Article

Productive and Unproductive Sectors' Interactions in Brazil: A Miyazawa Analysis

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Abstract

This article employs Miyazawa's method to investigate the interaction between productive and unproductive sectors during the 2002–2014 period in Brazil. The results showed a growing dependence of productive on unproductive sectors together with a rise in the unproductive share in the economy, particularly after 2008. Our findings stressed the relationship between the rising importance of unproductive industries and lower total output growth, as emphasized by the classical-Marxian literature.

JEL Classification: B51, C67, P16

Keywords

Miyazawa's model, classical-Marxian approach, unproductive sectors

1. Introduction

One of the central features of classical economics concerns the distinction between productive and unproductive sectors.[1] While ignored by neoclassicals and Keynesians, this difference is at the core of the Marxian debate associated with the creation of surplus, capital accumulation, and economic growth (Shaikh and Tonak 1994).

In Marxian economics, only productive sectors can create new wealth. Unproductive sectors (and their labor) are related to social consumption, destined for social reproduction, distribution, and maintenance of the social order (Paitaridis and Tsoulfidis 2012). The expansion of these

[1]There is a debate if this distinction is relevant. This discussion is beyond the scope of this article. For a brief list of studies that tackle this issue, see Laibman (1993, 1999), Moseley (1993), and Savran and Tonak (1999).

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sectors reduces the retained surplus that could be productively invested, hindering accumulation, and consequently diminishing the capacity of the economy to grow.

This crucial topic is overlooked in Brazil, especially when the interplay between productive and unproductive sectors is analyzed over time. This article investigates how these spheres interacted in the last Brazilian expansionary cycle (2002–2014). A growing unproductive sector in conjunction with a high reliance of productive on unproductive industries could underscore difficulties in sustaining economic growth.

We applied the classical-Marxian approach to separate productive and unproductive sectors. We broadly follow the partition strategy designed by Savran and Tonak (1999), and Tregenna (2011). A similar procedure was adopted by López and Insua (2019) in the case of Argentina. The unproductive group comprises market and non-market sectors: trade, financial intermediation, real estate, business services, public education, public health, and public administration. Public education and public health services were accounted for as unproductive sectors. Although workers in these two sectors produce use values, they are not productive for capital (Savran and Tonak 1999; Tregenna 2011). Social services are considered unproductive if they are produced (and supplied) on a noncapitalist and nonprofit basis. That is, they are not organized as commodity production enterprises (Savran and Tonak 1999; Tregenna 2011), as is the case in Brazil.

Unproductive sectors may stimulate the economy in the short term via their intersectoral linkages with the productive sector (Sweezy and Magdoff 1987; Smith 1993; Park and Rieu 2020). In line with Mazzucato (2018), we have redefined the productive boundary of the economy without losing sight of the potential feedback from unproductive sectors.

Miyazawa (1966, 1971) provided a method to partition the Leontief matrix, allowing for the investigation of dependence between productive and nonproductive sectors. Employing Miyazawa's framework, we assessed the interaction between each sector from the estimated Brazilian input-output tables (hereafter, IO tables) for 2002, 2008, and 2014. To the best of our knowledge, this is the first study to apply Miyazawa's model to empirically evaluate the interplay between productive and unproductive sectors.

The rest of the article is organized as follows. Section 2 outlines the distinction between productive and unproductive industries following the classical-Marxian approach. Section 3 presents the method and data. Section 4 reports the results. Section 5 concludes.

2. Productive and Unproductive Sectors in the Classical-Marxian Approach

The classical-Marxian approach adopts a specific procedure to define and gauge the productive boundary of an economy. It only considers sectors that create surplus value as productive.

The classical-Marxian definition of productive sectors was influenced by Smith (2003 [1776]). According to Smith, only work applied to produce physical goods could be accounted as productive.[2] Despite the status of many unproductive occupations, the employment of unproductive labor is incapable of producing new values and reduces the society's surplus available for capital accumulation.

[2]Smith ([1776] 2003) had a second definition for unproductive production based on social relations. In this sense, workers employed in factories would be considered productive, while servants that worked in capitalists' houses would be regarded as unproductive. He thought that both his views coincided. We thank a referee for raising this point.

Marx reformulated Smith's concept of productive and unproductive labor, rejecting Smith's viewpoint that only agriculture and industry are productive. For Marx, two prerequisites are required for considering labor as productive: being employed by capital and able to produce new value regardless its tangibility. In this sense, services located in the productive sphere of the circuit of capital are considered productive for Marx. Service labor that transforms an aspect of nature to satisfy a need and is employed by capital, produces surplus value (Savran and Tonak 1999). Tregenna (2011) gives an extensive analysis of service sectors in the Marxian tradition).

Under the classical-Marxian framework, certain market sectors are unproductive. They are unproductive because they cannot produce value. According to Shaikh and Tonak (1994), the classical-Marxian approach has a comprehensive view on social consumption. For them, economic sectors comprise four broad categories: production, distribution, social reproduction, and personal consumption. Contrary to the mainstream, only the first category is considered productive. Distributive sectors (which only circulate value) and maintenance of social order (e.g., public administration) are like consumption, as far as they only absorb value created by the productive sectors. The classification of unproductive activities to broad economic sectors includes finance, real estate, social security, and public administration, among others.

The growth of unproductive sectors is a common feature of many economies. Firms may increase their spending on unproductive uses (sales promotion, management, supervision activities, among others) as a response to a rise in competition in modern economies, with an aim to raise their market share (Tsoulfidis and Tsaliki 2019). Social cohesion in modern societies also requires a rise in unproductive sectors.

Shaikh and Tonak (1994), Moseley (1985, 1997), and Mohun (2005) claim that economic growth halts because of unproductive expansion. A greater size of the unproductive sector may increase the demand for productive industries, raising the productive output in the short-medium run (Dutt 1992). In the long term, the larger unproductive share leads to an increase in social consumption that hampers the propensity to save and reduces growth (Shaikh and Tonak 1994). These sectors use part of the social surplus value created by productive ones, limiting the growth potential of economies (Moseley 1997; Cronin 2001).

However, there is the possibility that certain types of unproductive sectors raise productive profits, capital accumulation, and growth. By allowing market expansion for productive goods, the unproductive sector might indirectly improve the capacity of the productive sphere to create value and may induce innovations (Dutt 1992). In a context of full employment, the expansion of unproductive sectors generates labor scarcity and higher productive wages. In response to this, firms may become more sensitive to wage rises, reducing the quantity of employed labor and consequently the wage bill (Park and Rieu 2020). Holding saving rate and capital stock constant, they found counteracting positive effects of the unproductive sector on productive profits.

Moreover, the provision of public goods such as education, health, and infrastructure, may reduce the value of labor power and the price of constant capital, acting as a countertendency for the falling profit rate. These add further complexity to the treatment of the dual character of the unproductive sector in the economy.

3. Methodology and Data

This section presents the methodology and the data employed in the article. Initially, we review the methodology developed by Miyazawa (1966, 1971) to disjoin the Leontief matrix, showing internal, induced, and external effects of productive and unproductive sectors. Then, we introduce the data set.

3.1 Method

The input-output model can be extended using Miyazawa's framework, to assess the relationship between groups of sectors. While the Leontief inverse shows the total effects of sectoral transactions, Miyazawa's model reveals disjoined effects. His method allows us to divide the Leontief's matrix into three aspects of propagation, computed as internal, induced, and external multipliers. Because of the high interdependence in the economy, it is critical not to focus solely on the individual sectoral level (Fritz, Sonis, and Hewings 1998). Following the classical-Marxian approach, our goal was to separate the Leontief matrix between productive and unproductive sectors.[3,4]

Starting with the Leontief (1953) model, we can present Miyazawa's procedure as follows. Using partitioned matrices, we can split up the technical coefficient matrix (A) in the two-block matrices:

$$A = \begin{pmatrix} A_{pp} & A_{pn} \\ A_{np} & A_{nn} \end{pmatrix} = \begin{pmatrix} A_{pp} & 0 \\ A_{np} & 0 \end{pmatrix} + \begin{pmatrix} 0 & A_{pn} \\ 0 & A_{nn} \end{pmatrix} = A_p + A_n, \tag{1}$$

where A_{pp} stands for the square matrix of direct inputs within productive sectors and A_{nn} is the matrix that shows the transactions inside the unproductive group. A_{np} and A_{pn} are rectangular matrices of direct input flows between productive and unproductive sectors.

Following Miyazawa (1966) and Sonis and Hewings (1999a), equation (1) can be extended to decompose the Leontief inverse matrix as presented below. They decompose the total propagation effect presented in the Leontief matrix into internal, intergroup induced, and external multipliers:

$$B = \begin{pmatrix} B_{pp} & B_{pp}A_{pn}B_n \\ B_{nn}A_{np}B_p & B_{nn} \end{pmatrix} = \begin{pmatrix} B_{pp} & B_pA_{pn}B_{nn} \\ B_nA_{np}B_{pp} & B_{nn} \end{pmatrix} \tag{2}$$

B_{pp} and B_{nn} stand for the part of the Leontief matrix that comprises productive and unproductive industries, respectively. B_p and B_n are the multiplier matrices for the productive and unproductive sectors, known as internal multipliers (Miyazawa 1966). They depict the interindustrial propagation effects within each group. In other words, they reveal the intragroup direct and indirect demands (Fritz, Sonis, and Hewings 1998). They are expressed in equations (4) and (5):

$$B_p = (I - A_{pp})^{-1} \tag{3}$$

$$B_n = (I - A_{nn})^{-1} \tag{4}$$

The intragroup and intergroup matrices display dependence and interdependence. For our purposes here, two intergroup effects are relevant and presented in section 4. They are expressed in these matrices:

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[3]A possible shortcoming is that some unproductive activities numbers (e.g., finance and real estate) might be imputed in national accounts (Assa 2017). This is a drawback presented in many Marxian studies.

[4]Overall, productive sectors use some unproductive labor (for instance, supervisory workers and workers in the financial divisions of productive industries) in their production and unproductive sectors employ some productive labor (e.g., in the trade sector). In line with Park and Rieu (2020), we assumed that productive sectors employ productive workers only. The expansion of productive sectors implies an increase in productive labor (Dutt 1992). In the same fashion, a rise in unproductive production spurs unproductive labor.

$$P_1 = A_{np}B_p \tag{5}$$

$$P_2 = B_pA_{pn} \tag{6}$$

These matrices exhibit the induced effects between groups. In this sense, P_1 denotes the sub-multiplier matrix that shows the inputs from the unproductive to the productive sectors induced by internal propagation within the productive group; P_2 stands for the matrix that indicates the internal propagation in the productive group induced by transactions from productive to unproductive sectors. Appendix B presents two additional intergroup effects.

Following Miyazawa (1966), the external matrix multipliers for the two groups are:

$$\Delta_{pp} = (I - B_pA_{pn}B_nA_{np})^{-1} \tag{7}$$

$$\Delta_{nn} = (I - B_nA_{np}B_pA_{pn})^{-1} \tag{8}$$

External multipliers capture what is known as self-influence (feedback loops) or meso-level feedback loops. In equation (7), the productive sector's (p) self-influence through the unproductive sector (n) can be described as a transfer of influence. Δ_{pp} comprises direct, indirect, and induced influences of the productive sectors' input demand from unproductive sectors on the productive sectors' production (Fritz, Sonis, and Hewings 1998). Equation (8) can be interpreted similarly. Appendix B provides a detailed explanation of external multipliers.

The Leontief matrix can be separated in terms of the internal, induced, and external propagation matrices, taking the additive or multiplicative form. The additive and multiplicative forms are as follows:

$$B = \begin{pmatrix} B_p + B_pA_{pn}MA_{np}B_p & B_pA_{pn}M \\ MA_{np}B_p & M \end{pmatrix} = \begin{pmatrix} B_p + P_2MP_1 & P_2M \\ MP_1 & M \end{pmatrix} = \begin{pmatrix} \Delta_{pp} & 0 \\ 0 & \Delta_{nn} \end{pmatrix} \begin{pmatrix} I & B_pA_{pn} \\ B_nA_{np} & I \end{pmatrix} \begin{pmatrix} B_p & 0 \\ 0 & B_n \end{pmatrix} \tag{9}$$

where M is the matrix that combines the product of the external (Δ_{nn}) and internal effects (B_n) of the unproductive group, $M = \Delta_{nn}(B_n)$. The M matrix denotes the total dissemination effect of unproductive sectors. The total effect originated in productive industries is equal to $B_p + B_pA_{pn}MA_{np}B_p$, or $B_p + P_2MP_1$. A proof for equation (9) is provided in appendix B.

The matrices $MA_{np}B_p$ and $B_pA_{pn}M$ in the block matrix in equation (9) show the effects of intergroup interactions on output levels. $MA_{np}B_p (or\, MP_1)$ shows the influence that productive sectors exert on unproductive ones. $B_pA_{pn}M$ (or P_2M) reveals the effect of unproductive propagation on productive output levels.

According to equation 9, the difference between B_{pp} and B_p is equal to $B_pA_{pn}MA_{np}B_p$. It captures interdependence and self-influence. Miyazawa (1966) noticed that the sectors' dependence on the rest of the economy can be detected by computing inside propagation ratios (*IPR*). These ratios are calculated by dividing the elements of the internal multiplier by the appropriate part of the Leontief inverse matrix:

$$IPR_p = B_p / B_{pp} \tag{10}$$

$$IPR_n = B_n / B_{nn} \tag{11}$$

Sectors with values higher than 0.9 are considered relatively independent from the rest of the economy (Miyazawa 1976; Okuyama, Sonis, and Hewings 1999). For example, a productive industry with many high values of IPR_p is independent of unproductive sectors. Similarly, an unproductive sector containing many high values of inside propagation ratios IPR_n is less

dependent on productive sectors. For further details on the model, see Miyazawa (1966), Sonis and Hewings (1993), Fritz, Sonis, and Hewings (1998), and appendix B.

3.2. Data

The data to estimate the IO tables for 2002, 2008, and 2014 comes from the Brazilian Statistical Office (IBGE 2019). To circumvent the problems created by the methodological change in the National Accounts in 2010, we computed the IO tables from the retropolated Make and Use tables from IBGE, following the procedure developed by Guilhoto and Sesso (2005). The Make and Use tables (containing 107 commodities and 51 sectors) provide the information to build the IO table at constant prices from 2002. The final matrices comprise 50 sectors (a total of 2,500 technical coefficients) since we excluded the domestic service activity, an imputed activity in national accounts. The aggregation of sectors follows the Brazilian Statistical Office classification. Table 1A, in the appendix, shows the productive and unproductive sectors of Brazil.

After the estimation of the three IO tables, we computed induced multipliers to assess interdependence between sectors and their changes over time. The inside propagation ratios were also calculated for the 2002–2014 period. We employed parametric and nonparametric statistical tests to investigate if there was a marked change in the sectoral interdependence over time.

4. Results

In this section, the empirical results of our estimations are presented. Section 4.1 provides a brief review of the Brazilian economic performance from 2002 to 2014. Section 4.2 highlights some broad trends in the IO tables for the years 2002 and 2014. Section 4.3 shows the results for the changes in inside propagation ratios for productive and unproductive groups. Moreover, the results of induced multipliers are also explored in this section.

4.1. The Brazilian economy between 2002 and 2014: A brief overview

The Brazilian economy grew relatively fast in the 2002–2014 period. Growth rates, however, slowed down after the great recession of 2008. The average annual growth of GDP was 4.2 percent between 2002 and 2008, falling to 2.8 percent in the 2008–2014 period (IBGE 2019).

The international economy expanded substantially, pushed by China and India's robust output growth rates. As a result of this process, the country benefited from increasing exports and booming commodity prices in the early 2000s. From 2002 to 2007, commodities prices grew 135 percent (Marquetti, Hoff, and Miebach 2020). Brazil turned out to be less prone to international crises, receiving a substantial inflow of foreign direct investment. When the 2008 recession hit, the country had international reserves and hence space to apply countercyclical policies. One of the immediate government responses to this crisis was the reduction in the value-added tax on industrialized goods, which stimulated the economy in the short term (Borghi 2017).

A key aspect of Brazil's achievements was the improvement of the domestic market because of three crucial measures. Firstly, the government employed redistributive policies, the *Bolsa Família*—a conditional cash transfer program—and increases in the minimum wage to foster consumption and consequently raise economic activity. The Gini coefficient declined from 0.589 in 2002 to 0.531 in 2010 (IPEA 2020). Secondly, the state-owned banks' credit supply soared, leading to a substantial rise in the credit-to-GDP ratio. The government also stimulated household borrowing through a ''new kind of credit with automatic repayments from the paycheck'' (Martins and Rugitsky 2021), an institutional change that impacted credit markets.

Thirdly, the government launched a plan to improve the infrastructure. The goal of the Growth Acceleration Plan was to recover the state's role in promoting public investments. As a result of these policies, the unemployment rate diminished markedly. There was a reduction in poverty since the extremely poor segments of the Brazilian society were able to find jobs in low labor productivity services (Singer 2012, 2018). The rise in the minimum wage and formalization of the economy fostered a cumulative causation process associated with a structural change toward services and commodities (Loureiro 2020).

Despite the higher economic growth, the exchange rate overvaluation reduced the international competitiveness of the manufacturing sector. To prevent the economic slowdown, the government promoted tax cuts for selected sectors and fostered capital centralization to expand the size of the largest Brazilian companies. It also sought to sustain the investment level, offering subsidized interest rates via state-owned banks. This model started to reveal its limits by the early 2010s.

President Dilma Rousseff was elected in 2010 with the daunting task to overcome the long-lasting effects of the great recession of 2008. This required substantial changes in economic policy. The government sought to boost private investment by reducing interest rates and devaluating the exchange rate. This movement was reinforced by additional spending on infrastructure. Another element of the strategy was the investment in the exploration of large offshore oil reserves by Petrobras and a policy of national content of activities related to oil production in the Pre-Salt reserves. These policies, however, were unable to forestall a new crisis.

Brazil fell into a deep political and economic crisis after 2014. The GDP growth rate dropped from 4.6 percent in 2011 to 2.3 percent in 2014 (Filgueiras 2017). The persistent fall in profitability after the crisis of 2008 halted the class alliance formed during Lula's government (Marquetti, Hoff, and Miebach 2020), triggering the economic downturn and the crisis of 2015. The rise in private health and education prices in conjunction with the deterioration in the provision of public goods further contributed to the crisis (Singer 2012, 2018; Pinheiro-Machado 2019).

4.2. Productive and unproductive sectors in Brazil, 2002–2014

Table 1 reports some statistics on the productive and unproductive sectors between 2002 and 2014. In this period, a structural change toward unproductive sectors took place in Brazil. The upper part of table 1 exhibits a rise in the unproductive-productive employment (L_n/L_p) and unproductive-productive output (X_n/X_p) ratios. There was an expansion in the share of the unproductive sector in output and employment. Moreover, both ratios grew faster in the 2008–2014 period, when the total output growth rate declined.

The middle part of table 1 shows the output and employment growth rates for the productive and unproductive sectors in the period of study. There was a drop in output and employment average annual growth rates for both sectors after 2008. The growth rates for the productive sector declined faster than for the unproductive one. The expansion of the unproductive sector's share and its relatively stronger growth rate indicate that this group explains a larger portion of overall economic growth rates in an economy that is growing less.

The lower part of the table reveals a decline in the unproductive-productive wage bill ratio and average unproductive-productive wage ratio. As mentioned before, the countercyclical government policies stimulated productive sectors after 2008.

The structural change in favor of unproductive sectors generated positive demand effects (via its intersectoral linkages) for productive sectors, stimulating the short-run expansion of the economy. The upsurge in capacity utilization up to 2008 raised the demand for labor, increasing the bargaining power of workers and real wages. Marquetti, Hoff, and Miebach (2020) showed that aggregate labor productivity growth fell behind wage growth after 2008. The rise in

Table 1. Brazilian Statistics, 2002–2014.

Periods (years)	2002	2008	2014
Unproductive-productive labor ratio (Ln/Lp)	0.57	0.59	0.64
Unproductive-productive gross output ratio (Xn/Xp)	0.52	0.55	0.59
Unproductive-productive wage bill ratio (Wn/Wp)	1.28	1.25	1.23
Average unproductive-productive wage ratio	2.26	2.13	1.93
Period (years), average growth rates	2002–2014	2002–2008	2008–2014
Productive sector gross output (Xp)	5.28	6.12	3.57
Unproductive sector's gross output (Xn)	7.67	7.59	5.94
Total gross output (Xt)	6.11	6.63	4.41
Number of workers in productive sectors (Lp)	3.06	3.73	2.08
Number of workers in unproductive sectors (Ln)	4.94	4.68	4.38
Total number of workers (Lt)	3.74	4.07	2.93
Period (years), change (%)	2002–2014	2002–2008	2008–2014
Unproductive-productive labor ratio (Ln/Lp)	12.13	3.34	8.50
Unproductive-productive gross output ratio (Xn/Xp)	13.36	4.72	8.30
Unproductive-productive wage bill ratio (Wn/Wp)	–3.92	–2.36	–1.60
Average unproductive-productive wage ratio	–14.31	–5.49	–9.33

Note: We considered a supply-side measure in choosing gross output following Assa (2017). The growth rates were computed with data at constant prices from 2002.
Source: Authors' elaboration.

productive wages played a role in diminishing the profit rate. Following Moseley (1997), we found that unproductive output and employment expansion from 2002 to 2014 (and particularly after 2008) were accompanied by an economic slowdown. The rise in minimum wages, principally after 2006, and the lower unemployment rate seem to have had a greater impact on the wages of the productive sector.

In a context of declining profits (and surplus value), where the growth of unproductive sectors is at a stronger rate than found in productive ones, culminates in an economy in which reproduction of the economic system becomes more difficult over time. There is a threshold to the expansion of unproductive sectors beyond which it threatens the stability of the whole economy (Tsoulfidis and Tsaliki 2019; Park and Rieu 2020).

4.3 Estimated results

This section explores the results for the inside propagation ratios and induced multipliers. Before we present the specifics, let us point out some broad trends in the matrices for the years 2002 and 2014. In this period, the mean of the difference between the two matrices shows a significant fall. The decline of matrix A_{pp} and the drop in B_{pp} revealed a reducing total propagation of the productive group in the economic structure. It also suggested a lower integration among productive sectors. The rise in A_{nn} and B_{nn} (the M matrix) indicated a growing influence of unproductive sectors in this period. There was a higher degree of integration between the two groups. The rise in A_{np} and B_{np} indicated that the productive sector increased its direct and indirect input requirements from unproductive ones. (Because of the large size of the tables, we decided to omit them. The tables are available on demand.)

Table 2. Statistical Tests (Parametric and Nonparametric) for the Productive and Unproductive Sectors' Inside-Propagation Ratios (IPR_p, IPR_n) for Brazil.

Productive	2002–2008	2008–2014
Mean *d*	–0.0130	–0.0209
t value (parametric)	–28.5536	–16.1652
H0: $d = 0$; $\alpha = 0.05$	Reject H0	Reject H0
Sign test (normal approximation) *t* value (nonparametric)	34.4651	19.2558
H0: $d = 0$; $\alpha = 0.05$	Reject H0	Reject H0
Wilcoxon signed rank (value)	31.8929	22.5920
H0: $d = 0$; $\alpha = 0.05$	Reject H0	Reject H0
Unproductive	**2002–2008**	**2008–2014**
Mean *d*	–0.0029	0.0141
t value (parametric)	–0.7796	4.5563
H0: $d = 0$; $\alpha = 0.05$	No reject H0	Reject H0
Sign test (normal approximation) *t* value (nonparametric)	1.1428	2.2857
H0: $d = 0$; $\alpha = 0.05$	No reject H0	Reject H0
Wilcoxon signed rank (value)	0.7261	3.8098
H0: $d = 0$; $\alpha = 0.05$	No reject H0	Reject H0

Source: authors' elaboration.

Table 2 shows parametric and nonparametric statistical tests for the difference between the means of the inside propagation ratio matrices for productive and unproductive sectors (IPR_p, IPR_n) for the 2002–2008 and 2008–2014 subperiods. The upper part of table 2 exhibits the results for productive sectors. From 2002 to 2014, it revealed a fall in the mean of inside propagation ratios. This decline was statistically significant for the two subperiods. The sectors' reliance on unproductive sectors rose between 2002 and 2008, as can be seen in table 2. This movement was stronger in the 2008–2014 subperiod. It seems that a new pattern marked by higher dependence and interdependence emerged after 2008. The combined effects of lower integration between productive industries, and higher integration between groups might have influenced this result.

Turning to unproductive sectors, the lower part of table 2 shows two different patterns. From 2002 to 2008, there were no statistically significant changes in the mean of the unproductive inside propagation ratios (IPR_n). That is, there were no significant changes in unproductive sectors' dependence on productive sectors in this period. However, we observed a significant rise in the mean of unproductive inside propagation ratios between 2008 and 2014. Increases in inside propagation ratios mean that the sectors' reliance on productive industries dropped. Overall, the results show that the productive sector as a group became more dependent on unproductive sectors, while the opposite occurred for unproductive sectors.

Table 3 exhibits the coefficients of unproductive inputs induced by internal propagation in productive sectors in Brazil. The results show which unproductive sectors are more induced by productive ones. Looking at unproductive sectors, the three sectors most affected by the productive group were trade, business services, and financial intermediation and private pension (hereafter finance for brevity). The productive capacity to induce finance fell during this period. These results are persistent throughout this period.

Table 3. Coefficients of Unproductive Input Induced by Productive Sector's Internal Propagation $(P_1 = A_{np}B_p)$.

	2002	2008	2014
Trade	3.311	3.888	4.117
Financial intermediation and private pension and related services	2.077	1.991	1.893
Real estate activities and rentals	0.262	0.276	0.253
Business services	2.699	2.647	2.707
Public education	0.124	0.095	0.093
Public health	0.013	0.010	0.010
Public administration and social security	0.196	0.226	0.201

Source: authors' elaboration

Table 4. Coefficients of Productive Internal Propagation Caused by Productive Inputs in Unproductive Sectors $(P_2 = B_pA_{pn})$.

Unproductive Sector	2002	2008	2014
Trade	0.384	0.374	0.391
Financial intermediation and private pension and related services	0.138	0.133	0.116
Real estate activities and rentals	0.030	0.029	0.030
Business services	0.326	0.316	0.293
Public education	0.183	0.220	0.303
Public health	0.282	0.284	0.313
Public administration and social security	0.187	0.193	0.192
All unproductive sectors	1.529	1.551	1.635

Source: authors' elaboration.

Table 4 reveals which unproductive sectors had more influence on the internal propagation of productive ones. From the analysis of table 4, we realized that the overall capacity of unproductive sectors to foster productive sectors increased, particularly during the 2008–2014 years. This rise helped to avoid a larger drop in productive sectors' growth rates. These years were marked by lower economic growth when compared to the previous ones.

Within this group, trade, business services, and public health presented an important capacity to influence productive sectors. In relative terms, finance exhibited a reduced power to induce productive internal propagation. Moreover, and in line with Dávila-Fernández and Punzo (2020), we could not find support for the financialization thesis at the mesoeconomic level of analysis in Brazil. Finance seems to function as a follower sector. However, the financialization thesis has many dimensions, for example, the increasing ratios of indebtedness at the microeconomic level, which are not treated here. Further studies should focus on macroeconomic and microeconomic levels of analysis to assess the effects of financialization in Brazil.

The approach applied here allowed us to explore in greater detail the changes that occurred in Brazil between 2002 and 2014. From 2002 to 2008, the economy grew rapidly, pushed by domestic policies and positive external conditions. There was plenty of excess capacity in the economy in this period. Between 2004 and 2007, the profit rate expanded despite the increase in the wage share. By 2008, the profit rate started to fall, and the capacity utilization peaked (Marquetti, Hoff, and Miebach 2020). Some studies found a profit squeeze and a falling profit rate that combined with the peak in capacity utilization that left little space for expansionary policies (Marquetti et al. 2019; Marquetti, Hoff, and Miebach 2020; Martins and Rugitsky

2021). In Keynesian fashion, the Brazilian government decided to implement countercyclical policies to fight the great recession. The output growth rate dropped after 2008.

The output growth of unproductive sectors was higher than productive ones between 2008 and 2014. The expansion of the former had positive short-run effects on the latter since it indirectly demanded goods from productive segments, avoiding a steeper drop in growth rates.

However, the expansion of unproductive segments triggered a structural change toward low labor productivity sectors. This was coupled with the cumulative effects of the commodities boom and the aftermath of the 2008 crisis, which further impacted productive sectors. These factors contributed to the decline in total labor productivity. The rise of the unproductive sector after 2008 also implied that there was a relatively lower amount of labor allocated in productive sectors. This drop in productive labor had negative effects on profits since this labor is the only source of value. The rise of direct purchases from unproductive sectors (A_{np}) usually played a part in reducing the profit and accumulation rates (Moseley 1992; Dutt 1991). Unfortunately, it seems that countercyclical policies have limited power to boost the profit and accumulation rates (Moseley 1997).

The estimated results, therefore, show that the productive group became more dependent on unproductive sectors over time. A rising share of the gross output and surplus value created in productive industries relied on feedback from the unproductive sector. The rising dependence on productive sectors together with the expansion of unproductive ones and the slowdown in overall growth rates raises questions about the recovery of the Brazilian economy after the 2008 great recession. In line with Filgueiras (2017), it seems that the Brazilian expansionary phase was externally determined, with domestic policies playing a secondary role. These policies failed in reigniting rapid growth.

5. Summary and Final Remarks

This article has applied Miyazawa's (1976) analytical device to detect the structural interdependence of productive and unproductive sectors in Brazil between 2002 and 2014. This method allowed us to verify the changing sectoral interrelationship in this period. We estimated the IO tables for the years 2002, 2008, and 2014. Applying this method, we were able to select the industries with high and low dependence in Brazil.

The results indicated a growing dependence of productive on unproductive sectors between 2002 and 2014. This dependence was stronger between 2008 and 2014 when there was a period of lower growth rates and rising shares of unproductive segments in the total economy. As Shaikh and Tonak (1994) found in the case of the US economy, the expansion of unproductive sectors was associated with countercyclical policies. The three main results can be summarized as follows:

1. The unproductive sectors increased their propagation power between 2002 and 2014. This growth was concentrated in the 2008–2014 subperiod.
2. An increasing share of the gross output and surplus value generated in productive industries hinged on feedback from the unproductive sector.
3. Finance and trade were induced by productive sectors, but only trade stimulated productive industries. For the financial sector, this inducement declined.

This increasing dependence of productive sectors on unproductive ones in conjunction with the expansion of the unproductive group raises doubts about the sustainability of economic expansion in Brazil. In the 2008–2014 period, the stronger inducement of unproductive on productive industries is associated with lower aggregate growth rates of the economy. This pattern

relates to the fall in profit rates and the unfolding of the economic crisis of 2015. Without deep changes in this scenario, bleak prospects for the economy are expected.

This is the first attempt to apply Miyazawa's (1966) model to analyze productive-unproductive interactions in an emerging economy. Miyazawa's work together with the Marxian approach produces interesting insights, allowing for a deeper analysis of sectoral dynamics, a topic usually absent in Marxist approaches. Future research could address this issue for other advanced and peripheral countries, enhancing the comprehension of the internal structures of economies.

Appendix A: Supplemental Tables

Table 1A. Sectors' Classification in Brazil.

Sectors	Productive/Unproductive
Agriculture, forestry, and logging (1)	Productive
Livestock and fisheries (2)	
Oil and natural gas (3)	
Iron ore (4)	
Others from the extractive industry (5)	
Food and beverages (6)	
Tobacco products (7)	
Textiles (8)	
Apparel and accessories (9)	
Leather and footwear (10)	
Wood products—exclusive furniture (11)	
Pulp and paper products (12)	
Newspapers, magazines, and discs (13)	
Oil refining and coke (14)	
Alcohol (15)	
Chemicals (16)	
Manufacture of resin and elastomers (17)	
Pharmaceutical products (18)	
Pesticides (19)	
Perfumery, hygiene, and cleaning (20)	
Paints, varnishes, enamels, and lacquers (21)	
Other chemical products and preparations (22)	
Rubber and plastic items (23)	
Cement and other nonmetallic mineral products (24)	
Steel manufacturing and derivatives (25)	
Metallurgy of nonferrous metals (26)	
Metal products—exclusive machinery and equipment (27)	
Machinery and equipment, including maintenance and repairs (28)	
Appliances and electronic equipment (29)	
Office machines and electronic equipment (30)	
Automotive manufacturing (31)	
Motor vehicle parts and accessories (32)	
Other transport equipment (33)	
Furniture and products from various industries (34)	
Production and distribution of electricity, gas, water, sewage, and urban cleaning (35)	
Construction (36)	
Transport, storage, and mail (37)	
Information services (38)*	
Maintenance and repair services (39)	
Accommodation and food services (40)	
Private education (41)	
Private health (42)	
Services provided to families and associations (43)*	
Trade (44)	Unproductive
Financial intermediation and private pension and related services (45)	
Real estate activities and rentals (46)	
Business services (47)	
Public education (48)	
Public health (49)	
Public administration and social security (50)	

*These sectors contain some unproductive segments. These segments account for a small part of the sector and are assumed to be productive. Simulations including services provided to families in the unproductive group were computed with no substantial change in the results. We also applied a simulation that included public health and public education into productive activities. Joint inclusion of these two sectors produced no qualitative change in our results.
Source: Authors' elaboration.

Appendix B

Two Additional Intergroup Effects

We present two additional intergroup effects below. These matrices reveal induced effects between groups:

$$S_1 = A_{pn}B_n \; S_2 = B_nA_{np}$$

S_1 refers to the matrix multiplier of input from the productive to the unproductive group, steamed by internal activity in unproductive sectors; and S_2 indicates the submultipliers for internal propagation in the unproductive group induced from transactions taking place from unproductive to productive sectors. In Miyazawa's words:

> These submultipliers… show the coefficients of induced effects on output or input activities between two sectors and call themselves the production-generating process in succession. (Miyazawa 1966: 39)

External Multiplier in the Miyazawa Model

The productive sector's self-influence, captured by the external multiplier, is generated by the component $B_pA_{pn}B_nA_{np}$ and can be schematically depicted as follows (Sonis and Hewings 1999b):

$$(p) \underset{A_{np}}{\longrightarrow} (n) \underset{B_n}{\longrightarrow} (n) \underset{A_{pn}}{\longrightarrow} (p) \underset{B_p}{\longrightarrow} (p).$$

If we assume a rise in productive sectors' purchases of unproductive inputs—as expressed by a higher A_{np}—we can see that it has a positive impact in terms of higher propagation within the unproductive group (B_n). This leads to increases in unproductive sectors' purchases from productive sectors, causing a rise in internal propagation within the productive group. The transfer of the stimulus from productive to unproductive groups returns, at least partially, to the productive group.

Proof of equation 9 based on Miyazawa (1976)

$$B = (I - A)^{-1} = \begin{pmatrix} B_p + B_pA_{pn}MA_{np}B_p & B_pA_{pn}M \\ MA_{np}B_p & M \end{pmatrix}$$

Considering that the product of any matrix by its inverse is equal to the identity matrix, we can expand to $(I - A)^{-1}x(I - A) = I$. In equation (9), $(I - A)^{-1}$ is our B matrix. Then, we can mathematically prove equation (9):

$$\begin{pmatrix} B_p + B_pA_{pn}MA_{np}B_p & B_pA_{pn}M \\ MA_{np}B_p & M \end{pmatrix} x \begin{pmatrix} I - A_{pp} & -A_{pn} \\ -A_{np} & I - A_{nn} \end{pmatrix} = \begin{pmatrix} I & 0 \\ 0 & I \end{pmatrix}$$

$$\because B_p\left(I - A_{pp}\right) + B_pA_{pn}MA_{np}B_p\left(I - A_{pp}\right) - B_pA_{pn}MA_{np}$$
$$= \underbrace{B_p\left(I - A_{pp}\right)} + B_pA_{pn}MA_{np}B_p\left(I - A_{pp}\right) - B_pA_{pn}MA_{np} =$$

$$\because = I + B_pA_{pn}MA_{np}I - B_pA_{pn}MA_{np} = I$$

$$MA_{np}B_p\left(I - A_{pp}\right) - MA_{np}$$

$$= MA_{np} - MA_{np} = 0$$

$$-B_pA_{pn} - B_pA_{pn}MA_{np}B_pA_{pn} + B_pA_{pn}M(I - A_{nn})$$

$$= -P_2 - P_2\Delta_{nn}B_nA_{np}P_2 + P_2\Delta_{nn}B_n - P_2A_{nn}$$

$$= -P_2 - P_2\Delta_{nn}S_2P_2 + P_2\Delta_{nn}B_n(I - A_{nn})$$

$$= -P_2 - P_2\Delta_{nn}S_2P_2 + P_2\Delta_{nn}$$

$$= -P_2[I + \Delta_{nn}S_2P_2 - \Delta_{nn}]$$

$$= -P_2[I - \underbrace{\Delta_{nn}(I - S_2P_2)}_{I}] = 0$$

$$-MA_{np}B_pA_{pn} + M(I - A_{nn})$$

$$= -\Delta_{nn}B_nA_{np}B_pA_{pn} + \Delta_{nn}B_n(I - A_{nn})$$

$$= -\Delta_{nn}S_2P_2 + \Delta_{nn}$$

$$= \Delta_{nn}(I - S_2P_2) = 0$$

Miyazawa Model. In this part, we borrow the model's explanation and proofs from Sonis and Hewings (1999a):

$$A = \begin{pmatrix} A_{pp} & A_{pn} \\ A_{np} & A_{nn} \end{pmatrix} = \begin{pmatrix} A_{pp} & 0 \\ A_{np} & 0 \end{pmatrix} + \begin{pmatrix} 0 & A_{pn} \\ 0 & A_{nn} \end{pmatrix} = A_p + A_n$$

$$B_p = \left(I - A_{pp}\right)$$

Considering the inverse of the two-block matrices A_p and A_n as E_p and E_n, we can write E_p as follows:

$$E_p = (I - A_p)^{-1} = (I - A_{pp} - A_{np})^{-1}$$

Since:

$$\left(I - A_p\right) = \begin{pmatrix} I & 0 \\ 0 & I \end{pmatrix} - \begin{pmatrix} A_{pp} & 0 \\ A_{np} & 0 \end{pmatrix} = \begin{pmatrix} I - A_{pp} & 0 \\ -A_{np} & I \end{pmatrix}$$

then, using the theorem of the inverse for partitioned matrices we find (Miller and Blair 2009):

$$E_p = (I - A_p)^{-1} = \begin{pmatrix} B_p & 0 \\ A_{np}B_p & I \end{pmatrix}$$

Now:

$$E_p(I - A) = E_p[\underbrace{(I - A_p)}_{I} - A_n] = I - E_pA_n$$

$$= \begin{pmatrix} I & 0 \\ 0 & I \end{pmatrix} - \begin{pmatrix} B_p & 0 \\ A_{np}B_p & I \end{pmatrix}\begin{pmatrix} 0 & A_{pn} \\ 0 & A_{nn} \end{pmatrix}$$

$$= \begin{pmatrix} I & 0 \\ 0 & I \end{pmatrix} - \begin{pmatrix} 0 & B_pA_{pn} \\ 0 & A_{nn} + A_{np}B_pA_{pn} \end{pmatrix}$$

$$= \begin{pmatrix} I & -B_pA_{pn} \\ 0 & I - A_{nn} - A_{np}B_pA_{pn} \end{pmatrix}.$$

$$E_n = (I - E_pA_n)^{-1} = \begin{pmatrix} I & B_pA_{pn}M \\ 0 & M \end{pmatrix}$$

Thus:

$$E_nE_p(I - A) = I \; or, equivalently \; E_nE_p = (I - A)^{-1}$$

$$E_nE_p = \begin{pmatrix} I & B_pA_{pn}M \\ 0 & M \end{pmatrix}\begin{pmatrix} B_p & 0 \\ A_{np}B_p & I \end{pmatrix}$$

$$= \begin{pmatrix} B_p + B_pA_{pn}MA_{np}B_p & B_pA_{pn}M \\ MA_{np}B_p & M \end{pmatrix}$$

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