

**University admissions policies: A Utility Analysis Based on Academic Quality  
and Economic Efficiency Considerations**

By: Talia Haimovich

Ph.D student at the Psychology Department

The Hebrew University of Jerusalem

ISRAEL

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Several approaches for Admissions policies and procedures to higher education have been documented (Beller, 1994; Klitgaard, 1986). A prevalent approach that was adopted in this study is a meritocracy-based policy (i.e., attempting to accept applicants with best chances of success in academic studies). Typically, such an approach must rely on good predictors of academic success (e.g., high school achievements, scholastic aptitude tests and personality measures).

Admissions procedures based on this approach have provoked extensive public debate and criticism in many countries around the world, mainly because they relate to social and economical mobility, allocation of restricted resources, and increasing gaps between majority and minority groups (e.g., Coleman, 1991; Zeidner, 1986).

Clearly, universities cannot admit all applicants, and hence, setting quotas is a main component of the selection process. Fixed-quota situations are very common in the industrial personnel selection context, as the selection problem is typically defined in terms of a certain fixed number of job vacancies. When screening applicants in the educational context it is reasonable to rely on a fix-quota procedure in fields of study where the number of places for enrollment is limited and is exceeded by the number of applicants. In these situations, applicants are rank-ordered according to their predicted academic success, and those with the highest scores are admitted until the quota is filled. Yet, in other less popular fields of study, where demand does not exceed the number of available places or when there is no apparent capacity issue, admissions should not necessarily rely on pre-set quotas.

In establishing admissions policy for the research universities in Israel, policymakers have assumed that supply for student places is lower than demand, and that each department would set its admissions quota at its maximum capacity. However, although many departments are not facing realistic supply/demand deficit, it is still common to implement an admission process based on restricted, and often arbitrary quotas.

Two conflicting views of the role of higher education have some bearing on policy in regard to quotas. One view typifies educational institutions that are interested in providing basic post-high school education to masses of students. This view reflects the belief that an opportunity should be given to any individual who may graduate with minimal passing grades, and it may result, in some cases, in an open admissions policy. The opposite view expresses a concern for keeping or raising the academic level by identifying the outstanding applicants with the highest probability of merit. These conflicting views are often resolved by a compromise reflected by arbitrary quotas (and arbitrary cutoff points) which are not necessarily optimal.

The number of applicants to be admitted has an effect on the profile and amount of students admitted, and hence, has academic and financial consequences. The general aim of this study is to get a broader insight of the academic and financial consequences and implications of varying quotas, which in turn result in raised or lowered cutoff points. This led us to a three-folded study:

- 1) Examining the relationship between the admissions requirements and a criterion of graduation at the different fields of study at the Hebrew University of Jerusalem.

- 2) Demonstrating how an expected utility model can be applied to evaluate admissions decisions in universities. Using a data set from the Hebrew University of Jerusalem, we illustrate the way it can be interpreted by policy makers in higher education institutions. Specifically, the objectives were to determine the optimal decision rule for each department and faculty, and to evaluate the selection procedures in terms of the range of utility ratios<sup>1</sup> for which the predictor is useful.
  
- 3) Examining the students' admission policy from a cost-benefit perspective. Estimation of the economic consequences deriving from different quotas was based on incomes and expenditures relating to students. In the current study the incomes are based on tuition fees and allocation from the government, and expenditures are based on staff, TA, and laboratories.

### **Study 1:**

The admission requirements for undergraduate studies at research universities in Israel are regularly based on the weighted average of the matriculation certificate grades - "Bagrut", and the score on the Psychometric Entrance Test - PET (For a detailed description of these selection procedures, see Beller, 2001). While the predictive validity of the combined predictors for predicting the grade point average (GPA) at the end of the full course of studies is relatively high (between 0.49-0.64 after correction for range restriction, see Kennet-Cohen, Bronner & Oren, 1999) using

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<sup>1</sup> The tradeoff between the utilities of false positive (admitting applicants that will eventually drop off) and false negative errors (rejecting a potential graduate).

it for applicants' admissions generates harsh dispute and criticism (Beller, 1994; Kenneth-Cohen, 2001; Zeidner, 1986).

The present study shifts the focus to different criteria of academic performance – graduation and attrition. There are several substantial reasons for using a graduation criterion. First, in most cases, graduation is a required condition for a professional and social growth. In other words, high achievements, best teachers and studies in selective institutions would not be sufficient, unless the student attains a degree. Second, given that the students invest a great deal of money, time and effort during their studies, the cost of a potential failure (i.e., incompleteness) is very high. Third, universities suffer from dropout rates, as it is one of the measures of quality and prestige of an institution.

The graduation factor is particularly important in Israel because the main financial resource of the Israeli universities is derived from government allocation based, to a large extent, on the duration of studies until graduation. Dropout or prolongation of studies beyond the predefined term significantly reduces the allocated budget from the government. Indeed, a criterion of GPA is more widespread, but it does not take into account the students who dropped out. This shortcoming is naturally corrected when using a criterion based on graduation.

The relationship between Bagrut, PET and a composite score - and graduation is examined at the university level, and at the faculty and departmental level.

Method: Data were collected for 7,736 students from the faculties of humanities (all departments except the school of education), social sciences (sociology, international relation, political sciences, geography & statistics) and natural sciences (mathematics, physics, biology, chemistry & earth sciences) who started their studies at the Hebrew

University of Jerusalem between the years 1992-1996 (students from highly selective departments were excluded).

The selection procedure in these faculties was based on a weighted average of the student's high school matriculation scores and a psychometric entrance test. The criterion in this study is defined as graduation at the Hebrew University within 4 years of studies. Analyses were performed at the faculty level and the departmental level.

Due to a moderately low number of students in the various departments in the humanities, we grouped together departments belonging to the same institute (e.g., Jewish studies, Asian & African studies, arts and letters studies). This was possible given the similarity of the departments within each group, in terms of the content of studies and the applied cutoff scores. The mathematics and physics departments, as well as chemistry and earth sciences, were combined for the same reasons.

Results and Discussion: Only 56.2% of the students for whom data were collected graduated within 4 years (see Table 1 for a full description of the graduation rate in each department and faculty). A strong relationship was found between each predictor score and the probability of graduation when the data were analyzed across individual students (the higher the admission category the students belong to, the higher their odds to graduate, see Table 2). This pattern was found for the Faculty of Natural Sciences and the Humanities; however, at the Faculty of Social Sciences, probability of graduation was generally quite high, and the difference in graduation rate between the highest and the lowest admission categories was only 20 percent. It seems that the probability of graduation depends to a certain degree on the area of studies (The relationship between area of study and graduation rate is demonstrated in table 3).

A plausible explanation for the variance of the graduates' rates at the lower admission categories in the different fields of study can be found in the different academic requirements during the course of studies. For example it is possible that the academic demands of the physics and the mathematics departments are relatively high, and hence, many students fail to meet them and drop out. On the other hand, the academic demands in the department of sociology may be adjusted to the lower ranking students in the department, making graduation less of an effort.

In most departments, Bagrut scores predicted graduation probability better than did the PET scores. This pattern was found mostly in the Humanities and Social Sciences, and less in the Natural Sciences, where PET's contribution was higher.

The reason for this may be that the Bagrut is related to achievements measured over time, persistence and motivation, while the PET is intended to assess intellectual skills. In the humanities and social sciences it seems that effort, persistence and motivation are sufficient for reaching the minimal academic demands for graduation, whereas in the natural sciences there is a greater need for analytic ability. In any case, the predictive power of both Bagrut and PET scores is higher in the Faculty of Natural Sciences than it is in the other two faculties (see table 4).

The validity of Bagrut and PET scores for predicting a criterion of success (i.e., graduation) in our study was lower than that reported in American universities. This can be explained by several factors: First, selective departments were excluded from the study, and hence, high scoring students were not represented. This consequence resulted in a range restriction at the university level.

Second, whereas at the professional departments (e.g., law, accounting, medicine) the objectives of the students are generally straightforward and clear, this is not the case for the departments included in our study. Due to the vagueness of the

professional future of the students, other considerations (e.g., motivation and finance) may play a bigger role when making a decision whether or not to drop out.

Furthermore, the non-cognitive considerations (such as financial burden) are stronger for the Israeli student who is older than his American counterpart (due to the compulsory military service of at least two to three years that takes place after high school).

### **Study 2:**

Validity coefficients are often insufficient for assessing the practical value of tests, as they ignore several important features of the personnel decisions made on the basis of test results (e.g., the consequences of the decisions' outcomes, the cost of testing). To overcome these limitations, various attempts have been made to apply decision-theoretic models to assess the utility of tests and measures used for personnel decisions (e.g., Cronbach & Gleser, 1965; Schmidt, Hunter, McKenzie, & Muldrow, 1979).

However, while the utility models (e.g., Brogden-Cronbach-Gleser [B-C-G] model), that rest on fixed quota selection procedures are appropriate for most personnel selection contexts in the industry, they are not always applicable to the educational context, (e.g., screening of applicants for academic studies in Art and Sciences). Two major distinctions exist between the typical industrial personnel selection context and the university admissions context: (a) in the educational context admissions quotas are not always rigorously defined (b) While in the industrial setup it is relatively easy to estimate the standard deviation of the criterion in terms of dollars (e.g., Schmidt et al. 1979), it often does not make much sense to express academic achievements in monetary terms.

These differences led Ben-Shakhar & Beller (1983) and Ben-Shakhar et al. (1996) to adopt the threshold utility model (see, Gross & Su, 1975), which is applicable to situations where it is impossible to convert the outcome of decisions to concrete monetary terms and where fixed quotas don't exist. The model provides estimates of the utilities of selection procedures as a function of the payoff ratio (Ben-Shakhar & Beller, 1983; Rorer, Hoffman, & Hsieh, 1966) - the ratio between the utility of admitting applicants who will eventually fail (false positive) and the utility of rejecting potentially successful applicants (false negative).

Because it is very difficult to provide an exact estimation of the utility function of academic achievements, Ben-Shakhar and Beller (1983) computed instead the range of utility ratios for which the predictor was useful. For this purpose, an index of usefulness was defined in terms of the predictor's contribution to the expected utility, and was computed across the possible outcomes of the decision problem. Ben-Shakhar and Beller (1983) computed the range of utility ratios for which the predictor was useful for three dichotomous definitions of success (arbitrary cutoffs defined on the grade point average) and for several values of operating costs. The results displayed reasonably large ranges of usefulness for the predictor.

The present study relies on the same utility model used by Ben-Shakhar & Beller (1983), but it extends the previous study in several important aspects. While the previous study used an arbitrary cutoff on a continuous criterion of GPA, the present study adopts an "authentic" binary criterion, defined as graduation within four years (the typical undergraduate programs in Israeli universities is a 3 years course). This definition is more suitable to a threshold utility model and often more important to the institution than GPA.

In addition, while the previous studies were based on students from a single faculty (the Faculty of Humanities), this study examines the utilities of the selection procedures in the three major faculties (Humanities, Social Sciences and Natural Sciences).

The objectives of the study are to determine the optimal decision rule for each department and faculty, and to evaluate the selection procedures in terms of the range of utility ratios for which the predictor is useful.

Method: (description of subjects and definition of graduation is same as in first study).

A maximum likelihood procedure was used (with a special MATLAB program) to correct for the restricted sample and generate estimates of the unrestricted conditional distributions of the predictor (i.e., the distribution of the graduate applicants and the distribution of the non-graduate applicants). This procedure was based on the assumptions that the two conditional distributions of the predictor are normal with equal variances, and that all applicants with predictor scores above the specified cutoff point were admitted, while all other applicants were rejected. New actual means and standard deviations were generated for each conditional distribution, along with the number of applicants in each group.

Results:

#### *The Utility Model*

The utility model used here is similar to the one described in Ben-Shakhar & Beller (1983) and it relies on three factors:

1. The utilities associated with the possible outcomes of the decision problem.

A 2 by 2 matrix can be constructed to represent the utilities associated with the

possible outcomes (see Table 5). The constraints that  $TP, TN > 0$  and  $FN, FP < 0$  reflect the preference for accepting applicants who will be successful and rejecting those who will not, over the other two outcomes.

2. The base rate of success ( $P$ ) is the percentage of potential successes (i.e., graduates) in the applicant population. This parameter was not available due to the nature of the data (applicants with a score below the cutoff point were rejected) but it was estimated from the actual data.

3. The conditional distributions of the predictor ( $X$ ) for the graduates and non-graduates groups are denoted by  $f_S(X)$  and  $f_{US}(X)$ , respectively. The likelihood ratio at a given point  $X_0$  is defined as  $LR(X_0) = f_S(X_0) / f_{US}(X_0)$ .

Under the assumption that these two distributions are normal with equal variances, we estimated, by the procedure described above, the unrestricted conditional distributions and their standardized mean difference ( $d'$ )

The optimal decision rule, in terms of maximizing the expected utility is

satisfied iff: 
$$LR(X) > \frac{1-P}{P} \cdot \frac{TN - FP}{TP - FN} \equiv \beta \quad (1)$$

Under the assumption of normal distributions with equal variances, this optimal decision rule can be expressed in terms of  $X$  (the standardized predictor):

$$X > \ln(\beta) / d' + d' / 2. \quad (2)$$

The parameter  $\beta$ , which defines the optimal cutoff point, is a product of two factors:  $(1-P)/P$ , which represents the prior odds for non-graduation over graduation; and  $r \equiv (TN - FP) / (TP - FN)$ , which represents the ratio between the utility difference associated with non-graduated students to the utility difference associated with the graduate ones. In order to allow for a better understanding of the model, and to facilitate the interpretation of the results, a simplified version, which was also used

by Ben-Shakhar and Beller (1983) and Ben-Shakhar et al. (1996), was adopted. It was assumed that either all rejection decisions results in zero utilities (Cronbach & Gleser, 1965) or that the payoff matrix is symmetrical, such that the positive utility of accepting a student who would graduate is equal in absolute magnitude to the negative utility of rejecting the same student,  $TP = -FN$ , and similarly,  $TN = -FP$ . Either assumption reduces the utility ratio to the ratio between the utilities of the two possible errors (FP/FN).

To calculate the optimal cutoff point ( $X_c$ ), a range of utility ratios ( $r$ ) that runs from 10:1 (i.e., 10 False Positives [FP] are equivalent to 1 False Negative [FN]) up to 1:10 (i.e., 1 False Positive [FP] are equivalent to 10 False Negatives [FN]) was set. For each specific  $r$  value,  $\beta$  was calculated ( $\beta = (1 - P/P) * r$ ), and then  $X_c$  was generated using equation (2).

Table 6 illustrates the computation of  $X(c)$  as a function of  $r$  in the faculty of humanities. Although the specific choice of the  $r$  values, which range from 1:10 to 10:1, was arbitrary, it is sufficiently wide to cover all realistic utility ratios a reasonable decision maker may adopt. The effectiveness of the predictor ( $X$ ) was estimated according to the range of utility ratios for which the optimal cutoff points were still useful. A cutoff point was considered useful when it allowed for an acceptance of no more than 95% of the unsuccessful applicants, on the one hand, or a rejection of no more than 95% of the successful applicants, on the other. When the optimal cutoff point exceeded these numbers, it designated that the predictor was not practical, in which case the strategy of either accepting all applicants or rejecting all applicants (according to the value of  $\beta$ ) is associated with larger expected utility. For example, the highlighted segment in table 6 represents the range of optimal cutoff scores for which the test is useful. The lowest limit should not be lower than the

standardized cutoff score of -1.65 (to include no more than 95% of all unsuccessful applicants), and the upper limit should not be higher than the standardized cutoff score of +2.0041 (to include no less than 5% of all applicants who would succeed). In other words, the test would be useful for r-values within the range of 1:2.5 (i.e., a ratio of 2 FP to 5 FN) to 2:1 (i.e., a ratio of 2 FP to 1 FN).

This analysis demonstrated that the different faculties and study areas are characterized by considerable variations in the ranges of utility ratios for which the test is useful (See table 7). The broadest ranges were found at the faculty of natural sciences, and the narrowest at the faculty of social sciences. Similar analyses were performed at the departmental level, and the results appear in the table. These analyses also reveal large variations among the various departments. For example, the usefulness range for the departments of mathematics and physics was 0.06 – 15, whereas the range of usefulness in the department of geography was 1.25 – 4.5.

Discussion: It is very difficult for decision makers in the educational context to provide precise estimates of the utilities associated with the various outcomes of their decisions. Thus, we avoided an exact estimation of the utility ratio ( $r$ ), and estimated, instead, the ranges of  $r$  for which the predictor is useful. The utility ratio reflects the tradeoff between the two types of errors (i.e., the number of false positive errors that are equivalent to a single false negative error).

For example, the range of usefulness in the departments of mathematics and physics (0.06 – 15) means that the predictor is useful if the ratio of the absolute utility of a false positive to that of a false negative is between 1:16 and 15:1. If, for instance to avoid a single false negative error the decision makers are willing to tolerate more than 16 false positive errors - the preferred policy should be open admissions, in

which case the predictor is useless. If, on the other hand, to avoid a single false positive error the departments are willing to sacrifice more than 15 false negative errors - the predictor is also useless, and according to the model the preferred policy should be to reject all applicants from these departments. This alternative may sound absurd, but a strategy of closing a department would be appropriate only if a decision maker truly believes that accepting an applicant who will eventually drop out is associated with such an extreme cost (i.e., the decision maker would rather give up more than 15 applicants who could graduate just to avoid a single dropout). Clearly, it is unreasonable that any decision maker would adopt such an extreme utility ratio, and consequently there is no real danger that the mathematics and physics departments will not admit any student.

Nonetheless, the optimal cutoff point is determined by the precise utility ratio of the decision makers, and the usefulness of the predictor is a byproduct of this cutoff point. For example, a decision maker who is much more concerned about the false negative outcomes, will tend to accept more applicants by using a relatively low cutoff point, thus the utility ratio will be very small ( $FP/FN < 1$ ).

Conversely, a decision maker who is much more concerned about the false positive outcomes, will prefer to use a relatively higher cutoff point. In this case, the utility ratio will be high ( $FP/FN > 1$ ).

One of the major goals of higher education institutions is to “generate” graduates. Accordingly, we would expect that the utility associated with rejecting a potentially successful applicant would be much greater than the utility associated with accepting an applicant who would eventually fail. But the utility ratio depends on several other factors. For example, the utility of the decisions’ outcomes may depend,

to a certain degree, on the base rate of success (i.e., graduation) in the different fields of studies, and on the cost of teaching in the various departments .

In general, a very high base rate reflects a large proportion of true positive decisions. Conversely, false positive decision errors are much more likely with a very low base rate. Naturally, when base-rates are low and many students fail to graduate in time, missing those who could have succeeded has severe consequences. On the other hand, when base-rates are high and a large proportion of the students graduate in four years, missing a potential graduate is not associated with severe costs. Thus, there is a negative correlation between the base rate and the utility ratio.

Inspection of Table 3 reveals that the base rates in the different field of studies included in the current study range between .0.36 and 0.71. The base rate in the Humanities is the lowest (0.47). Accordingly, the utility of the FN should be the highest in this area, as it relatively difficult to track those students who can graduate. In other words, the importance of identifying potential successes should be part of the decision makers' considerations. On the other hand, the base rate of graduation in the faculty of social sciences (the statistics department is formally part of the faculty but its characteristics resembles to the natural sciences) is relatively high (0.70), indicating that it is fairly easy to graduate in these departments. Thus, rejecting applicants who could have been successful is not a major threat because there are many others who will graduate. This can be translated to a relatively low FN utility and a higher weight for FP.

Another factor determining the utility ratio is the type and amount of the resources required to produce graduates. The costs invested in a student determine the utility of a false positive decision. There are considerable variations among the various fields of study with respect to this factor. Studies in some fields (e.g.,

sociology, philosophy, law) require no more than a lecturer and a proper classroom, and are therefore associated with relatively low costs. In these areas the number of students in a class is limited by the capacity and the availability of the classrooms, and the marginal cost of a student is relatively small. In other fields of studies (e.g., biology, medicine, chemistry) teaching methods involve laboratories, expensive equipment and teaching assistance. As a result, the utility associated with a student who will eventually drop out is much higher in the latter than in the former fields. From this perspective, the utility of FP decisions is much higher in the natural sciences than in the humanities and the social sciences.

Finally, the range of utility ratio in the faculty of natural sciences was relatively wide, suggesting that the predictor is likely to be useful in this faculty. In summary, our analysis proposes that the predictor is expected to be useful in the faculties of Sciences and Humanities, but not in the Social Sciences, where an open admission policy may be more desirable.

Clearly, the specific results from the Hebrew University are not of interest by itself. However, it illustrates the use of the utility model and the way it can be interpreted by policy makers in each university .

In conclusion, using a decision-theoretic model, and framing the question in terms of examining whether their own utility structure fits within a given range, can be meaningful to most decision makers. Adopting a decision-theoretic approach for students' admissions would provide a more rational basis for the students' admissions process, rather than relying upon arbitrary quotas and cutoff points.

**Study 3:**

(I am at the beginning stage of this work)

The results of study 2 supported our argument that the current quotas applied in the various departments are not always optimal. The aim of the study is to introduce a tool that can present the financial implications of varying cutoff score for different departments.

In this study we examine the implications (from the university's point of view) of increasing or decreasing quotas in different departments. The cost-benefit perspective would be mainly in monetary terms, but academic implications will be discussed too.

Estimation of the economic consequences deriving from the different cutoff points will be based on incomes and expenditures relating to students. In the current study the university incomes are based on tuition fees and allocation from the government, and expenditures are related to academic staff, teaching assistance (TA), and laboratories equipment.

In studies 1 and 2 we found greater variance between faculties than within them. Therefore, we focus on one department in each faculty. However, dropout implications at the department level differ from those at the university level; for example, a student who transfers from one department to another has dropped out of a department, but not out of the university. Hence, analyses will be performed at the university level as well (Other implications that derive from changing a course of studies will be discussed later).

Method: Data were collected for 1,744 students who started their studies at the Hebrew University of Jerusalem between the years 1992-1996 in the departments of Philosophy (Faculty of Humanities), Physics (Faculty of Natural Sciences) and Political Science (Faculty of Social Sciences).

The selection procedure is the same as was described in Study 1 & 2. The criterion is defined as the number of years till graduation at the Hebrew University of Jerusalem.

*Calculation of income (related to students):*

- Tuition was calculated according to the number of years a student has been registered. After 3 years of full tuition, partial tuition is paid according to the number of credits taken.
- Allocation from the government was considered according to a calculation that is performed regularly by The Planning and Budgeting Committee (of the council for Higher Education). The rationale of the model applied at the research universities in Israel is based on production. Teaching production is supposed to be estimated according to the number of students who graduate each year. Given that funding is needed throughout the year of studies, the universities get funds based on the graduation rate forecast (based on the rate in previous years). This model of allocation applies the rule of paying the whole amount that was allotted for a graduate, and paying nothing for students who drop out (the absolute amount per student varies across fields of study).

*Calculation of expenditure (related to students):*

- Academic staff expenses were based on salaries of senior faculty and teaching assistants.

After calculating the current income and expenditure related to students, we will apply the same calculations for different quotas and the resulting cutoff scores.

New quotas will be established according to the number of student's admitted/rejected. These numbers are affected by the curriculum offered at each department. This will be done in the following steps:

1. Each department Chair will report the maximum/minimum number of students who can attend compulsory courses, tutorials and laboratories.
2. The number of students necessary for opening a new class will be set. For example, if a lesson with a TA includes no more than 20 students, raising the cutoff point or lowering it should result in multiples of 20, otherwise it will be considered inefficient to the university (e.g., admitting 30 students will cost as much as admitting 40 students).
3. According to this figure, we will try to estimate how many applicants should be accepted/rejected, taking into account the ratio of accepted applicants who actually carry out admittance. This number of applicants will dictate the new cutoff score.
4. Income and expenditure will be calculated according to previous data on the relationship between admission score and years to graduation. For example, rejecting a certain number of applicants in the physics department will result in raising the cutoff score. The absolute number of students will be lower, nevertheless graduation rate will increase because there are more students with higher admission score.

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