A Glance at Performance Management in Departments for Preparation of Secondary Mathematics, Engineering, Technology and Science Teachers in France

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Abstract

In France, secondary teachers are public sector employees. Becoming a STEM (Science, Technology, Engineering, and Math) teacher in secondary education is subject to passing public competitive entry examinations. Preparation for these examinations is provided in College Departments, which are essentially assessed on the basis of their success performance in the exams. This paper analyses the determinants of Departments' success performance. We first present the broad lines of the French system of secondary STEM teacher recruitment. Next, by means of statistical analysis of data from a survey of Departments, we isolate significant determinants of success performance. Finally, from this analysis, we derive some strategic implications for the management of STEM Departments' success performance.

Introduction

In France, secondary teachers are public sector employees. Every year, about 40 public competitive examinations are organized to recruit secondary teachers in Science, Technology, Engineering and Mathematics (STEM). Some 20,000 candidates take these examinations. Preparation for examinations is provided by Exam Preparation Departments, within the framework of IUFM (Instituts universitaires de formation des maîtres), which are University Institutes for Teacher Training. Exam Preparation Departments receive funding for their mission, and are assessed on the basis of their success performance in the exams. Therefore, it is important for Department Heads to know which factors determine success performance, in order to improve their Department's performance through adapting its pedagogical and material organization accordingly.

In this paper, we aim first, to isolate significant determinants of success performance in Departments preparing candidates for STEM teacher recruitment, and secondly, to emphasize the strategic implications of these determinants for the management of Departments' success performance.

French IUFM were created in 1990. Probably owing to the youth of these institutions, very few papers have been written so far on this topic in international academic literature. Therefore, we think that this paper should be relevant to readers generally interested in STEM education and STEM teacher preparation and recruitment, and especially to those interested in the French educational system.

First of all, in Part I, we intend to sketch the French system of secondary STEM teacher recruitment. Secondly, in Part II, we will present the method of analysis. Then in Part III, we will present and comment on the results obtained.

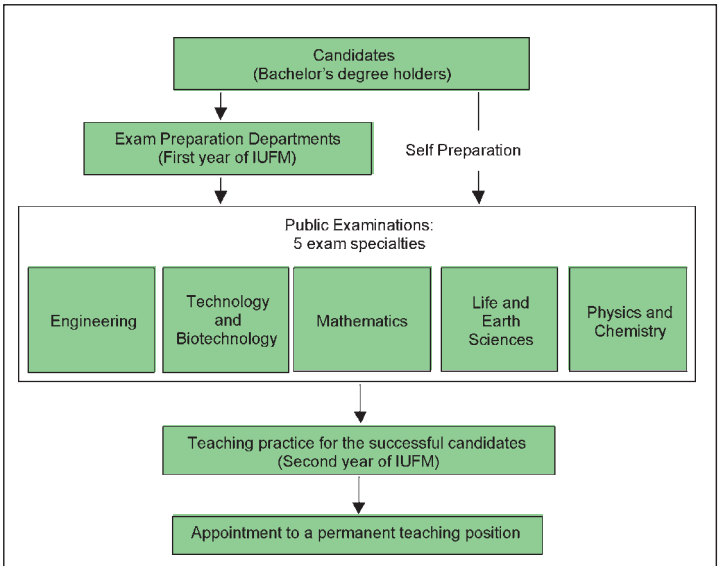
I. Some broad lines of the French system of secondary STEM teacher recruitment

Teacher recruitment examinations and examining boards are organized by the Ministry of Education. A predetermined number of posts to fill is set for each examination. The 40 STEM teacher recruitment examinations can be grouped into five main specialties:

- Engineering, including Civil Engineering, Chemical Engineering, Electrical and Electronics Engineering, Industrial Engineering, Mechanical Engineering, Optical Engineering, Thermal Engineering;
- Technology and Biotechnology;
- Mathematics;
- Life and Earth Sciences;
- Physics and Chemistry.

About 5,000 candidates pass these exams each year. Successful candidates go on teaching practice during one year. Save for exceptional circumstances, all trainees become qualified secondary STEM teachers.

Since 1990, preparation for the examinations, as well as training the successful candidates to teach, have been structured in the framework of the IUFM (Asher & Malet, 1996; Bonnet, 1996; Brisard & Hall, 2001; Caldwell & Mailhos, 2002; Cornu, 2002; Holyoake, 1993; Zay, 1997). There are 31 IUFM, spread across the whole national territory, including overseas. In each IUFM, several Exam Preparation Departments are organized, each Department preparing specifically for one examination. Not all specialties are covered in each IUFM, the coverage depending on social demand and on the available means. In 2001, 273 Preparation Departments for STEM teacher recruitment exams were active (CNE, 2001). IUFM and their Departments take part neither in the organization of the examinations nor in the examining



Graph 1. The process to become a secondary STEM teacher in France

boards. Graph 1 illustrates the general organization of the system.

Each Department is managed by a Department Head, nominated by the Director of the IUFM. The Department Head is in charge of the administrative and pedagogical organization of the Department. He/she chooses the educators and lecturers who teach in the Department. The Head also designs the program contents and schedules, the student recruitment policy, and the bibliographical policy, and deals with problems. A secretary's office provides administrative support.

II. Method and data

The method consists of isolating significant performance determinants by means of statistical analysis of data from a survey on Exam Preparation Departments.

Survey

The objective of the survey was to gather as much data as possible on success performance determinants. Generally speaking, a large number of factors may influence success performance. Table 1 gives some examples of such potential factors.

Many other potential determinants of success performance might be found, which have not been analyzed in this study. Table 2 provides some examples.

The survey was conducted from July 2002 to February 2003. All 31 existing IUFM were surveyed. 11 IUFM communicated their data. These data were complimented with national data published by the Ministry of Education. Thus, we have a representative sample, in which 121 Departments preparing candidates for STEM teacher recruitment (44.3% of the total), and 30 STEM teacher recruitment examinations (75% of the total), are represented. These data cover the period 1992-2002. However, only data relating to the first five factors (listed in Table 1) and to performance could be obtained.

Indicators

In regards to success performance, we make a distinction between three indicators:

- the number of successful candidates from a Department;
- the pass rate of the Department, which is the ratio

$$\frac{\text{Number of successful candidates from a Department}}{\text{Number of candidates from this Department who were effectively present at the exam}}$$

- and the share of the Department in the total number of successful candidates, which is the ratio

$$\frac{\text{Number of successful candidates from the Department}}{\text{Total number of successful candidates in this exam}}$$

Concerning the determinants, we take into ac-

Potential factor	Expected effect on the success performance of Departments
1. The national number of examinees	The higher the national number of candidates taking an examination, the lower the success performance of each Department preparing for this examination.
2. The size of the Department	The bigger a Department (for instance, the number of candidates registered in the Department), the higher the probability of having good candidates and, therefore, good success performance.
3. The number of posts to fill set for the examination	The higher the number of posts to fill set for an examination, the higher the success performance of each Department preparing for this examination.
4. The specialty of the examination	The nature of the examination tests vary according to the specialty of the examination. Therefore, the specialty may influence the success performance of Departments.
5. The location of the Department	Since context differs from one Department to another, success performance may be influenced by the location of the Department.

Table 1. Some potential factors of success performance in Exam Preparation Departments

Potential factor	Expected effect on the success performance of Departments
6. The quality of the Department's pedagogical staff	In so far as quality of the pedagogical staff can be measured, the higher the pedagogical quality, the higher the Department's success performance.
7. The size of the Department's pedagogical staff	The number of professors teaching in the Department may influence success performance positively (a large staff gives access to more knowledge) or negatively (pedagogical and material coordination becomes more and more difficult when the size of the staff increases).
8. The number of training hours by student in the Department	To some extent, the higher the number of training hours received by each candidate in the Department, the higher the Department's success performance.
9. The competition between Departments	The number of Departments preparing for the same examination can influence the Departments' success performance positively (pedagogical and administrative staff increase their efforts under the pressure of competition) or negatively (the higher the number of Departments, the lower the mean number of successful candidates by Department).
10. The pedagogical methods used in the Department	It seems possible that the success performance of Departments differ according to the pedagogical methods used.
11. The quality of the candidates	The higher the quality of the candidates (for instance, their knowledge and learning ability), the higher the Department's success performance .
12. The recruitment policy applied by the examining board	In agreement with the Ministry, or on its own initiative, each examining board may design a recruitment policy, and apply extra-academic criteria (such as geographical or social equity), which can influence the Departments' success performance.

Table 2. Other potential factors not analyzed in this study

count alternative indicators for the first three factors.

The national number of candidates going in for an examination can be represented by:

- the national number of candidates registered for this examination (that we name X1A),
- or the national number of actual candidates, which are the candidates registered for and present at the exam (X1B),
- or the number of external registered competitors, which are the registered candidates outside the Department (X1C = X1A – X2A),
- or the number of external actual competitors, which are the registered and present candidates outside the Department (X1D = X1B – X2A).

The size of a Department can be represented by:

- the number of departmental candidates, which are the candidates registered in this Department (X2A),
- or the weight of this Department in the national number of registered candidates (X2B = X2A/X1A),
- or the weight of this Department in the national number of actual candidates (X2C=X2A/X1B).

The number of posts to fill at an examination can be defined as:

- the initial number officially announced before the beginning of the examination (X3A),
- or the final number of positions effectively filled at the end of the examination (X3B),
- or the initial number of positions per departmental candidate (X3C = X3A/X2A),
- or the final number of positions per departmental candidate (X3D = X3B/X2A).

Statistical model

We investigate the links between factors and performance by means of a linear regression model. We use a panel data regression model with random effect (Baltagi, 2001). The use of panel data statistics is justified by the fact that the data of this study constitute a panel of several individuals (the Departments) observed during several periods (11 years from 1992 to 2002). Mainly two different models of panel data statistical analysis exist: the model with fixed effects (FEM) and the model with random effects (REM). We present the results of these two models. We run the Hausman test to compare these results and select the best model. For comparison purposes, we also present the ordinary least squares (OLS) estimates. In the OLS regression, we use White's estimator, which is robust to heteroscedasticity of unknown form.

III. Results and comments

Each of the three performance indicators have been regressed on the potential determinants. Table 3 reports the coefficients of the regressions. Each coefficient is associated with a Student test statistic (t-stat), noted in parentheses. T-stats indicate the statistical significance of coefficients. T-stats are interpreted as follows: a coefficient is statistically non significant (NS) if the absolute value of the associated t-stat is inferior to 1.64; weakly significant (*) if the absolute value of t-stat equals 1.96 at the most; and highly significant (***) if the absolute value of t-stat is superior to 2.57.

The results of the Hausman test indicate that the random effects model can be considered as the

Variables	Regression of the pass rate (N=658)			Regression of the number of successful candidates (N=683)			Regression of the share in the total number of successful candidates (N=683)		
	REM	FEM	OLS	REM	FEM	OLS	REM	FEM	OLS
Number of external actual competitors	-5.96e-05*** (-5.04)	-4.01e-05** (-2.33)	-7.09e-05*** (-8.86)	-2.18e-03*** (-8.72)	-1.59e-03*** (-3.82)	-2.14e-03*** (-7.00)	-1.00e-05*** (-4.27)	-8.21e-06*** (-3.29)	-8.93e-06*** (-8.17)
Department size	3.49e-03*** (2.62)	1.55e-03 NS (0.81)	4.49e-03*** (5.13)	0.58*** (20.22)	0.45*** (9.81)	0.57*** (13.5)	1.08e-03*** (4.14)	1.37e-03*** (4.95)	8.05e-05NS (0.53)
Marginal effect of the size	-1.39e-05** (-2.43)	-1.15e-05 NS (-1.43)	-1.57e-05*** (-4.42)	-1.57e-03*** (-12.43)	-1.56e-03*** (-7.98)	-1.47e-03*** (-6.82)	-3.44e-06*** (-3.11)	-4.58e-06*** (-3.92)	9.14e-09NS (0.01)
Final number of posts per departmental candidate	4.11e-03*** (5.00)	4.78e-03*** (4.70)	4.00e-03*** (3.70)	0.10*** (5.47)	0.087*** (3.62)	0.09*** (5.28)	-6.53e-04*** (-4.72)	-4.68e-04*** (-3.25)	-1.51e-03*** (-7.68)
Specialty	1.71e-03 NS (0.13)		1.16e-04 NS (0.15)	-0.017 NS (-0.73)		-8.21e-03 NS (-0.56)	6.12e-04 NS (1.19)		-1.02e-04NS (-0.83)
Location	5.47e-03NS (1.12)		4.18e-03 NS (1.39)	-0.071 NS (-0.81)		-0.09 NS (-1.24)	4.32e-03** (2.00)		6.75e-04NS (1.21)
Constant	0.35*** (5.10)	0.39*** (7.60)	0.34*** (8.39)	-0.38 NS (-0.29)	1.62 NS (1.31)	-0.47 NS (-0.49)	0.011 NS (0.46)	0.038*** (5.25)	0.084*** (12.20)
R2	0.12	0.09	0.13	0.75	0.71	0.75	0.11	0.04	0.24
Hausman $\chi^2_{5\%}(5) = 11$	5.22 ((p=0.26))				58.59 ((p=0.00))			21.23 ((p=0.00))	

t-statistics are in parentheses. NS: Non significant. *: Significant at the 10% level. **: Significant at the 5% level. ***: Significant at the 1% level.

Table 3. Regression of the success performance of a Department

best in the regressions of the pass rate. In both other cases, the random effects model is not consistent and must be rejected, and the model to take into consideration is the fixed effects model.

As can be seen from Table 3, in Departments preparing candidates for STEM teacher recruitment, the pass rate, the number of successful candidates, and the share in the total number of successful candidates depend on the same set of variables. A Department's success performance depends significantly on the number of external actual competitors, on the number of departmental candidates, and on the final number of positions per departmental candidate. The number of departmental candidates has a positive influence, while the number of external actual competitors has a negative one. The final number of positions per departmental candidate has a positive influence on the pass rate and on the number of successful candidates. But it has a negative influence on the Department share in the total number of successful candidates, essentially because an increasing number of positions filled per departmental candidate means, conversely, that the weight of the Department in the total number of successful candidates decreases. According to the R-square statistics of the OLS estimates, this model explains up to 75% of the variance of the success performance.

We also investigate whether there is a limit in the positive influence of the Department size on success performance. We wonder if a point exists beyond which the growth of the Department has decreasing positive influence – or even negative influence – on success performance. Theoretically, such an efficiency limit is possible and would be explained by the fact that growth generates increasing difficulties in material organization and coordination. We insert the squared size in the regressions, in order to capture the effect of an increasing size ("marginal effect"). If an efficiency limit exists, the coefficient of the quadratic variable must be negative.

We effectively observe a significant efficiency limit in all cases. This means that increasing the size of a Department raises success performance, but less than proportionately, and only up to a certain threshold beyond which additional growth lowers success performance. Graph 2 illustrates this phenomenon.

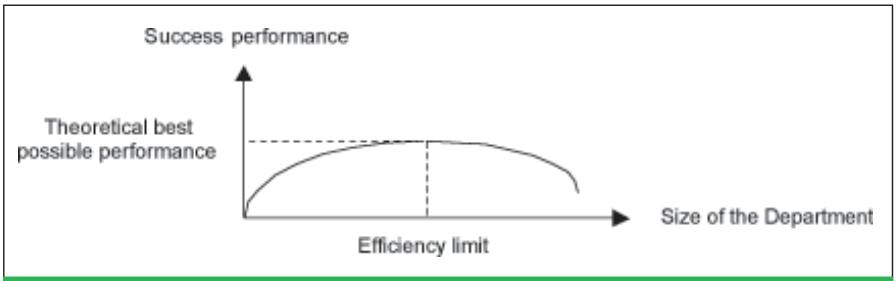
We can compute the efficiency limits. In the case of the pass rate, given the regression coefficients obtained, the efficiency limit equals 126. This means that the pass rate will increase until the Department size reaches 126 registered candidates. In the same way, the efficiency limit equals 146 in the case of the number of successful candidates and 150 in regards to the Department share in the total number of successful candidates. However, it must be kept in mind that the accuracy of these results is limited since the regressions we have run do not totally explain the variance of the success performance indicators (just 75% of the variance at the most).

Another observation is that neither the location of the Department nor the examination specialty have highly significant influence on success performance.

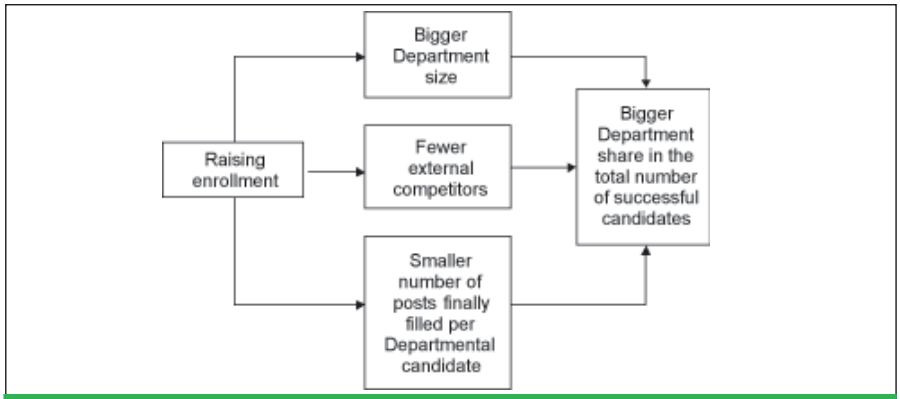
In terms of success performance management, these results suggest that Department Heads have two main strategic options.

The only variable that a Department Head can control is the number of applicants that he/she authorizes to register at the Department. Thus, the Department Head can lower enrollment, or favor it.

The first option – development strategy – consists in raising enrollment. Raising enrollment increases the Department size, which – up to the efficiency limit – has a positive influence on success performance. Besides, other things being equal, raising enrollment has two additional effects. On the one hand, raising departmental enrollment lowers the number of external competitors, which in turn generates an additional positive effect on success performance. On the other hand, raising enrollment lowers the final number of positions per departmental candidate, which has a positive effect on the Department share in the total number of successful candidates, but a negative influence on the Department pass rate and number of successful candidates. Consequently, the net effect of raising enrollment depends on the performance indicator. The net effect is quite positive if the share in the number of successful candidates is used as a performance indicator (Graph 3).



Graph 2. The efficiency limit of the size factor



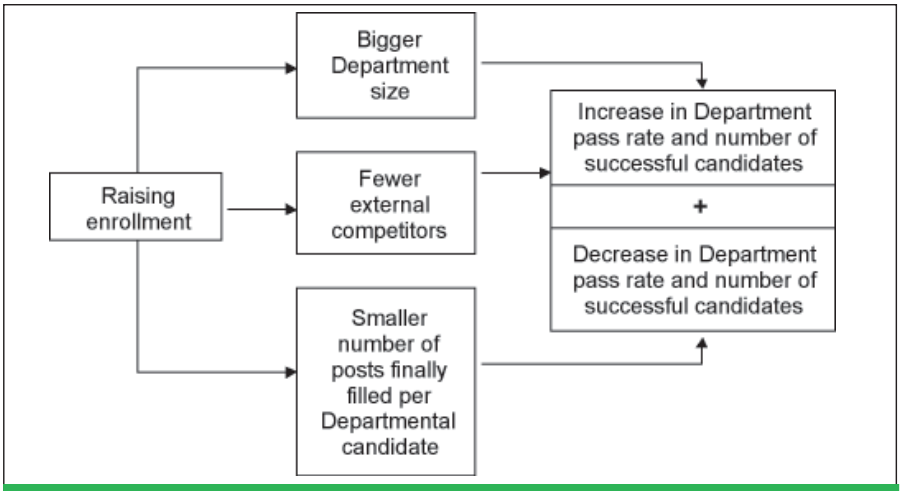
Graph 3. The net effect on the Department share in the total number of successful candidates caused by raising enrollment

But for both other performance indicators, the net effect is the sum of the positive and negative influences (Graph 4).

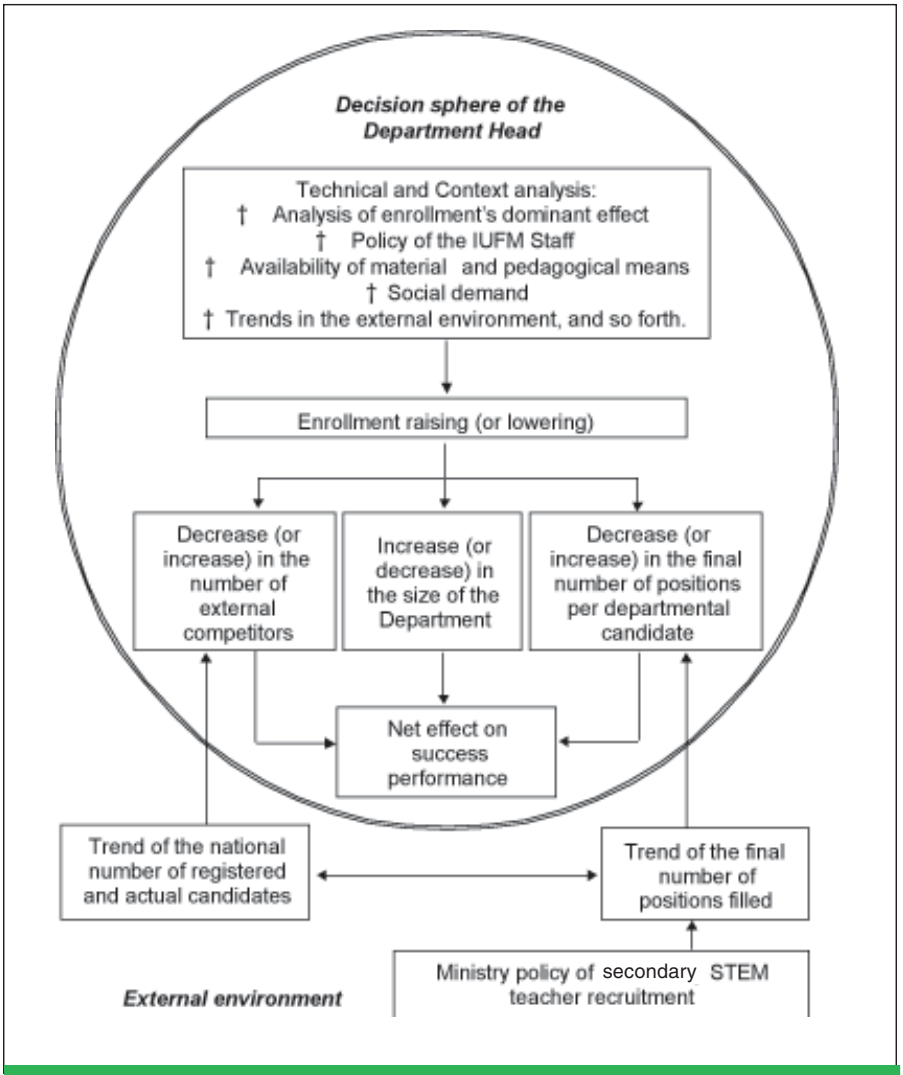
On the contrary, the second option – strategic withdrawal – consists in lowering enrollment. Other things being equal, on the one hand, lowering enrollment reduces the Department size and raises the number of external competitors, and has, therefore, a negative influence on success performance. On the other hand, lowering enrollment increases the final number of positions per departmental candidate, which has a negative influence on the Department share in the total number of successful candidates, but a positive influence on the Department pass rate and number of successful candidates. Graph 5 illustrates both strategies.

It is clear that the choice of the performance indicator matters. The choice of a performance indicator implies that this indicator will be the only policy target of the Department Head, the only relevant criterion on the basis of which the Department policy and efficiency should be assessed, and the main reference on which the Department should base its communication to attract potential applicants. If the performance indicator is the Department share in the total number of successful candidates, the net effects of both strategies are unambiguous. Development strategy has a straight positive net effect, whereas strategic withdrawal has a straight negative one. If the Department Head chooses this indicator, development strategy will be the most adequate.

On the contrary, if the performance indicators are the pass rate or the number of successful candidates, both strategies have ambiguous effects. In this case, the choice depends on the dominant effect of enrollment. Development strategy will be chosen if the positive influence of enrollment through the Department size and the number of external competitors dominates the negative effect that raising enrollment generates via the number of positions per candidate. Otherwise, strategic withdrawal will be the best strategy.



Graph 4. The indeterminate effect exerted by enrollment raising on the Department pass rate and number of successful candidates



Graph 5. Strategies for raising success performance

Conclusion

In the French system of secondary STEM teacher recruitment, candidates are provided preparation in Exam Preparation Departments. Departments are assessed on the basis of their success performance in the exams. In this study, we have isolated some significant determinants of success performance, and emphasized their strategic implications for the management of Departments' success performance. More precisely, we have shown that the number of competitors, the Department size and the number of posts to fill are major determinants of a STEM Department's success performance. We have also shown that STEM Depart-

ment Heads can improve their success performance through adapting their Departments' size according to their performance indicator. In practical terms, this means, for example, that a STEM Department Head who chooses to be assessed on the basis of the Department share in the total number of successful candidates and who publishes the results of his/her Department in terms of this indicator, will have to develop his/her Department size up to the efficiency limit of 150 registered candidates in order to reach the best possible success performance.

However, the data analyzed in this study do not cover the totality of the potential determinants of success performance. Therefore, a full understanding of the determinants at work and of the precise strategies to apply requires availability of more data.

The approach developed in this article is obviously different from those prevailing in countries like the United States, Australia or the United Kingdom, where one of the main concerns is rather how to attract and keep new STEM teachers into the educational system. But this approach is not so far from the situation in some other European countries like Belgium, Germany, Italy or Spain where, like in France, secondary teachers are public sector employees. In spite of the recent decrease in the number of candidates, job security linked with the status of public sector employees generally still attracts a great number of candidates for STEM teaching. As a consequence, it is necessary to set up rigorous selection of candidates, which in turn generates competition not only between candidates, but also between Departments. Such a problem could not be ignored in international comparisons and debates on perspectives in STEM education and STEM teacher preparation and recruitment.

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