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THE EVOLUTION OF DIRECT BACKWARD AND FORWARD LINKAGES IN THE ROMANIAN ECONOMY

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Abstract
After the 1989 Revolution, a number of significant structural economic changes took place in Romania. The country's GDP has grown considerably, especially after 2007. This paper analyses the structural changes in Romania's economy using the Input-Output model over the period 1996-2021. Using this model the strongest and weakest technological dependencies and sectoral influences were identified. In this respect, technical input coefficients for backward linkages and technical output coefficients for forward linkages were calculated. The results of the analysis revealed that industry is the largest consumer and supplier. In second place are construction in terms of inputs and agriculture in terms of outputs. The strongest backward linkages are between industrial branches and between construction and industry. The weakest backward linkages occur between agriculture and construction and vice versa, and between services and agriculture. The strongest forward linkages are between agriculture and industry respectively between industrial branches, while the weakest forward linkages exist between agriculture and construction and between construction and agriculture.

Keywords: *Romania, input-output model, economic interdependencies; backward linkages; forward linkages*

JEL Classification: *D57, E23, O11*

I. INTRODUCTION

In the period after 1996, Romania experienced important structural changes in its economy. Our country has seen significant increases in GDP over time, especially after its accession to the EU. According to Eurostat data (https://ec.europa.eu/eurostat), by the end of 2023 Romania had a total GDP, expressed in current prices, of over EUR 324 billion. This puts it in 12th place after Denmark, although it was in second last place with €17,030 per capita GDP. But the increase is spectacular if we consider the situation in 1996 and 2007 (the year of Romania's integration). In 1996, Romania's GDP was around €29 billion (more than 11 times less than in 2023), and in 2007 it was €127.6 billion (more than 2.5 times less than in 2023).

Structurally, Romania's economy has also been reconfigured. According to website analizeeconomice.ro, while during the years of the communist regime the main contributor to GDP was industry (46% in 1985), this gradually decreased to 32.7% in 1996 and 25.9% in 2015. At the same time, services contributed only 22.8% to total GDP in 1985, 37.3% in 1996 and 48.1% in 2015, and continued to grow in the following years. At the same time, according to the same sources, agriculture has also long held a significant share in the economy, 21% in 1993 and over 12% in 2008. In the case of constructions sector, however, there has been, with small exceptions, a certain stability in the share of GDP (between 6-7.5%). Values of less than 6% were recorded in 1989-1993 and higher values of over 7.5% in 2006-2012.

Data from the National Institute of Statistics (NIS) show that in 2021, the share of industry in total GDP was 21.3%, while the contribution of services was 58.2%. At the same time, the contribution of agriculture was significantly lower at 4.4% and that of construction at 6.6%. In the context of these changes we wanted to analyse the relationships between the four sectors in Romania through the input-output flows from 1996 to 2021.

There are a number of analytical works on the topic of Input-Output intersectoral relations in the local literature (Dobrescu et al., 2010; Dobrescu, 2013; Dobrescu & Gaftea, 2019). This paper, however, proposed a different, more synthetic approach from the perspective of four sectors of activity. Its purpose was to analyse the evolution of relations between Romanian`s four sectors through input-output flows from 1996-2021. In these sense, the objectives pursued were: 1) the evolution of direct backward and forward links of each sector; 2) identification of the largest consumers and suppliers of intermediate products; 3) identifying the sectors with the strongest and weakest direct backward and forward links; 4) the evolution of highest and lowest input and output coefficients.

The paper contains an overview of the Input-Output model, the methodology used and the results and conclusions obtained.

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II. INPUT-OUTPUT MODEL

The Input-Output Model (IOM), also called the Leontief model, was presented for the first time by Wassily W. Leontief in 1936 in his paper ”Quantitative Input and Output Relations in the Economic Systems of the United States”. The model allows the analysis of interdependencies between economic sectors of a national economy. It is a main tool in the analysis of the effects of changes in production and consumption allowing the assessment of the total impact of final demand components on the productive sector (Gaftea, 2013, p. 213).

The model involves a systematic picture that highlights the input-output flows of goods and services between the sectors of a national economy during a calendar year, as well as flows with foreign countries, based on the system of national accounts (Leontief, 1986, p. 21). In essence, the model reflects, in fact, the equality between demand and supply of goods and services (Jana et al., 2021, p. 237), or in other words, between the resources of an economy and consumption.

At the same time, input-output tables are extremely important theoretical, forecasting and economic planning tools (European Communities, 2008, p. 532) and are useful in tracking structural changes in a national economy. They provide essential information for informing and analysing policies related to energy, natural resources and economic structure. In this way, input-output analysis can be used to anticipate economic policy decisions (Capanu et al., 1994, p. 85) and to assess economic risks. At the same time, these tables allow the identification of import-dependent sectors in order to establish specific policies to stimulate domestic sectors and reduce imports (Coşkun & Başkol, 2022).

Currently, IOM has a wide application. It has evolved over time from a simple method of intersectoral economic analysis to a complex and indispensable tool in modern macroeconomic analysis. While it was initially used in macroeconomic analysis to understand the economic linkages between different sectors of a national economy, it has subsequently been extended and adapted to address new economic and environmental challenges. It is often used in the analysis of intra-sectoral/intra-industry linkages, especially industrial linkages (Cella, 1984; Miller & Blair, 2009; Olteanu, 2009; Ojaleye & Narayanan, 2022), inter-regional interdependencies (Isard, 1951; Leontief & Strout, 1963; Antonescu, 2003; Miller & Blair, 2009; Polenske & Rockler, 2014; Boero et al., 2018; Wang & Lin, 2023, Azorin et al., 2024), the implications of economic activity on the environment (Butnar & Llop, 2006; McGregor et al., 2008; Miller & Blair, 2009; Kitzes, 2013; Li et al., 2022), the implications of natural disasters on the economy (Okuyama, 2007; Rose & Liao, 2005). IOM is also used in forecasting price developments (Przybyliński & Gorzałczyński, 2022; Oosterhaven, 2024), and even in health (Jewczak & Suchecka, 2014).

With the help of IOM, direct backward and forward linkages can be established for each economic sector. These notions were presented for the first time, in 1958, by Albert O. Hirschman in his work ”The Strategy of Economic Development”. Backward linkages highlight the connections of a sector with other sectors regarding the supplies of inputs necessary to obtain its own production. Forward linkages reflect the connections of a sector with other economic sectors in terms of supllies of intermediate products made by it. In the specialized literature, there are numerous papers that deal with the issue of direct backward and forward links (Hefner & Guimaraes, 1994; Drejer, 2002; European Communities, 2008; Jaunzems & Balode, 2018; Ha & Trinh, 2018; Choi et al., 2021; Coşkun & Başkol, 2022; Lima & Banacloche, 2022; Ojaleye & Narayanan, 2022).

III. METODOLOGY

The period 1996-2021 was considered for the analysis of cross-sectoral linkages. The lack of statistical data at the time of the research did not allow the extension of this interval until the year of 2023 including. The input-output table - restricted form, comparable prices - CAEN Rev.2, downloaded from TEMPO online, was used.

The sectors covered were agriculture (A), industry (I), construction (C) and services (S). To establish the inter-sectoral linkages, input and output coefficients were established according to the IOM.

According to relation (1), to calculate the input coefficients (k_{ij}), the intermediate consumption of sector j from sector "i" (X_{ij}) was divided by the total output of sector "j" (Q_j). The so-called matrix of input coefficients (with 4 lines and 4 columns) was formed for each individual year.

$$k_{ij} = \frac{X_{ij}}{Q_j} \quad (1)$$

The input coefficients show how many monetary units of intermediate consumption from other sectors are returned to one monetary unit of output of an economic sector (the output of sector "i" required to produce one unit of output in sector "j"). The higher the coefficients, the stronger the technological linkages between sectors. The total input coefficients established at the level of a sector (U_j) highlight the so-called direct backward linkages (see formula 2), which represent the total direct intermediate demand for an indutry ”j” (Hefner & Guimaraes, 1994, p. 234).

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$$U_j = \sum_{i=1}^{4} k_{ij} \qquad (2)$$

Based on the input coefficients we then identified the strongest and weakest technological linkages. In this respect, at the level of each year, we considered the maximum and minimum level of the input coefficients in the matrix of these coefficients.

In establishing the output coefficients (q_{ij}), the output of sector "i" to sector "j" (X_{ij}) was divided by the total output used by sector "i" (Q_i) – formula 3. Similarly, the annual matrix of output coefficients was also constructed.

$$q_{ij} = \frac{X_{ij}}{Q_i} \qquad (3)$$

The output coefficients show the influence of a sector on the economic sectors that use the sector's goods as intermediate inputs (output of sector "i" sold to sector "j"). The total output coefficients of a sector (T_i) reflect the direct forward linkages (formula 4) wich represent the total intermediate production delivered by an industry ”i”.

$$T_i = \sum_{j=1}^{4} q_{ij} \qquad (4)$$

Similarly, we also identified the strongest and weakest influences on sectors by setting the maximum and minimum output coefficients of the matrix annually.

To perform the analysis, the following input-output table (IOT) was considered:

Tabel 1. IOT – the case of four economic sectors

Inputs		**Intermediate Outputs (j)**				**Total Intermediate Outputs**	**Final Demand**	Q_u
		Agriculture (A)	**Industry (I)**	**Construction (C)**	**Services (S)**			
IC (i)	A	X_{AA}	X_{AI}	X_{AC}	X_{AS}	$X_A = \sum_{j=1}^{4} X_{Aj}$	$D_A = Q_A - X_A$	Q_A
	I	X_{IA}	X_{II}	X_{IC}	X_{IS}	$X_I = \sum_{j=1}^{4} X_{Ij}$	$D_I = Q_I - X_I$	Q_I
	C	X_{CA}	X_{CI}	X_{CC}	X_{CS}	$X_C = \sum_{j=1}^{4} X_{Cj}$	$D_C = Q_C - X_C$	Q_C
	S	X_{SA}	X_{SI}	X_{SC}	X_{SS}	$X_S = \sum_{j=1}^{4} X_{Sj}$	$D_S = Q_S - X_S$	Q_S
Total IC		$IC_A = \sum_{i=1}^{4} IC_{iA}$	$IC_I = \sum_{i=1}^{4} IC_{iI}$	$IC_C = \sum_{i=1}^{4} IC_{iC}$	$IC_S = \sum_{i=1}^{4} IC_{iS}$	$IC_{total} = \sum_{j=1}^{4}\sum_{i=1}^{4} IC_{ij} = \sum_{j=1}^{4}\sum_{i=1}^{4} X_{ij}$	$D_{total} = \sum_{i=1}^{4} D_i$	$Q_{total} = \sum_{i=1}^{4} Q_i$
VA		VA_A	VA_I	VA_C	VA_S	$VA_{total} = \sum_{j=1}^{4} VA_j$		
Q		Q_A	Q_I	Q_C	Q_S	$Q_{total} = \sum_{j=1}^{4} Q_j$		

Note: IC – intermediate consumption; VA – value added; Q – the production of goods and services obtained; X_{ij} – intermediate consumption delivered by sector „i“ for sector „j“; Q_u – the production of goods and services used; D – final demand; i – the line in the colored area; j – the column in the colored area; $Q = Q_u$

Source: adapted by the author after Capanu et al. (1994, p. 78)

IV. RESULTS AND DISCUSSIONS

For an overview of the four economic sectors, we first looked at the share of value added (VA) in total national VA. According to the calculations, services make the largest contribution to GDP. They have had an intermediate consumption of less than 42% in recent years. Services were followed, at a significant distance of 45.81% in 2021, by industry (see Figure 1).

Moreover, the results of the calculations showed an upward trend in the share of VA in the services sector in total VA at national level (see Figure 1). The indicator recorded values ranging from 41.78% (in 1997) to 66.94% (in 2021), with a gap between the two values of 25.16%. Agriculture has been at the opposite pole in recent years. This has been on a downward trend. The minimum recorded was 4.29% in 2020, the maximum being reached in 1997, at 19.64%. The gap between the two values was 15.36%.

Industry was in second place with minimum and maximum values of 21.13% (2021) and 36.25% (2011) respectively. The fluctuation of the construction sector's VA share in the national VA total was between a minimum level of 5.36% (year 2018) and a maximum level of 12.88% (year 2008), with a gap of 7.52%. In terms of construction, there is a change in the place held in this respect. While between 1996 and 2006 they were in fourth place after agriculture, construction has since overtaken agriculture.

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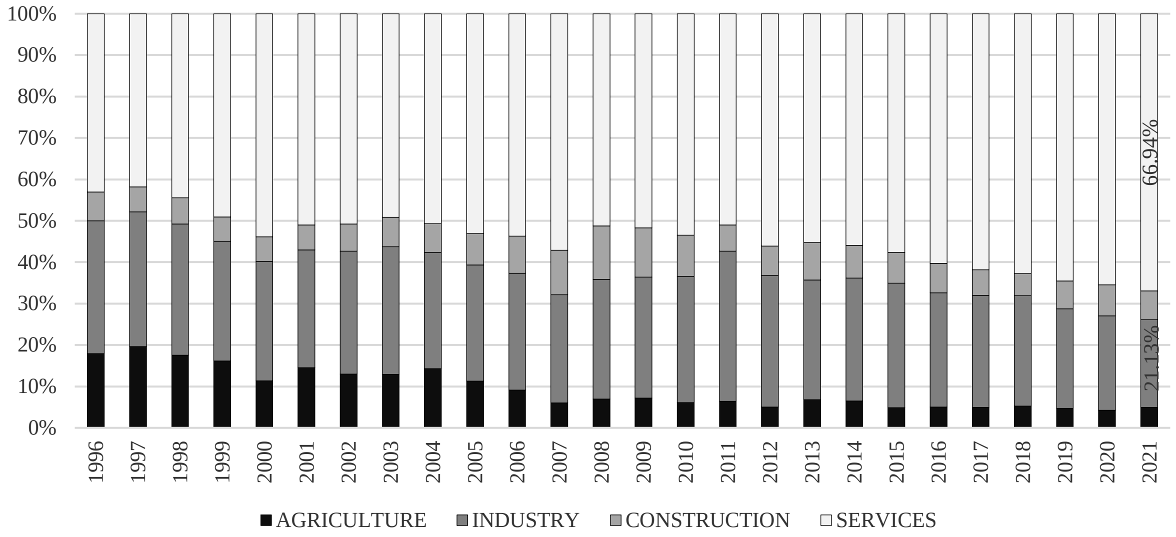

Figure 1. The share of VA of each sector in the total national VA – Romania (1996-2021)
Source: own calculations based on NIS data

As already mentioned, intersectoral inward linkages, also called backward linkages, have been highlighted using technological input coefficients. The results showed their fluctuation for all four economic sectors. In fact, Figures 2-5 show the value of inputs by sector of activity according to their origin. Comparing these figures, we can see that industry has the most expensive inputs and the construction sector has seen significant changes since 2010.

At the same time, according to Figure 2, the least resources used in agriculture come from construction and the most from agriculture. In the industrial sector (the largest consumer among the four sectors), most inputs come from industry and the fewest from construction (see Figure 3). As can be seen, each of the two sectors provides the resources needed to carry out its activities from its own sector (in agriculture from agriculture and in industry from industry).

This is not the case for constructions. Here, most inputs came from the industrial sector, while the least from agriculture (see Figure 4).

In services, industry and services competed for the most resources. Thus, in the period 1996-2012, it was industry that provided most inputs, while in the period 2013-2021 it was services. In contrast, the fewest resources were provided by agricultural producers (see Figure 5).

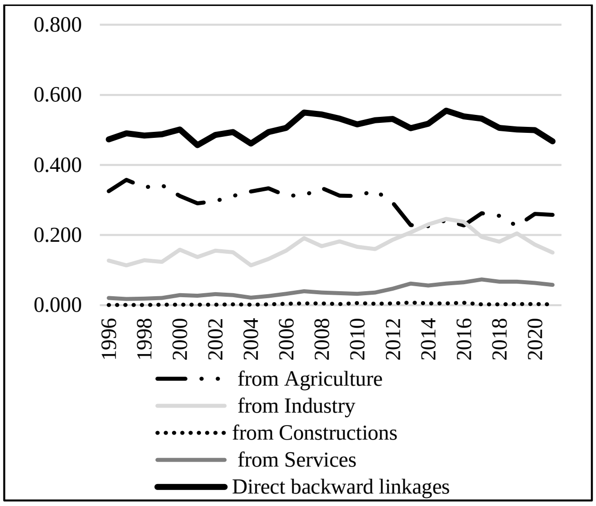

Figure 2. Input coefficients – Agriculture - Romania (1996-2021)
Source: own calculations based on NIS data

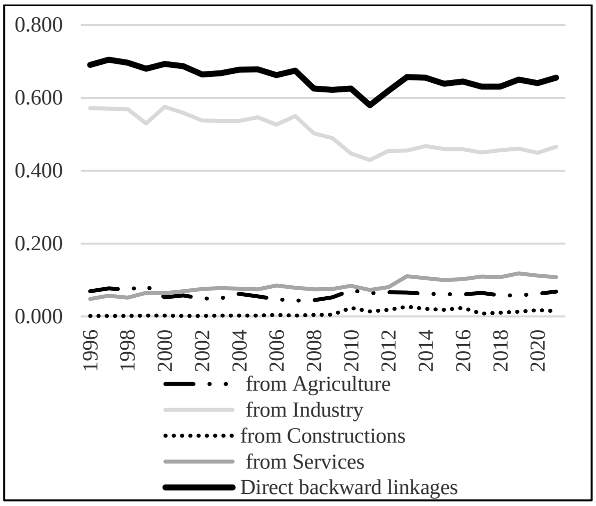

Figure 3. Input coefficients – Industry - Romania (1996-2021)
Source: own calculations based on NIS data

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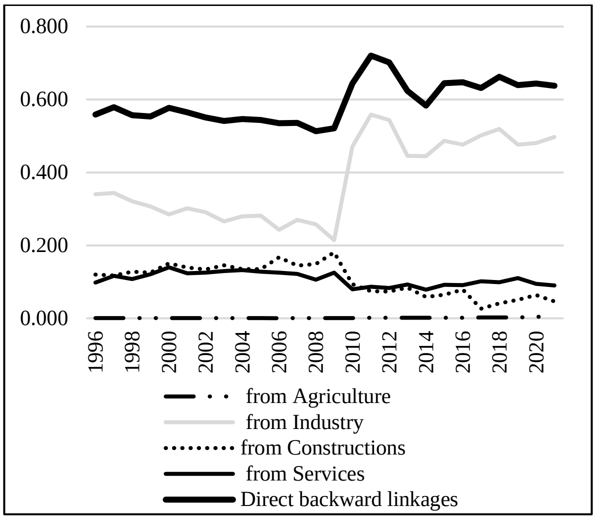

Figure 4. Input coefficients – Constructions - Romania (1996-2021)
Source: own calculations based on NIS data

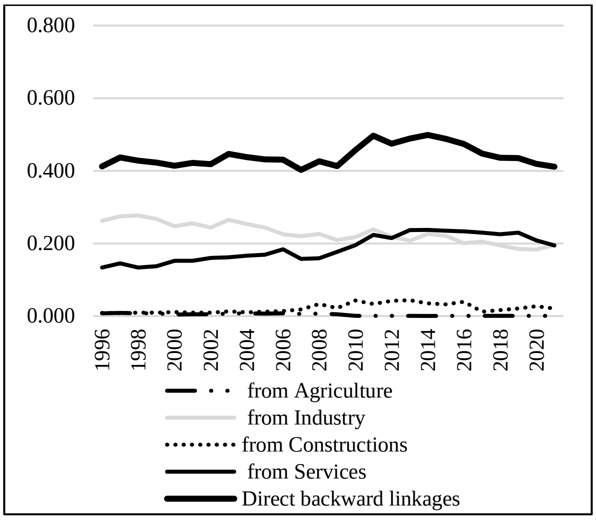

Figure 5. Input coefficients – Services - Romania (1996-2021)
Source: own calculations based on NIS data

However, if we look at total input coefficients by sector of economic activity (direct backward linkages), we see that the highest values were recorded in construction and industry respectively, which means that the highest total intermediate consumption was achieved in these sectors (see Table 2). In constructions, total input coefficients fluctuated between a minimum of 0.513 and a maximum of 0.720, while in industry the fluctuation was between 0.580 and 0.705. At the opposite pole were services, with values ranging from 0.402 to 0.499.

Table 2. Direct backward linkages by economic sectors (U_j) - highest and lowest values - Romania 1996-2021 (monetary units of inputs/monetary unit of output)

Sector	The highest values		The lowest values	
	Values	Years	Values	Years
Agriculture	0.555	2015	0.456	2001
Industry	0.705	1997	0.580	2011
Construction	0.720	2011	0.513	2008
Services	0.499	2014	0.402	2007

Source: own calculations based on NIS data

According to Table 3 (made on the basis of the annual matrices of the input coefficients), the most intense technological entry relationships were held by industry (for 16 years) and constructions (for 10 years). Thus, for industry, the most intense linkage was Industry-Industry, while for construction it was Constructions-Industry.

The weakest intersectoral linkages were for constructions, services and agriculture. Over the period studied, constructions were predominant (for 14 years), followed by services (for 11 years). In the case of constructions, the link was Constructions-Agriculture, and in the case of services it was Services-Agriculture. In 1997, agriculture was the sector with the lowest construction input (Agriculture-Constructions).

Table 3. Annual intersectoral input correlations - strongest and weakest

The strongest link / The weakest ink	Agriculture	Industry	Construction	Services
Agriculture			k_{CA} (1996); (1998-2010)	k_{SA} (2011-2021)
Industry		k_{II} (1996-2009); (2013-2014)	k_{CI} (2010-2012); (2015-2021)	
Construction	k_{AC} (1997)			
Services				

Source: own calculations based on NIS data

Also the annual matrices of the input coefficients show that the evolution of the strongest and weakest technological links has been fluctuating (see Figures 6 and 7). For the strongest linkages, the coefficient ranged from a minimum of 0.4555 (reached in 2013) to a maximum of 0.5752 (in 2000), while for the weakest linkages the coefficient ranged from 0.0003 (in 2001, 2006, 2007, 2013-2015) to 0.0008 (in 1996, 1999, 2000).

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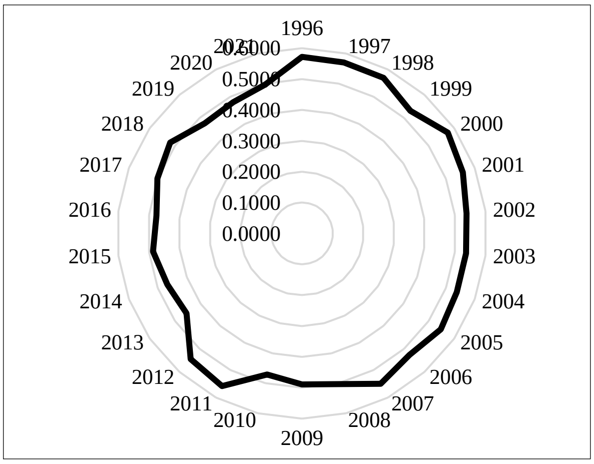

Figure 6. Evolution of the highest input coefficients (1996-2021)
Source: own calculations based on NIS data

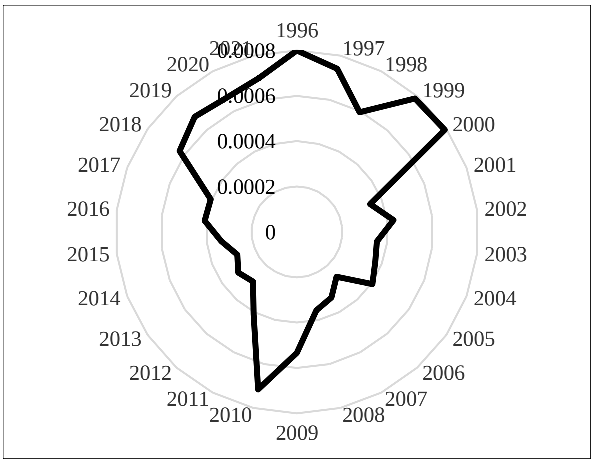

Figure 7. Evolution of the lowest input coefficients (1996-2021)
Source: own calculations based on NIS data

The intersectoral forward links are shown in Figures 8-11. According to them, the output coefficients have shown oscillations throughout the period under analysis. The top two positions, in order of total output coefficients (direct forward linkages), were industry and agriculture. Industry had the highest outflows to industry and services, which means that the industrial intermediate products supplied were essential for the production of industrial finished products and the provision of services. It is also worth noting that the value of intermediate products supplied to industry gradually decreased over the period, while those supplied to services increased (see Figure 9).

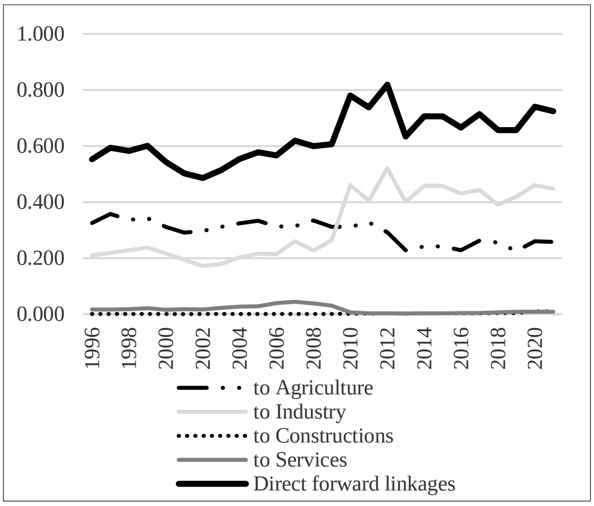

Figure 8. Output coefficients – Agriculture - Romania (1996-2021)
Source: own calculations based on NIS data

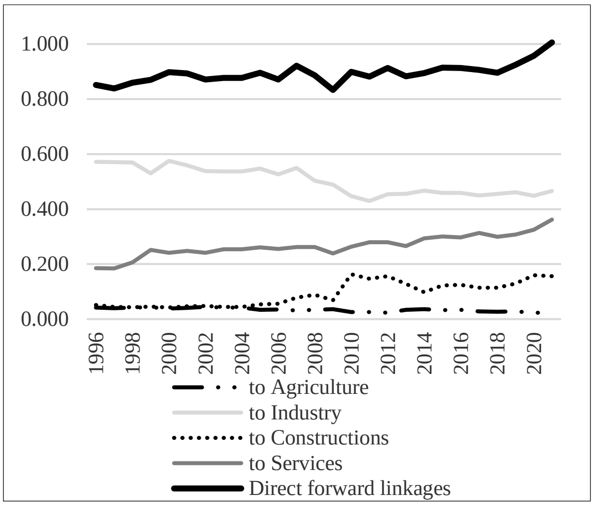

Figure 9. Output coefficients - Industry- Romania (1996-2021)
Source: own calculations based on NIS data

In the case of the agricultural sector, up to and including 2009, most agricultural intermediate products were supplied to agriculture and the fewest to industry. Since 2010, however, the situation has reversed (see Figure 8).

A similar pattern is observed for constructions. According to Figure 10, while up to and including 2012, most intermediate products supplied were, in order, to constructions and industry, after this year, the situation changed (constructions supplied more to industry and less to constructions).

In the case of services there was some consistency in terms of outputs. Throughout the period, most outflows went to services (see Figure 11).

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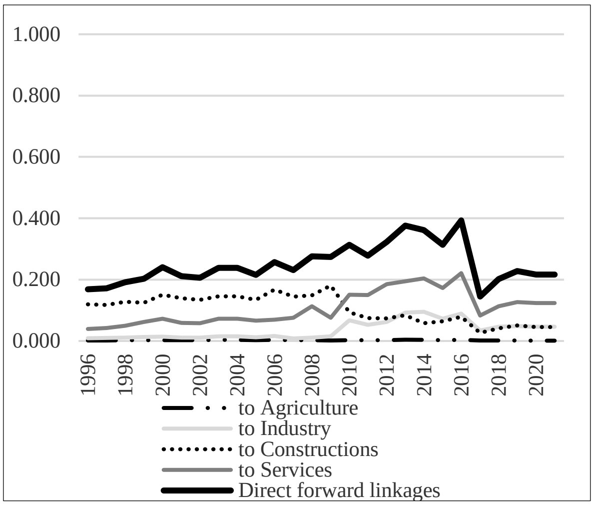

Figure 10. Output coefficients - Constructions-Romania (1996-2021)
Source: own calculations based on NIS data

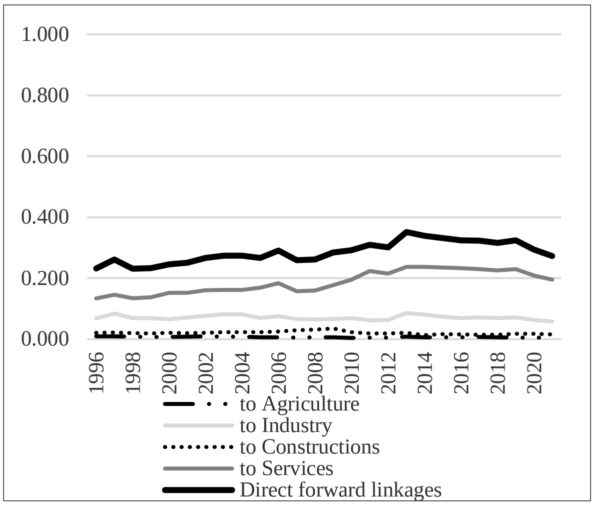

Figure 11. Output coefficients – Services - Romania (1996-2021)
Source: own calculations based on NIS data

In terms of total output coefficients by economic sector (direct forward linkages), the highest values were recorded in industry and agriculture (see Table 4). In the industrial sector, a paradoxical situation of exceeding the maximum value (1) for the last year was noted. According to NIS data, the output used was lower than the output supplied to other sectors. Total output coefficients fluctuated between 0.833 and 1.006 in industry and between 0.486 and 0.819 in agriculture. At the opposite pole were services, with values ranging from 0.231 to 0.351.

Table 4. Direct forward linkages by economic sector (Ti) - highest and lowest values - Romania 1996-2021 (monetary units output/monetary unit of output used)

Sector	**The highest values**		**The lowest values**	
	Value	**Year**	**Value**	**Year**
Agriculture	0.819	2012	0.486	2002
Industry	1.006	2021	0.833	2009
Construction	0.393	2016	0.145	2017
Services	0.351	2013	0.231	1998

Source: own calculations based on NIS data

The annual matrices of output coefficients allowed us to draw up table no. 5. According to this, industry and agriculture had the strongest influence on the sectors in terms of outflows. In the case of the industrial sector, over most years (1996-2009; 2011; 2013-2019 and 2021), the strongest influence was on industry itself.

Table 5. Annual intersectoral output correlations - strongest and weakest

The strongest link / **The weakest link**	**Agriculture**	**Industry**	**Construction**	**Services**
Agriculture		q_{AI} (2010); (2012); (2020)	q_{AC} (1996-2011); (2013-2016)	
Industry		q_{II} (1996-2009); (2011); (2013-2019); (2021)		
Construction	q_{CA} (2012); (2017-2021)			
Services				

Source: own calculations based on NIS data

Agriculture also had the strongest influence on industry in the years 2010, 2012 and 2020, but agriculture, together with constructions, also had the least influence. As can be seen from Table 4, the two sectors influenced each other at the lowest level (agriculture-constructions and constructions-agriculture).

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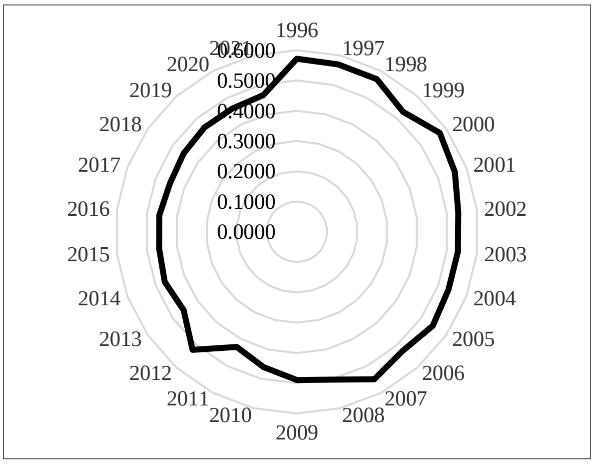

Figure 12. Evolution of the highest output coefficients (1996-2021)
Source: own calculations based on NIS data

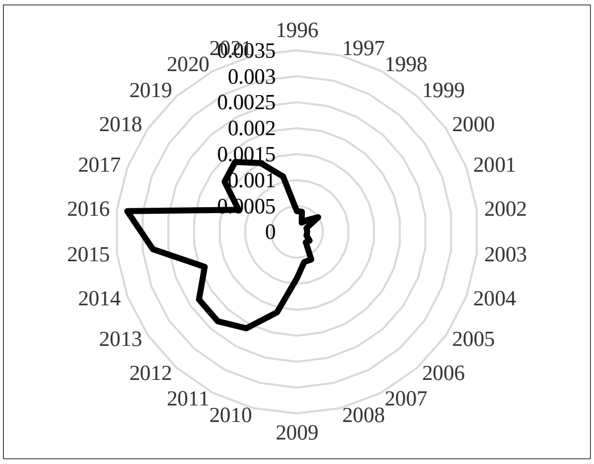

Figure 13. Evolution of the lowest output coefficients (1996-2021)
Source: own calculations based on NIS data

According to Figures 12 and 13, the evolution over time of the highest and lowest output coefficients has been fluctuating. The highest coefficients ranged from a minimum of 0.4294 (in year 2011) to a maximum of 0.5752 (in year 2000), while the lowest ranged from 0.0002 (in years 1998, 2001-2004) to 0.0033 (in years 2016).

V. CONCLUSION

From the analysis we can conclude the following:

1. Direct backward and forward links fluctuated throughout the analyzed period. They revealed the fact that the industry is the biggest consumer but also the biggest supplier of intermediate products. According to the IOM, in terms of total input and output coefficients, the industrial sector outperforms the other three sectors in both inputs and outputs. On the one hand, industry has the highest intermediate consumption as the sector most dependent on the other sectors, and on the other hand, it also has the greatest influence on it. Calculations show that industry's highest dependence is on its own intermediate products (industry-industry input coefficients being the highest).
2. Another sector with strong technological links are constructions, which ranks second in terms of total input coefficients. Constructions are mainly dependent on industrial intermediates and less dependent on agricultural intermediates.
3. Services are considered the least dependent on the other sectors as the total input coefficients were the lowest compared to the other sectors. However, the highest dependence of services is on industry up to and including 2012 and on services after 2012.
4. The strongest annual intersectoral input correlations were industry-industry and constructions-industry, while the weakest were agriculture-constructions, constructions-agriculture and services-agriculture.
5. In terms of influences (direct forward linkages), agriculture ranked second (after industry). The greatest influence of the agricultural sector was on itself (most agricultural products were supplied to agriculture) and on industry. According to the values of the output coefficients, constructions had the least influence on agriculture and agriculture on services.
6. The strongest annual intersectoral output correlations were industry-industry and agriculture-industry, while the weakest were agriculture-constructions and constructions-agriculture.
7. The maximum levels of input and output ratios have also fluctuated. The minimum levels of these coefficients experienced the same oscillating evolution.

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