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Article

The uneven expansion of engineering in brazilian higher education (2011-2017)

A expansão desigual das engenharias na educação superior brasileira (2011 – 2017)

La expansión desigual de las ingenierías en la educación superior brasileña (2011-2017)

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Abstract: Analysis of the expansion of engineering in Brazilian higher education. Between 2011 and 2017, engineering was among the areas with the greatest expansion in Brazilian higher education. This study analyzes whether this expansion process led to a higher or lower concentration of graduates within its specialties. Using the Brazilian Higher Education Census from 2011 to 2017, the analysis showed that engineering programs expanded unevenly. It was identified that only two specialties in the private sector accounted for 60.1% of the expansion in engineering. In the public sector, the expansion was smaller and occurred in a balanced manner across specialties. The analysis at the specialty level revealed that the expansion occurred through two dynamics: concentration of graduates in a few specialties in the private sector (isomorphism) and greater institutional differentiation between public and private institutions (differentiation).

Keywords: engineering; higher education; isomorphism.

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Resumo: Análise da expansão das engenharias na educação superior brasileira. Entre 2011 e 2017, a engenharia esteve entre as áreas com maior expansão de concluintes na educação superior brasileira. Este trabalho investiga se esse processo de expansão levou a uma maior ou menor concentração de concluintes entre suas habilitações. A partir do Censo da Educação Superior, de 2011 a 2017, a análise mostrou que as engenharias se expandiram de forma desigual. Identificou-se que apenas duas habilitações no setor privado foram responsáveis por 60,1% da expansão das engenharias. No setor público, a expansão foi menor e ocorreu de forma equilibrada entre as habilitações. A análise no nível das habilitações revelou que o crescimento ocorreu a partir de duas dinâmicas: concentração de concluintes em poucas habilitações no setor privado (isomorfismo) e maior diferenciação institucional entre públicas e privadas (diferenciação).

Palavras-chave: engenharias; educação superior; isomorfismo**.**

Resumen: Análisis de la expansión de las ingenierías en la educación superior brasileña. Entre 2011 y 2017, la ingeniería estuvo entre las áreas con mayor expansión en la educación superior brasileña. Este trabajo analiza si este proceso de expansión condujo a una mayor o menor concentración de graduados en sus especialidades. A partir del Censo de Educación Superior de 2011 a 2017, el análisis mostró que las ingenierías se expandieron de manera desigual. Se identificó que solo dos especialidades en el sector privado fueron responsables del 60,1% de la expansión de las ingenierías. En el sector público, la expansión fue menor y ocurrió de manera equilibrada entre las especialidades. El análisis a nivel de especialidades reveló que la expansión se produjo a partir de dos dinámicas: la concentración de graduados en pocas especialidades en el sector privado (isomorfismo) y una mayor diferenciación institucional entre las instituciones públicas y privadas (diferenciación).

Palavras clave: ingenierías; educación superior; isomorfismo.

1 Introduction

The aim of this work is to analyze the expansion of engineering programs in Brazil, taking into account their internal differentiations. I aim to answer whether there was greater or lesser differentiation among engineering specializations during a period of expansion in the field. Studies have shown that engineering is among the areas with the highest growth in Brazilian higher education (Santos; Lima; Carvalhaes, 2020). During a period in which distance education (DE) played a significant role in enrollment expansion, this field stands out for concentrating its programs almost exclusively in the face-to-face modality. Although the dynamics of engineering expansion in Brazil are well-known – through the private sector and in the face-to-face mode – the impact of this expansion on their internal differentiations is still poorly documented. To do this, the participation of each specialization in the total field will be investigated; the participation of each of them in recent expansion, and the distribution of different engineering programs among the teaching[1].

The study of engineering is relevant given the impacts of its expansion on the stratification of Brazilian higher education. Engineering, along with medicine and law, is considered one of the imperial professions (Barbosa, 2003; Coelho, 1999; Vargas, 2010). These are historically prestigious courses in Brazil and, compared to other fields, tend to provide better economic and social returns (Medeiros; Galvão, 2016; Ribeiro; Schlegel, 2015). However, unlike its imperial counterparts, engineering has an additional dimension of diversification, which is its specializations offered in the form of courses. Studies on the horizontal stratification of higher education indicate the relevance of diversification factors for the social composition of students in this sector (Arum *et al.*, 2007). In a previous study, I identified that engineering was the field that

[1] The modality (face-to-face or distance) will not be analyzed as a dimension of engineering diversification. Graduating in engineering through distance courses was an exception and represented 0.1% of all graduates in the field in 2017. It's worth noting that the number of new enrollments in the distance mode was already showing growth in the analyzed period. Further analyses can verify the impact of the expansion of this modality on the diversification of engineering offerings.

diversified the social profile of its students the most when compared to medicine and law (Rodrigues, 2023). In this case, this extra dimension of diversification can not only enable the expansion of engineering programs but also a greater diversification of its student profile. Understanding how diversified the supply of engineering professionals is by higher education may also be relevant for analyses of inequalities in the job market.

2 Diversification and differentiation in higher education

Research on higher education has indicated a relationship between greater institutional diversification within the system and an increase in the number of available spots (Santos; Lima; Carvalhaes, 2020, Van Vught, 2008). Beyond quantitative consequences, there are also qualitative effects within the sector. Some approaches suggest that the level of diversification within a higher education system plays a significant role in responding to various societal demands (Harris, Ellis, 2020, Huisman et al., 2007). Van Vught (2008), through a literature review, synthesizes a series of arguments in favor of institutional diversification. Among them, it's highlighted that more diverse systems would allow for the inclusion of a more heterogeneous student profile (Van Vught, 2008). In other words, a more diversified system would be better equipped to combine both mass and elite education, unlike a less diversified system. Diversification in higher education can occur at the institutional level (size and type), within the system's structure (legal and historical frameworks), and in terms of reputation (status and prestige), among other dimensions (Van Vught, 2009).

In this work, the focus will be on the diversification that occurs among engineering specializations: how graduates are distributed among these specializations and whether this distribution has become more or less homogeneous in the expansion process. This will help answer whether different specialties are related to a more diversified system as well.

Furthermore, it is of interest to understand how this dimension interacts with differentiation among the teaching sectors. This point is important because there were significant differences in the participation of each sector in the expansion of Brazilian higher education, with an advantage for the private sector (Santos; Lima; Carvalhaes, 2020). In other contexts, there is evidence that the private sector can be the main driver of educational system expansion without necessarily leading to greater differentiation within the system (Teixeira *et al.*, 2012). In these cases, the sectors may have become more similar to each other, resulting in a more homogeneous higher education system. According to literature based on organizational studies, the homogenization of the education system can occur due to institutions replicating successful institutional models and avoiding risks (Fumasoli *et al.*, 2020, Van Vught, 2008).

The process of homogenization within an organizational structure, in this case, higher education, is conceptualized as isomorphism (DiMaggio; Powell, 1983; Hannan; Freeman, 1977). Some studies attempted to explain why competition between different institutions, in some cases, didn't lead to specialization and differentiation effects, as expected by parts of the Weberian and Parsonian traditions. One of the explanations proposed by DiMaggio and Powell (1983) is that during periods of instability or uncertainty in organizational structure, institutions would mimic each other. This mechanism is consistent with findings that later confirmed the homogenization of higher education institutions during expansion (Fumasoli *et al.*, 2020, Rossi, 2009, Teixeira *et al.*, 2012). Under the isomorphism framework, the relationship between expansion and diversification would occur paradoxically. This would mean, for example, that the diversification of engineering would enable a greater quantitative expansion of its students while reducing its internal differentiations. Similarly, the difference between the public and private sectors does not necessarily result in a more heterogeneous system.

The evidence of system homogenization contrasts with hypotheses that competition among institutions in the process of expanding the education sector would lead to greater specialization and segmentation of training offerings (Teixeira *et al.*, 2012). In this case, in the competition for niches within the system, there would be greater diversity of institutional types, with different organizations, values, and objectives. Furthermore, distinct institutional designs can react differently to the same expansion context.

According to Fumasoli, Barbato, and Turri (2020), the factors that lead institutions to follow a particular dynamic are related to three interconnected dimensions: the environment, the institution's managerial logic, and organizational structure.

The broadest and external dimension is related to the environment in which the institution operates. External factors, such as labor market demands, government regulations, and professional groups, influence the organization of institutions. In the case of higher education, an increase in demand for spots or government incentives for system expansion can be considered factors within this external dimension. Studies focused on this dimension have presented evidence of a coercive effect of the environment on institutions (Fumasoli; Barbato; Turri, 2020). The result is a higher isomorphism within the system.

There is also a dimension related to managerial logic, characterized by the strategic decision-making of institutions. In this case, the focus is on the rationality of those making decisions regarding the institution's direction. For example, managerial logic explains whether an institution will specialize in niche areas or follow the trends of dominant institutions. Unlike the previous approach, the managerial dimension tends to emphasize the differences between institutions and the specialization processes unique to each.

Finally, Fumasoli, Barbato, and Turri (2020) propose the analysis of an intervening dimension between these last two, which is the organizational dimension. According to the authors, each institution has distinct values, norms, and histories that make up its organizational dimension. This dimension would explain how different institutions react differently, even though they share the same external constraints (environmental dimension) and similar strategies (managerial logic). According to the authors, this dimension can be operationalized based on the organizational structure of institutions, which includes institutional mission and tasks.

The interaction between these three dimensions helps explain the process of specialization within the same system. In the case of Brazil, it is possible to identify differences in the organizational perspective unique to each sector. In general, the institutional mission of public and private institutions is distinct (Sampaio, 2014). The author shows how the public and private sectors had distinct and complementary roles in responding to market and student demands. For example, it was the private sector that met the increasing demand for higher education spots that the public sector could not fulfill. Prates, Silva, and Paula (2012) identified a relationship between the type of management of institutions and the emphasis of their programs (academic or vocational). Training in academic institutions would provide better student integration into the job market (Prates; Silva; Paula, 2012). As public and private institutions are distributed unevenly among these categories – with private institutions generally being vocational – the type of management would imply a functional diversification of institutions. There is not a perfect correspondence between the institutional sector and other characteristics related to the organizational dimension. Confessional organizations, for example, are characterized as private and, at the same time, can share similar values to public ones. However, in general terms, it is possible to identify patterns in the organizational structure specific to each of the sectors.

This approach, therefore, suggests an alternative hypothesis to isomorphism between the sectors. While, on the one hand, the public and private sectors share the same environmental dimension – regulatory frameworks and student demands, professional groups, and labor market needs, for example – on the other hand, the difference between the sectors indicates distinctions in the organizational dimension that can lead to disparate behaviors within the education system. This approach will be important to explain potential contrasts between the sectors and how various factors contribute to the organization of the system.

Finally, differentiation among institutions has a particularly relevant impact on engineering. Maciente *et al.* (2015), in comparing recent graduates in engineering, medicine, and teaching, identified that the entry of engineers into the job market is more related to their training institution than in the other two fields (Maciente *et al.*, 2015). The quality of the programs, as measured by the Enade score, is associated with higher chances of entering typical engineering occupations and occupations with higher salaries.

In light of this literature and motivated by the potential consequences of diversification on the social composition of graduates, the objective is to identify whether there has been greater or lesser diversity among specializations and between sectors in the expansion of engineering. The analysis of graduates will help identify how heterogeneous the supply of engineers for the job market is by specialty and sector. The main terms to describe this process are found in the table below (Table 1).

In the literature on the subject, the same term can be used in different ways, depending on the context and the units of analysis. Therefore, a conceptualization similar to Santos, Lima, and Carvalhaes (2020) will be used for the terms diversification and differentiation. Diversification is related to qualitative differences in the education sector; in this analysis, it refers to engineering specializations and the institutional sector. Differentiation refers to a process over time (2011 – 2017) in which the

diversification structures (specializations and sectors) become more heterogeneous. The terms isomorphism and homogenization refer to the opposite process, in which these same structures become more similar. The study will aim to describe the expansion of engineering and determine which process better fits the dynamics of specializations: differentiation or isomorphism.

Table 1 - Summary of key terms, analytical dimensions, and corresponding measures

Term	Analysis dimension	Measure
Diversification	Engineering specializations institutional sector (public and private)	Distribution of graduates among specializations and between sectors
Isomorphism and Homogenization	Process in which diversification structures become more similar to each other	Higher concentration of graduates among specializations and between public and private sectors (2011 - 2017)
Differentiation	Process in which diversification structures become more heterogeneous	Greater balance among specializations and between sectors (2011 – 2017)

Source: Own elaboration.

3 Data

To describe the expansion process, data from the Higher Education Census (Census) between 2011 and 2017 were used. Engineering programs were disaggregated into all available specializations in this database. As a measure of differentiation, the same technique as Huisman *et al.* (2015) was used: comparing the distribution of graduates among specializations. If graduates were distributed more evenly among specializations over time, we would have evidence of a differentiation process among specializations. Regarding the institutional sector, differentiation would occur if the sectors showed distinct behaviors in how their graduates were distributed

among courses. In contrast, isomorphism would occur if the distribution of graduates had become more similar between sectors.

It was not possible to extend the analysis to periods before 2011. While processing the databases between 2002 and 2017, atypical variations in the concentration of graduates in engineering between 2008 and 2010 were identified. These variations suggested a change in the categorization methodology of specializations, particularly in programs that were previously categorized as "Engineering" and were later categorized under different specializations[2]. Therefore, it is not possible to determine whether the differences among engineering programs occurred due to variations in the field or due to a categorization bias in years prior to 2011.

The chosen time frame (2011 - 2017) is not sufficient for a satisfactory analysis of the engineering specialization process: whether certain types of programs emerged or were discontinued. Generally, this refers to longer[3]-term processes. The literature used would call this phenomenon diversification, which is the process by which new structures (such as specializations) would emerge in a certain institutional dimension (in engineering programs) (Santos; Lima; Carvalhaes, 2020). Therefore, the goal is not to determine whether there was an increase or decrease in the specializations offered in Brazilian higher education. What is of interest is whether graduates are distributed more or less evenly among specializations according to the sector and the period analyzed. In this work, this is the meaning employed for greater or lesser differentiation.

[2] Upon request, the tabulations of this data can be provided by the author.

[3] An example of this exercise can be found in the works of the sociology of knowledge and the sociology of professions that analyze the longer processes of specialization within a field of knowledge or profession. See, for example, Abbott (1988) and Freidson (2001).

4 Results

Table 1 below shows the 10 specializations with the highest number of graduates in the analyzed period (the table with all specializations was not presented due to space constraints, but it can be obtained from the author). By comparing the columns of accumulated percentages, it is evident that the expansion favored the concentration of graduates in these specializations. In 2011, they accounted for 86% of graduates, and in 2017, the concentration is 93.4%. Even among the 10 most populous specializations, there is a significant difference in the concentration of graduates. Civil engineering accumulated 38.1% of graduates in 2017, more than double the concentration in 2011 (16.8%). In second place, industrial engineering has 16.7%. Only these first two account for more than half (54.8%) of all engineering graduates. With the exception of civil and mechanical engineering, all other specializations have decreased their relative participation in the total number of graduates, despite also increasing the number of graduates.

Table 1 - Number and proportion of graduates by specialization and year

	2011			2017		
Specializations	N	%	% acum	N	%	% acum
Civil Engineering	7508	16.8	16.8	43521	38.1	38.1
Industrial Engineering	8322	18.6	35.4	19057	16.7	54.8
Mechanical Engineering	4790	10.7	46.1	13116	11.5	66.3
Electrical Engineering	5842	13.0	59.1	10582	9.3	75.5
Environmental Engineering	3497	7.8	66.9	6663	5.8	81.4
Chemical Engineering	2289	5.1	72.0	4838	4.2	85.6
Control and Automation Engineering	1869	4.2	76.2	3199	2.8	88.4
Computer Engineering	1750	3.9	80.1	2562	2.2	90.6
Forestry Engineering	1419	3.2	83.3	1660	1.5	92.1
Food Engineering	1229	2.7	86.0	1471	1.3	93.4

Source: Higher Education Census – Inep, 2011 - 2017.

Different factors can explain the concentration of graduates in these engineering fields, especially in civil engineering. Regarding the effects of the environment, some studies can contribute to understanding the differences between engineering specializations in the Brazilian context. Lins (2018) identifies institutional arrangements in Brazil by professional groups and the government that favored what the author refers to as "national engineering." Between 2005 and 2014, Lins points to increased state involvement in economic activities that were closely aligned with professional regulation. The Public Procurement Law and the Growth Acceleration Program (PAC)[4], for example, had institutional designs that demanded engineering services while protecting the market for Brazilian engineers (Lins, 2018). Simultaneously, the economic scenario in the early 2000s favored optimism about education in these fields. Nascimento *et al.* (2014) point to a connection between the attractiveness of engineering courses and the country's economic performance (Nascimento *et al.*, 2014). Through an analysis of the participation of engineering courses in Brazilian higher education, the authors identified increased optimism about education in this field from 2004 to 2005, which persists until at least 2012.

However, these factors had different effects depending on the engineering field of practice. For example, the context was favorable, primarily for professionals in civil engineering and for the prestige of working in that sector. However, even with the increase in the number of engineers in Brazil, analyses identified a shortage of labor (Lins, 2018, Nascimento *et al.*, 2014). In the industrial sector, there was greater demand for more experienced engineers. The evidence found in these studies would explain not only the expansion of engineering in higher education but also the greater concentration of graduates in civil engineering.

[4] The Public Procurement Law refers to Law n. 12,745 of 2012, which deals with the requirements of bidding notices for PAC (Growth Acceleration Program) projects.

In addition to civil engineering, other traditional engineering specializations appear among the top 10 most populous: mechanical engineering (3rd in the ranking), electrical engineering (4th), and chemical engineering (6th). "Traditional engineering specializations" is the term some studies use to refer to specializations that emerged in Brazil in the 19th or early 20th century (Oliveira, 2010). They differ from new specializations (such as industrial engineering or food engineering) that emerged in the second half of the 20th century.

The mentioned studies indicate some environmental factors that help explain why specializations related to the civil sector and traditional engineering fields have a higher prevalence in terms of the number of graduates. Additionally, it's possible that internal factors within higher education may influence this composition. It could be speculated whether different specializations have varying costs or levels of requirements for establishing programs. This could potentially explain the predominance of one specialization over another, beyond labor market factors. However, there haven't been studies that have addressed this issue. For now, we can investigate how these factors have manifested, indicating a decrease in the variety of engineering specializations for newly graduated engineers.

The expansion was uneven, not only among specializations but also in the overall system. Most of the growth occurred through the private sector (81.7%). The private sector accounted for 59% of graduates in 2011 and increased to 72.8% in 2017.

Table 2 - Number and proportion of graduates by institutional sector

	2011		2017		Growth dynamics		
Network	N	%	N	%	Balance	Growth (%)	Dynamics (%)
Private	26404	59.0	83135	72.8	56731	81.7	68.2
Public	18371	41.0	31109	27.2	12738	18.3	40.9
TOTAL	44775	100.0	114244	100.0	69469	100	—

Source: Higher Education Census - Inep, 2011-2017. Own elaboration.

The participation of each sector in the expansion is similar to what was found for the entire education system, and the explanations provided by the literature also apply to engineering. In summary, this dynamic may have occurred because private institutions responded more quickly to market demands, such as opening or closing courses (Sampaio, 2014). Specific conditions in the private sector made these institutions react to the optimism about the engineering career and the economic situation. Furthermore, the history of deregulation and government subsidies for the private sector (such as FIES and PROUNI) are among the causes for the expansion of this sector (Carvalhaes; Medeiros; Santos, 2022). Various public policies have contributed to the concentration and oligopolization of the higher education market. The specificity of engineering is that, in this case, concentration occurred despite the distance learning mode, which was the primary way in which the system expanded.

In comparison to other professions, the significant participation of the private sector in engineering may be due to the lack of constraints from the professional group for opening courses (Oliveira *et al.*, 2013). Therefore, environmental conditions would explain the increased demand for this education, and institutional conditions would account for the private sector's participation in this expansion (81.7%).

The performance of each sector is variable, also in relation to the specialty. The set of graphics below aims to demonstrate the different dynamics visually.

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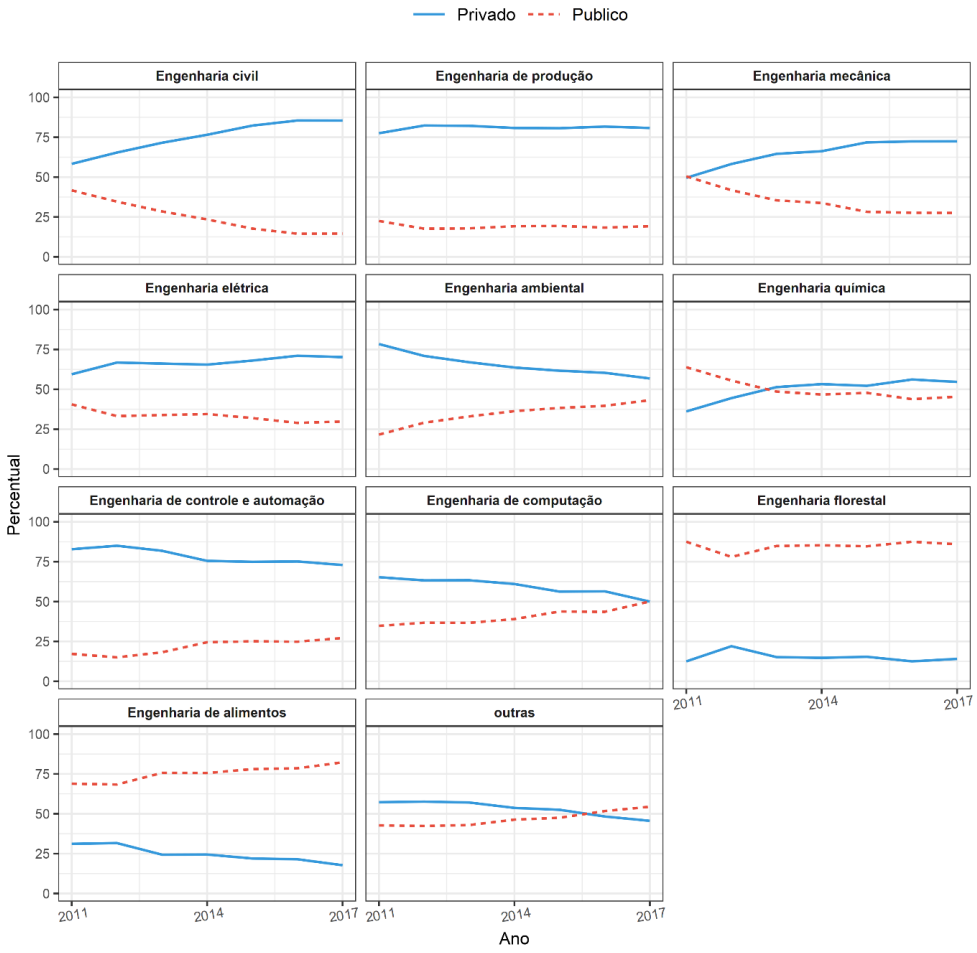
Chart 1 - Sector's participation in the total number of graduates by specialty and year



Source: Higher Education Census - Inep, 2011-2017. Own elaboration.

Three out of the four specializations with the highest expansion showed a similar dynamic. Civil, mechanical, and electrical engineering achieved more balance in 2011 than in 2017 when they became more concentrated in favor of private institutions. The exception is industrial engineering, which demonstrated greater stability in the concentration within the private sector (increasing from 75% to 80% of graduates). Concentration in private institutions also occurred in chemical engineering (rising from 36.1% to 54.6%). However, since there was a higher concentration in the public sphere in 2011, the result was a greater balance between the sectors, with a slight advantage for the private sector.

In the public sector, the highest concentrations are in food engineering, which became even more concentrated (82.3% of graduates in 2017), and in forest engineering (86% of graduates in 2017), which showed stability between 2011 and 2017. In areas previously concentrated in the private sector, such as computer engineering (65% in 2011) and 'other engineering' (52.3% in 2011), the public sector becomes the primary one. What seems to have happened is that the private sector concentrated enrollments, mainly in the more traditional specializations (civil, electrical, mechanical, and chemical engineering) and in industrial engineering. The result is that there are different dynamics for specializations depending on the institution. At this point, the analysis reinforces the specific characteristics of the organizational dimension, in the terms of Fumasoli, Barbato, and Turri (2020).

These results point to a preference for a specific institutional profile. In summary, the expansion dynamics have focused on certain engineering fields, especially civil, industrial, electrical, and mechanical engineering, as well as on private institutions. However, there are significant differences in how concentrated students are in the private sector depending on their specialization. The dynamics of each specialization – whether it has increased, decreased, or maintained its distribution among sectors – may be related to how much each specialization has expanded over the period. The

interplay between these two dimensions in the expansion process is the subject of the next topic.

4.1 Expansion by institutional profile

In this section, the goal is to analyze the expansion in which the dimensions of specialization and institution are interconnected. Each of the specializations was broken down by sector, and then its participation in the total expansion of engineering was measured. Therefore, civil engineering in private institutions forms a specific institutional profile, different from civil engineering in public ones. In total, the interaction between the 11 specializations and the two sectors results in 22 distinct institutional profiles. This is an analytical approach adapted from Santos, Lima, and Carvalhaes (2020).

From Figure 2, it is possible to visualize that the combination of civil engineering and private institutions was responsible for 47.2% of the expansion in the number of graduates during the period. The private sector is related to the three other main expansion profiles in engineering: production engineering, mechanical engineering, and electrical engineering. The first profile associated with public institutions is also in civil engineering (4.6% of the entire expansion). These top five institutional profiles together account for 80.7% of the total expansion.

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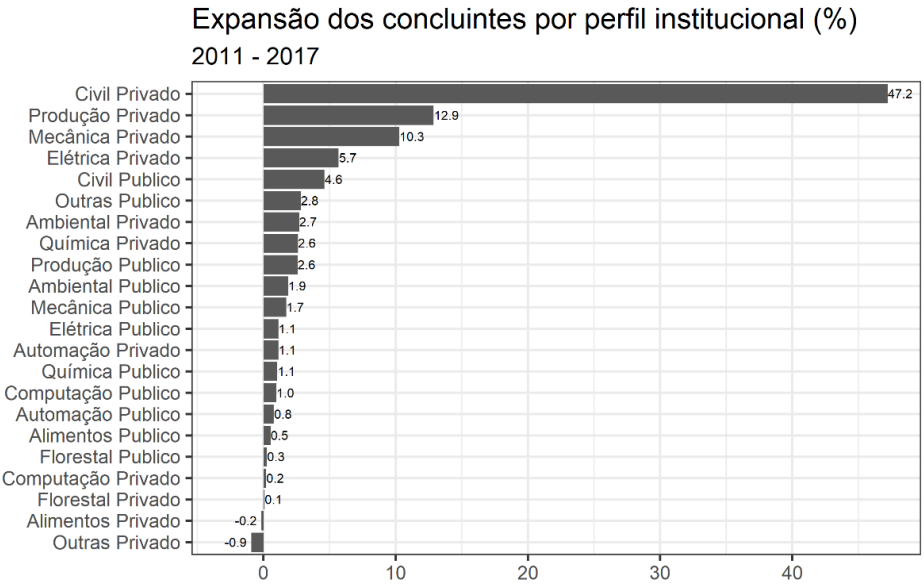
Graph 2 - Expansion of graduates by institutional profile (%)



Source: Prepared by the author, adapted from Higher Education Census (2011-2017).

The sixth most relevant institutional profile in the expansion is "Other Engineering" in the public sector. However, in the private sector, these engineering fields saw a decrease of 0.9% during the period. Graph 2 is polarized by the private sector, with a greater concentration in civil engineering and a decrease in the others. The institutional profiles linked to the public sector occupy the intermediate part of the graph. This indicates that there was less growth and it was less concentrated in this sector.

The public sector expanded less than the private sector and with a greater balance among the specialties. There are cases where it's possible to identify a unique dynamic at the specialty level, for example, the low participation of forestry engineering and the prevalence of civil engineering in both sectors. However, in most cases, the intensity of expansion in a particular specialty is linked to the interplay of these two dimensions.

The analysis of expansion by institutional profile reinforces a dynamic found in previous analyses that, despite the variety of specializations in engineering, there is a concentration, both in participation and in expansion, in a few specialties. Additionally, following a trend in the education system as a whole, there was a prevalence of the private sector in both absolute and relative numbers. The evidence suggests, therefore, a lower diversity in the institutional profile regarding the recent expansion in the number of graduates, and this diversity may vary by sector.

4.2 Differentiation or Isomorphism?

The results so far indicate that the isomorphism hypothesis is more suitable for the expansion of graduates among specialties. Graduates have become more concentrated in some specialties, especially civil engineering. On the other hand, the analysis by institutional profile indicates greater differentiation between public and private sectors. The distribution of graduates among specialties has become more heterogeneous according to the sectors. To assess this process of isomorphism among specialties and differentiation between sectors, I used the Herfindahl-Hirschman Index (HHI hereinafter), also used by Huisman *et al.* (2015) for a similar purpose.

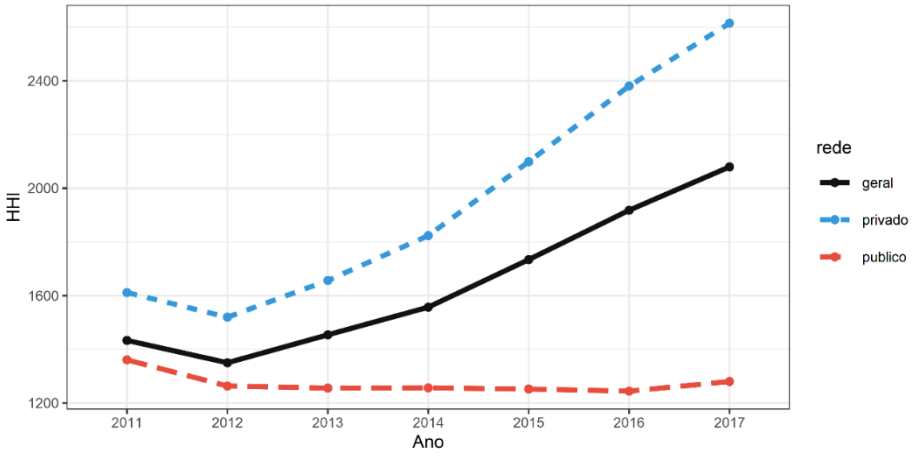
The goal was to measure the distribution of graduates in the system between the two periods analyzed and between the public and private sectors. The calculation was performed using the HHI package in R (Waggoner, 2018). The index varies between 1 and 10,000. If all graduates were equally distributed among the engineering specialties, the index would be 0, and conversely, if all graduates belonged to the same specialty, the index would be 10,000. In summary, the higher the index, the greater the concentration and the lower the differentiation. There is no established parameter for the diversity of higher education that allows us to assess whether diversity is high or low based on this index. Therefore, in this analysis, the index will be used only in relative

terms: whether the system and the sector have become more or less concentrated. The value was estimated using the following formula:

$$\sum_{i=1}^{N} \frac{r_j}{R}, i = 1, \ldots, n,$$

N represents the number of courses, r represents the number of students in course (i), and R represents the number of students in all courses. The technique was applied for each year (between 2011 and 2017), for the entire system, and then for each institutional sector.

Graph 3 - Concentration index of graduates by institutional type and year



Source: Prepared by the author, adapted from Higher Education Census - Inep (2011-2017).

Graph 3 shows the index value and its changes over the period (the higher the value, the more concentrated). The black line represents the HHI for engineering across the entire system (public and private). You can see that there was a concentration of graduates in specific specializations during the period analyzed. The separation between the sectors indicates that this concentration primarily occurred because of the grouping of private institutions. In 2011, the private sector already had a higher concentration than the public sector. While the public sector maintained a stable level of concentration, with a slight decrease in the index, the private sector became even more concentrated in 2017. Despite the number of engineering specializations, the

expansion dynamics, focused on a few specializations and the private sector, led to a more concentrated system over the period. As a result, the concentration in the system not only increased, but also the difference between the public and private sectors, which already existed in 2011, became even more pronounced.

5 Conclusion

The measurement of differentiation among engineering fields indicates a scenario similar to those in which there has been a greater standardization of higher education as it expanded. Graduates concentrated even more in a few engineering fields during this period. This corroborates analyses that have indicated that quantitative expansion tends to reduce internal differences in higher education (Harris; Ellis, 2020). The isomorphism identified for engineering primarily occurred due to the dynamics of the private sector, which not only expanded more than the public sector but also favored specializations that were already more populous.

While the dynamics found exhibit isomorphic characteristics, it's challenging to assert that the explanations for this phenomenon align with those offered by the literature. One of the main reasons for isomorphism is the tendency of institutions to copy successful models and avoid unsuccessful ones (Huisman, 2020). However, the dynamics between the sectors are too distinct to claim there is emulation of one by the other. Except for the cases of graduate concentration in civil engineering and the neglect of forest engineering, the overall context does not reveal significant similarities between the sectors.

While isomorphism would be caused by a process of institutions mirroring each other, specialization would be a product of niche-seeking. On the one hand, the dynamics of engineering in general are consistent with formulations about isomorphism; on the other hand, the differentiation between the sectors indicates a specialization-related dynamic. The private sector has become even more segmented,

focusing on traditional specializations and production engineering. Similar results were found in Balkan countries and in Portugal (Brankovic, cited in Fumasoli *et al.*, 2020; Teixeira *et al.*, 2012). In this case, the authors explain the greater specialization in the private sphere as institutions' response to students' demands. Following Fumasoli, Barbato, and Turri's (2020) approach, this could be explained by the private sector's higher susceptibility (organizational dimension) to environmental demands. The emphasis on expanding civil and production engineering shows that this sector sought a specific niche.

The result is the intensification of specialization in private institutions in the most popular areas. A similar process was found by Rossi (2009) in the Italian context. During student recruitment competitions, institutions tend to specialize in the most popular fields. Specialization, in this case, is not an attempt to differentiate from other institutions but to tap into a more secure demand. In Brazil, given the size of the private sector, its segmentation has led to a decrease in differentiation of the entire system. The isomorphism of specializations is mainly related to segmentation in private institutions. This segmentation did not occur because of an emulation of established institutional models but by investing in specializations with greater appeal to potential students.

The peculiarities of each sector draw attention to how environmental effects produce different outcomes. Distinct dynamics at the organizational level may explain why there are such differences in the diversification of specializations. Teixeira et al. (2012) speculate that, in the case of Portugal, regulatory constraints can hinder the opening of courses and their capacity to diversify. Just like in the case of Portugal, institutions' responses to these constraints in Brazil vary by sector.

In the country, the difference between sectors can be identified as a functional diversification of institutions. Institutional mission and how it affects the response to labor market demands are examples of this functional diversification. Unique structures in public institutions - their institutional mission, for instance - can explain why a particular sector ensured greater uniformity in the supply of engineering graduates to the labor market. Similarly, it would also explain the specialization of private institutions in their expansion process, focusing on meeting the demands of students and the market. Finally, the size of the sector itself can be a characteristic of this institutional mission. For public institutions, the goal would be to offer a more homogeneous but narrower pool of professionals to the market. For private institutions, the offering of professionals is both larger and more specific.

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