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Abstract
Higher education is crucial for the development of states and societies and improving the overall quality of life. However, entry into higher education is often influenced by factors beyond qualifications, and individuals in the field face suppression from the controlling parties. These challenges undermine the value of education and the integrity of democratic processes like elections. In this paper, we study academic freedom in Lebanon and propose a technique that dynamically extracts the factors that might affect academic freedom. This technique comprises multiple stages: data collection, data preprocessing, static extraction of factors, dynamic extraction of factors, and evaluation. In the data collection stage, data was obtained from 254 participants through a questionnaire that discusses various facets of academic freedom. The preprocessing stage enhances data quality through cleaning, normalizing, and transforming. For static extraction, factors impacting academic freedom are identified using naive K-means clustering. In dynamic extraction, the Apriori algorithm identifies key metrics. Finally, a customized K-means algorithm clusters data based on a specific metric. This algorithm was applied on both, the statically and dynamically extracted metrics, and comparison was done based on the accuracy of the resultant clustering. This comparison demonstrates the effectiveness of the proposed technique in identifying and analyzing factors impacting academic freedom.

Keywords Artificial intelligence · Higher education · Dynamic and static metrics · Clustering · Apriori algorithm · Equity

1 Introduction

The world is changing. Development, science, and technology are evolving at a fast pace, producing complex issues in different sectors and industries. This diversity challenges today's generations to cope with and contribute to those issues, creating a scene of innovation in the heart of every industry. Higher education intervenes to prepare students to be up to those challenges with the spirit of determination and grit. It is one of the key drivers of growth

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performance, prosperity, and competitiveness in national and global economies [1]. The state of artificial intelligence in higher education has seen a rapid rise in publications, with new trends emerging in terms of research locations, researcher affiliations, and subject domains [2]. In this article [2], the authors conducted a systematic review of Artificial Intelligence in higher education from 2016 to 2022, using a priori, and grounded coding, the data from the 138 articles were extracted, analyzed, and coded. The vast importance of higher education lies in its impact on society, economy, education, students, and world development. It aids students to acquire skills related to critical thinking, innovation, stepping out of comfort zones, teamwork, oral communication, and problem-solving. Designed to broaden an individual's knowledge and experience, higher education provides its holders with higher employability, creating a cloud of knowledge and civilization for society as a whole. By doing this, it provides countries with higher revenues, inducing governments to allocate a portion of their funds to this specific sector. Unfortunately, this vital sector faces a host of challenges that threaten its value. Applicants find themselves judged based on their political and religious background rather than the qualifications and capabilities they have gained in their lives. The better the connections the greater the possibility of acceptance is, regardless of value and educational level acquired. Empirical evidence shows that in Lebanon, academic freedom and admissions are influenced by sectarianism and political affiliations. Various studies, such as those by Altbach [3], discuss how political and religious factors impact higher education in Lebanon and other countries. Similarly, Agbo and Lenshie [4] explore how academic freedom in African countries is often compromised by political pressures. The stereotyping and discrimination observed in Lebanon can be generalized to other countries with similar socio-political dynamics. For instance, in Saudi Arabia, academic freedom is influenced by gender and age, as shown by Al-Saeed [5]. In Turkey, academic freedom is debated more philosophically than factually, indicating a need for more empirical studies, as highlighted by Ertem [6].

The socio-political system plays a crucial role in embedding academia. For example, in the United States, academic freedom is seen as a key indicator of liberal democracy but faces threats due to attacks on individual liberties, as discussed by Cole [7]. These examples underscore the importance of considering the socio-political context when examining academic freedom and the factors that influence it. Stereotyping can lead to discriminatory hiring practices where individuals are judged based on characteristics unrelated to their qualifications. This creates an environment where meritocracy is undermined, affecting both hiring and retention rates. In Pakistan, for example, gender inequality affects academic freedom and employment opportunities, with females facing more barriers than males [8]. In Africa, the lack of funding and political interference are significant barriers to academic freedom and employment stability [4]. These examples highlight the pervasive impact of socio-political factors on academic freedom and employment practices globally.

Adopting this mentality, academic institutions are impeded to achieve their lofty goal of building a knowledge-based society. Entities concerned such as professors, students, librarians, educational institutions, and society as a whole are subject to the rule of repression and restrictions that threaten the act of pursuing knowledge and research [9]. Reporting the right to educate and propose suggestions that appear awkward for authority or political parties, as absent also entails difficulties. In addition, in their decisions, proposals and opinions, the entities concerned may be deemed to be regulated, where it is forbidden to address any contentious material that could compromise the reputation of the political or religious parties supporting their presence in this sector. Deprived freedoms in this sector include the freedom in research and publications, the freedom to write and speak about any topic, and the classroom freedom of discussion. To sum up all these issues, it can be claimed that this sector is under the denial of academic freedom attack.

As Louis Menand once wrote, "Academic freedom is not just a nice job perk. It is the philosophical key to the whole enterprise of higher education" [10]. Regarded as a cornerstone of higher education, multiple aspects can influence academic freedom. In this paper, we propose a technique that dynamically extracts these metrics that play a role in the existence of academic freedom. Multiple stages can be outlined in the proposed method, where the preprocessing step was initiated after gathering real data from participants using a questionnaire. All missing values and irrelevant attributes were cleaned from the data and then converted into two versions, one consisting of pure nominal data and another of numeric data. After data collection and processing, the data are ready to enter the analysis stages. Further phases are aimed at extracting from a given dataset the metrics that shape academic freedom. Firstly, the extraction process is carried out statically by either adopting what is established in studies and research or implementing the clustering algorithm of K-Means and attempting to recognize common factors in a certain cluster of low or high academic freedom. Secondly, this operation, using the Apriori algorithm, is performed dynamically. The condition for considering an attribute as a metric of the given dataset is to have this attribute repeated in most of the strongly generated rules by the algorithm. Finally, a comparison is made to measure the performance of

dynamic extraction. It is carried out using a developed new version of K-Means algorithm that clusters a given data according to a given attribute. This clustering is conducted for each of the selected metrics and a comparison of the sum of square errors (SSE) of the resulting clusters is performed. The lower the SSE, the better the metric selected would be. Final findings revealed that dynamic extraction was able to obtain better metrics evidenced by the lower SSE values garnered after clustering.

The remainder of this paper is organized as follows. Section 2 presents an overview of techniques proposed for studying the metrics that might affect academic freedom. In section 3, we present a detailed illustration of the technique while exploring each of its stages. Section 4 exposes the simulation and the discussion of the obtained results. Finally, section 5 concludes the paper and gives directions for future work.

2 Related work

Academic freedom is not a modern concept; it has long been discussed and researched in a variety of countries. Many researchers debated its existence, others studied its impact and relation with higher education. [5] studied how academic freedom is being applied in a Saudi Arabia university. From data collected from different faculty members, the study showed that female members claim more academic freedom than their male peers, and younger members are more aware of their academic rights than older professors and academic staff. The study emphasized that the smooth operation of the university administration is often disrupted by this state of uncertainty of academic rights and freedom. In [11], a more narrow view of academic freedom as a professional privilege rather than a human right is previewed. Science, teaching, and speech independence were the categories included in this concept. It was also contended that intellectual freedom requires equality from authority, whether governmental, religious, or social. Academic freedom in Turkish literature was the core of what [6] studied. After reviewing sixty-one studies on research and scholarships in the Turkish literature, they found out that academic freedom was debated as a national, local, and structural term, but that most of these debates were philosophical rather than factually focused. More empirical studies of academic freedom are required, according to the paper, especially in the Turkish context. Moving to the United States, [7], argued that the presence of academic freedom is a key indicator of liberal democracy. Additionally, they stated that the creativity, discovery, research, and academic freedom of industrialized nations, including the United States are being exposed to jeopardy because of the attacks on the principles of individual liberty and freedom of expression. A study was conducted by [12], on the universities of Bologna mirroring the academic values in the European context, and the National University of Singapore is seen as a spot involved and engaged in the region's university developments. To fulfill the study's goal of gaining knowledge about academic freedom from various angles, interviews with a sample of participants who are diverse in their disciplines, career stages, and genders were done. After analyzing those interviews, the definition of academic freedom, its importance, its existence, associated obligations, and limitations were extracted to result out by stating that academic freedom varies from one country to another, and from one age to another as younger ages need to enjoy an equal amount of freedom as their supervisors to be fully integrated in the academic world. Also, funding was one of the main factors spotted out by the results, as it plays a role in the choice of research conducted whether theoretical or practical, because as stated practical research is favored as it consumes less time. While [13] tried to shape academic freedom and frame it in an academic scope, integrating the limits that might be imposed by the Federal Constitution of 1988. Along with this frame, [13], concluded that academic freedom is an umbrella for various freedoms including the freedom of teachers to teach, students to learn, researchers to research, and knowledge to be shared. As for the Federal Constitution of 1988, it enshrines the teacher's right to expose only reasonable ideas and positions, i.e. considering the right to education as a mechanism for preserving ideological pluralism, rather than a standalone freedom. [14] went further to elaborate on academic freedom being a stiff wall protecting universities and their members from any governmental or other universities' intrusion. In that scope, the author expressed the danger of exceptional cases where academic freedom is used by professors in a classroom to harass, bully, or verbally assault students the idea of putting limits to academic freedom. But, at last, he emphasized by the assistance of the First Amendment that protects the speech of all thoughts, including those that are controversial, uncivil, repulsive, or worrisome, that intrusions on academic freedom must be battled from the beginning, and if those challenging cases were encouraged, they will gain momentum in suppressing free expression, and it will become more difficult to defend the respected speech. The research by [15] identified sixteen significant challenges facing universities in the United Kingdom, each posing a threat to their core mission. Among these, the issue of instrumentalism stands out. This mentality shifts the university's focus from the pursuit of knowledge for its own sake to objectives such as social mobility, career development, sustainable

futures, or economic rejuvenation. This shift frames academic freedom in materialistic terms, undermining its noble intent. Additionally, marketisation poses a threat to academic freedom by transforming students into customers and education into a commercial product. Financial crises also emerged as a challenge, highlighted ironically by the observation that while universities claim to be financially strained, they still invest heavily in non-academic roles.

In a related vein, [16] introduced the influence of social media on academic freedom. The features of social media, combined with academic institutions' concern for their reputation, have created an environment where expressions made outside university walls are more vulnerable and perilous than before. Universities now monitor and respond to faculty members' social media posts, sometimes criticizing, repudiating, or even punishing them for their comments. To foster a more supportive environment for such expressions, [16] recommended updating the guidelines of the American Association of University Professors (AAUP). This update would aim to protect social media posts and positions, addressing the current exploitation of the AAUP's silence on this issue by institutions to impose limits on individuals, which conflicts with the protections stated in First Amendment case law. Where [17] defines academic freedom in a simpler and broader approach saying that it is the freedom to do academic work. Using this conception, six freedoms were inserted under this definition, where academic freedom was defined as the freedom to teach, learn, and question, and considered as a type of intellectual freedom unique to academic positions and perspective, critical at all levels of education and in any other educational settings, collaborative, and institutional, and intrinsic to the academic credibility of any academic journey or organization. All this is to state that, the entirety of academic freedom can not be accomplished without understanding its relevance to all academics and its position in all academic contexts. Cormac McGrath et al. [18] examine the attitudes of university teachers toward the adoption of artificial intelligence (AI) in higher education, employing an experimental philosophy approach. Through an online survey involving three distinct scenarios, focusing on first-generation students, a typical student, and students with learning disabilities, and 18 consistent questions, the study gathered responses from 194 out of 1773 teachers. The findings highlight varying perceptions of responsibility and equity in AI implementation, with a notable willingness to use AI tools to support equitable outcomes, particularly for first-generation and disabled students. Additionally, the results show significant differences in responses based on demographic factors such as gender, age, and academic position in certain cases. The study also uncovers prevalent concerns among teachers regarding fairness, responsibility, and their understanding and resources for integrating AI into teaching practices.

Specialized to countries, [4] explores the relationship between the state and academics to determine the dialectics of African academic freedom struggles. In Africa, the challenges of intellectual freedom through academic institutions are tied to the lack of funding and oppressive state authority, where the political class when gained power after independence, was hesitant to permit academic freedom to intellectuals on whom they depended heavily for fear of losing power. So academic freedom was only allowed to the degree that it does not coup the citizens against the state. [4] also stated that the reluctance of African academics to criticize Africa's political elites is to blame for the system's deterioration, where they have also been charged with being quiet while encouraging African leaders to plunder wealth for personal benefit by using religion, territory, race, and other primal identities to mislead the population. Moving to Pakistan, [8], found that higher education is not equal for both genders, where females' academic freedom is less than that of males, where societal values clash with corporate politics, placing female workers at a disadvantage. In that scope, the author suggested that the Higher Education Community (HEC) should introduce educational programs to teach male workers about the importance of women's jobs and responsibilities in society which necessitates a shift in mindsets to be more accepting of female employees and the 'cleansing of the male mentality'. Finally, [19] conducted a comparative study using systematic data analysis to define academic freedom in India and the United States and explore where academic freedom is more safeguarded. As a result, the author found that both have similar definitions of academic freedom, yet different protection mechanisms. India was found to have breaches in the Indian Penal Code, used to outlaw freedom of expression when it is incompatible with the country's dignity and reputation, the government has the power to curb it and the insanity activities designed to insult religious sentiments and expression that encourages religious hatred within Higher Educational Institutions (HEI). Thus the study proposes that some particular provisions of the Indian Penal Code be revised to secure academic freedom in India.

3 Proposed technique

As a definition, academic freedom might seem plain, but it is deep. It lies at the core of every educational institution's mission. The existence of academic freedom can be closely linked to the development of the higher education system. It can be stated as the freedom of the professor to teach and the freedom of the student to learn [3]. This simple definition

holds the profound meaning of having no external control over the professor and no limitations on the curiosity of students to ask. However, academic freedom is struggling to exist in an environment that comprises several factors influencing it. In this section, we introduce a technique that provides the ability to extract dynamically the metrics that affect academic freedom. This operation of extracting metrics can be done statically, but using the proposed technique, better factors are extracted. This is evident by the accuracy of resulting clusters of clustering data based on these factors. The proposed technique relies mainly on the Apriori algorithm and a customized version of the K-Means clustering algorithm. Figure 1 illustrates the five stages of the technique, with the algorithm and procedure done in each of them. In what follows, is an exploration of each stage.

3.1 Sample selection

Participants were selected based on their expertise in the higher education sector. They included employees and academic staff from both government and private sector institutions in Lebanon. The participants were aware of the content of the questionnaire and voluntarily accepted participation. To ensure the reliability of the questionnaire, it was pre-tested with a smaller group of similar participants to check for consistency in responses. Content validity was established by having the questionnaire reviewed by experts in higher education and academic freedom. Construct validity was ensured through factor analysis to confirm that the questions effectively measured the intended constructs.

3.2 Data collection

The primary stage of the proposed technique is gathering data about academic freedom and its level of dependence in Lebanon. To collect data, a questionnaire was formulated comprising 69 questions tackling different aspects of interest. Two versions of the questionnaire were prepared, one in English and the other in Arabic. A web-based application was created to conduct this questionnaire. The link to this application was distributed to employees and academic staff in official and private departments in Lebanon, and responses were accepted in the period between 11 May, 2023, and 24 June. In total from both the Arabic and English version, 254 participants registered a record. The questions of the survey were perfectly studied to cover a variety of titles. Each title can be regarded as a section in the questionnaire, containing a set of questions. Those sections can be listed as such:

- *Demographic questions*: As the title states, questions about age, gender, country of residence, workplace, university, and position are asked in this section. Seven questions are involved under this title.
- *Academic Freedom in General*: This type of question aims to collect information about the current state of academic freedom in educational institutions and how participants look to academic freedom. For this purpose, seven questions are asked under this title.
- *Essentials of Academic Freedom*: Four questions aiming to understand if the essentials of academic freedom do exist were specialized to this part of the questionnaire. Questions included asking about freedom in teaching and discussion in classes, freedom in suggesting ideas, especially controversial ones, and whether there exists any political or religious prejudice when considering job decisions.

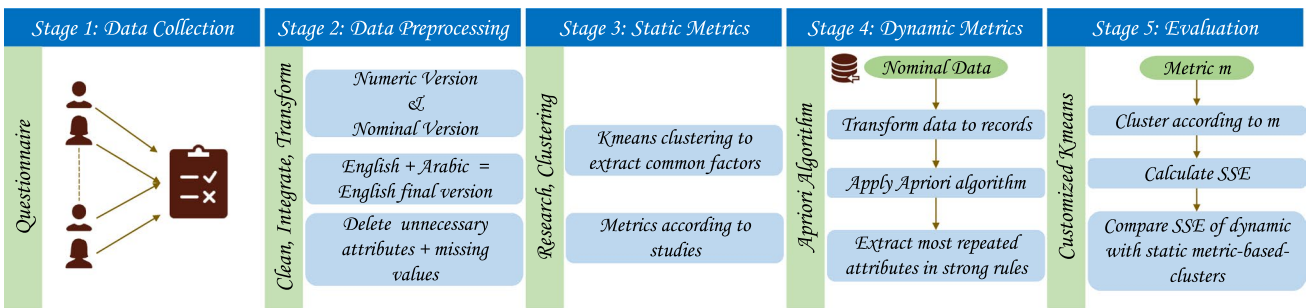

Fig. 1 Architecture of the approach

- *Flow of Knowledge*: Questions in this part enquire about freedom of thought, decisions, and whether there are protecting laws for academic freedom. Four questions were dedicated to fulfilling the aim.
- *Environmental Issues*: As the title implies, the four questions in this part are all related to the link between academic freedom and society in general.
- *External Forces*: In this survey, our mere goal is to examine the factors that might influence academic freedom. Eight questions in this section were dedicated to collect the needed information about factors like politics, religion, positions, and others.
- *Educational Objectives and Policies*: Funding preferences for academic freedom, research, access to libraries, and the extent of acquiring academic freedom are all interrogated in a set of seven questions under this title.
- *Institutional Accountability*: Three questions to shape the responsibility of the academic institutions were put in this section.
- *Rights and Freedoms of Higher-Education Teaching Personnel*: The two questions in this section are bounded to ask if the entrance to the higher education sector is judged solely by qualifications or other factors that contribute.
- *Terms and Conditions of Employment*: This is one profound part of the survey that enquires about the bond between employment in particular in academic institutions and academic freedom. 12 questions related to the job positions, salaries, perks, employing criteria, promotions, and other job-related aspects, were inserted under this title in the questionnaire.
- *Free Teaching Profession*: The majority of the ten questions in this section are to be answered by a number from 1 to 10. The scope of this section is testing the extent of the influence of factors that affect academic freedom. For instance, political, economic, and religious challenges are questioned.

Out of the 69 questions, only 65 of them were promoted to the second stage of the technique. The four eliminated attributes were the ones that hold multiple answers resulting from multiple-choice questions. This measure was considered to mitigate the complexity in the following levels of analysis.

3.3 Data preprocessing

The trivial tunnel that data shall pass through after being collected is processing. Applied to the used dataset are cleaning, integrating, and transformation.

- Cleaning: Upon collection of data, participants may leave intentionally or unintentionally an empty field. Those missing values are in particular treated in the cleaning stage, in addition to the removal of irrelevant data. The type of all data fields is either a number or a word, whenever a number is missing it is replaced by 0, while if a word is missing it is replaced by "none". This criterion was considered because the percentage of missing values was small. As for the removal of irrelevant data, the date of filling the survey that was added to the records was removed because it lies out of the scope of our interest.
- Integration: As mentioned earlier, two copies of the survey were prepared and the records collected from each can be seen in Table 1. To integrate the records from both surveys, the Arabic records were translated to English to end up with a single final English version of 254 records. This version is to be used in further stages.
- Transformation: In this phase of processing, the data were rendered to create two versions: one consisting purely of nominal values and another consisting purely of numeric values. This step was of profound importance because the used machine learning algorithms require a specific type of data. In particular, the Apriori algorithm only accepts nominal attributes. The K-Means clustering algorithm can accept both, yet it depends on the criteria for calculating the difference between any two records. In our case, the difference is computed via the Euclidean

Table 1 Records per Survey

	Number of data records
Arabic	139
English	115
Total	254

Table 2 Types of Collected Data

Type	Number of attributes
Numeric	9
Nominal	60
Total	69

Table 3 Numeric to nominal

Numeric Range	Replaced By
[1,3]	LOW
[4,6]	MEDIUM
[7,10]	HIGH

distance which calls for numeric values to be given as parameters. To perform this operation, first, we studied the nature of the used attributes as presented in Table 2.

To create a pure nominal version, the nine numeric values had to be treated. Those values are answers to questions that ask "To what extent...", and so they range from 1 to 10. The treatment of those attributes is illustrated in Table 3.

To create a pure numeric version, all 60 nominal attributes had to be treated. The yes-no questions were simply replaced by 1(yes) and 2(no). Similarly, other types of questions were replaced, for example, if a question has five distinct answers, then they are replaced by numbers from 1 to 5 respectively.

3.4 Static metrics

Organizational innovative strategies in the hyperdynamic environment are locked in the historical path of decision-making. The reason why organizations lose their flexibility and fluidness and become sticky and rigid relies on the drawn paths they form intentionally or unintentionally over time. Awkward practices, built-in rational maps, and group culture and thinking constitute the major conditions that lead organizations and universities to become path dependent according to the literature. Their strategies become irreversible and past events map future actions; contrary of strategic management. Decisions become historically inured. The educational institutions if path dependent, will be rigid with conditioned innovation and pre-drawn nonergodic outcomes [20]. According to [21], path dependence refers to complex nonergodic processes that are 'unable to shake free of their history' [22, 23].

[20] determined "three developmental phases of path dependence (Fig. 2), starting with (1) singular historical events, (2) which may, under certain conditions, transform themselves into self-reinforcing dynamics, and (3) possibly end up in an organizational lock-in". each phase develops under different administrations, but the path continues to be shaped. Different studies identify self-reinforcing practices as dynamics that tend to build up a specific path of decision with a state of total inflexibility. The first phase is the preformation phase where the adoption of a choice is unpredictable. The picked decision, or critical juncture, becomes the push towards a self-reinforcing process. The second phase comes when a new regime reinforces the afore dynamics and makes the system more irreversible. Hence, the extent of choices diminishes and the decision processes remain contingent but nonergodic. Constrictions increase to reach the third phase, the lock-in phase with a patterned decision. The organizations end up with a repeated predominant approach with an inefficient system. However, the social character of organizations gives them a narrow range of unpredictable decisions that effectively will not alter the routine action pattern.

As a result, to test whether academic freedom is path dependent, a longitudinal study would be appropriate or more conveniently, a cross-sectional study of academics comparing three age groups that will represent the trend of thought of an ensemble of academics over a long time as per ergodic studies [23].

Thus to extract the factors that might impact academic freedom, in this phase we counted on what research and studies have accomplished. Another approach could have been considered, which is applying the simple K-Means clustering,

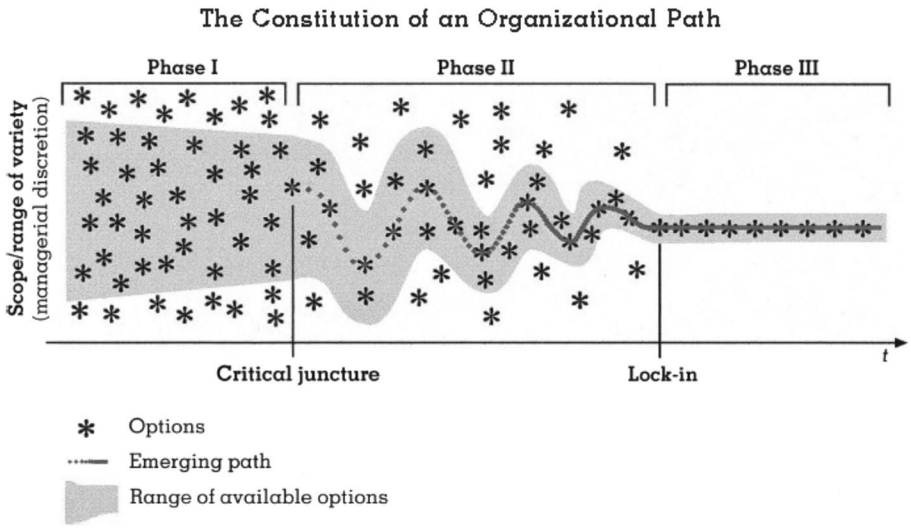

Fig. 2 Developmental phases of path dependence [20]

and trying to observe common factors among clusters. Yet in our case, this was not efficient because the data were not strongly correlated. Being so, we counted on research and studies to get static metrics. As a result, we considered age and description as two metrics that affect academic freedom. The age in our dataset can have three values "Less than 35 years", "Between 35 and 50", and "More than 50". Whereas the description attribute specifies the position of the filling participant. This attribute can hold the following values: "A researcher", "A full-time professor", "A part-time professor", "An hourly-paid lecturer", "An academic-related staff".

3.5 Dynamic metrics

This phase of the chain is the core of this technique. In an attempt to dynamically extract the factors that influence academic freedom, the Apriori algorithm was used. The Apriori algorithm is a very simple algorithm for identifying frequent itemsets from large transactions in the database. The name of the Apriori algorithm is derived from the fact that this algorithm uses previous knowledge of frequent itemsets for the next iteration process [24]. The resulting itemsets undergo rules analysis to generate rules having support, confidence, and lift values meeting the conditions. The equations to calculate those criteria are provided below respectively:

- Support value: The support value of an association rule is a measure of how frequently the itemset appears in the dataset. Specifically, it is the proportion of transactions in the dataset where both X and Y occur together, where T is the total number of transactions.

$$sup(X \rightarrow Y) = \frac{Number\ of\ transactions\ containing\ X\ and\ Y}{Total\ number\ of\ transactions} = \frac{|X \cup Y|}{|T|} \tag{1}$$

- Confidence value: Is a measure of the reliability of an association rule. The confidence value measures the number of transactions containing both X and Y and the number of transactions containing X.

$$conf(X \rightarrow Y) = \frac{Number\ of\ transactions\ containing\ X\ and\ Y}{Number\ of\ transactions\ containing\ X} = \frac{|X \cup Y|}{|X|} \tag{2}$$

- Lift value: Is a measure of the strength of an association rule compared to the expected frequency of Y if X and Y were independent. It shows the validity of the transaction process, where the confidence of a transaction $conf(X \rightarrow Y)$ is normalized by the support $sup(X \rightarrow Y)$.

$$lift(X \rightarrow Y) = \frac{conf(X \rightarrow Y)}{sup(X \rightarrow Y)} \tag{3}$$

The application of this algorithm in the scope of this technique is examined in Algorithm 1. First, the dataset is transformed into a set of "records" to be ready to enter the algorithm. Each data record in the dataset is transformed into an Apriori record. Those records take the form of transactions having items, as it is well known when using Apriori. So for instance, as seen in Fig. 3, "A=Yes" and "B=No" are two itemsets.

Algorithm 1 Apriori Algorithm

Require: Nominal Dataset $\mathcal{D}$
Ensure: List of selected metrics: $\mathcal{M}$.
$\mathcal{M} \leftarrow \emptyset$
Records $\leftarrow \emptyset$
for each row $\in \mathcal{D}$ **do**
  Formulate a record $\mathcal{R}$
  Records $\leftarrow$ Records $\cup\, \mathcal{R}$
end for
for $conf \leftarrow 6$ to 9 **do**
  $conf \leftarrow conf/10$
  for $sup \leftarrow 6$ to 9 **do**
    $sup \leftarrow sup/10$
    $rules \leftarrow$ apriori(Records, $conf$, sup)
    for $r_i \in rules$ **do**
      if lift$(r_i) < 1$ **then**
        Remove r_i from $rules$
      end if
    end for
    $\mathcal{M} \leftarrow \mathcal{M} \cup$ item in rules with highest frequency
  end for
end for

Considering A, B, C, D, and E as attributes, the data record illustrated becomes as seen in the figure. After applying the same criteria to all data records, the Apriori records are sent to the algorithm, in addition to specified confidence and support. As for the lift value, only rules with lift > 1 are accepted.

After the Apriori algorithm is applied, and rules complying with the conditions of specified support(sup), confidence(conf), and lift are generated, those rules are treated to extract the attributes found in each rule. For instance,

- Example of rules:R1: {A=Yes} → {B=Yes, C=Yes, D=Yes} (conf: 0.958, supp: 0.906, lift: 1.006) R2: {A=No} → {E=Yes} (conf: 0.968, supp: 0.926, lift: 1.306)
- Attributes extracted from the rules are:R1:{A, B, C, D}R2:{A, E}
  - A: 2
  - B: 1
  - C: 1
  - D: 1
  - E: 1

To extract the metrics, the algorithm is repeated on a set of values for confidence and support. For each support *sup* and confidence *conf*, we count the repetition of each extracted attribute from the generated rules, the most repeated

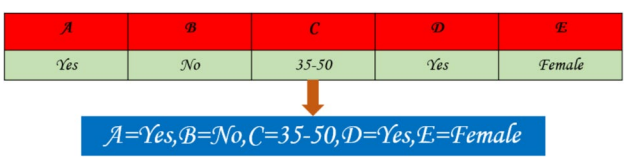

Fig. 3 Record Formulation

item is regarded as a metric. For different values of confidence and support, multiple metrics can be extracted. In this example, attribute A is mostly repeated, then "A" is considered a metric.

3.6 Evaluation

This is the final stage of the technique, where the comparison between the accuracy of the factors extracted statically and dynamically is examined. To do this comparison, the usage of the K-Means clustering algorithm was required. Yet, the used algorithm is not the naive simple one, but a customized version developed for the purpose. In this study, K-Means Clustering was employed to categorize the survey data into distinct clusters based on 69 attributes related to academic freedom. The attributes were selected through a comprehensive review of existing literature, expert consultations, and preliminary data analysis to ensure their relevance to academic freedom. The clustering process involved initializing centroids and iteratively assigning data points to the nearest centroids based on Euclidean distance, refining the clusters until convergence was achieved. This method allowed us to identify patterns and group respondents with similar perceptions and experiences of academic freedom, providing a nuanced understanding of the factors influencing academic freedom in different contexts. The K-Means is generally an iterative algorithm in which the process begins by choosing an initial centroid randomly for each cluster and the number of clusters to be created. Then, using the Euclidean distance, each data point is allocated to the nearest centroid, and the first cluster creation round is done. The cluster centroids are then modified and the procedure is replicated before convergence is achieved (Algorithm 2). As for the customized K-Means algorithm used in this technique, the process begins by specifying additionally a metric to cluster upon (Algorithm 2). The difference in application is that, when calculating the distance between two data points, this metric, which is originally an attribute found in the dataset, is removed from the calculation process.

Algorithm 2 Customized K-Means Clustering Algorithm

Require: Set of data points: $\mathcal{P}$; Clusters number: $\mathcal{K}$; Metric $\mathcal{M}$.
Ensure: clusters: $\mathcal{C} = \{C_1, C_2, \ldots, C_K\}$.

for $j \leftarrow 1$ to K **do**
  randomly choose centroid c_j among $\mathcal{P}$ belongs to C_j
end for
repeat
  for each data point $P_i \in \mathcal{P}$ **do**
    minDist $\leftarrow$ min
    for each cluster $C_j \in \mathcal{C}$ **do**
      new$P_i \leftarrow$ Remove $\mathcal{M}$ from P_i
      new$c_j \leftarrow$ Remove $\mathcal{M}$ from c_j
      d $\leftarrow$ EuclideanDistance(newP_i,newc_j)
      if d $<$ minDist **then**
        minDist $\leftarrow$ d
      end if
    end for
  end for
  for each cluster C_j, where $j \in \{1, \ldots K\}$ **do**
    Update the centroid c_i to be the centroid of all records currently in C_j
  end for
until Convergence
return $\mathcal{C}$

After applying the K-Means clustering algorithm, the accuracy of the resultant clusters must be tested. For this purpose, the sum of square errors (SSE) is used. The SSE value is computed using the equation below. To interpret this value, it is stated that the lower the value is, the higher the accuracy and the better the results are.

$$\mathcal{SSE} = \sum_{j=1}^{k} \sum_{x \in C_j} distance(x, m_j)^2 \tag{4}$$

where C_j is the j^{th} cluster; m_j presents the centroid of C_j; $distance(x, m_j)$ is the distance between a data point x and the centroid m_j.

4 Performance evaluation

In this section, we will emphasize the importance and accuracy of the proposed technique to extract dynamically better metrics that mostly influence academic freedom. The implementation was accomplished using the Python language.

4.1 Attribute definitions

Before presenting the detailed results, we define the key attributes used in our analysis:

- Gender: The gender identity of the respondent.
- Age: Categorized into three groups:–Less than 35 years–Between 35 and 50 years–More than 50 years
- Professional Description: The professional role of the respondent (e.g., researcher, professor).
- HighestDeg: The highest degree obtained by the respondent.
- UnivYears: The number of years the respondent has worked in a university setting.
- SECHigherEdu?: Whether the respondent believes higher education plays a role in social equity and change.
- ReshapeEdutoSEChanges?: The respondent's view on whether education should be reshaped to promote social equity.
- TPParticipate?: Whether the respondent participates in political or social activities.
- AcedCommVulnerableToPoliticalPressures?: Perception of the academic community's vulnerability to political pressures.
- RightToEduEnjoyedInAnAtmosphereOfAcademicFreedom?: Whether the respondent enjoys their right to education in an atmosphere of academic freedom.
- TypesOfDiscriminationInEdu?: Types of discrimination faced in the educational setting.
- RightToPutNewIdeasWithoutLosingYourJob?: The right to express new ideas without the fear of job loss.
- FreedomInTeachingAndDiscussionInClass?: Freedom to teach and discuss topics in class.
- FiredIf_OfDifferentPoliticalParty_RefuseToRevealUrPoliticalBeliefs?: The risk of being fired for political beliefs or affiliations.
- HinderedUFromUrRightToPursueTruthInUrOwnWay?: If respondents feel hindered in their pursuit of academic truth.
- LoseJobForPublishingIdeasUnfavorableTo?: Risk of losing a job for publishing controversial ideas.
- AcFreImportantForSociety?: This attribute measures the perceived importance of academic freedom for societal development.
- VulnerableToPoliticalPressure: Indicates the perceived susceptibility of academic freedom to political influence.

The attributes used in this analysis encompass a broad range of factors affecting academic freedom. These include:

- Demographic Factors: Such as age, gender, and country of origin, which can influence personal experiences and perceptions of academic freedom.
- Institutional Characteristics: Such as the level of institutional independence from state control and the existence of policies supporting academic freedom.
- Personal Experiences: Such as the ability to publish freely, engage in political debates, and participate in international academic collaborations.

Each attribute was selected for its potential impact on academic freedom, allowing us to create a comprehensive profile of the academic environment as experienced by respondents. This detailed analysis enables us to pinpoint specific areas where academic freedom is either upheld or compromised.

4.2 Apriori implementation and results

As stated before, the Apriori algorithm was used in the mission of extracting metrics dynamically. The algorithm was tested for 16 different combinations of confidence and support values, attaining a lift value greater than one to ensure a positive correlation between the different sides of the rule. The number of rules generated in each of those 16 permutations of confidence and support values are presented in the graph of Fig. 4.

After generating the rules, and the rules are treated by extracting the comprising attributes from each, the frequency of the detected attributes is calculated. The result of this step is a graph generated from code for each value of confidence and support, showing the detected attributes and the frequency of each in the generated rules.

Figures 5, 6, 7, and 8 show the most frequent attribute in the rules generated for different values of confidence and support. The results for the 16 graphs of the 16 different combinations of confidence and support values, with the most frequent attribute are presented in Table 4.

Extracting the dynamic metrics and concerning Table 4, we would end up with three attributes: "AcFreImportantForSociety?", "ReshapeEduToSE", and "VulnerableToPoliticalPressure".

4.3 K-means and comparison

After performing the above steps, it is time to validate and prove the added value of this technique to the world of academic freedom and data analysis. To do this, we applied the customized K-Means clustering algorithm (Algorithm 2) according to the aforementioned static (Age and Description) and dynamic (AcFreImportantForSociety?, ReshapeEduToSE, and VulnerableToPoliticalPressure) chosen metrics. Then we calculated the sum of square errors of the resulting clusters in each of the cases. The final results of the metrics with the SSE, using four as the number of clusters created in each case, are presented in Table 5.

In an examination of the SSE values illustrated in Table 5, we can see that the SSE value of the clusters resulting from any dynamic metric is lower than all SSE values of clusters resulting from the static metrics. The lower the SSE, the more accurate the cluster results. Starting from this interpretation we can conclude that the proposed technique was able to provide dynamically, better metrics affecting academic freedom than statically.

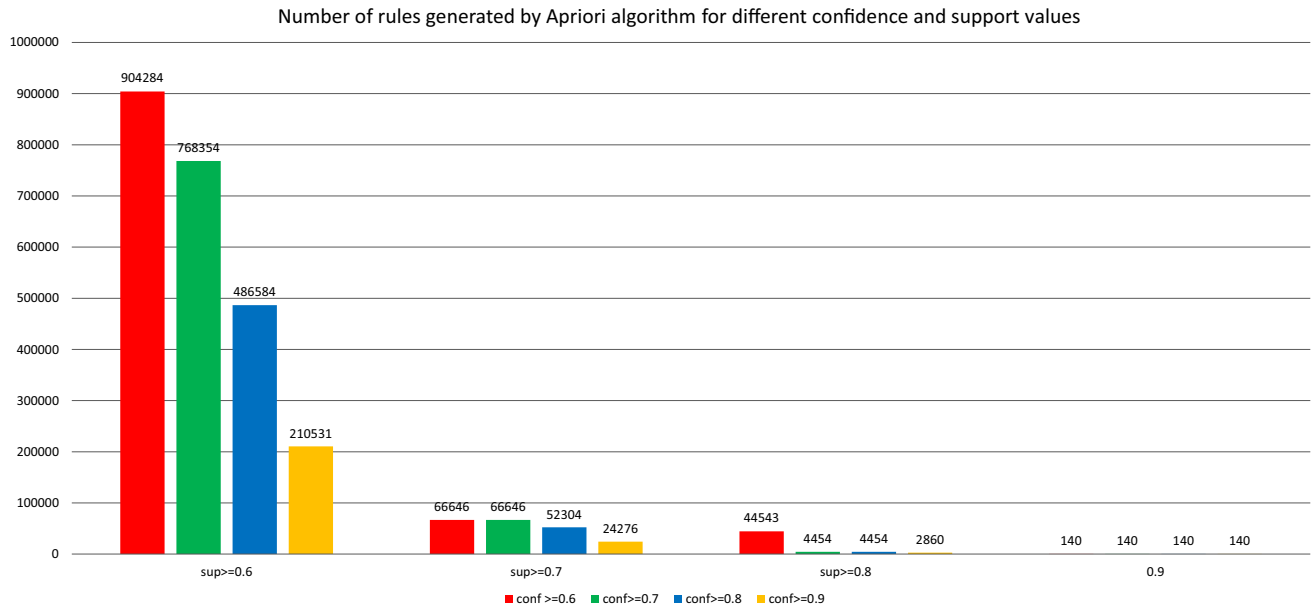

Fig. 4 Number of generated rules for different support and confidence values

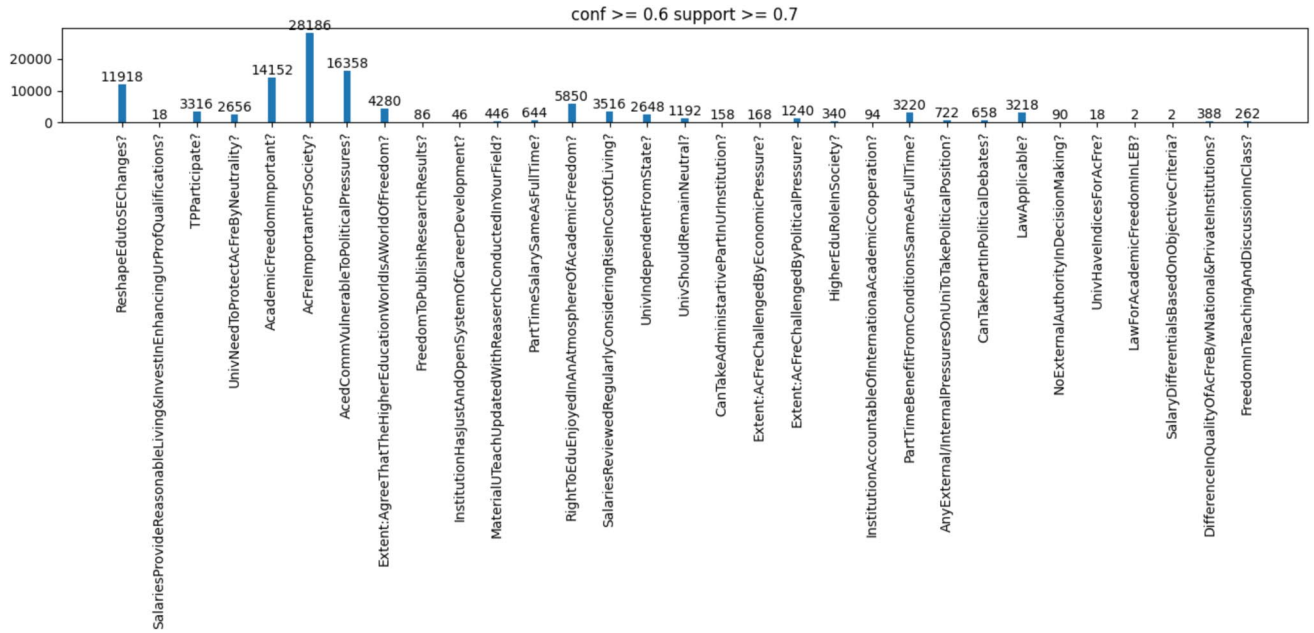

Fig. 5 Rules and attributes detected for (conf ≥ 0.6, sup ≥ 0.7)

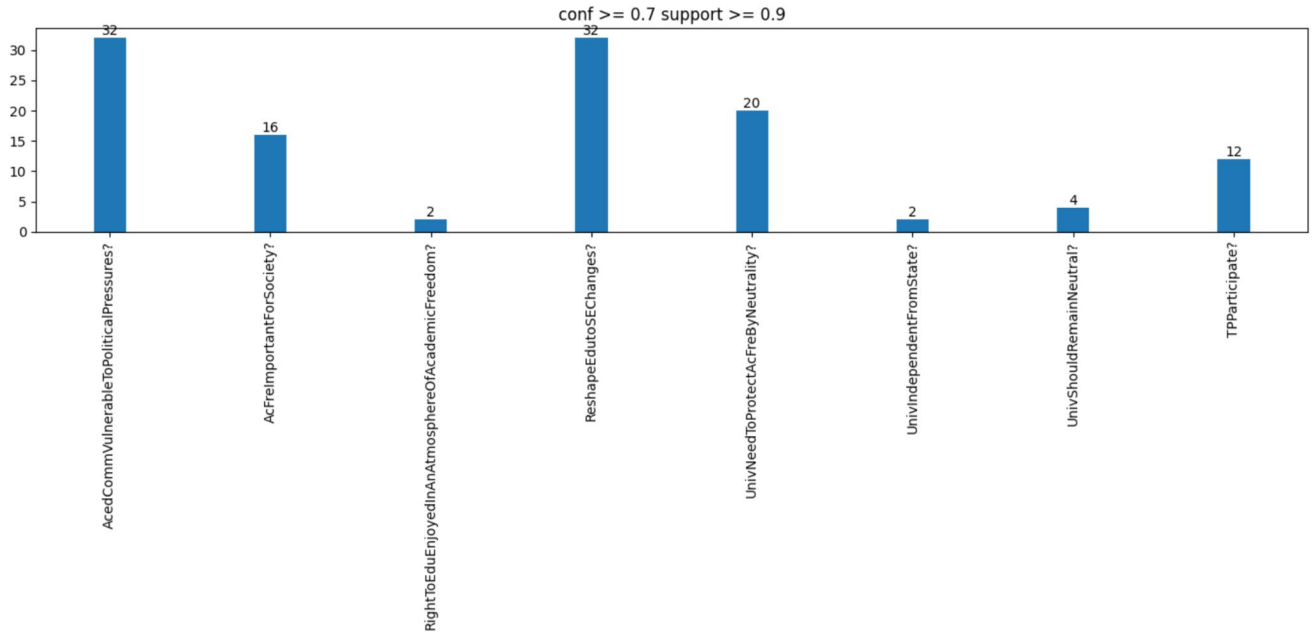

Fig. 6 Rules and attributes detected for (conf ≥ 0.7, sup ≥ 0.9)

5 Conclusion, study implications and future works

In conclusion, this research delved into the elements impacting freedom, in Lebanon using K-Means clustering to pinpoint characteristics and their connections. The analysis uncovered that factors like religious ties, age and institutional policies play a role in determining academic freedom. The study shed light on the difficulties academics in Lebanon face due to pressures and discrimination linked to political and religious views.

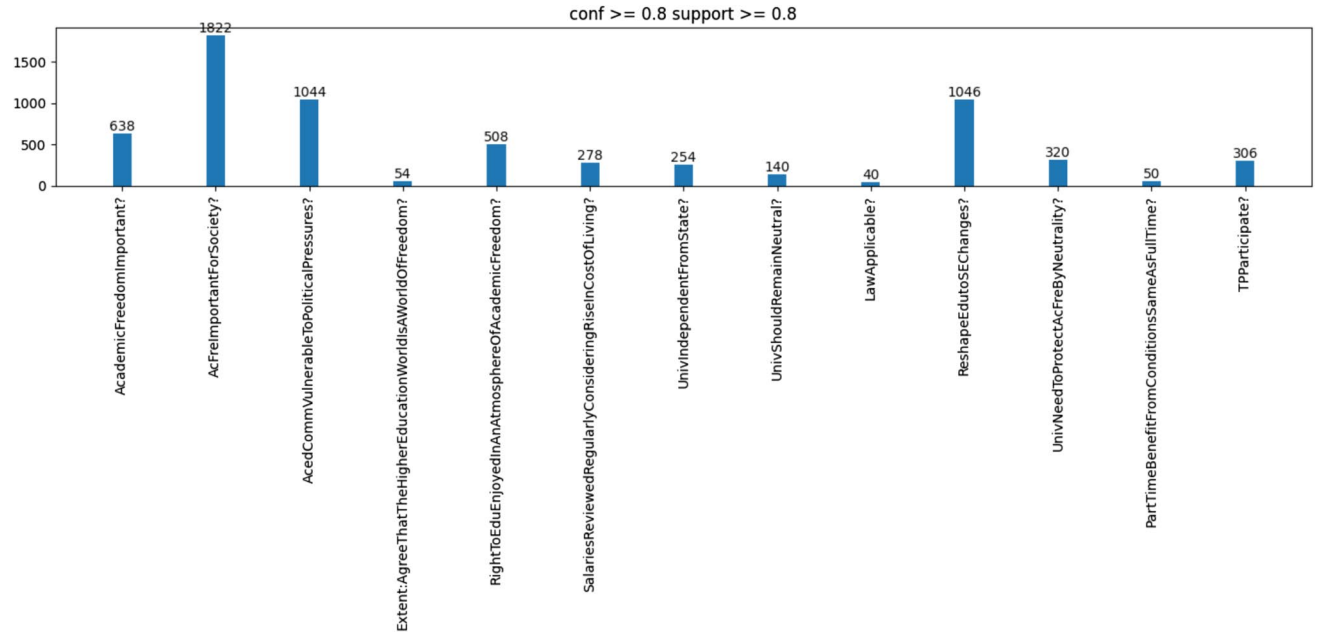

Fig. 7 Rules and attributes detected for (conf ≥ 0.8, sup ≥ 0.8)

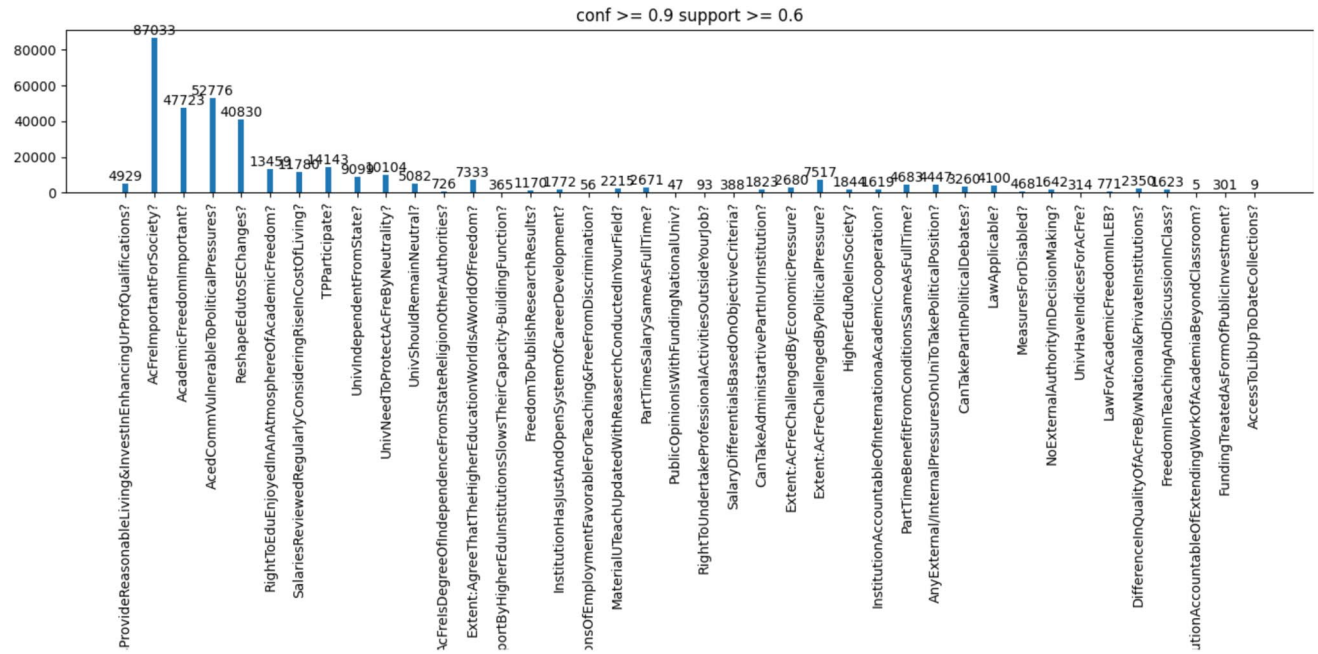

Fig. 8 Rules and attributes detected for (conf ≥ 0.9, sup ≥ 0.6)

5.1 Implications of the study

The results emphasize the need to address cultural biases within settings. Policymakers and educational leaders must acknowledge these biases in order to foster an open academic atmosphere. The study methodology provides a framework for examining freedom in similar circumstances offering valuable insights for regions with comparable sociopolitical landscapes. Promoting freedom requires implementing policies that reduce influences and promote inclusivity ensuring that educational institutions serve as impartial hubs of knowledge and research.

Table 4 Results of Apriori Algorithm

Confidence	Support	Most Repeated Attribute
0.6	0.6	AcFreImportantForSociety?
	0.7	AcFreImportantForSociety?
	0.8	AcFreImportantForSociety?
	0.9	ReshapeEduToSE, VulnerableToPoliticalPressure
0.7	0.6	AcFreImportantForSociety?
	0.7	AcFreImportantForSociety?
	0.8	AcFreImportantForSociety?
	0.9	ReshapeEduToSE, VulnerableToPoliticalPressure
0.8	0.6	AcFreImportantForSociety?
	0.7	AcFreImportantForSociety?
	0.8	AcFreImportantForSociety?
	0.9	ReshapeEduToSE, VulnerableToPoliticalPressure
0.9	0.6	AcFreImportantForSociety?
	0.7	AcFreImportantForSociety?
	0.8	AcFreImportantForSociety?
	0.9	ReshapeEduToSE, VulnerableToPoliticalPressure

Table 5 Clustering Results of dynamic metrics and static metrics

Type	Cluster according to attribute	SSE
Static Metrics	Age	12498.544148722664
	Description	12287.817810005254
Dynamic Metrics	AcFreImportantForSociety?	12286.678779237955
	ReshapeEduToSE	12283.496694130808
	VulnerableToPoliticalPressure	12260.452711223203

5.2 Future directions

Subsequent research should build upon this study by exploring factors influencing freedom, such as economic pressures and gender dynamics. Longitudinal studies could offer an understanding of how these elements change over time. Moreover applying the framework to regions, with varying sociopolitical backgrounds can help validate the findings and broaden the applicability of the results. Working with scholars from, around the world can offer viewpoints. Enrich the overall comprehension of academic freedom, on a global scale.

Author contributions All authors contributed to the study conception, literature review, and design. N.J., H.H., and C.Z. performed material preparation, data collection, and analysis. Validation was done by A.R., N.M., L.S., and L.T. The first draft of the manuscript was written by N.J. H.H., A.R., and C.Z. reviewed and edited the manuscript. All authors commented on previous versions of the manuscript. All authors participated in follow-up meetings related to the research. All authors read and approved the final manuscript.

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Data availability The data that support the findings of this study are available from the authors upon request due to restrictions eg privacy or ethics.

Declarations

Ethics approval and consent to participate The study was performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. Ethical approval for this study was obtained from the Scientific Committee of the Faculty of Economics and Business Administration, Lebanese University. Informed consent was obtained from all individual participants included in the study.

Consent for publication Informed consent was obtained from all subjects involved in the study.

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