**RAStaff**

**Sample Only**

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[Problem statement](#ProblemStatement)

The intended users of the RAStaff model are the administrative departments at a local University involved in employee hiring, research staff management and centralized financial planning. The purpose of the RAStaff model is to predict the number of research assistants (RAs) the University needs to hire and retain in order to produce a minimum number of faculty research publications per year. The model also calculates the associated salary and overhead costs of the research staff pool. The model allows the user to explore the impact of different assumptions about staff turnover rate and learning on productivity, hiring, and costs.

Simplifying assumptions

This is essentially a capacity planning problem, similar to predicting how many workers you need in a factory to produce a certain number of widgets. However, to make the situation something that we could quantify and build within the scope of the course, we had to make a large number of assumptions and simplifications from reality. For the purposes of the model, this is how the University research and RA hiring system works:

* The model covers three University fiscal years (12 quarters). Each year Quarter 1 (Q1) runs from July – September, Q2 from October – December, Q3 from January – March, and Q4 April – June.
* There are three types of faculty by tenure level (assistant, associate, and full professors), who engage in four quantifiable types of research activity (writing articles, writing books, conducting field research, and performing data analysis). As professors move up the tenure track, the type and quantity of research product they focus on changes, as the scholarly pressure to “publish or perish” diminishes. The greatest pressure to produce is on associate professors, before they are granted status as a fully tenured faculty member. Writing books takes the longest, writing articles takes the least time. Within each category of research activity, products are treated as equally time-consuming (in other words, it takes as long to write one book as another book).
* Within each fiscal year, there is quarterly seasonality in faculty research (of the annual output of books, the University produces fewer books in summer and winter due to holidays). However, the output of research products per faculty remains constant from year to year.
* The key driver of the demand for RAs is the total quantity of research publications that the University produces, not an individual assignment to a certain faculty member or a fixed salary budget. The demand for RAs is reduced by the capacity of centralized research services, composed of permanent University staff (writers, librarians, and statisticians) who can produce some percentage of the faculty research projects. The annual quantity of faculty research minus the centralized service output is equivalent to a floor, a minimum that the total RA pool must produce, on an annual, not a quarterly basis.
* The number of RAs needed is determined by the productivity of an ideal RA, in other words how many books can an RA write per year. This productivity is assumed to be independent of the productivity or activities of a faculty member. In other words, if a faculty member needs 10 articles written a year to use in a course for students, and centralized writing services can cover two articles, but an ideal RA can produce only 3 articles per year, then 2.67 ideal RAs would work on the articles of this faculty member. The model assumes that RAs can be assigned to several faculty’s projects at once, by a central RA staffing planner who assures that the overall product capacity needs of the University are met. (In reality, quality of products is just as important as quantity in determining which RAs are desirable employees, and many factors can influence RA productivity, including frequency of faculty feedback, discontinued “dead ends” in exploratory research, etc.).
* Each RA works full-time only on one of the four types of research activity (for example, writing articles or analyzing data). There is a quantifiable learning curve over time for each type of RA skill. By the end of their third year, newly hired RAs are assumed to reach the annual level of output of ideal RAs. Articlewriters and analysts have similar personality profiles in terms of productivity and turnover— because those are the two products RAs can produce most in a year, those types of RAs are likely to want to move on sooner to other types of work.
* The model contains a mechanism for allocating the need for RAs by the four research product types across the three educational backgrounds, so the hiring need the model fills is a need for 12 different RA types (BA article writers, MBA analysts, etc.) The basis of this allocation could be budget or level of responsibility needed. This is similar to a staff pyramid in consulting firms with fewer (expensive) senior than junior consultants. In the University setting, faculty tend to want RAs with different levels of skills and backgrounds, depending on their specific project needs. Central administrators also have a preference for there to be proportionately more RAs paid at a lower salary rate.
* RAs are contract employees that are hired for renewable, year-long, full-time contracts (the model measures RA positions in FTEs, full-time equivalents). RAs start and leave only once a year, at the beginning of the first quarter of each academic year (July). In the model, RAs stay for a maximum of three years (the length of the model).
* RAs already on staff at the start of the model follow the same distribution of turnover (ie some were hired one year ago and now follow the turnover pattern of 2nd year RAs; others were hired two years ago and follow the turnover pattern of 3rd year RAs.)
* It is possible to output fractions of a research product (ie write half of a book), but it is not possible to hire fractional RAs. The model rounds fractional staff needs to whole RA positions.
* Educational degree is the only thing that determines staff turnover, learning curve / productivity, and salary within each of the four skill types. RAs with advanced doctoral and business degrees learn faster than RAs straight from bachelor’s programs. RAs with PhDs are assumed to stay longest, because they like academia, especially multi-year book projects; BA RAs stay second longest, because they often use the RA position as a first job to gain work experience or explore interests, but then are likely to leave after two years to move on to graduate school or a more permanent job. RAs with MBAs stay the shortest period because it is only a temporary position before they can find something more lucrative and managerial.
* The model only allows for expected, predictable staff turnover (i.e. how long we think an RA with a bachelor degree will stay based on average historical patterns of retention.) The model does not let the user adjust staff need for unexpected, last-minute turnover (if more or fewer RAs than expected suddenly leave due to personal circumstances). To support the principle of staff retention, the model also does not provide us with a mechanism for firing staff if we find we have too many RAs.
* Direct salary costs of RAs are charged to faculty research budgets, but faculty do not pay for other overhead. The University uses other central budgets to pay for the employee benefits costs (vacation, etc.) of the RAs, as well as the associated overhead of hiring them. The model assumes that training and recruiting costs are incurred only for new RAs, but office costs are incurred for all RAs. Hiring and training costs reflect the time that various University employees spend on these RA-related activities. The model assumes all costs are constant over time, i.e. RAs are locked into their initial contract salary and receive no raises or cost of living adjustments.

# Modeling Approach

In building this model, we varied our approach several times. At first we:

* Assumed the University produced an equal amount of output each quarter, i.e. no seasonality factor, and that RAs were hired each quarter. With the steep learning curve, this produced quite a front-loading of the system. In other words, many more RAs had to be hired in the first quarter to meet the demand than were needed by the last quarter. This would have required a firing mechanism to even out staff levles or created too much expensive excess capacity.
* Had no existing RAs on staff, but this also increased front-loading.
* Were trying to use the Convolve macro to model the situation, by combining the learning curve and turnover in one time stream. (We were expressing turnover as a point when the learning curve drops from 100% to 0%), and convolving that against a replacement rate for RAs. This was leading to some circularity, where we had to calculate numbers of RAs hired before replaced. Plus this seemed to violate the conditions when Convolve is valid.
* Included actual numbers of RAs leaving each quarter (as opposed to expected turnover) as a parameter that the user could input, but to replace these RAs in hiring, this meant making complicated assumptions about the associated productivity loss of each RA leaving.

To reduce the huge quarterly fluctuations and overcapacity in RA hiring we were getting, and to simplify the model, we decided that meeting the average annual, not exact quarterly, quantity of University of publications was the important goal for the RA pool. We switched the model so RAs start/leave only once a year. Instead of modeling turnover as a time stream, it is now a “fixed” input parameter with a distribution for each year that an RA can stay.

Instead of using Convolve, we now use a series of averages. The model now converts the quarterly learning curve to an average productivity for each year that an RA stays. The model uses the difference between the yearly averages for required RA output and the annual output of RAs already on staff to calculate the new number of RAs to hire each year. Basically, in each year of the model, there is a different group of RAs categorized in their first (and second, and third year), with the relevant associated productivity and turnover.

The results of this modeling approach are visible on the “AnnualSummary and QtrSummary” worksheets, where we have summarized the output of the model on both an annual and a quarterly basis. “Capacity” here is defined as the actual number of products that the RAs produce as compared to the minimum they are required to produce. The hiring system that the model recommends meets the required output quantity as measured for the total RA pool on an annual basis (with some product overcapacity), but not on as measured on a quarterly basis for each RA type. Some of the overcapacity is also due to rounding, in other words the assumption that RAs can only be hired in whole positions. We assume that some, but not much, overcapacity is acceptable to the University in terms of excess research products produced that could beor RA time that can be used for administrative activities.

(Besides admitting the possibility of part-time or hourly RA hires, a more sophisticated way to model this would be to have a series of cascading “if-then” functions that would hire not on the basis of a grid of 12 RA degree-skill types, but hire one type of RA only if the previous type of RA was not able to produce the total needed number of products. Or in terms of decreasing cost of productivity.)

# Scenario Testing

To focus on the impact of the key variables of turnover (the named array “**TurnoverAnalysis**”) and productivity (the named array “**ProductivityAnalysis**”), we left all other input variables, including costs, constant between the two scenarios.

In both scenarios, the 100 University professors require the RA pool to produce 388 articles, 34 books, 274 field research projects, and 197 data analysis projects a year. (The rest is produced by the centralized research services). The bulk of the work is produced between January and May each year (29% in third quarter, etc.). There are 44 RAs of various types already on staff when the system starts. Of new RAs, 60% are recruited by human resources for faculty, and 40% directly by faculty. An ideal RA produces 6 articles, 0.5 books, 2 field research projects, and four analysis projects a year.

Scenario One describes the current staffing situation at the University: high RA turnover and low productivity. As can be seen in the range “TurnoverAnalysis”, the percentage of RAs leaving within their first year is high. A high of 70% of MBA articlewriters / analysts and 60% of MBA bookwriters / field researchers leave within the first year. The implicit average RA length of service ranges between 1.35 and 1.9 years for Scenario One.

**TURNOVER: SCENARIO ONE**

In Scenario Two, we assume that the RA turnover situation at the University has improved. Perhaps the non-monetary aspects of the job have changed (more interesting work; more opportunities for teamwork or recognition within University; change in job title or better chances for promotion into a permanent central staff job) or perhaps this reflects a externally-driven situation when an RA position becomes more desirable (worsening general economy). In Scenario Two, the number of RAs leaving in their first year decreases and the average stay increases from one to two years.

**TURNOVER: SCENARIO TWO**

In Scenario One, in the range “ProductivityAnalysis”, you can see that many RAs leave before they become fully productive, with bachelor-level bookwriters / field researchers not reaching 100% ideal productivity until their third year. Doctoral RAs get fully up to speed by the end of their first year.

## LEARNING CURVE: SCENARIO ONE

In Scenario Two, this learning curve improves slightly for each RA type because a more effective form of training for new RAs is used (at the same cost). For example, the $150 that is used for new analyst training is switched to a series of self-paced on-line courses instead of several hours of an outside trainer’s time. Another reason for an improved learning curve could be the introduction of a mentorship program, where experienced RAs help new RAs get up to speed faster. In Scenario Two, each RA reaches 100% productivity one quarter earlier than in Scenario One. For example, MBA articlewriters reach 100% in fourth quarter of their first year, not first quarter of their second year as in Scenario One.

## LEARNING CURVE: SCENARIO TWO

The positive impact of improved productivity and turnover is clear. As you can see on the “output summary” worksheet of each scenario, under Scenario Two, the University can produce the same amount of faculty publications with smaller staff and at lower cost, as one would expect. If you add up the three years hiring and spending patterns into one lump sum, under Scenario One the University hires a total 1,132 RAs; the faculty are charged $49.3 million in salary charges; and the University incurs $16.1 million in overhead costs. In Scenario Two, the University hires only 983 new RAs, charges faculty $47.8 million in salary, and incurs $15.5 million in overhead. Even if the University has to incur higher costs to improve turnover / productivity, the costs in staff savings are probably worth it, as is the more manageable number of RAs. The amount of overhead not reflected in faculty budgets is significant in both cases.

If you look at both scenarios on a quarterly basis, then Scenario Two also produces less spiking. In other words, it requires fewer new staff members to be hired in the first quarter of each year. Both scenarios still require a fair number of new people to be brought in the third year, due to large departures of people on staff by then. Interestingly, the total salary and overhead costs in Scenario Two decrease in a step-like fashion each year, whereas in Scenario One they actually increase from year two to year three.

**QUARTERLY STAFF AND COSTS: SCENARIO ONE**

**QUARTERLY STAFF AND COSTS: SCENARIO TWO**

[Lessons learned](#LessonsLearned)

* Simplicity in model-building is important. It is impossible to account for the rich variability of how organizations work in real life. A more limited number of variables is easier to test, and simpler, cascading formulas with named ranges are easier to explain to other users. Our model was a compromise between wanting to include enough to simulate a real-life situation but not too much so the programming became too complicated. In another model, we might start with a smaller number of input variables.
* Model-building is iterative. Before jumping into the spreadsheet, it is important to: sketch out the mathematical relationships between variables; plan the physical layout of spreadsheets so array formulas work; and question and test results of interim calculations to make sure numbers are making sense. We should have started building and testing the complicated productivity part earlier.
* Modeling projects take more time and are more complicated to manage than initially anticipated. In some senses, it is hard to share on a team, if one part of a model depends on another’s being built; in other senses, passing things off between people generates better approaches and makes sure everything is questioned. It is important to make sure that everyone on a team can understand and explain all parts of the model. We should have kept better written record of our verbal discussions and changing approaches to the modeling.

Actual vs expected budget

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| --- | --- | --- |
|  | Budget | Actual |
| Concept research / devt  | Not included in proposal | 20 |
| Planning | 10 | 10 |
| Modeling / Auditing | 36 | 40 |
| Documents / Graphics | 16 | 20 |
| Scenario Testing | 8 | 10 |
| Total | 70 hours | 100 |