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Structural Change: Do Services Substitute or Complete the Industry?

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Abstract

This study analyzes the nature of the relationship between the services and the industry, i.e., substitution or complementarity, given the increasing share of services (tertiarization process) in the world economy. The economies in the world evolved towards a services-dominated structure over a half-century. This evolution resulted in a decreasing industry share despite continuously increased industrial production. We used a dataset covering the 1970-2018 period for 173 countries to investigate this question by employing the panel vector of auto-regression analysis (Panel VAR). We also approached the problem by estimating a dynamic panel data model by the two-step system GMM for robustness. The study also calculates the linkages between the industry and the services. The empirical results show that services do not substitute industry. There is a complementary role of the services for the industry, but the complementary role of the industry for services is ambiguous.

Keywords: Structural change, tertiarization, services, industry, de-industrialization.

JEL Codes: O10, O11, O14.

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1. Introduction

Structural economic change has intrigued economists since the 17th century (Petty, 1690/1899). There was a struggle between the agricultural and the non-agricultural sectors three centuries ago. A structural change is also observed in economies in a different context than in the 17th century. Agricultural and industrial output shares have declined over the years, while the share of services increased rapidly in most economies (UNCTAD, 2021). Many economies have similar services-weighted compositions in their development process, although developed economies experienced this change earlier than developing ones. The literature proposes that the structural change led by the rapid growth in services is one of the inevitable economic growth and development outcomes. This claim is known as the Clark-Fisher hypothesis (Clark, 1940; Fisher, 1935).

At first glance, the services sector might be developed as a substitute for the industry because it seems to replace the economic activity in many countries due to the increasing share of services (tertiarization). However, tertiarization could also result from using the service activities as an input (Ballesta et al., 2012; Genaro & Melchor, 2009). This point of view refers to the complementary role of the services for the industry. Our study aims to unravel the underlying relationship between the services and the industry, i.e., do services replace or complement the industry? The complementarity implies a sort of mutual interdependence of these sectors. However, some service activities may not be dependent on the industrial output. For example, some tourism-dominated island economies or some African countries whose economy consists of some mining activities are not dependent on the industry. Therefore, the direction of complementarity matters here. There may not be two-way complementarity. This study attempts to clarify the nature and the direction of the relationship. To the best of our knowledge, no other study deals with the complementarity or substitution relationship between these sectors.

Our study uses the vector of auto-regression (VAR) analysis method by using the dataset covering the years between 1970 and 2018 for 173 countries obtained from UNCTAD (2021). We also estimated a dynamic panel data model using the two-step system GMM to check the findings' robustness. We also calculated the backward linkages of the industry and the services using the World input-output tables. The countries included in the analysis are in the appendix. The paper's outline is as follows: The following section draws the theoretical framework for structural change. The third section formalizes the relationship between the services and the industry within a simple supply function by connecting the inter-sectoral relations and presenting the calculated direct backward linkages. The fourth section is devoted to the data and the estimation of the VAR model. The fifth section presents the system GMM estimations for the robustness check, and the final section concludes.

2. Theoretical Framework

Petty's (1690/1899) observations in the 17th century provided a foundation for the so-called Petty's Law, implying a tendency to shift resources away from agricultural activities towards non-agricultural activities, causing an increase in the non-agricultural employment accompanying the economic development process in London. Engel (1857) also emphasized the structural change reducing the share of agriculture by pointing out the relationship between the increases in income level and the demand for non-agricultural products in the Kingdom of Saxony. By the 20th century, the so-called three-sector theory (Clark, 1940; Fisher, 1935; and Fourastié, 1949) provided a more general basis for the structural change in an economy, including the flourishing services sector. This theory states that the development of economies occurs gradually as the shift of activity from agriculture to industry and from industry to services. Clark (1940) inferred that the high employment rate in services is related to high per capita income by interpreting the increase in economic activity in services resulting from economic development. Briefly, countries reached their highest level of industrialization, and the share of the secondary sector (manufacturing, mining, and building) began to decline relative to the tertiary (services, commerce, transport, and other economic activities) production (Clark, 1940). As per capita income increases, the services sector tends to outweigh the industry in the economy, as does employment in services. Kaldor (1966) also refers to this tendency to decline manufacturing output. Numerous studies in the literature investigate this de-industrialization process (e.g., Berry, 1997; Caves et al., 1980; Chenery, 1979; Fuchs, 1968; Kuznets, 1957; 1966). Several of these empirical studies, such as Kuznets (1957, 1966), Chenery (1979), and Fuchs (1968), supported the hypothesis. Berry (1997) concludes that the Clark hypothesis holds for high-income countries, especially post-1980. Upper-middle and lower-middle-income countries were decoupled from high-income ones as these economies failed to grow despite the structural shift in favor of services. In brief, the Clark hypothesis holds for developed countries, whereas a failure of growth mechanism is at work in developing countries (Berry, 1997, pp. 461-465). There was no significant opposition to the consensus on the relationship between the increasing share of services and economic development until the 1970s.

Service activities increased with the improved scientific knowledge and information and communication technologies (ICT) during the 1970s, so economies were transformed into a more multidimensional and complex structure. Following the 1970s and today, technology's effect on service growth is different. By the 1970s, two views emerged as, post-industrialism and neo-industrialism in discussing the structural change in favor of services (Desmarchelier & Gallouj, 2013, p. 832). The post-industrialists (e.g., Bell, 1973, 1976; Fourastié, 1949) regarded the increasing share of services as a beneficiary process for economies, whereas neo-industrialists (Attali, 1981; Bacon & Eltis, 1976; Cohen & Zysman, 1987; Gershuny, 1978; Gershuny & Miles, 1983; Lipietz, 1980) stand against this argument. The neo-industrialists regard the structural change with the increasing share of services as negative because service productivity is generally lower and the number of occupations with low productivity, e.g., salespersons and clerks. However, the productivity in occupations in industrial activity, e.g., machine operator, is higher. The other view, post-industrialism, acknowledges structural change as a natural outcome of the increased complexity in economies.

The post-industrial society following the 1970s experienced two significant changes simultaneously: the decline in industrial manufacturing and the increase in service activities. Besides, as the company blends services and manufacturing, the border between these activities is blurred (Vogt, 2016, pp. 367–368). This blurring suggests a sort of complementarity. Service activities support manufacturing growth. Thus, post-industrialists do not view the rise of services, especially after 1970, due to income growth and economic development and point out other factors. For example, companies faced difficulties in marketing their products due to the economic crisis of 1974. This challenge raised the need for new marketing strategies, creating occupations such as clerks, sales, and personal services workers. Furthermore, service activities like consultancy and software services increased with the ICT revolution.

Business culture has been changing definitely with technological improvements starting from the 2000s. New customer services have developed rapidly; for instance, two-way video chats enable technical personnel to examine broken pieces of devices sold to customers remotely or solve problems about their products, thereby creating mutual trust between buyers and sellers. Additionally, new types of services occurred. For example, some mobile applications provide information to customers, such as JetBlue and JustFly, without human support. Furthermore, virtual assistants improved with machine learning and speech recognition (Condon, 2016). The Amazon Alexa Voice Services (AVS) has artificial intelligence that connects to the other intelligent devices for checking the news, playing music, and managing the calendar. Also, the payments and commerce sectors have tested the AVS for payment or delivery methods (Amazon Alexa, 2020). New service activities arise in many sectors in different ways.

Moreover, recent researchers have approached the issue with a different perspective. Lin and Wang (2020) express that service production is asymmetric at different levels of development. So the tertiarization process is more complicated than ever before. Also, the tertiarization process has not developed traditionally. Baldwin (2019) and Baldwin & Forslid (2020) raised the concept of globotics, referring to combining a new form of globalization and a new form of robotics. This kind of globalization shows us that service or professional jobs do not need face-to-face communication now (Baldwin, 2019). For example, firms hire engineers using Upwork, the most extensive website freelancing from any country worldwide. Employees can work in other countries virtually as telemigrant (Baldwin, 2019). So, this service complements the activity of an engineer. Therefore, it is clear that service employment and production processes have been more intricate than ever before.

We have discussed thus far a general tertiarization process with particular emphasis on the changing nature over time. Economies also experience this process differently at a specific point in time. East and Southeast Asia, Latin American countries, and some African countries had different development patterns. Akarçay-Gürbüz (2011) discusses that while the European countries and South Korea were going through a genuine tertiarization process, the countries such as Argentina, Brazil, Mexico, and Turkey had a spurious tertiarization process. The spurious expansion of services is in line with the neo-industrialist view. Dasgupta & Singh (2007) describe the experience of peripheral countries as a pathological phenomenon because it restrains reaching potential growth, employment, and resource utilization of an economy. Financialization and debt crisis are the common characteristics of these economies. Also, unskilled labor employment in services increases in this process. Despite the food shortages and insufficient employment opportunities, agriculture employment has lost importance. This kind of expansion of services is a "spurious tertiarization" (Pinto, 1984) or negative de-industrialization (Rowthorn & Wells 1987, p. 24). This latter concept is closely related to premature de-industrialization. Many developing countries over-invested in services without adequate manufacturing investment and thus experienced a "premature de-industrialization." Premature de-industrialization refers to the circumstance that the late industrialized countries reach the peak level of their industrialization at lower income levels than early industrialized countries (Rodrik, 2016). Rodrik (2016) explains this concept as the European countries such as the United Kingdom, Sweden, and Italy reached the peak of their industrialization at 14 thousand dollars income level, while India and many Sub-Saharan African countries reached the peak of manufacturing at an income level of 700 dollars.

Finally, the process we discussed above can be clearly defined as the de-industrialization and strengthened following the 1980s as manufacturing activity shifted from the core economies to the peripheral ones. In contrast, service-oriented economic activities related to manufacturing, such as management, marketing, and R&D, were left to carry out in former economies. Firms focused on service-oriented economic activities such as product design, marketing, and R&D, and outsourced manufacturing activity in the value chain. Therefore, today while the industrial share is declining today, the services share increased in these economies. Enhanced trade volumes induced manufacturing activity and the need for service activities supporting business operations. For example, the share of financial services has increased in many economies, especially after 1990.

3. The Relationship between the Services and the Industry

We can simply envisage the mutual relationship between the industry and the services sector by considering the supply function of each industry in the following way:

$$Q_i = f(P_i, C_i\left(P_j(Q_j, X_i)\right)) \tag{1}$$

The i and j subscripts stand for the industry or the services sector. Q is the real production, P is the prices of the goods, C is the cost, and X is all the sectors' other costs. The cost of any sector is precisely a function of the input prices purchased from the other sector. These prices depend on the other industry's supply, in turn.

Our concern here is limited to the effects on sectors' production through inter-industry linkages to determine the complementarity or substitutability between the industry and the services. In other words, the partial derivative of one sector's production concerning the other highlights the relationship between the two sectors. The partial derivative uses the chain rule in derivation as

$$\partial \mathrm{Q_i}/\partial \mathrm{Q_j} = (\partial \mathrm{Q_i}/\partial \mathrm{C_i})(\partial \mathrm{C_i}/\partial \mathrm{P_j})(\partial \mathrm{P_j}/\partial \mathrm{Q_j}) \tag{2}$$

If this partial derivative is positive, then j is a complementary sector for sector i. If this partial derivative is negative, these two sectors are substituting each other.

It might also illuminate to descriptively analyze the inter-industry relationship between the industry and the services before estimating this relationship. We can approach the inter-industry linkages between the sectors by calculating the backward linkages of each sector on the other. The calculation of backward linkages of sectors uses a simple input-output model. One can represent a simple input-output model as

$$\mathrm{Q = AQ + Y} \tag{3}$$

Here, Q is the nx1 vector of real production of sectors, A nxn is the technical coefficient matrix, and Y is the nx1 final demand vector. Each element of matrix A, i.e., technical coefficients, is calculated by dividing the flows between sectors by the total output of the relevant sector. One can also write the equation above as

$$\mathrm{Q = (I - A)^{-1}Y} \tag{4}$$

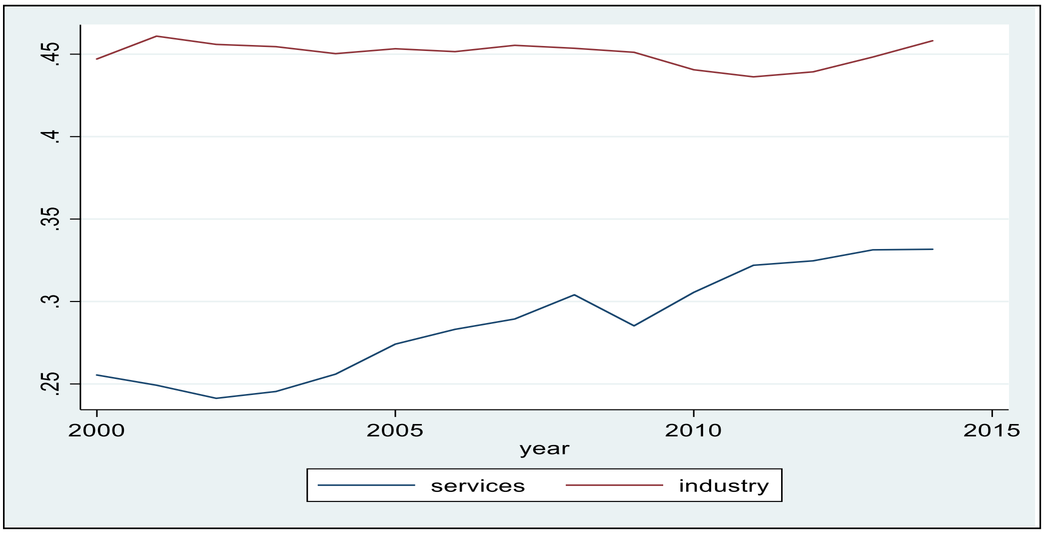
Here, I is nx1 the identity matrix. The matrix pre-multiplying the final demand vector is known as the Leontief inverse matrix. Each column sum of this matrix yields the direct backward linkages of sectors. The direct backward linkages measure the inter-industry dependence among sectors in terms of the sectors as input purchasers. It shows the impact of the output increases in any sector on the production of other sectors. In other words, when there is a change in the final demand for a sector by one US dollar, the output production is expected to increase by the same amount to meet this increase in demand. As the output of this sector induces input purchases from other sectors, the production in the input-using sectors would also rise. In this way, we can capture the interaction between the productions of sectors. The direct backward linkages measure the connections between the sectors in terms of the sectors as input sellers. We do not present the direct forward linkages as the use of backward linkage measure here would be sufficient to grasp the interaction between the productions of sectors. Therefore, we examine the direct backward linkages to understand the relationship between the industry and the services.

We calculated the backward linkages of these two sectors, excluding the aggregate agriculture sector, using the World input-output tables (Timmer et al., 2015). These tables are available for the years from 2000 up to 2014. Therefore, we can calculate the backward linkages of sectors for a shorter period. The World input-output tables collect detailed data for 43 economies but represent the entire world economy as the flows of other countries are in the rest of the world category. We summed all sectors and collapsed the tables into the 2x2 matrices, including the industry and the services as broad categories. As explained above, we used the Leontief inverse of the input-output tables to calculate the backward linkages (Miller & Blair, 2009). We excluded the diagonal elements of this matrix because we are interested in the linkages of any industry, excluding the own sector. Figure 1 displays the direct backward linkages of each industry to the other. For example, the direct backward linkages of the industry indicate the induced output production of the services sector as input providers.

If the services sector complements the industry, the industry must use a significant amount of inputs purchased from the services sector. In other words, the direct backward linkages of the industry from the services in the world must be very high. The services sector also uses inputs from the industry, so this must be true for the industry's direct backward linkages if the industry complements the services.

Figure 1

The Direct Backward Linkages of the Industry and the Services, 2000-2014



Source: Author's calculations using the World Input-Output Tables (Timmer et al., 2015).

Figure 1 exhibits that the direct backward linkages of the services in the industry are strikingly higher than that of the industry sector on services in the world overall. The direct backward linkages of the industry from the services in the world economy have remained more or less stable during the 2000-2014 period. One can observe a slight decrease in the direct backward linkages of the industry following the global financial crisis in 2008 and a recovery of these linkages in 2014. The calculated value of the direct backward linkages of the industry on services is around 0.45, on average, for the entire period. In other words, an increase worth of one dollar in the final demand of the industry causes the production of the services sector as an input provider to increase by forty-five cents.

On the other hand, the direct backward linkages of the services in the industry seem relatively less important; but these linkages display a positive trend. The decline in these linkages of the services in 2009 due to the global crisis is also apparent. The backward linkages of the services are around 0.26 initially, whereas these linkages escalated to 0.33 and have been 0.29, on average. This average number means that one US dollar increase in the output production of the services leads to an increase in the industry's output by twenty-nine cents. The figure displays that despite the positive trend for the direct backward linkages of the services, the gap between the direct backward linkages of the industry and the services is still not negligible.

The significant amount of the backward linkages of the services on the industry and the relatively weaker backward linkages of the industry on the services support the idea that the services complement the industry more than the industry does the services. Figure 1 draws a picture in coherence with the observed tertiarization process in the world economy over the last half-century. The industry's much stronger direct backward linkages on the services lead to the services sector flourishing. Observing the upward trend of the backward linkages of the services' services might be puzzling. In contrast, the backward linkages of the industry from the services are stable in the figure given the increasing share of the services and decreasing share of the industry in the world economy. One should expect the industry sector to reclaim its share in GDP due to the sales to the services sector as it develops.

Nevertheless, the input provider role of the industry to the services sector seems to be relatively weaker. The services provide more inputs to the industry than the industry does to the services. In brief, if there is a complementary relationship between the industry and the services, the services sector complements the industry more.

We need to clarify the relationship between the direct backward linkages and the supply function in equation (1). If we are interested in the output change of the industry in response to the change in the production of the services can be stated as $\partial \mathrm{Q}_{\text{industry}}/\partial \mathrm{Q}_{\text{services}}$. The calculation of the backward linkages of the industry draws on the inverse of technical coefficients, which emphasize the importance of the services sector as the input provider in the production of industrial goods. In other words, backward linkages emphasize the input provider roles of all other industries except for which these linkages were calculated. So, we should evaluate the direct backward linkages by the partial derivative expressed in equation (2). For instance, high backward linkages of the industry can be interpreted as the contribution of the services sector to industrial production. In turn, it means a high partial derivative of the industrial output with respect to the output of the services, $\partial \mathrm{Q}_{\text{industry}}/\partial \mathrm{Q}_{\text{services}}$ considering equation (1).

4. Data and Estimation

The data used in the analysis were retrieved from the UNCTAD (2021) statistics. The symbols used for variables, definitions, descriptive statistics, and correlation are presented in Table 1. There are 8477 observations between 1970 and 2018 for 173 countries. We were able to include 173 countries for which the data is available. The mean sectoral values added are close to each other. There is a strong positive correlation between the two variables.

Table 1

Variable Definitions, Summary Statistics, and the Correlation

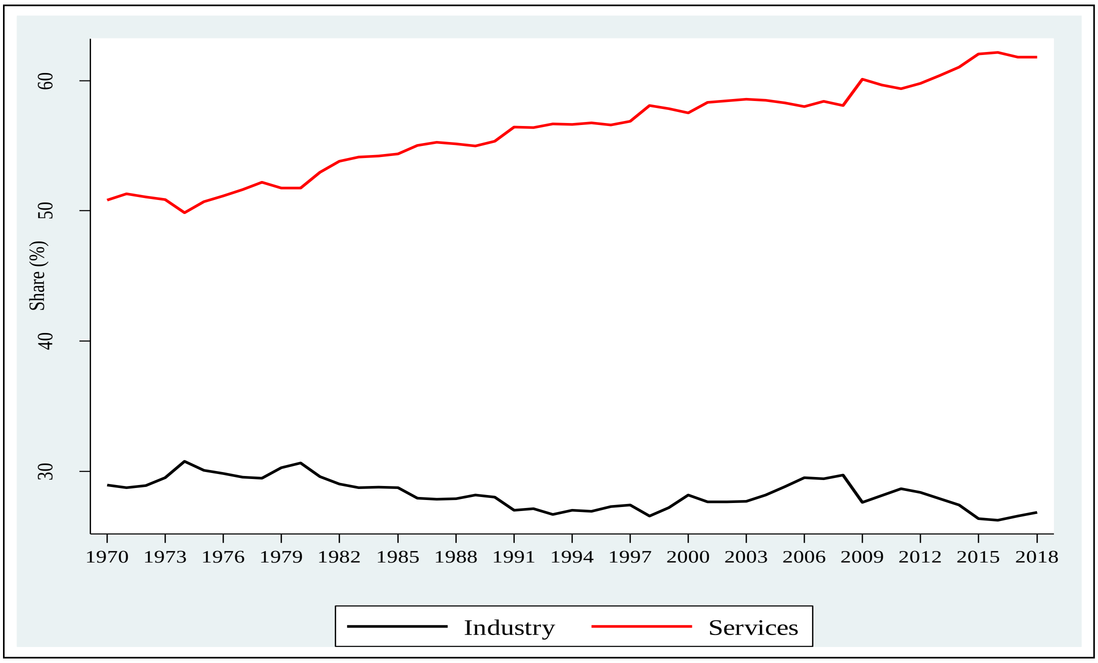
Variables	Description	Observation	Mean	Min	Max	Correlation
Inser	Log of real services value-added	8477	22.77	15.42	30.38	0.9655
Inind	Log of real industry value-added	8477	21.98	13.59	29.31	

Note: All variables are in USD in 2015 Prices.

Figure 2 indicates the average shares of the industry and the services of the economies in the world between 1970 and 2018. The figure suggests that the increase in the share of the services sector has been a manifested phenomenon in the world economy. The ever-increasing gap between the shares of services and the industry in the world economy is particularly striking. The share of the services has continuously increased, and the industry share had a steady downward trend throughout the period. The service share had risen from 50 % in 1970 to 61 % in 2018. In contrast, the industry share has declined from the 29 % to 27 % in the same years (UNCTAD, 2021).

Figure 2

The Services and the Industry in the World Economic Shares, on average, 1970-2018.



Data Source: UNCTAD, 2021.

The formal test of the complementary/substitute relationship between services and industry sectors was carried out using the variables in Table 1. If there is a positive co-integrating relationship between the values added of the services and the industry, i.e., lnser and lnind, then the complementarity between these sectors would be inferred. A negative relationship would suggest substitutability between the industry and the services.

It is important to determine whether the two series are stationary before conducting the co-integration. In case both series are stationary to the same degree, co-integration can be performed. An analysis of VAR can be conducted using the differenced variables if there is no co-integration. Some stationary tests do not consider the cross-section dependency, so we need to employ a test to investigate the existence of such a dependency and choose the stationarity test accordingly. To this end, we first used the Pesaran (2004) test to examine the cross-section dependency. The results of this test are in the table below.

Table 2

Pesaran Cross-Section Dependence Test

H_0= Cross-section independence; H_1= Cross-section dependence					
Variables	CD Test Statistics	P-value	Cross-Section	Observation	Results
lnser	721.57	0.000	173	8477	Reject H_0
lnind	563.18	0.000	173	8477	Reject H_0

Table 2 shows that the two series are cross-sectional dependent. This dependence requires choosing a test accounting for the cross-section dependency. The cross-section dimension is greater than the time dimension of the data, i.e., N>T, so we employed the Pesaran non-stationary test. This stationarity test is convenient for heterogeneous panels. The Table 3 presents the results of this test statistics.

Table 3

Pesaran Non-Stationary Test

H_0= Non-stationary; H_1= Stationary					
Variables	Z (t bar)	P Values	Lags	Observations	Results
lnser	1.579	0.943	1	8131	Accept H_0
lnind	2.798	0.997	1	8131	Accept H_0
Δlnser	–30.574	0.000	1	7958	Reject H_0
Δlnind	–31.639	0.000	1	7958	Reject H_0

Note: Lag numbers were determined according to the Akaike information criterion.

In accordance with the unit root test results, the variables are stationary at the first difference or are defined as I (1) variables in order to allow the series to be co-integrated. As we are using a very long period and the changing nature of the tertiarization process over time, we also need to consider any possible structural break in the series over the period considered.

Therefore, we tested whether there is a structural break in the series to decide which test to apply for the co-integration analysis using the Chow test for panel data. The table below displays the results of this test. Table 4 suggests structural breaks in 1974 and 2009, representing the effects of the world oil shock and the global financial crisis.

Table 4

Structural Change Test

H_0 = No Structural Change			
Structural Change	Chow	$F_{statistics}$	P-value
1974	F (3, 43)	22.95	0.000
2009	F (3, 43)	33.15	0.000

As the structural breaks are available in the data series, we employed the Westerlund co-integration test accounting for the structural breaks and the cross-section dependency (Chudik & Pesaran, 2015; Eberhardt & Presbitero, 2015; Gengenbach et al., 2016; Persyn & Westerlund, 2008; Westerlund, 2007). The other co-integration test statistic ignores either of these estimation problems. This test examines the significance of the panel error correction term for the inference. If significant, there is a co-integrating relation. The Westerlund co-integration test is based on the error correction model below, estimated for each panel separately.

$$\Delta yit = \beta 0i + \beta 1i1yit\text{-}1 + \beta 2i1\ xit\text{-}1 + \alpha 2i0\Delta xit + \sum_1^p \alpha_{1ip}\ \Delta y_{it-p} + \sum_1^p \alpha_{2ip}\ \Delta x_{it-p} + \beta 1i2ca\ (yit\text{-}1) + \beta 2i2\ ca\ (xit\text{-}1) + \sum_1^p \gamma_{1ip}\ \Delta ca(y_{it-p}) + \sum_1^p \gamma_{2ip} \,.\, \Delta ca(x_{it-p}) + uit \quad (5)$$

i=1,...,N; t=1,...,T. All variables in levels are assumed to be I (1). The symbol y stands for the dependent, x is the independent variable, and ca (.) is the cross-sectional average of the particular variables, u is the error term, and p is the selected lag term. We assumed the value-added of the services is the dependent variable and the value-added of the industry is the independent variable first, and vice versa. A specific lag level was selected for each country, and a trend term was added to the estimation. The results of this test are presented in Table 5.

Table 5

The Westerlund Co-Integration Test for the Services and the Industry

Panel-EC Test

H_o= No Co-integration			
ΔInser	Coefficient	$\overline{T}$ Statistics	Prob.
Inser_t-1*	–0.232	–2.378	>0.1
ΔInind	Coefficient	$\overline{T}$ Statistics	Prob.
Inind_t-1*	–0.270	–2.427	>0.1

Note: *Inser_t-1 and Inind_t-1 is the error correction term.

The error correction term was estimated as –0.232 in the model, in which the services value-added is the dependent variable. This estimated coefficient is statistically insignificant. The error correction term in the other model in which the dependent variable is the value-added of the industry was estimated as –0.270. This estimation is also statistically insignificant. These findings imply that the value-added of the services and the value-added of the industry are not co-integrated.

The lack of the co-integration relationship between the services and industry value added led us to use the VAR analysis in the first differences without losing information. The VAR model can be represented as follows:

$$\Delta yit = \mu 0 + \sum_{j=2}^{j} \mu_{1j}\Delta x_{it-j} + \sum_{k=2}^{K} \mu_{2k}\Delta y_{it-k} + uit \tag{6a}$$

$$\Delta xit = \gamma 0 + \sum_{j=2}^{j} \gamma_{1j}\Delta y_{it-j} + \sum_{k=2}^{K} \gamma_{2k}\Delta x_{it-k} + \varepsilon it \tag{6b}$$

i=1,...,N; t=1,...,T. The initial step in the VAR analysis is the lag selection of the variables. We used the moment model selection criteria of the Bayesian information criterion (MBIC), the Akaike information criterion (MAIC), and the Hannan & Quin information criterion (MQIC) to select the lag level of variables. Two of the three criteria, MBIC and MQIC, suggest lag 1. (Table 6).

Table 6

Specification of VAR Model

Lag	MBIC	MAIC	MQIC
1	–190.9434	–0.0714712	–65.96471 |
2	–160.2994	3.305074	–53.17485
3	–138.2215	–1.88443	–48.95103
4	–109.9003	–0.8306687	–38.48395

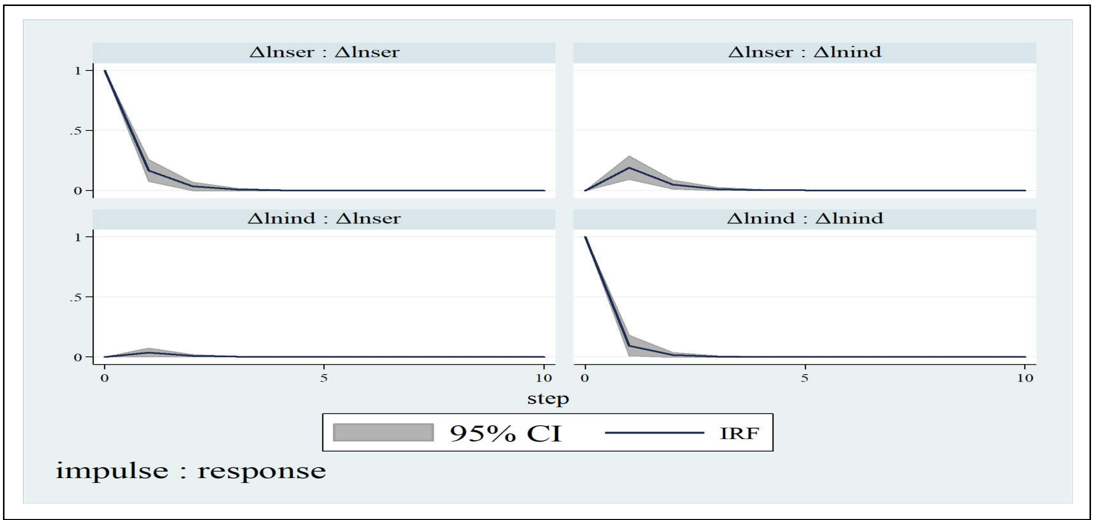
We estimated the panel version of the VAR model in equations (6a) and (6b) (Abrigo & Love, 2016). The model involves lagged dependent variables on the right-hand side, which raises the issue of correlation between the regressors and the error term, i.e., endogeneity. The instrumental variable method was used in the estimation to deal with this endogeneity issue. The first and second lagged levels of the lagged dependent variables were used as instruments, and the model was estimated by the Generalized Method of Moments (GMM) with the robust variance-covariance error matrix. The Hansen J test of over-identifying restrictions statistic is 3.03, and the associated p-value is 0.552, confirming the validity of instrumental variables. The minimized value of the GMM criterion function turned out to be 0.0004.

We do not report the estimated coefficients of the VAR model as they are not directly interpreted. Instead, we present the impulse-response functions, allowing inference in the VAR analysis. We are interested in the responses of one sector due to the impulses from the other. Figure 3 exhibits the impulse-response functions of the values added to the services and the industry. The northeast and the southwest diagrams indicate interactions between the sectors. The confidence intervals at the 5 percent level are also plotted in the diagrams.

The one standard deviation increase in the services' value-added services causes an increase of around 0.19 the standard deviation in the value-added of the industry significantly at 5 percent level in the first period. This effect of the services on the industry value added gradually disappears in five periods. The response from the services to the one standard deviation impulse from the industry is also statistically significant at the 5 percent level, but the effect is remarkably marginal 0.04 standard deviation. This slight response disappears in three periods. The Figure 3 suggests that the service sector has a positive effect on the value-added of the industry overall. The industry's effect on the services is also positive and significant but is considerably lower. These results imply the complementarity nature of services and industry. Nevertheless, services complement the industry more than the industry does.

Figure 3

The Impulse-Response Functions of the Services and the Industry



5. The System GMM Estimation for the Robustness Check

We used an alternative estimation method to verify the results obtained in the previous section. More specifically, we examined the complementarity relationship between the two sectors in a dynamic panel data model estimated by the two-step system GMM approach. Dynamic panel data estimation enables controlling for any possible omitted variable and endogeneity problems (Arellano & Bond, 1991; Arellano & Bover, 1995; Blundell & Bond, 1998; Holtz-Eakin et al., 1988).

We estimated an interaction model involving the multiplication of any interacting right-hand side variables, which can be shown as

$$y_{it} = \alpha_0 + \alpha_1 x_{it} + \alpha_2 z_{it} + \alpha_3 x_{it} z_{it} + u_{it} \tag{7}$$

i=1,...,N; t=1,...,T. The estimated coefficients in this model and their statistical significance should not be directly interpreted. Because the effect of any right-hand side variable on the dependent variable is measured by the derivative of the dependent variable, e.g., the derivative of y concerning x, involves $\alpha_1 + \alpha_1 z$. Therefore, the derivatives concerning the right-hand side variables, the marginal effects, and their statistical significance must be calculated for inference.

We assumed the lagged dependent variable in the dynamic panel data model is an interacting variable with the independent variable. More formally, we can state this interaction as

$$y_{it} = \alpha_0 + \alpha_1 y_{it-1} + \alpha_2 x_{it} + \alpha_3 y_{it} x_{it} + u_{it} \tag{8}$$

i=1,…,N; t=1,…,T. We estimated the dynamic panel data model in equation (8), and the value-added of the industry was defined as the dependent variable first to understand whether or not the services complement the industry. We also investigated whether the industry complements the services by defining the services value-added as the dependent variable and the industry value-added as the independent variable. The system GMM estimation method is designed for short panels, i.e., large cross-section units and the short-time dimension. As the time dimension is large in our dataset, we used the five-year mean of the variables.[1] In the estimation to reduce it; thereby, the time dimension was collapsed into 10. The two-step system GMM estimation results are presented in Table 7.

Table 7

The Two-Step System GMM Estimations

	Dependent Variable	
	Industry value-added	Services value-added
lnind	-	0.091 (0.413)
lnind_t-1	0.597 (0.141)***	-
lnser	0.431 (0.189)**	-
lnser_t-1	-	1.14 (0.540)**
lnind_t-1*lnser	–.0002 (0.005)	-
lnser_t-1*lnind	-	–0.049 (0.015)
Constant	–0.846 (2.615)	–3.784 (4.617)
Time Dummies	Yes	Yes
Wald	8706.3	2834.5
No of Instruments	14	14
AR	0.685 (3)	0.643 (5)
Hansen Test	2.23 (0.527)	1.33 (0.721)
Country	173	173
Observations	1384	1384

Note: The values in the parentheses report the robust standard errors for the coefficient estimations and the p-values for the Hansen test. The values in the parentheses in AR results indicate the order of the Arellano- Bond autocorrelation test; the parentheses show different lagged levels of the explanatory variables used as instruments. The collapsed version of the instruments matrix was used. Forward orthogonal deviations were used for instruments. ***,**,* means statistically significant at 1, 5, and 10 percent, respectively.

[1] We used the four-year average for the last mean of observation.

Although we do not interpret the estimated coefficients, the reliability of the estimations should be checked by post-estimation statistics to obtain reliable marginal effect estimations. There are three criteria for the system GMM estimations to be valid. First, the number of instruments must be kept at a minimum level (Roodman, 2009). The number of instruments seems 14, which is relatively low considering the number of countries. Second, the Arellano-Bond autocorrelation test must accept the null hypothesis of no autocorrelation. Third, the Hansen test of over-identifying instruments should accept the null hypothesis stating that the instruments used are exogenous. Table 7 indicates that both estimations satisfy all these criteria.

Table 8 presents the calculated marginal effects of independent variables and their statistical significance and standard errors of the estimations. Recall that the marginal effects are equal to the derivative of the dependent variable concerning the relevant independent variable. The derivatives are calculated at various levels because they involve multiplying another continuous interacting variable (the lagged dependent variable) and the estimated coefficient of interaction terms. The derivatives of the dependent variable with respect to the explanatory variables were calculated at four equal slices of the interacting variables.

Table 8 shows that the marginal effect of the services on the industry is around 0.43, which is significant at 1 percent at all levels of the interacting variable. The estimations show that the marginal effect of the industry on the services is 0.017 at the first slice of the lagged share of services. This estimation turns to negative coefficients at the other slices. These marginal effects are statistically insignificant.

Table 8

Marginal Effects

	$\partial \mathbf{lnind} / \partial \mathbf{lnser}$	$\partial \mathbf{lnser} / \partial \mathbf{lnind}$
1	0.428 (0 .149)***	0.017 (0.312)
2	0.427 (0 .138)***	–0.002 (0.309)
3	0.426 (0 .131)***	–0.022 (0.318)
4	0.426 (0 .128)***	–0.042 (0.387)

Note: *** means statistically significant at 1 percent. Derivatives were calculated at four equal slices of the relevant interacting variables. Standard errors are reported in parentheses.

It is customary for interaction models to draw the marginal effects on a diagram with confidence intervals. The figures below exhibit these estimated marginal effects with a 95 percent confidence interval. Figure 4 displays the marginal effects of the services on the industry. There is a constant and positive marginal effect of the services on the industry. The confidence intervals lie in the positive region of the fitted values implying the statistical significance of this positive marginal effect of the services on the industry. Figure 5 draws the marginal effect of the industry on the services. The calculated marginal effect changes its sign, and the confidence intervals extend both in the positive and negative regions of the fitted values, suggesting the marginal effects' insignificance.

Figure 4

The Marginal Effects of Services on Industry

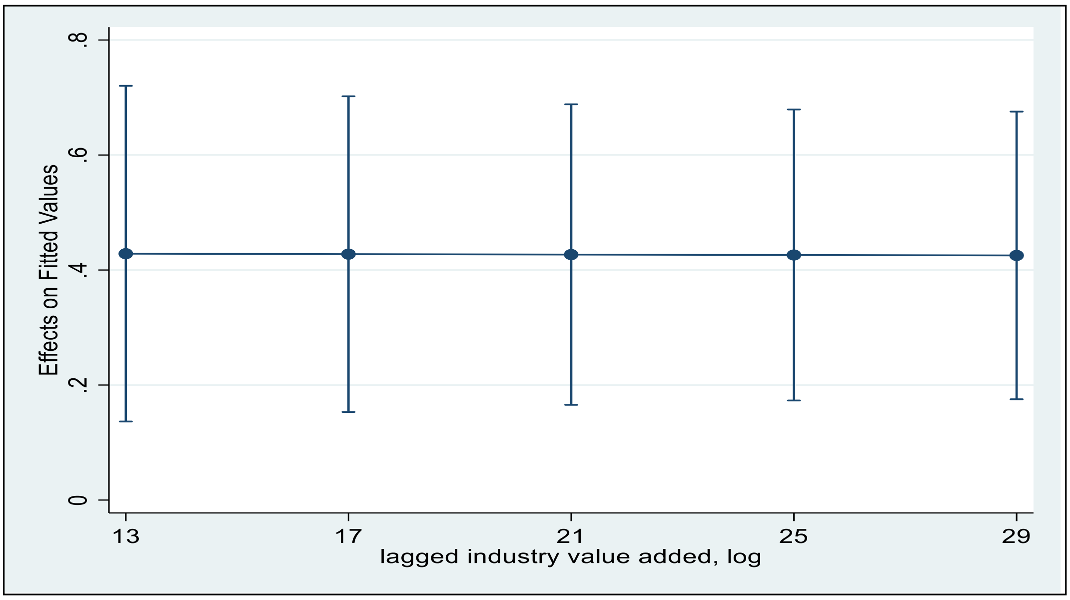
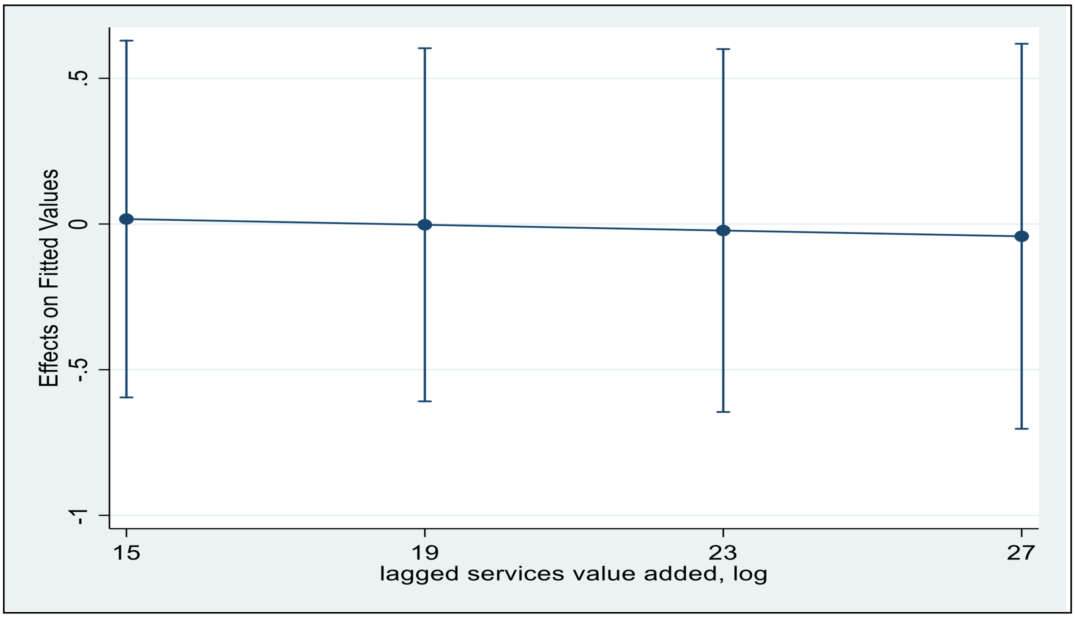


Figure 5

The Marginal Effects of Industry on Services



In sum, the positive effect of the services value-added on the industry value-added is a robust result. However, the relatively weaker positive effect of the value-added of the industry on the value-added of the services obtained in the previous section appears to be not robust.

6. Conclusion

This study proposes that the structural change in favor of the services experienced over the last fifty years can be explained to some extent based on the complementarity between the services and the industry. Our formal analyses forwarded that there is a complementary role of the services sector for the industry in the world. Nevertheless, the complementary role of the industry for the services is not evident, or at least weaker. It means that both sectors provide their output as inputs for the other, but the service inputs in industry outweigh the industrial inputs in services. Despite a limited subsample, outstanding backward linkages of industry and the relatively weaker backward linkages of services also support this result. This interlinkage between the services and the industry can partly explain the ever-increasing gap between the industry and the services shares in GDP. We can interpret these results as the industry's dependence on the services inputs, whereas the production of the services does not necessarily require the industrial inputs. For instance, a barber's only industrial output is a scissor.

One can also interpret the de-industrialization discussion in the literature from this perspective. The high level of the direct backward linkages of the industry implies a high dependence on the service inputs. The service dependence of industry can also be traced back to the 1970s. The role of financialization and information and communication technologies starting from the 1970s seems relevant in this respect. These services have provided the industry with substantial productivity gains and have become increasingly vital in the industrial production process. Thus, the tertiarization or the de-industrialization process may not be interpreted as abandoning the industry in economies, per se; on the contrary, it is driven by industrial development. This last remark agrees with the Clark hypothesis discussed in the literature, stating that an increasing share of the services is a natural outcome of economic development if we regard economic and industrial development as associated.

Our study used the aggregate data at the industry and the services level. Also, we did not take into account that economies must reach a certain industrialization level due to the tertiary perspective for identifying complementary or substitute relationships between the industry and services sector. Because, in the theoretical framework, within the scope of the economic development process, even if the economies are developed, developing, or underdeveloped, their economic development takes place in their employment or production shifts from agriculture to industry and services, respectively (Clark, 1940). Accordingly, even for economies where the level of industrialization and production technologies cannot exceed a certain threshold, there may be a possibility that the services sector will be a substitute for the industrial sector. However, if the subject is approached in the context of the industrialization process rather than the development process (tertiarization) of services, it is seen that the complementarity relationship between the services sub-sectors (especially knowledge-intensive service subsectors) and the manufacturing industry has increased particularly in the post-1980 period. However, due to data constraints, the relationship between services and the manufacturing industry could not be examined in terms of sub-sectors. More detailed analysis, e.g., the inter-relations between the subsectors of the industry and services, can provide further insights into this issue. There are also some sources of variation across economies which might matter in this process, so studies focusing on specific cases in this subject can be very illuminating. Further studies can analyze the following questions: Will there be a limit to this tertiarization process? What percentages of the industry share can be downsized further, or can the services climb up? The answers to these questions would enrich the discussion on this issue.

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