, R&D, and product design, especially in high-tech industries, have become crucial to maintaining regional competitiveness. The post-pandemic economic recovery, however, has highlighted various challenges within Sumatra’s manufacturing landscape, notably a slower growth rate in manufacturing output and foreign direct investment (FDI). From 2022 onward, Sumatra's economy has consistently grown below the national average, primarily due to factors like limited labor productivity, labor shortages, and challenges in service integration.

Manufacturing services in Sumatra, particularly in areas such as logistics, marketing, and R&D, are largely conducted in-house. This choice aligns with efforts to optimize cost efficiency and maintain tighter control over core production processes. However, Sumatra's dependence on in-house services also reflects a broader limitation: a skills gap in the regional labor force that complicates service

outsourcing, especially in advanced sectors like electronics. The electronics industry, for instance, heavily depends on specialized skills for components like semiconductors and photovoltaic systems, which are in short supply locally. As a result, companies such as PT Infineon Technologies in Batam have had to import skilled engineers from neighboring countries to support operations. This skills gap underscores the need for sustained investment in human capital development to improve Sumatra's manufacturing competitiveness in global markets.

Sumatra's proximity to Singapore remains a strategic advantage for its participation in Global Value Chains (GVCs), particularly through the Batam Free Trade Zone (FTZ), which has served as a manufacturing hub since the 1970s. The Batam FTZ, encompassing several islands, facilitates export-oriented manufacturing by offering streamlined customs, tax, and labor regulations that attract foreign investment. In the past few years, provinces like Riau Islands have maintained high manufacturing output, driven largely by non-resource-based, capital-intensive industries such as electronics, shipbuilding, and electrical machinery. However, in recent years, FDI in Sumatra has been inconsistent, with foreign investment slowing even as domestic investment shows moderate growth. This uneven investment trend has implications for productivity, as foreign investment typically brings in new technologies and best practices essential for advancing manufacturing efficiency. Additionally, stringent regulatory processes, particularly in import procedures, have introduced operational delays and increased production costs, impacting the region's competitiveness. These regulatory and infrastructural challenges highlight the need for policy improvements to better integrate Sumatra into the GVC and enhance regional productivity.

4.3.1.2 Anecdotal Evidence

The Batam Free Trade Zone provides practical examples of how local companies adapt to service-related challenges in manufacturing. PT Infineon Technologies, for example, focuses on semiconductor services within the electronics sector. As a subsidiary of a German multinational, PT Infineon benefits from global expertise but faces local constraints, especially a shortage of skilled labor in semiconductor manufacturing. Consequently, the company frequently imports technical expertise from countries like the Philippines and Malaysia. This reliance on external expertise illustrates the local skills gap in high-tech fields, highlighting a critical area for policy intervention. In response, PT Infineon has strengthened collaborations with educational institutions like Batam Polytechnic to train local talent, though results are yet to meet the demand fully. Additionally, PT Infineon faces infrastructural challenges such as inconsistent power supply, which hinders smooth operations and increases production costs. The company's strategy involves focusing on sustainable growth, in part by advocating for local infrastructure improvements.

Similarly, PT McDermott Batam, a major player in procurement, construction, and installation, relies on a local workforce of approximately 13,000 employees, emphasizing employee welfare and skill development to remain competitive. McDermott has a robust employee loyalty program, offering annual salary adjustments that exceed inflation rates, which strengthens retention amid global competition, particularly from Chinese firms. However, recent regulatory changes in import procedures have introduced operational complexities that delay project timelines and increase costs. Additionally, as the company expands into large-scale renewable energy projects, it faces challenges in recruiting skilled local workers, especially for roles like welders and fitters, which are essential for the firm's renewable energy projects in partnership with entities like Aramco and Qatar Energy. To mitigate this challenge, McDermott has initiated training programs in

collaboration with local institutions, though it acknowledges the need for ongoing policy support to streamline regulatory processes and attract skilled labor for these high-demand roles.

PT Asia Cocoa Indonesia, a Malaysian-owned cocoa processing firm, also offers insights into the service challenges in manufacturing. The firm primarily produces semi-finished cocoa products for export, relying heavily on imported raw materials. However, recent regulatory shifts, such as requiring the retention of 30% export proceeds in local banks for at least three months, have impacted operational cash flow and increased costs. To counter supply chain risks, PT Asia Cocoa Indonesia actively works with local cocoa farmers in regions like Palu to improve local sourcing, aiming for a more sustainable and reliable supply chain. This collaboration demonstrates an approach to integrating local services into the production process, though regulatory and market challenges persist.

4.3.1.3 Policy Recommendations

To support the continued development and integration of services within Sumatra's manufacturing sector, several policy recommendations are proposed:

- **Sustainable Investment:** Targeted fiscal incentives, such as tax holidays and allowances, could attract sustainable investment in medium- to high-tech manufacturing, which provides high value-added output. Incentives should specifically address services within manufacturing that are currently outsourced, to foster local capacity in service provision and support manufacturing productivity. Furthermore, incentivizing investment in high-value manufacturing segments could enhance competitiveness in Sumatra's manufacturing sector and attract FDI, which is crucial for technology transfer.
- **Technology Adoption:** Fiscal incentives to encourage the adoption of advanced technologies, including digitalization, would increase efficiency and product quality across manufacturing firms. This would enable Sumatra's firms to compete in both local and global markets. Support for technology upgrades, including subsidized access to Industry 4.0 technologies, would allow local manufacturers to enhance their service-related capabilities, improve operational efficiency, and adapt to evolving market demands.
- **Human Resource Development:** Developing skilled labor remains a high priority, given the labor shortages in high-tech sectors across Sumatra. A triple-helix collaboration model among corporations, universities, and the government could promote workforce training, skill development, and retention. Corporations can partner with academic institutions for targeted training programs, while the government can offer tax incentives to offset training costs. This approach would create a steady pipeline of skilled labor, meeting the needs of firms in both high-tech and low-tech sectors.

In conclusion, Sumatra's manufacturing sector holds substantial potential to integrate services effectively into its industrial operations, thereby enhancing productivity and global competitiveness. With targeted investment incentives, support for technology adoption, and a concerted focus on workforce development, Sumatra can position itself as a regional manufacturing hub that leverages services for sustainable growth. By implementing these recommendations, policymakers can support a thriving, service-integrated manufacturing industry that adapts to both local and international market demands.

4.3.2 Java region

4.3.2.1. Current State of Servicification in Java Region

Java's manufacturing industry significantly contributes to the regional economy, comprising about 28.15% of Java's Gross Regional Domestic Product (GRDP), with food and beverages (24.65%), transportation equipment (14.11%), metal and electronics (10.62%), and chemicals and pharmaceuticals (10.02%) as dominant subsectors. Despite a post-COVID recovery, the manufacturing sector has yet to reach its full potential, facing challenges like a high dependency on imported raw materials. This dependency impacts the competitiveness of Java's manufacturing industry, particularly when compared to countries like the United States, China, Japan, South Korea, and Thailand. Although the manufacturing labor force share has declined, certain sectors—such as food and beverage, which leverage servicification for greater value-added through enhanced efficiency and GVC integration—show steady improvement.

Servicification plays a pivotal role across different industries in Java, enabling enhanced value through logistics, R&D, and after-sales services. For instance, in the transportation equipment industry, servicification includes repair, reconditioning, and financing options, though strict regulations like SNI standards occasionally pose challenges. The chemicals and pharmaceuticals industry uses servicification to customize products for specific client needs, which can boost local market share but may increase production lead times. In metal and electronics, servicification centers around R&D to develop new products, although fluctuating domestic demand and regulatory barriers persist as challenges.

4.3.2.2 Anecdotal evidence

In the Java region, the servicification of manufacturing industries is gaining momentum, driven by the need to increase efficiency, add value, and respond to shifting market demands. The food and beverage sector, for example, has embraced servicification to offer consumers enhanced value through customized products and tailored experiences. Companies in this sector are increasingly investing in service functions like logistics, packaging, and digital marketing to optimize their operations and meet evolving consumer expectations. In some cases, this shift has created new revenue streams by enabling companies to diversify their offerings beyond traditional product lines. However, challenges remain, particularly regarding the need for technological upgrades and regulatory compliance. To provide high-quality, service-based solutions, companies must often invest in technology and infrastructure, which requires significant upfront capital and skilled labor. Additionally, stringent regulatory standards for health-related services, such as nutrition consulting, may pose barriers for firms looking to expand their service portfolios.

In the transportation equipment industry, servicification is also advancing, particularly among automotive manufacturers. Companies are increasingly integrating service functions such as financing, insurance, and after-sales support into their core business operations to offer customers a comprehensive suite of services. For example, Astra International has created Astra Finance as a separate entity dedicated to providing financing options, enabling a seamless support system for vehicle sales. This integration enhances customer loyalty by bundling vehicle purchases with financial services and ongoing maintenance, fostering a more holistic consumer experience. However, the integration of services with core manufacturing operations brings its own set of challenges. The alignment between service and production divisions is not always optimal, sometimes leading to discrepancies in strategic objectives. Effective integration also requires significant investment in technology, such as real-time data-sharing systems, to ensure that information flows

smoothly between service and production teams. Consequently, firms must balance the costs of technological and operational integration with the long-term benefits of offering an end-to-end service experience.

In the chemical and pharmaceutical sectors, servicification has opened new avenues for growth, particularly through logistics, warehousing, and product customization services. Companies like PT Nippon Shokubai Indonesia have capitalized on servicification by providing consulting and product modification services to meet specific customer needs, thus enhancing customer satisfaction and fostering long-term business relationships. These value-added services allow firms to strengthen their market position by tailoring products to individual specifications, which is increasingly important in a competitive landscape. However, the customization process adds complexity to production timelines, requiring companies to adopt advanced production management systems to balance efficiency with flexibility. Additionally, these firms must invest in technology and staff training to support service-based operations effectively, which adds to operational costs. Nonetheless, companies in this sector are finding that the advantages of servicification—such as improved customer loyalty, expanded service offerings, and a differentiated market presence—often outweigh the initial challenges, making it a promising strategy for sustained growth.

In the metal and electronics sector, companies like Polytron use R&D-intensive servicification to develop new products, such as electric motorcycles and design chips, allowing for competitive innovation. Polytron also incorporates servicification through after-sales services, including insurance, which increases customer loyalty and adds product value. Despite its benefits, R&D incurs substantial costs and time, posing financial and operational challenges for companies.

4.3.2.3. Policy Recommendation

To optimize the role of servicification in Java's manufacturing sector, several strategic recommendations are proposed:

- **Enhancing Service Expenditures to Boost Output:** The government can encourage higher service spending by providing tax incentives for supportive manufacturing services while adjusting taxes on raw materials and consumer goods to maintain product competitiveness. By fostering investment in manufacturing services, companies can improve operational efficiency and boost productivity.
- **Expanding GVC Participation**: Simplifying regulations and trade agreements with non-traditional partners could provide local firms with better access to global markets and raw materials, thus strengthening productivity and export reach. Facilitating exports and easing market entry requirements can support broader GVC integration, particularly for sectors like food and beverage and chemicals.
- **Improving the Foreign Investment Climate:** Streamlining regulations and offering incentives to foreign investors, especially those focused on technology in manufacturing, would enhance local productivity and technological advancement. This approach would attract more foreign capital and knowledge transfer, supporting high-tech growth in Java's manufacturing sector.
- **Developing Workforce Skills**: Increasing training programs tailored to service-specific skills, such as logistics and supply chain management, can optimize the impact of manufacturing services. Government-sponsored training or partnerships with educational institutions could ensure a steady pipeline of

skilled labor capable of supporting servicification within the manufacturing sector.

In conclusion, while servicification is gaining traction across Java's manufacturing industries, there remains untapped potential to elevate efficiency and competitiveness. By implementing these recommendations, Java can strengthen its position as a manufacturing hub that effectively integrates services, meeting both regional and global market demands for sustainable growth.

4.3.3 Eastern of Indonesia (EoI) region

4.3.3.1. Current State of Servicification in Eastern of Indonesia (EoI) Region

The Eastern of Indonesia (EoI) region (Sulawesi, Maluku, Papua) has a robust manufacturing sector concentrated in agriculture, manufacturing, trade, and construction. These industries contribute significantly to regional GDP and employment, with the manufacturing sector, particularly nickel processing, driving economic growth. The manufacturing sector's value-added share in GDP is high, but the workforce share remains relatively low due to capital intensity, as seen in large-scale industries like nickel processing. Nickel processing, a complex sector requiring extensive collaboration with domestic and international partners, has led to an increase in manufacturing services, including pre-production (e.g., raw material sourcing), production (e.g., equipment calibration), and post-production (e.g., logistics and auditing). Despite the rise in local services, certain roles, especially in engineering and advanced technology, rely heavily on foreign expertise, primarily from China.

In contrast, the food and beverage processing industry in Eastern of Indonesia (EoI) is less integrated into high-value manufacturing services. The limited downstream processing capacity restricts service needs to logistics, packaging, marketing, and raw material procurement. Fish processing companies leverage additional revenue from waste sales, contributing up to 20% of income. As digitalization becomes increasingly important, food and beverage manufacturers face challenges in adopting technology-based services, often relying on external providers.

4.3.3.2. Anecdotal evidence

In Eastern of Indonesia (EoI), the nickel processing industry exemplifies how strategic servicification can boost productivity and operational efficiency. Due to the complex and technical demands of nickel processing, companies frequently depend on specialized services, both local and international, to support each stage of production. Pre-production services such as land clearing, raw material sourcing, and smelter construction are crucial for operational setup and efficiency. During production, outsourced services for power supply, raw material testing, and equipment calibration ensure quality control and regulatory compliance. In the post-production phase, logistics, port services, and sustainability auditing streamline processes, allowing firms to concentrate on core activities. Many of these essential services are provided by external partners, reducing costs, improving time management, and providing expertise that would otherwise require significant in-house investment. Additionally, joint ventures in the sector facilitate technology transfer and boost local skill levels.

A unique aspect of Eastern of Indonesia (EoI)'s nickel industry is its dependence on foreign expertise, particularly from China, to fill specialized engineering and procurement roles. This reliance highlights a gap in local technical skills, underscoring the need for targeted training and upskilling initiatives. However, to bridge this gap, companies are increasingly partnering with local institutions to develop technical competencies within the local workforce, aiming to reduce long-

term reliance on foreign expertise. These partnerships align with broader goals of building local capacity in critical roles, such as smelter operation and engineering, to support the industry's sustainable growth while fostering knowledge transfer and technical skill development among regional employees.

In contrast, Eastern of Indonesia (EoI)'s food and beverage sector reflects a simpler model of servicification, as companies focus primarily on logistics, packaging, marketing, and raw material procurement. In the fish processing segment, companies leverage servicification by generating extra income through waste product sales, which can contribute up to 20% of their revenue. This circular economy approach demonstrates adaptability in maximizing limited resources, though the industry faces significant challenges in digital adoption. Digital services, including marketing and supply chain management, are often outsourced due to limited in-house capabilities. As market competition grows and consumer preferences shift, food and beverage companies are beginning to recognize the need for more advanced digital solutions. These firms are now exploring partnerships with digital service providers to modernize operations, enhance competitiveness, and expand market reach in response to evolving industry demands.

4.3.3.3. Policy Recommendation

To optimize manufacturing services in Eastern of Indonesia (EoI) region, several targeted strategies are proposed:

- **Production Factor Improvements:** Expanding vocational training programs to develop a skilled workforce and partnering with private industry to establish a regional technology innovation center would enhance domestic capabilities in advanced manufacturing services. For example, a dual vocational education model, involving public-private partnerships, could strengthen the local skill base in technical fields, as seen in Central Sulawesi.
- **Institutional and Regulatory Support:** Encourage service providers to adopt ISO 14001 and ISO 45001 standards to meet environmental and health requirements. Financial subsidies could support compliance, while long-term contracts may mitigate logistical cost fluctuations, enhancing service stability and reliability.
- **Trade Promotion and Collaboration:** Diversify trade partnerships to reduce dependency on specific trading partners. Investment forums and regional investment relations units could facilitate new partnerships and encourage service integration in sectors like nickel processing and food manufacturing. Additionally, closer collaboration with local educational institutions could support specialized training programs relevant to the manufacturing industry's needs.

  In conclusion, servicification in Eastern of Indonesia (EoI)'s manufacturing sector is expanding, yet untapped potential remains, especially in technology adoption and local skill development. By implementing these recommendations, the region can strengthen its industrial base and enhance its position in global value chains, supporting sustainable economic growth.

4.3.4 Key Challenges in Implementing Servicification in Indonesia's Manufacturing

Based on anecdotal evidence from Sumatra, Java, and Eastern of Indonesia (EoI), implementing servicification in Indonesia's manufacturing sector faces significant challenges. Key issues include a shortage of skilled labor, limited domestic technology, and inadequate capabilities in processing, maintenance, and quality

assurance. Companies must invest in technology and training to address these gaps, but weak collaboration with local educational institutions hinders skill development.

Regulatory changes and market fluctuations also pose challenges. Shifting government policies on imports, foreign exchange, and environmental standards, alongside volatile logistics costs due to supply chain disruptions, strain operations. Dependence on specific trade partners further reduces flexibility in adapting to market dynamics.

Additionally, the low value of manufacturing services, especially in subcontracting industries dominated by principals in R&D and innovation, highlights the need for greater process flexibility and managerial capacity. Collaboration among stakeholders is essential to address these challenges and ensure the effective implementation of servicification, adding value to Indonesia's manufacturing sector.

5. Conclusion

This study examines the impact of servicification on productivity, GVC participation, digital adoption, and regional variations within Indonesia's manufacturing sector, providing a nuanced understanding of how integrating services into manufacturing processes can drive economic growth and competitiveness. Our findings suggest that servicification, encompassing logistics, R&D, and digital services, plays a pivotal role in enhancing productivity. This study contributes to existing literature by highlighting both the potential and challenges of servicification in an emerging economy like Indonesia, particularly across its diverse regions.

Prior research underscores the importance of servicification in boosting productivity and GVC participation, especially in sectors with high-value-added services. The literature further identifies key factors—such as labor skills, technological capacity, and regulatory conditions—that influence the degree to which firms benefit from servicification. In line with global findings, our study reveals that Indonesian firms integrating external services see more significant productivity gains, particularly those in export-oriented and high-tech sectors. However, the literature also indicates that regional and firm-specific characteristics, such as industrial composition and skill availability, are crucial for capturing the full benefits of servicification.

The results confirm a positive relationship between servicification and firm productivity, with outsourced services showing a stronger impact than in-house services. Higher service expenditure correlates with a 4-5% greater likelihood of GVC participation, indicating that servicification is not only beneficial for productivity but also for global competitiveness. Additionally, our findings emphasize the importance of labor skill intensity and financial access, suggesting that these factors are essential for optimizing the productivity gains from servicification. Firms with better access to skilled labor and capital resources are more likely to experience substantial benefits from integrating services.

Digitalization in services, such as cloud-based management systems and e-commerce platforms, significantly enhance productivity and GVC participation, particularly in competitive sectors. Our results indicate that firms adopting digital servicification experience more substantial gains, although digital adoption varies by region. High-tech industries in Java and Sumatra exhibit advanced digital integration, while regions like Eastern of Indonesia (EoI) rely more on traditional services due to limited access to digital infrastructure. This disparity points to the

need for digital-focused policies to ensure equitable servicification benefits across regions.

Regional analysis reveals distinct patterns in servicification influenced by each area's industrial profile and economic infrastructure. Advanced servicification practices are observed in Java and Sumatra, particularly in high-tech and export-oriented sectors, where investments in R&D and logistics drive productivity. In contrast, Eastern of Indonesia (EoI), which relies on primary manufacturing, faces challenges in adopting high-value services due to a skills gap and limited access to specialized services. This regional diversity suggests the need for targeted policies to support servicification in line with each region's strengths and constraints.

Our findings suggest several policy directions to optimize servicification's impact on Indonesia's manufacturing sector. Policies that incentivize investment in advanced services, streamline GVC access, and foster digital adoption can enhance productivity and competitiveness. Furthermore, targeted skill development programs are essential to address the labor shortages and skills gaps that limit servicification in regions like Eastern of Indonesia (EoI). Encouraging foreign investment and collaboration with global partners can also facilitate knowledge transfer, benefiting regions with limited resources.

Servicification offers a powerful pathway to enhance productivity and global competitiveness across Indonesia's manufacturing sector. By implementing policies that support digitalization, promote regional collaboration, and invest in human capital, Indonesia can strengthen its position as a service-integrated manufacturing hub. These efforts will be critical for achieving sustainable economic growth and positioning Indonesia competitively on a global scale.

Reference

Abudureheman, M.; Jiang, Q.; Gong, J.; Yiming, A. Estimating and Decomposing the TFP Growth of Service-Oriented Manufacturing in China: A Trans-logarithmic Stochastic Frontier Approach. Sustainability 2023, 15, 6027. https://doi.org/10.3390/su15076027

ADBI report. (2019). *Leveraging Services for Development: Prospects and Policies*.

Antras, P., Chor, D. (2021). Global value chain. NBER Working Paper Series, 28549.

Ariu, A., Mayneris, F., Parenti, M. (2020). One way to the top: How services boost the demand for goods. Journal of International Economics, 123.

Bamieh, O., Fiorini, M., Hoekman, B., & Jakubik, A. (2020). Services Input Intensity and US Manufacturing Employment Responses to the China Shock. *Review of Industrial Organization*, *57*(2), 333–349. https://doi.org/10.1007/s11151-020-09770-2

Chen, G., Liu, Y., Gao, Q., & Zhang, J. (2023). Does regional services development enhance manufacturing firm productivity? A manufacturing servitization perspective. *International Review of Economics and Finance*, *86*(February), 451–466. https://doi.org/10.1016/j.iref.2023.03.020

Duggan, V., Rahardja, S., & Varela, G. (2013). Service Sector Reform and Manufacturing Productivity Evidence from Indonesia. *World Bank Policy Research Working Paper*, *6349*(January).

Haven, Thomas, and Erik Van Der Marel. Servicification of Manufacturing and Boosting Productivity through Services Sector Reform in Turkey. Policy Research Working Paper No. 8643, World Bank, 2018, https://documents1.worldbank.org/curated/fr/752341541775831554/pdf/WPS8643.pdf

Hoekman, B., & Shepherd, B. (2017). Services Productivity, Trade Policy and Manufacturing Exports. *World Economy*, *40*(3), 499–516. https://doi.org/10.1111/twec.12333

Javorcik, Beata; Fitriani, Fitria; Iacovone, Leonardo. Productivity performance in Indonesia's manufacturing sector (English). Indonesia PREM policy note; no. 5 Washington, D.C.: World Bank Group. http://documents.worldbank.org/curated/en/485831468044119749/Productivity-performance-in-Indonesias-manufacturing-sector

Kupriyanova, Marina, et al. "The Impact of Digitalization on the Manufacturing Industry." E3S Web of Conferences, vol. 431, 2023, p. 05030, doi:10.1051/e3sconf/202343105030.

Lee, W. (2019). Services liberalization and global value chain participation: New evidence for heterogeneous effects by income level and provisions. Review of Industrial Economy.

Mercer-Blackman, V., & Ablaza, C. (2018). *The Servicification of Manufacturing in Asia: Redefining The Sources of Labor Productivity* (Issue 902). ADBI Working Paper Series. https://doi.org/10.1007/978-1-349-67278-3_116

Pattnayak, S. S., & Chadha, A. (2022). Servicification and manufacturing exports: Evidence from India. *Economic Modelling*, *108*(January). https://doi.org/10.1016/j.econmod.2022.105756

Reddy, K., Sasidharan, S., & Thangavelu, S. (2023). Does servicification of manufacturing increase the GVC activities of firms? Case of India. *World Economy*, *46*(1), 153–181. https://doi.org/10.1111/twec.13318

Rodrik, D. (2016). Premature deindustrialization. *Journal of Economic Growth*, *21*(1),

1–33. https://doi.org/10.1007/s10887-015-9122-3

Shen, Lei, Cong Sun, and Muhammad Ali. "Role of Servitization, Digitalization, and Innovation Performance in Manufacturing Enterprises." Sustainability, vol. 13, no. 17, 2021, p. 9878, doi:10.3390/su13179878.

Taguchi, H.; Lar, N. Servicification in Global Value Chains in Emerging and Developing Asian Economies. Economies 2024, 12, 125. https://doi.org/10.3390/economies12060125

Thangavelu, S. M., Wang, W., & Oum, S. (2018). Servicification in global value chains: Comparative analysis of selected Asian countries with OECD. *World Economy*, *41*(11), 3045–3070. https://doi.org/10.1111/twec.12712

World Bank. (2023). Services for Growth. In *World Bank East Asia and Pacific Economic Update, October 2023: Services for Growth* (Issue October). https://doi.org/10.1596/40383

Appendix

Table 4 Effect of Servicification on Firm Productivity (by expenditure)

	Fixed Effect				Fixed Effect – Lag Regressor				System-GMM			
Total Factor Productivity	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**
Service input intensity	**0.304*****				**0.319*****				**0.168*** **			
	(0.036)				(0.043)				(0.040)			
Service expenditure		**0.414*****				**0.417*****				**0.168*** **		
		(0.039)				(0.046)				(0.040)		
Royalty expenditure			-0.071				0.178				**2.060***	
			(0.184)				(0.237)				(1.252)	
Service outsourced				**-0.477*****				**-0.404*****				**0.336*** **
				(0.092)				(0.112)				(0.095)
Capital intensity	0.142***	0.142***	0.142***	0.141***	0.126***	0.126***	0.125***	0.125***	0.081***	0.079***	0.116***	0.085***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.005)	(0.005)	(0.005)	(0.005)	(0.015)	(0.016)	(0.028)	(0.023)
Financial access	0.185***	0.185***	0.189***	0.191***	0.186***	0.186***	0.190***	0.192***	0.018***	0.019***	0.027***	0.020***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.010)	(0.010)	(0.010)	(0.010)	(0.006)	(0.006)	(0.010)	(0.007)
Export	0.494***	0.493***	0.499***	0.500***	0.491***	0.490***	0.496***	0.496***	0.021**	0.021**	0.030**	0.024**
	(0.013)	(0.013)	(0.013)	(0.013)	(0.015)	(0.015)	(0.015)	(0.015)	(0.009)	(0.009)	(0.013)	(0.010)
Foreign ownership	0.523***	0.522***	0.531***	0.532***	0.491***	0.490***	0.498***	0.500***	-0.037***	-0.035***	-0.049***	-0.035***
	(0.018)	(0.018)	(0.018)	(0.018)	(0.021)	(0.021)	(0.021)	(0.021)	(0.009)	(0.009)	(0.015)	(0.011)
Lag TFP									0.750***	0.783***	0.129	0.681*
									(0.181)	(0.210)	(0.405)	(0.348)
Lag2 TFP									0.178	0.147	0.770**	0.245
									(0.174)	(0.201)	(0.387)	(0.331)
Constant	8.491***	8.489***	8.508***	8.512***	8.738***	8.736***	8.757***	8.761***				
	(0.039)	(0.039)	(0.039)	(0.039)	(0.046)	(0.046)	(0.045)	(0.045)				
Observation	118,964	118,964	118,964	118,964	81,176	81,176	81,176	81,176	59,836	59,836	59,836	59,836
Adj. R-sq	0.397	0.398	0.396	0.397	0.375	0.375	0.373	0.373				
Industry-FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year-FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Hansen *p-val*									0.312	0.266	0.711	0.255
Kl-Pap *p-val*									0.000	0.000	0.000	0.000
AR(2) *p-value*									0.945	0.928	0.124	0.821

Clustered robust standard errors in parentheses * p < 0.1, ** p < 0.05, *** p < 0.01

Table 5 Effect of Servicification on Firm Productivity (by revenue)

	Fixed Effect			Fixed Effect – Lag Regressor			System-GMM		
Total Factor Productivity	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
Service output intensity	**0.199*****			**0.273*****			**0.131****		
	(0.021)			(0.027)			(0.059)		
Service revenue		**0.199*****			**0.276*****			**0.136****	
		(0.023)			(0.029)			(0.064)	
Other service revenue			**0.204*****			**0.257*****			**1.342****
			(0.058)			(0.074)			(0.642)
Capital intensity	0.141***	0.141***	0.141***	0.125***	0.125***	0.125***	0.100***	0.097***	0.101***
	(0.004)	(0.004)	(0.004)	(0.005)	(0.005)	(0.005)	(0.026)	(0.025)	(0.029)
Financial access	0.191***	0.191***	0.189***	0.192***	0.192***	0.190***	0.026***	0.026***	0.024***
	(0.009)	(0.009)	(0.009)	(0.010)	(0.010)	(0.010)	(0.009)	(0.009)	(0.009)
Export	0.504***	0.504***	0.499***	0.502***	0.502***	0.496***	0.032***	0.031**	0.030**
	(0.013)	(0.013)	(0.013)	(0.015)	(0.015)	(0.015)	(0.012)	(0.012)	(0.013)
Foreign ownership	0.527***	0.527***	0.530***	0.494***	0.494***	0.498***	-0.043***	-0.041***	-0.048***
	(0.018)	(0.018)	(0.018)	(0.021)	(0.021)	(0.021)	(0.014)	(0.013)	(0.017)
Lag TFP							0.475	0.529	0.405
							(0.365)	(0.359)	(0.424)
Lag2 TFP							0.437	0.386	0.505
							(0.346)	(0.340)	(0.402)
Constant	8.498***	8.499***	8.507***	8.745***	8.745***	8.757***			
	(0.039)	(0.039)	(0.039)	(0.045)	(0.045)	(0.045)			
Observation	118,964	118,964	118,964	81,176	81,176	81,176	59,836	59,836	59,836
Adj. R-sq	0.398	0.398	0.396	0.376	0.376	0.374			
Industry-FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year-FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Hansen *p-val*							0.477	0.385	0.295
Kl-Pap *p-val*							0.000	0.000	0.000
AR(2) *p-value*							0.448	0.532	0.411

Clustered robust standard errors in parentheses * p < 0.1, ** p < 0.05, *** p < 0.01

Table 6 Impact of servicification on GVC participation and channels of servicification

Variable	(1) GVC	(2) GVC	(3) GVC	(4) GVC	(5) GVC	(6) GVC	(7) GVC
Service input intensity $_{t-1}$	0.188***	0.042***	0.039**	**0.056*** **			
	(0.018)	(0.015)	(0.015)	(0.017)			
Service exp. $_{t-1}$					**0.054*** **		
					(0.018)		
Royalty exp. $_{t-1}$						**0.205***	
						(0.114)	
Service outsourced $_{t-1}$							0.062
							(0.046)
TFP_{t-1}		0.011***	0.011***	0.020***	0.020***	0.020***	0.020***
		(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Capital intensity		0.001	0.001	0.002	0.002	0.002	0.002
		(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Labor skill int. $_{t-1}$		0.032***	0.035***	0.029***	0.029***	0.029***	0.029***
		(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Foreign own $_{t-1}$		0.280***	0.277***	0.262***	0.262***	0.263***	0.263***
		(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
Financial access $_{t-1}$		0.035***	0.034***	0.033***	0.033***	0.034***	0.034***
		(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Firm size $_{t-1}$		0.048***	0.041***	0.041***	0.041***	0.041***	0.041***
		(0.005)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
_cons	0.077***	-0.520***	-0.560***	-0.578***	-0.577***	-0.577***	-0.578***
	(0.002)	(0.028)	(0.031)	(0.033)	(0.033)	(0.033)	(0.033)
Observation	81,176	81,176	81,176	81,176	81,176	81,176	81,176
Adj. R-sq	0.006	0.241	0.243	0.257	0.257	0.256	0.256
Industry-FE	NO	NO	NO	YES	YES	YES	YES
Year-FE	NO	NO	YES	YES	YES	YES	YES

Clustered robust standard errors in parentheses * p < 0.1, ** p < 0.05, *** p < 0.01

Table 7 Impact of servicification on Productivity by size classification

	Medium-Firms				Large-Firms			
Total Factor Productivity	**(1)** FE	**(2)** *FE-Lag regressor*	**(3)** FE	**(4)** *FE-Lag regressor*	**(5)** FE	**(6)** *FE-Lag regressor*	**(7)** FE	**(8)** *FE-Lag regressor*
Service input intensity	**0.093*****	**0.124*****			0.072	**0.092***		
	(0.033)	(0.040)			(0.046)	(0.055)		
Service output intensity			**0.211*****	**0.297*****			**0.168*****	**0.214*****
			(0.018)	(0.024)			(0.036)	(0.045)
Capital intensity	0.155***	0.133***	0.154***	0.132***	0.102***	0.090***	0.102***	0.090***
	(0.003)	(0.004)	(0.003)	(0.004)	(0.006)	(0.006)	(0.006)	(0.006)
Financial access	0.047***	0.047***	0.050***	0.050***	0.146***	0.140***	0.148***	0.141***
	(0.007)	(0.009)	(0.007)	(0.009)	(0.014)	(0.017)	(0.014)	(0.016)
Export	0.098***	0.098***	0.104***	0.105***	0.213***	0.214***	0.219***	0.220***
	(0.012)	(0.015)	(0.012)	(0.015)	(0.015)	(0.018)	(0.015)	(0.018)
Foreign ownership	0.343***	0.345***	0.340***	0.343***	0.215***	0.212***	0.214***	0.210***
	(0.021)	(0.025)	(0.021)	(0.025)	(0.019)	(0.023)	(0.019)	(0.022)
Const	8.202***	8.499***	8.200***	8.497***	9.741***	9.916***	9.734***	9.908***
	(0.033)	(0.040)	(0.033)	(0.039)	(0.062)	(0.066)	(0.061)	(0.066)
Observation	82,077	54,764	82,077	54,764	36,887	26,412	36,887	26,412
Adj. R-sq	0.430	0.382	0.433	0.388	0.289	0.269	0.291	0.271
Industry-FE	YES	YES	YES	YES	YES	YES	YES	YES
Year-FE	YES	YES	YES	YES	YES	YES	YES	YES

Clustered robust standard errors in parentheses * p < 0.1, ** p < 0.05, *** p < 0.01

Table 8 Impact of servicification on Productivity by technology classification

	Low-tech				Medium-tech				High-tech			
Total Factor Productivity	**(1)** FE	**(2)** *FE-Lag regressor*	**(3)** FE	**(4)** *FE-Lag regressor*	**(5)** FE	**(6)** *FE-Lag regressor*	**(7)** FE	**(8)** *FE-Lag regressor*	**(9)** FE	**(10)** *FE-Lag regressor*	**(11)** FE	**(12)** *FE-Lag regressor*
Service input intensity	**0.396*****	**0.399*****			-0.019	0.022			**0.486*****	**0.563*****		
	(0.043)	(0.051)			(0.079)	(0.091)			(0.104)	(0.127)		
Service output intensity			**0.180*****	**0.273*****			**0.191*****	**0.217*****			**0.393*****	**0.458*****
			(0.026)	(0.034)			(0.040)	(0.046)			(0.080)	(0.112)
Capital intensity	0.155***	0.135***	0.155***	0.135***	0.115***	0.111***	0.114***	0.110***	0.112***	0.092***	0.110***	0.089***
	(0.005)	(0.006)	(0.005)	(0.006)	(0.006)	(0.007)	(0.006)	(0.007)	(0.013)	(0.018)	(0.013)	(0.018)
Financial access	0.171***	0.170***	0.179***	0.178***	0.202***	0.212***	0.200***	0.211***	0.247***	0.241***	0.260***	0.252***
	(0.010)	(0.013)	(0.010)	(0.013)	(0.017)	(0.020)	(0.017)	(0.020)	(0.033)	(0.045)	(0.033)	(0.045)
Export	0.485***	0.485***	0.498***	0.499***	0.525***	0.508***	0.528***	0.512***	0.421***	0.422***	0.440***	0.441***
	(0.015)	(0.018)	(0.015)	(0.018)	(0.027)	(0.031)	(0.027)	(0.031)	(0.051)	(0.066)	(0.050)	(0.066)
Foreign ownership	0.652***	0.618***	0.658***	0.622***	0.338***	0.314***	0.334***	0.311***	0.577***	0.542***	0.580***	0.546***
	(0.024)	(0.028)	(0.024)	(0.028)	(0.032)	(0.037)	(0.032)	(0.037)	(0.051)	(0.065)	(0.052)	(0.066)
Const	8.245***	8.525***	8.256***	8.533***	9.050***	9.162***	9.044***	9.158***	8.907***	9.253***	8.928***	9.289***
	(0.051)	(0.060)	(0.051)	(0.059)	(0.065)	(0.072)	(0.065)	(0.072)	(0.132)	(0.182)	(0.133)	(0.183)
Observation	81,444	54,941	81,444	54,941	30,333	21,841	30,333	21,841	7,187	4,394	7,187	4,394
Adj. R-sq	0.372	0.348	0.372	0.349	0.333	0.320	0.335	0.322	0.400	0.337	0.402	0.339
Industry-FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year-FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Clustered robust standard errors in parentheses * p < 0.1, ** p < 0.05, *** p < 0.01

Table 9 Impact of servicification on Productivity by region

	Outside Java-Bali				Java-Bali			
Total Factor Productivity	**(1)** FE	**(2)** *FE-Lag regressor*	**(3)** FE	**(4)** *FE-Lag regressor*	**(5)** FE	**(6)** *FE-Lag regressor*	**(7)** FE	**(8)** *FE-Lag regressor*
Service input intensity	**0.170****	**0.236****			**0.358*****	**0.360*****		
	(0.079)	(0.097)			(0.041)	(0.047)		
Service output intensity			**0.214*****	**0.259*****			**0.190*****	**0.267*****
			(0.051)	(0.064)			(0.023)	(0.030)
Capital intensity	0.159***	0.147***	0.159***	0.147***	0.133***	0.116***	0.132***	0.115***
	(0.007)	(0.008)	(0.007)	(0.008)	(0.005)	(0.005)	(0.005)	(0.005)
Financial access	0.228***	0.233***	0.228***	0.232***	0.175***	0.176***	0.183***	0.183***
	(0.020)	(0.024)	(0.020)	(0.024)	(0.010)	(0.011)	(0.010)	(0.011)
Export	0.428***	0.433***	0.433***	0.437***	0.508***	0.502***	0.520***	0.516***
	(0.025)	(0.030)	(0.025)	(0.030)	(0.016)	(0.018)	(0.015)	(0.018)
Foreign ownership	0.465***	0.424***	0.459***	0.421***	0.525***	0.496***	0.532***	0.502***
	(0.038)	(0.046)	(0.038)	(0.046)	(0.021)	(0.024)	(0.021)	(0.024)
Const	8.423***	8.610***	8.423***	8.613***	8.557***	8.814***	8.567***	8.823***
	(0.072)	(0.080)	(0.072)	(0.080)	(0.046)	(0.053)	(0.045)	(0.052)
Observation	21,973	14,378	21,973	14,378	96,991	66,798	96,991	66,798
Adj. R-sq	0.436	0.421	0.437	0.422	0.394	0.371	0.394	0.373
Industry-FE	YES	YES	YES	YES	YES	YES	YES	YES
Year-FE	YES	YES	YES	YES	YES	YES	YES	YES

Clustered robust standard errors in parentheses * p < 0.1, ** p < 0.05, *** p < 0.01

Table 10 Summary Statistics of Key Variables Used in the Analysis

Variable	Available Obs	Sample	Mean	Std. Dev.
TFP	779	747	2.319	1.807
Sales (log)	4,236	747	21.372	3.637
Labour (person)	4,985	747	162.791	599.779
Age (year)	4,790	747	19.143	13.001
Exporter (1=Yes)	4,320	747	0.226	0.419
Foreign affiliated (1=Yes)	4,398	747	0.143	0.351
Foreign-technology (1=Yes)	4,770	747	0.143	0.351
Website (1=Yes)	4,930	746	0.552	0.498
Internet (1=Yes)	4,925	743	0.933	0.251
Electronic payment (1=Yes)	3,473	636	0.786	0.41
Digital (1=Yes)	4,985	747	0.963	0.19

Table 11 Impact of servicification on Productivity by region

Dependent	TFP				New process		New product	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Estimation	OLS	Q25	Q50	Q75	OLS	Probit	OLS	Probit
Sales (log)	0.08***	0.05***	0.06***	0.07***	0.01	0.06	0.01*	0.07**
	(5.91)	(3.24)	(5.37)	(4.60)	(1.14)	(1.55)	(1.68)	(2.00)
Firm age	-0.00	-0.00	-0.00	-0.00	0.00**	0.01***	0.00	0.00
	(-1.53)	(-0.54)	(-0.05)	(-0.50)	(2.19)	(2.86)	(0.30)	(0.34)
D.Exporter (1=Yes)	-0.06	-0.03	-0.00	-0.05	-0.04	-0.19	0.02	0.08
	(-0.86)	(-0.53)	(-0.04)	(-0.76)	(-1.25)	(-1.06)	(0.57)	(0.55)
D.RnD (1=Yes)	0.02	0.11*	0.06	0.12	0.27***	1.08***	0.33***	1.03***
	(0.34)	(1.78)	(0.81)	(1.01)	(4.46)	(5.51)	(5.13)	(5.79)
D.Foreign affiliation (1=Yes)	-0.14*	-0.13***	-0.14**	-0.11	0.01	0.01	-0.07*	-0.35**
	(-1.87)	(-2.63)	(-2.32)	(-1.55)	(0.15)	(0.02)	(-1.82)	(-1.97)
D.Forreign technology (1=Yes)	0.07	0.00	0.02	0.02	0.07*	0.31*	0.08*	0.33**
	(1.01)	(0.10)	(0.30)	(0.34)	(1.89)	(1.75)	(1.77)	(2.07)
Digital adoption level								
1: Digital payment < 10%	0.00	-0.06	-0.11	-0.02	0.02	0.04	-0.05	-0.30
	(0.02)	(-0.42)	(-0.78)	(-0.05)	(0.37)	(0.09)	(-0.81)	(-0.83)
2: Digital payment 10%-30%	-0.05	-0.04	-0.02	-0.03	0.09**	0.68***	0.04	0.17
	(-0.69)	(-0.64)	(-0.36)	(-0.40)	(2.08)	(2.58)	(0.92)	(0.82)
3: Digital payment >30%	0.09*	0.11*	0.08*	0.06	0.05*	0.43**	0.05	0.20
	(1.78)	(1.84)	(1.91)	(0.85)	(1.88)	(2.23)	(1.33)	(1.31)
Constant	0.92***	0.90***	1.09***	1.34***	-0.11	-3.13***	-0.02	-1.94***
	(5.99)	(5.86)	(9.60)	(8.25)	(-1.61)	(-6.21)	(-0.24)	(-4.83)
Observations	747	747	747	747	743	678	747	737
Country FE	Y	Y	Y	Y	Y	Y	Y	Y
Industry FE (ISIC Rev.4)	Y	Y	Y	Y	Y	Y	Y	Y
Adjusted R-Square	0.90				0.10		0.09	
Pseudo R-Squared		0.69	0.71	0.72		0.17		0.13