

AN INTERACTIVE DYNAMIC SIMULATION MODEL
OF
A UNIVERSITY MANAGEMENT SYSTEM

by

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ABSTRACT

The main objective of this research is to construct an interactive simulation model, on which a range of problems concerning the academic aspects of a university management system can be analyzed and certain policies for overcoming these problems can be tested. More specifically, the model focuses on long-term, strategic university problems that are dynamic and persistent in nature. The model generates numerous performance measures about the three fundamental activities of a university, namely, teaching, research and professional projects. To construct such a game, a system dynamics model of the academic aspects of a university system is built. The model is validated and verified by standard tests. After these tests, some illustrative scenario experiments are done to demonstrate the analysis capabilities of the model. Next, the necessary changes are made on the model to construct the interactive gaming version and the gaming interface is programmed. After the game is validated, it is played by a group of faculty members, teaching assistants and students. Finally, the game results of these players are analyzed and compared. Differences in performances reveal that players with different orientations focus on different performance measures in making decisions

ÖZET

Bu araştırmanın ana amacı, tipik bir üniversite yönetim sisteminin akademik cephesiyle ilgili sorunların analiz edilebileceği ve bu sorunları çözmeye yönelik politikaların sınırlanabileceği bir etkileşimli benzetim oyununun kurulmasıdır. Model, özellikle dinamik ve süreklilik gösteren, uzun vadeli, stratejik üniversite problemleri üzerinde odaklanmıştır. Model, bir üniversitenin üç ana fonksiyonu olan öğretim, araştırma ve projeler hakkında bir dizi performans ölçütü hesaplamaktadır. Böyle bir etkileşimli benzetim modelinin kurulması için öncelikle üniversite sisteminin akademik cephesinin bir sistem dinamiği modeli kurulmuştur. Daha sonra, bu model üzerinde bir dizi standart geçerlilik sına testi yapılmıştır. Geçerlilik testlerinden sonra, modelin sağladığı analiz imkanlarını sınamak üzere bir dizi senaryo deneyi yapılmıştır. Modelin etkileşimli versiyonunu hazırlamak için gerçekleştirilen değişikliklerden sonra oyun arayüzü programlanmıştır. Daha sonra, oyun geçerlilik açısından sınanmış ve öğretim üyeleri, araştırma görevlileri ve öğrencilerden oluşan bir grup oyuncu tarafından oynanmıştır. Son olarak, bu oyuncuların oyun sonuçları incelenmiş ve karşılaştırılmıştır. Oyuncuların performansları arasındaki farklar değişik akademik önceliklere sahip oyuncuların karar alırken farklı performans ölçütlerini gözönünde bulundurduklarını göstermiştir.

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LIST OF ABBREVIATIONS

Act	Actual
Ave	Average
Cha	Change
Coef	Coefficient
Comm	Commitment
Dec	Decrease
Des	Desired
Eff	Effect
Fac	Faculty
Faci	Facilities
FTE	Full Time Equivalent
GF	Graduate Faculty
GI	Graduate Instruction
Grad	Graduate
Hist Ave	Historical Average
IGP	Income Generating Projects
Inc	Increase
Ind	Indicated
Instr	Instruction
Lab	Laboratory
Max	Maximum
Min	Minimum
Pap	Papers
Prog	Programs
Pub	Published
Qua	Quality
Rea	Realized
Redu	Reduction
Res	Research
Spons	Sponsored

Stu	Students
UG	Under-graduate
UGF	Under-graduate Faculty
UGI	Under-graduate Instruction
Unspans	Un-sponsored
UP	Unofficial Projects

1. INTRODUCTION

The information age we are living in is a time when humanity witnesses the truth that lies behind the proverb "Knowledge is power.", as clear as never before. Today, all the nations of the world try to cover the path that leads to the 'information society', as soon as possible. The most important driving force towards that destination is a well educated human potential. During the recent decades, it has become quite clear that the most critical agents for generating a qualified human potential are the universities. The universities further deserve the merit of being the leading actors behind the formation of the information society, because of their role in accumulating and shaping scientific knowledge.

With the increasing emphasis on the importance of universities, the intensity of the debates concerning the universities seemed to increase, as well. This fact can be explained by the need of a radical and extensive reform in the structure and the functions of the universities, in order to cope with the rapid changes in the demands and expectations of the society from universities.

While the need for reviewing and reshaping the objectives, strategies and policies become inevitable, the more urgent problems concerning the financial and the academic aspects of the universities still wait to be solved. Especially in developing countries, where the university problems have a systemic and chronic nature, the actions for solving these problems deserve to be among the main priorities towards constructing a better future for the society.

Most of the problems concerning the universities are unlikely to be solved without macro level policies, which must be employed by governments and international organizations. However, there are many lower level problems, which can be handled and solved to a certain extent within a single, individual university. Developing and implementing such solutions deserve considerable effort, because university administrations can not set all hopes upon the actions from government and wait for the day when some help will reach from outside the university.

This study is done with the goal of constructing a model, a quantitative platform to analyze the problems concerning the academic aspects of a university system and to test the effects of possible solutions.

2. PROBLEM BACKGROUND

Administrators of contemporary universities face the challenge of maintaining the quality of the fundamental functions of a university, namely teaching, research, academic and professional service, while trying to serve an increasing number of students, under the pressure of limited resources in terms of faculty, facilities and income.

The most often discussed problems of the contemporary universities are [1, 2, 3, 4, 5]

- (a) an unbalanced growth in student population;
- (b) increasing student / faculty member ratios because of an insufficient increase in faculty body;
- (c) an infrastructure that can not keep up with the student growth;
- (d) faculty members unable to carry out sufficient research;
- (e) insufficient funding for research infrastructure;
- (g) concerns about quality of class instruction.

Though these problems are encountered in academic environments of almost all countries, the size and complexity of the problems seem to be greater in developing countries like Turkey. [1, 4]

An important fact about these problems is that most of them are persistent ones. For example the sheer growth of student population is addressed as the most important problem of Turkish higher education system and it is not likely to diminish in the visible future. The ratio of high school graduates who seek higher education to those who can acquire it is greater than three and this ratio seems to increase though there are considerable efforts to channel the pressure to 'open universities' (In Turkey , the percentage of students who attend to 'open universities' among all university students is 42 per cent.) [1]. All these figures, together with the low likelihood of a dramatic increase in funds dedicated to higher education, which would generate new university capacity, indicate that the problem of sheer growth in student population is a persistent one. The fact that emerges directly from

recognizing the above mentioned problems as persistent ones is that university administrations have to continuously seek solutions that alleviate the severity of these problems.

Most of the innumerable studies written on university problems include the authors' different suggestions for solutions. Almost all the authors emphasize the necessity of increasing the budgets of the universities [1, 3, 5, 6]. One of the possible ways to realize this increase is pointed out as giving the universities administrative and financial autonomy, so that the administrations can expand their means of finance and choose the policies that will optimize the use of their limited resources [1, 3, 6]. Another suggestion is to increase the share of the students' tuition in covering the teaching expenses along with implementing proper scholarship policies [1, 2].

A suggestion to decelerate the student population growth is to expand the associate degree education. The current percentage of associate degree students among all higher education students is 10 per cent, in Turkey [1].

Another important concern about universities is the quality and quantity of research activities. Current figures about the research activities in Turkey are far from being satisfactory. The number of research papers published in international journals per faculty member per year is around 0.17 [1]. The solutions suggested to increase the quality and quantity of research are centralized around increasing the ratio of graduate education against undergraduate education. But the problem of insufficient funds appear as an obstacle. One way to overcome this obstacle is proposed as increasing the funds received through research and development projects [2, 1].

An important facet of the university problems in Turkey is insufficient faculty body. The current student/faculty ratio in Turkey is around 24, while the recommended ratio is at most 15 [1]. The quality of the faculty members is an important concern, as well. There are noteworthy suggestions to increase the quantity and quality of the faculty members. One of these is to establish 'elite universities', which would have low students/faculty ratios, high graduate/undergraduate student ratios, high teaching and research budgets [1]. Another

suggestion is forming extensive and lasting exchange programs with reputable higher education institutions. These programs, which would involve both students and faculty members, are expected to increase instruction quality [2].

All the solutions suggested above are large scale ones and require plans and initial actions from government. But until these plans are made and actions are taken, university administrations should develop and implement their own methods and policies in order to tackle their own problems at an 'individual' level.

A radical solution is to implement professional administration in universities. The argument is that most rectors, not having a professional administration background, lack some important experiences which are possessed by professional managers and administrators [1, 2]. Some authors propose a synergy among the rector, who should be an academic personality, and professional administrators [2], while some others suggest that academic background should not be a must for a rector [1].

Along with professional administration, implementing strategic planning and total quality management in universities are suggested, as well [2]. There are considerable efforts on TQM implementations in universities of various countries. In 1989, Oregon State University became one of the first American higher education institutions to implement the TQM methodology. At the beginning of 1990s not less than 78 institutions were either exploring or attempting to implement TQM [7]. The attempts towards TQM in the U.S. were followed by efforts in other countries [8, 9, 10].

Yet another methodology used to improve university administrations in order to cope with the existing problems is System Dynamics. Though not numerous, there have been notable work on the use of System Dynamics methodology on university systems and problems.

An important study, which was done by Zhang, Zhang and Mong in 1990, presents a system dynamics model of the management system of a Chinese college. The model was constructed in order to analyze the dynamics behind the development of a college. The

authors try to point out the problems and include some results of policy experiments. The paper includes some major conclusions and suggestions for improving the behavior of the system [11].

Another notable study was done by Mahmoud and Genta in 1993. The paper introduces a system dynamics model of Athabasca University, an open university in western Canada. Authors focus on issues such as service quality, course development and market potential. The necessity of a dynamic model for analyzing the long term implications of different policies is emphasized and some general conclusions reached through scenario analyses are presented [12].

In 1993, Saeed presented his study on the dynamics of higher education organizations in the developing countries. The author introduces a conceptual system dynamics model of a collegial system. The importance of the balance between administrative and academic, or professional activities as the authors puts it, within a collegial institution is emphasized throughout the paper. Finally, the author discusses the main dynamics, namely the feedback loops, that maintain and develop the productivity and the economic health of the collegial organizations [13].

Frances et al. have done a study on the use of System Dynamics methodology to improve planning and budgeting for higher education. The paper summarizes the System Dynamics projects realized in Arizona and Texas in order to improve higher education planning. The final part of the paper includes a section on advantages of using System Dynamics methodology for planning purposes [14].

Two other studies, which do not make use of System Dynamics methodology, deserve to be mentioned for they are based on system simulation methodology, which is closely related to System Dynamics. First of these is the study of Vemuri, published in 1982. This paper presents a methodology for modeling a university research support service system (RSSS). After the framework and main structural and functional components of an RSSS are introduced, the simulation model is explained. The rest of the paper includes the model validation and some scenario analyses [15].

The other study using system simulation methodology is a paper by Sinuany-Stern, published in 1984. The paper introduces a financial planning model for a multi-campus college. After the explanation of the model, some scenario analyses are presented [16].

3. PROBLEM STATEMENT

The problems that contemporary university administrations face and possible solutions have been studied both on macro and micro levels by many researchers, as presented in the preceding section. Most of the studies presented herein were based on certain quantitative research; yet, a great portion of literature on university problems and their solutions in Turkey do not have quantitative foundations, mostly because such systems involve qualitative (human) elements that are difficult to quantify and model. The link between the qualitative and the quantitative aspects of the problem is important and therefore deserves more research. A possible approach, in order to model and explore this link, is System Dynamics; a methodology which employs a set of techniques that allows quantitative and realistic representation of variables that are typically perceived to be qualitative. This study intends to construct a quantitative platform, on which a range of problems concerning a university administration system can be analyzed and certain policies for overcoming these problems can be tested and compared.

In particular, the model will focus on those university problems that are dynamic and persistent in nature and as such must be addressed by high level, strategic policy-making mechanisms within the university. These strategic policy making mechanisms are typically the rector, the deans, and the major policy-making councils at the university and divisional levels. The final goal of the research is constructing an interactive gaming version of the model that can be played by such policy makers.

4. RESEARCH METHODOLOGY

In this study, an interactive dynamic simulation model, which is intended to represent the academic aspects of a university system is built. The tool used to analyze the system and build the model, is System Dynamics methodology.

System Dynamics methodology was introduced in 1960's by a group of scientist at Sloan School of Management at MIT. At the beginning, it was applied to industrial systems. During 1970' and 1980's it has become extremely popular and has been applied to a wide range of systems, including ecological, economic, sociological and even psychological systems.

System Dynamics methodology performs satisfactorily in analyzing and modeling complex, large scale, non-linear, partially qualitative social systems. The main assumption of System Dynamics approach is that the world, with all its physical, ecological, sociological, economic aspects, is a whole and is composed of innumerable sub-systems. Other important assumptions of System Dynamics are:

- (a) direct causal relationships between variables,
- (b) interdependence of causal factors through feedback loops.

Whenever there is a two way causal relationship among variables, there exists feedback. For example, assume that a change in variable X changes variable Y and after a time delay a change in variable Y changes X; here exists a feedback loop between X and Y. A change in X changes Y, and this change in Y changes X and so on. Feedback loops typically involve more than two variables. There are two types of feedback loops: positive and negative. In case of a positive feedback loop, an initial increase in X returns back to X through the feedback loop as an increasing effect; and an initial decrease in X returns to X as a decreasing effect. Thus, positive feedback loops reinforces the initial change over time. On the other hand, an increase in X returns to X as a decreasing effect through a negative feedback loop, whereas a decrease returns as an increasing effect.

Almost every system includes a number of both negative and positive feedback loops, which interact and operate simultaneously. Large scale models include large numbers of feedback loops. It is not unlikely to encounter variables which are related to several thousand feedback loops within a model with several hundred variables. The length of feedback loops may vary from two variables to several hundred variables within a large scale model with around one thousand variables; but generally, as the length of the feedback loop increases, its impact decreases.

An important distinction of System Dynamics methodology is that it is used to analyze dynamic systems, in which the fundamental variables tend to change through time. This means difference equations are the main mathematical structures.

The variables are grouped into three according to their mathematical characteristics. First group are the 'stock (or level) variables', which represent values that accumulate or decay through time. The value of a stock variable, at a given time, depends on its previous values, and the sum of inflows and outflows in the previous time interval.

The second group are 'flow (or rate) variables'. These variables represent the changes in stock variables through time. So, they are connected directly to stocks that they change. Stock-flow relationships correspond to differential equations whereby the flows represent the derivatives of stock variables.

The third group are 'converters'. These variables represent quantities which are determined at every time increment only by the variables that effect them and not by their previous values. Thus, they simply represent how a certain variable depends on other variables at a point in time.

The models may be represented by causal loop diagrams, which show the causal relationships between variables without making any distinctions between stocks, flows and converters. Structure diagrams, on the other hand, which show both the causal relationships and the mathematical characteristics of the variables. Naturally, a set of mathematical equations, which demonstrate the algebraic relationships among the variables, accompany these diagrams. When expressing it mathematically, i.e. with equations, the model can be

reduced to equations that represent only the stock variables.

The normal procedure of constructing a System Dynamics model begins with describing the problem. After that the scope of the model is determined in order to set the boundary and define the variables of the model; this step is called 'model conceptualization'. The next step is 'model construction' which is self explanatory. After the initial construction step, various verification and validation test are executed on the model. These test can be grouped in two groups as 'structural' and 'behavior' tests. Structural tests include the verification stage during which the simulation program is examined in order to determine whether it is doing what it is expected to do according to the current structure and equations. Then comes the extreme condition tests, which are executed in order to determine whether the model exhibits expected behaviors under extreme conditions. After that the sensitivity tests are executed in order to determine whether the sensitivity of the model to changes of different parameters is at an acceptable level. After structure tests behavior tests are executed in order to determine whether the model behavior is statistically close enough to the behavior exhibited by the real system. During all these tests, necessary modifications on the model are made.

The model that is presented in this study is used to drive an Interactive Dynamic Simulation Environment. In recent years, Interactive Dynamic Simulation Environments have been one of the main areas of interest in the field of System Dynamics. Such simulation environments are developed to provide a realistic micro model of a given system, which lets the users test their decisions interactively without interfering the real system.

Interactive Dynamic Simulation Environments provide considerable benefits, both as a teaching/learning tool and as a research tool. Their main benefit is that they encourage active learning which relies mostly on the participation of the user, letting him to learn about the system that was modeled, as if he were interacting with the real system. Another benefit is that this method enhances communication between the individual learners who form a group within an organization, since it requires discussions in small project teams. The main benefit provided by Interactive Dynamic Simulation Environments as a research tool is that using these tools it is possible to test the validity and robustness of a model, by having a wide variety of participants play the game making all kinds of different decisions. Interactive

Dynamic Simulation Environments also have the potential of a research tool for analyzing the various aspects of dynamic decision making theory [17].

The micro models can be presented as computerized simulation games using interactive dynamic simulation game designing environments, like MicroWorlds Creator [18], dynamic system simulation packages like Stella, Dynamo, Vensim, etc., programming languages like Pascal, C, C++, etc. or even spreadsheets like Excel, Quattro Pro, etc. The software package used to build the model presented in this study is Vensim (Ventana Simulation Environment). The gaming interface was written in and is ran through Vensim's built-in Venapp (Ventana Application) facility.

5. MODEL DESCRIPTION

5.1. Overview

The model presented in this study focuses on the academic aspects of university administration system. The main concerns while modeling the system were faculty members' time allocation among main activity groups, the factors that determine this allocation, allocation of certain facilities and the performance indicators realized as a result of these allocations. The basic time step used in the simulation is a semester.

The model is constructed on sector basis. The main sectors are determined according to the main academic activity groups of the faculty members. Before determining their activities, faculty members are grouped into two. First group are 'Graduate Faculty Members', who are primarily involved in graduate instruction and research. These faculty members are also involved in under-graduate instruction. The second group are 'Under-graduate Faculty Members', who are involved only in under-graduate instruction and have little interest in research. Still, they are involved in research to a certain extend.

After this grouping, main activity areas of the faculty members are determined. Graduate and under-graduate instructions are the first two. These instruction activities are further divided into two within each one as (a) in-class instruction and (b) instruction overhead, which includes all out-of-class activities related to instruction, such as preparation of lectures and tests, revision of tests and homeworks, office hours and advising. Another main group are research activities. Research activities are divided into two as (a) unsponsored research activities, which are not sponsored financially except for the university's own resources and (b) sponsored research activities, which are supported by governmental or private organizations.

The last activity group are project activities, which are divided into two as (a) income generating projects, which are activities like seminars, courses or consulting realized

through university channels and generate income to the university and (b) unofficial projects, which are activities like seminars, courses or counseling realized through non-university channels and do not generate any income to the university.

Based on the grouping above, the activities of a graduate faculty member are determined as:

- (a) graduate instruction,
- (b) under-graduate instruction,
- (c) graduate instruction overhead,
- (d) under-graduate instruction overhead,
- (e) unsponsored research,
- (f) sponsored research,
- (g) income generating projects,
- (h) unofficial projects.

Similarly, the activities of an under-graduate faculty member are determined as:

- (a) under-graduate instruction,
- (b) under-graduate instruction overhead,
- (c) unsponsored research,
- (d) sponsored research,
- (e) income generating projects,
- (f) unofficial projects.

After these analyses, the sectors of the model are determined. The first sector is 'Graduate Instruction Sector'. In this sector, the potential graduate faculty workforce that can be assigned to instruction and the need for graduate instruction is calculated and the potential faculty workforce is assigned to graduate instruction. (Figure 5.1). If the potential workforce is not enough to compensate all the need, the discrepancy is tried to be eliminated with some other strategies that are explained in detailed sector description. On the other hand, if the potential graduate faculty workforce for instruction is more than the need for graduate instruction, the surplus is transferred to 'Under-graduate Instruction Sector'.

In 'Under-graduate Instruction Sector' the need for under-graduate instruction is determined and compensated with the potential under-graduate faculty workforce that can be assigned to instruction and the surplus graduate faculty workforce for instruction, that is transferred, if any, from 'Graduate Instruction Sector'. Again, if the need is more than the available workforce, some other strategies are used to eliminate the discrepancy. (Figure 5.2).

In 'Graduate Instruction Quality Sector' (Figure 5.3) and 'Under-graduate Instruction Quality Sector' (Figure 5.4), graduate and under-graduate instruction quality indicators are calculated.

In 'Graduate Faculty Instruction Overhead Sector' the instruction overhead load for graduate faculty members are determined and assigned to graduate faculty members and assistants. (Figure 5.5). The surplus graduate faculty workforce that remains after the in-class instruction and instruction overhead tasks is calculated and divided among research and project activities. This division procedure is explained in detailed sector description.

Similar calculations are made in 'Under-graduate Faculty Instruction Overhead Sector' about the instruction overhead loads for under-graduate faculty members. (Figure 5.6). The remaining under-graduate faculty workforce is divided among research and project activities.

In 'Graduate Faculty Research Sector' the total graduate faculty workforce for research is divided among unsponsored and sponsored research activities, according to unsponsored and sponsored research motivations. (Figure 5.7). These motivations are explained in detailed sector description. The outcomes of research activities, (research papers, funds and grants), are determined and some performance indicators are calculated.

Similar procedures take place in 'Under-graduate Faculty Research Sector' and similar workforce divisions, motivations, research outcomes and performance indicators are calculated for under-graduate faculty. (Figure 5.8). Except that research activity levels are much lower in this case.

In 'Graduate Faculty Projects Sector' the total graduate faculty workforce for projects is divided among income generating projects and unofficial projects according to the related motivations, which are explained in detailed sector description. (Figure 5.9). The funds obtained from income generating projects and the share of the faculty is calculated.

In 'Under-graduate Faculty Projects Sector' similar workforce divisions, motivations and outcomes are calculated for under-graduate faculty. (Figure 5.10).

In 'Lab Facilities Sector' the division of the laboratory facilities among instruction, research and project activities is made and the changes in laboratory facilities are calculated. (Figure 5.11).

In 'Assistants Sector' the assistant workforce is calculated and the maximum available assistant hours for instruction overhead assignment is determined. These figures are used in 'Graduate Faculty Instruction Overhead Sector' and 'Under-graduate Faculty Instruction Overhead Sector'. (Figure 5.12).

5.2. Sector Descriptions

5.2.1. Graduate Instruction Sector

The main variables in this sector are 'Number of Graduate Faculty' and 'Number of Graduate Students'. (Figure 5.1). 'Number of Graduate Faculty' decreases through 'GF that Leave' and increases through 'New Grad Faculty'. 'New Grad Faculty' is determined by 'GF Hiring Decision', under the constraints of 'Vacant Faculty Positions' and 'Indicated GF Supply'. 'GF Hiring Decision' is a user decision variable in the game version, but in the original model, it is computed so as to eliminate the discrepancy between the need for graduate faculty and the existing graduate faculty workforce. 'GF Supply' depends on

'Instruction Load per GF' and 'Historical Average GF Salary'. These variables effect 'GF that Leaves', as well.

The variable that represents the graduate faculty workforce that can be assigned to instruction is 'Operating Total FTE (Full Time Equivalent) Grad Faculty for Instruction'. 'Full time equivalent (FTE)' is a keyword that is used throughout this study and means the equivalent number of faculty members involved full-time in a certain activity. It can be explained better by an example: Suppose there are 20 faculty members who spend 1/4 of their time on research activities on the average; so we have $20 * (1/4) = 5$ FTE faculty members involved in research. 'Operating Total FTE Grad Faculty for Instruction' is the product of 'Number of Grad Faculty' and 'Operating Maximum Instruction Hours per Grad Faculty'. This latter indicates the maximum weekly instruction hours that can be assigned to a graduate faculty member under normal conditions and is calculated by subtracting 'Release Time for Grad Faculty' from 'Operating Maximum Instruction Hours per Undergraduate Faculty' minus three; which is the normal operating maximum instruction hours per graduate faculty. 'Release Time for Grad Faculty' is the amount of decrease made in the weekly instruction load per graduate faculty member on the average, in order to leave them more time for research. It is a user decision variable in the game version.

Graduate students are divided into two as 'Graduate Students 1', those who take courses and 'Grad Students 2', those who have completed their credits and prepare their theses. The need for graduate instruction is represented by 'Total Grad Student Hours', which is the product of 'Number of Graduate Students 1' and 'Average Hours per Grad Student'. 'Total Graduate Instr Hours Needed' is equal to the maximum of {'Total Grad Student Hours' divided by 'Desired Average Grad Class Size' and 'Number of Grad Programs' times 'Minimum Instr Hours per Grad Program'. 'Total FTE Needed for Grad Instr' is determined by dividing 'Total Graduate Instr Hours Needed' by 'Weekly Hours per Faculty'.

After 'Total FTE Needed for Grad Instr' and 'Operating Total FTE Grad Faculty for Instr' are calculated, these variables are compared to see whether a discrepancy exists between them. This discrepancy is represented by 'Extra FTE Need for Grad Instr'. This variable takes a positive value if the need is more than available FTE or takes the value zero,

otherwise. 'Extra FTE Need for Grad Instr' is compensated by 'Part Time FTE for Grad Instr'. 'Part Time FTE for Grad Instr' can not be more than a certain percentage of the FTE graduate faculty assigned to graduate instruction. So, it is equal to the minimum of {'Extra FTE Need for Grad Instr' and 'Operating Total FTE Grad Faculty for Instr' times 'Max Part Time Percentage for Grad Instr'}. Note that, in this case, the FTE graduate faculty assigned to Graduate instruction is equal to 'Operating Total FTE Grad Faculty for Instr', because it is all used up.

If 'Extra FTE Need for Grad Instr' is greater than 'Part Time FTE for Grad Instr', it can not be compensated totally and a discrepancy, 'Grad Instr Discrepancy', occurs. This discrepancy is tried to be eliminated by increasing the average class size. 'Maximum Grad Class Size Allowed' sets an upper limit for the 'Actual Average Grad Class Size' and if increasing the class size, even up to that limit can not eliminate the discrepancy, the variable 'Unsatisfied Need for Grad Instr' takes a positive value. This unsatisfied need is tried to be eliminated by assigning extra instruction hours to graduate faculty. Weekly instruction hours that can be assigned to a graduate faculty member, in cases of abnormally high instruction need is limited by 'Absolute Maximum Instr Hours per GF'. Assigning extra class hours to full-time faculty members increases the full-time FTE for instruction and therefor makes possible increasing the part-time FTE, because part-time FTE usage is limited by a certain percentage of full-time FTE for instruction. If the extra workforce which is given by the difference between 'Absolute Maximum Instr Hours per GF' and 'Operating Maximum Instr Hours per GF' and the additional part-time FTE is not enough to eliminate the unsatisfied need for graduate instruction, the courses that can not be assigned are canceled, so the variable 'Canceled Grad Lecture Hours' takes a positive value.

As an output of this sector and an input to 'Undergraduate Instruction Sector', 'Implied FTE Grad Faculty for UG Instr' is calculated as the positive difference between 'Operating Total FTE Grad Faculty for Instruction' and 'Total FTE Needed for Grad Instr'. Note that if this difference is positive, all graduate instruction need is compensated by graduate faculty within the limit of operating maximum instruction hours; and the surplus FTE graduate faculty for instruction is transferred to 'Undergraduate Instruction Sector' to be used for under-graduate instruction.

5.2.2. Under-graduate Instruction Sector

This sector resembles to 'Graduate Instruction Sector' in many aspects. (Figure 5.2). The dynamics governing 'Number of Under-graduate Faculty' are similar to the dynamics governing 'Number of Graduate Faculty'. The total faculty workforce for under-graduate instruction is represented by 'Implied Total FTE for UG Instr' and is equal to the total of 'Implied FTE Grad Faculty for UG Instr' and 'Operating Total FTE UG Faculty for Instr'.

If the available faculty workforce for under-graduate instruction is more than the need, which is represented by 'Total FTE Needed for UG Instr', 'Extra FTE Needed for UG Instr' takes a negative value. This workforce surplus is divided among 'Surplus FTE Grad Faculty' and 'Surplus FTE UG Faculty', in order to equalize the instruction loads of graduate faculty and under-graduate faculty members. On the other hand, if the need is more than the available faculty workforce for under-graduate instruction, then the discrepancy is tried to be eliminated by part-time faculty. Here, again, the amount of part-time FTE is limited by a certain percentage of 'Implied Total FTE for UG Instr'.

If part-time FTE fails to compensate the extra need, average class size is increased. The class size is limited by 'Maximum UG Class Size Allowed'. If increasing the class size even up to this limit fails to eliminate the discrepancy, the instruction loads on graduate and under-graduate faculty are increased. If increasing these loads up to absolute maximum instruction hour limits and using additional part-time faculty workforce can not compensate the need, some under-graduate courses are canceled.

As all the instruction assignments are completed, average instruction loads per graduate and under-graduate faculty member are calculated in this sector.

There are similar sub-systems in 'Graduate Instruction Sector' and 'Under-graduate Instruction Sector' to arrange the number of programs. Number of programs are determined by the historical average number of students in both instruction sectors. As historical average number of students increases new programs may be opened and as this average goes under certain threshold levels, some programs are closed.

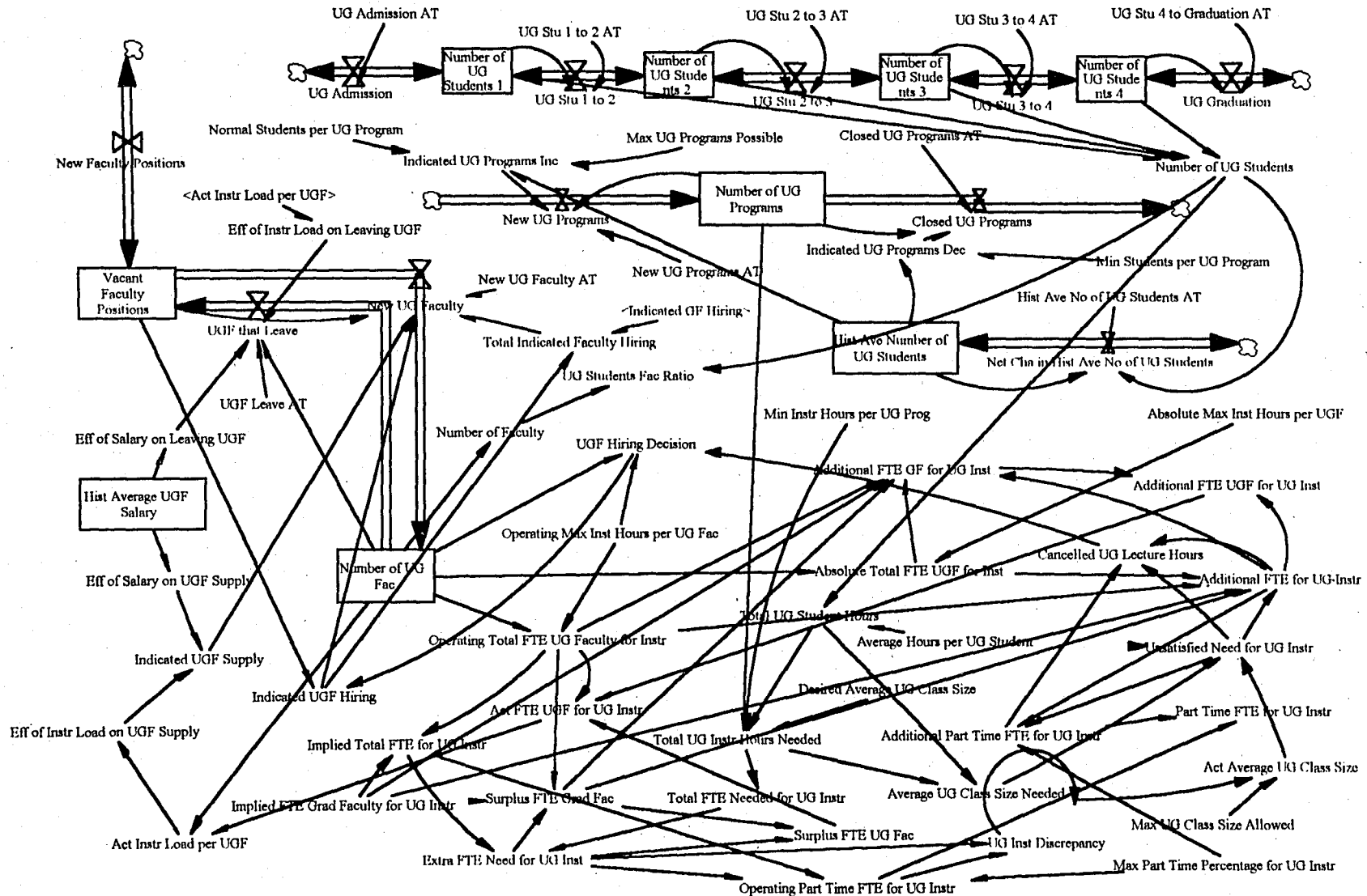


FIGURE 5.2. Structure Diagram of Under-graduate Instruction Sector

5.2.3. Graduate Instruction Quality Sector

This is the sector where the graduate instruction quality indicators are calculated. (Figure 5.3). The main instruction quality indicators are 'Graduate Students/Grad Faculty Ratio', 'Actual Graduate Instruction Overhead per Grad Student', 'Actual Average Graduate Class Size' and 'Lab Facilities for Graduate Instruction per Graduate Student'. 'Actual Graduate Instruction Overhead per Grad Student', 'Actual Average Graduate Class Size' and 'Lab Facilities for Graduate Instruction per Graduate Student', together with 'Historical Average Research Papers per Grad Faculty', determine the 'Graduate Faculty Teaching Commitment' through 'Graduate Instruction Quality Index'. Effects of these quality indicators determine the 'Period Grad Instruction Quality Index'. The historical average of this index is 'Perceived Grad Instruction Quality Index'. The ratio of the 'Assumed Graduate Instruction Quality Index', (which can be explained as the average graduate instruction quality goal of the faculty members), to the 'Perceived Grad Instruction Quality Index' indicates a teaching commitment. As the ratio increases in favor of the assumed index, 'Indicated GF Teaching Commitment' increases and as the ratio decreases, indicated commitment decreases. Another variable that effects 'Indicated GF Teaching Commitment' is 'Assumed/Perceived Under-graduate Instruction Quality Index' ratio, because graduate faculty is involved in under-graduate instruction, as well. 'Assumed/Perceived Under-graduate Instruction Quality Index' is a ratio that is determined in 'Under-graduate Instruction Quality Sector'. 'Graduate Teaching Culture, which is an indicator of the long-term attitude of the graduate faculty members about instruction quality, effects 'Indicated GF Teaching Commitment', as well. The historical average of 'Indicated GF Teaching Commitment' is 'GF Teaching Commitment' and it is used as an input to 'Graduate Faculty Overhead Sector'.

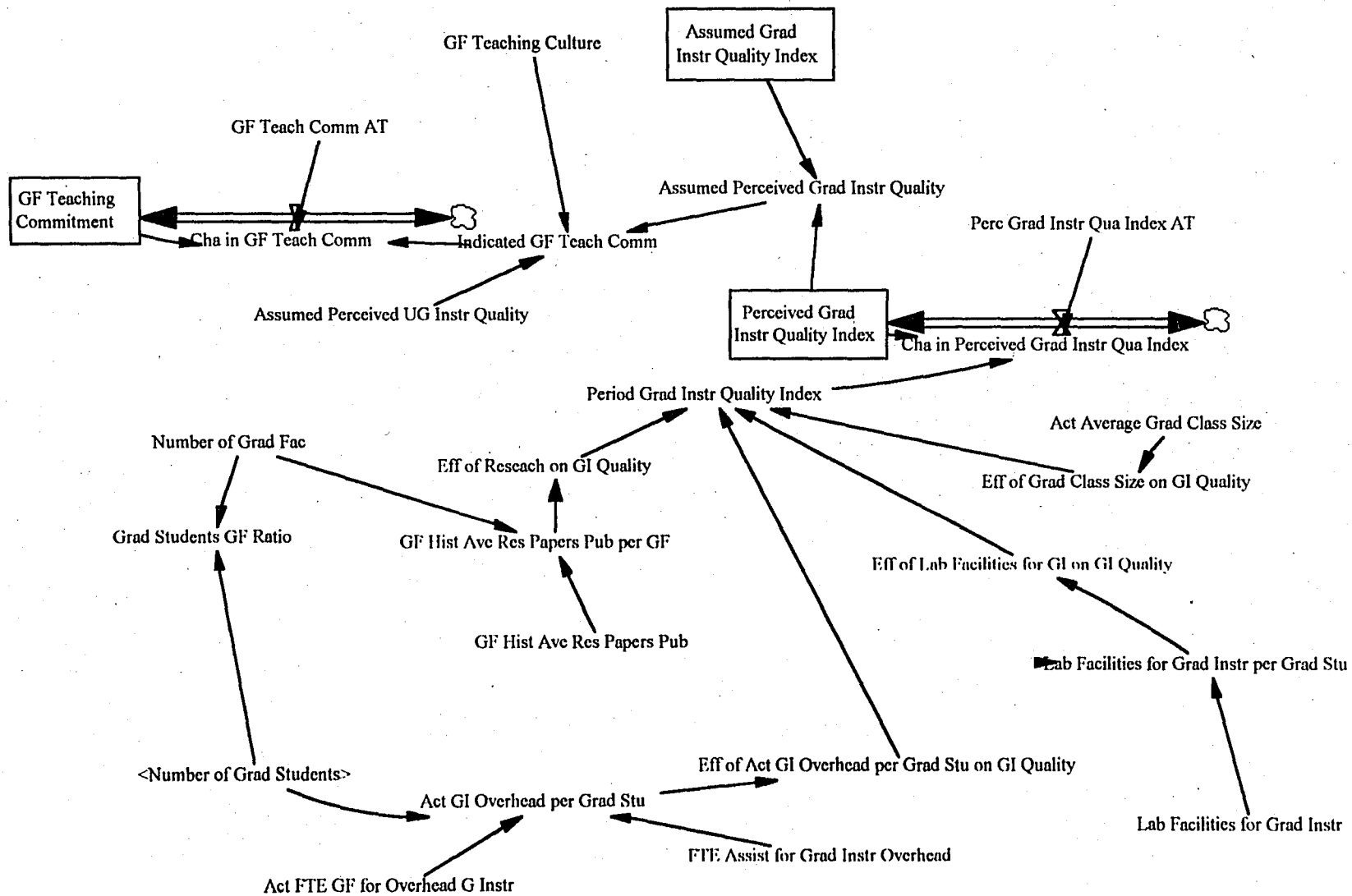


FIGURE 5.3. Structure Diagram of Graduate Instruction Quality Sector

5.2.4. Under-graduate Instruction Quality Sector

The quality indicators about under-graduate instruction are calculated in this sector. (Figure 5.4). This sector resembles to 'Graduate Instruction Quality Sector'. 'Actual Under-graduate Instruction Overhead per Under-graduate Student', 'Actual Average Under-graduate Class Size', 'Lab Facilities for Under-graduate Instruction per Under-graduate Student' and 'Historical Average Research Papers per Faculty' effect the 'Period Under-graduate Instruction Quality Index'. The ratio among the historical average of this index, 'Perceived Under-graduate Instruction Quality Index' and 'Assumed Under-graduate Instruction Quality Index' determine 'Indicated UGF Teaching Commitment' together with 'UGF Teaching Commitment'. The historical average of 'Indicated UGF Teaching Commitment' is 'UGF Teaching Commitment' and is used as an input to 'Under-graduate Faculty Overhead Sector'.

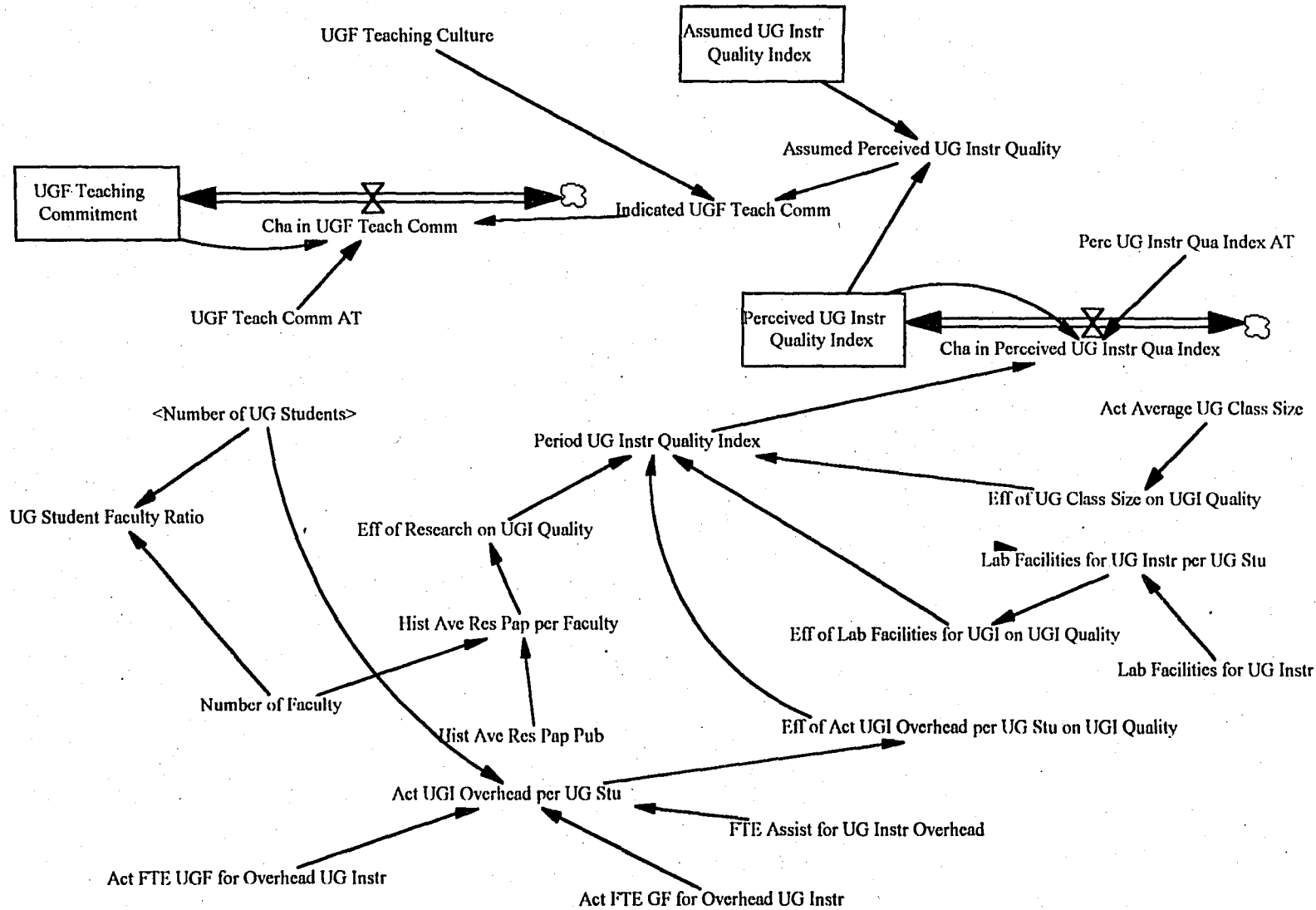


FIGURE 5.4. Structure Diagram of Under-graduate Instruction Quality Sector

5.2.5. Graduate Faculty Overhead Sector

In this sector the instruction overhead loads of graduate faculty members are calculated and the remaining graduate faculty workforce, after assigning in-class instruction and instruction overhead loads, is divided among research and project activities. (Figure 5.5).

Two different instruction overhead loads are calculated for graduate faculty members: graduate instruction overhead and under-graduate instruction overhead. The main variable that determines the graduate instruction overhead is 'Actual FTE Graduate Faculty for Graduate Instruction'. By assuming that a certain amount of in-class instruction implies a certain amount of instruction overhead, 'Normal FTE GF for Grad Instr Overhead' is calculated as the product of 'Actual FTE GF for Grad Instr' and 'Normal Overhead Ratio for Grad Instr'. 'Normal Overhead Ratio for Grad Instr' represents the instruction overhead load implied by unit in-class instruction load and is determined within certain limits by 'Actual Average Grad Class Size'; as average class size increases, instruction overhead implied by unit in-class instruction load increases. A certain portion of 'Normal FTE GF for Grad Instr Overhead' is assigned to teaching assistants through the procedures explained in the detailed description of 'Assistants Sector'. The rest of the implied instruction overhead load is represented by 'Indicated FTE GF for Grad Instruction Overhead'.

The same approach is used for calculating 'Normal FTE GF for Under-graduate Instr Overhead' and assigning a certain portion of this load to teaching assistants, 'Indicated FTE GF for Under-graduate Instruction Overhead' is determined.

By subtracting 'Total In-Class FTE GF', 'Indicated FTE GF for Graduate Instr Overhead', 'Indicated FTE GF for Under-graduate Instr Overhead' and 'FTE GF for Other Routine Tasks' from 'Total FTE Graduate Faculty', 'Total Indicated Non Instr FTE Graduate Faculty' is calculated. This is the maximum amount of FTE graduate faculty that can be involved in research and project activities by working the normal 'Weekly Hours per Faculty'.

On the other hand, 'Desired FTE GF for Research and Projects' is calculated as a function of the difference between 'Total FTE GF' and 'Total In-Class FTE GF', which can be stated as the total out-of-classroom FTE GF. The other variable that effects 'Desired FTE GF for Research and Projects' is 'Graduate Faculty Research and Projects Commitment', which is the arithmetic average of 'Graduate Faculty Research Commitment' and 'Graduate Faculty Financial Pressure'. 'Graduate Faculty Research Commitment' is explained in the detailed description of 'Graduate Faculty Research Sector' and 'Graduate Faculty Financial Pressure' is explained in the detailed description of 'Graduate Faculty Projects Sector'.

'Desired FTE GF for Research and Projects' does not have to be equal to 'Total Indicated Non Instr FTE GF'. It can be more or less than this value, as well as being equal to it. If it is less a certain amount of 'Inactive FTE GF' occurs. This gives the total idle graduate faculty hours. If 'Desired FTE GF for Research and Projects' is more than 'Total Indicated Non Instr FTE GF', 'Indicated GF Extra Work Load takes a positive value. This variable represents the average extra weekly hours per graduate faculty that must be worked in order to sustain the desired amount of time for research and project activities. If this extra load is more than a certain amount, a reduction need in overhead activities occurs; this is represented by 'GF Overhead Reduction Need' and implies 'GF Overhead Reduction Coefficient', which takes values between zero and one. This coefficient depends on 'GF Teaching Commitment', as well. As the teaching commitment increases the reduction coefficient decreases. Indicated overhead loads are multiplied by one minus 'GF Overhead Reduction Coefficient' and the actual overhead loads, 'Actual FTE GF for Overhead Grad Instr' and 'Actual FTE GF for Overhead UG Instr' are determined

By subtracting 'Total In-Class FTE GF', 'Actual FTE GF for Overhead Grad Instr' 'Actual FTE GF for Overhead UG Instr' and 'FTE GF for Other Routine Tasks' from 'Total FTE GF', the variable 'Actual Non Instr FTE GF' is calculated. 'Reduced GF Extra Work Load', which is the difference between 'Desired FTE GF for Research and Projects' and 'Actual Non Instr FTE GF', represents the average extra weekly hours per graduate faculty member after reducing the instruction overhead. If this extra load is more than 'GF Bearable Extra Work Load', which is the average maximum weekly extra hours that can be accepted by a graduate faculty member, this means that 'Desired FTE GF for Research and

Projects' can not be realized entirely. 'Available FTE GF for Research and Projects' is calculated as the total of 'Total Non Instr FTE GF', (which is remaining normal weekly graduate faculty workforce), and the minimum of desired and bearable extra work loads, represented by 'Reduced GF Extra Work Load' and 'GF Bearable Extra Work Load', respectively.

'Actual FTE GF for Research and Projects' is equal to the minimum of desired or available FTE GF for research and projects. 'Actual FTE GF for Research and Projects' is divided among 'Actual FTE GF for Projects' and 'Actual FTE GF for Research' according to the relative weights of 'GF Financial Pressure' and 'GF Research Commitment'.

5.2.6. Under-graduate Faculty Overhead Sector

This is the sector where the instruction overhead loads of under-graduate faculty members are calculated and the under-graduate workforces for research activities and for project activities are determined. (Figure 5.6). This sector resembles to 'Graduate Faculty Overhead Sector'. The dynamics in both sectors are similar. The main difference is that only under-graduate but no graduate instruction overhead is assigned to under-graduate faculty, because they are not involved in graduate instruction.

'Normal FTE UGF for UG Instr Overhead' is determined by 'Actual FTE UGF for UG Instr' and 'Normal Overhead Ratio for UG Instr', and then divided among under-graduate faculty members and teaching assistants. The share of under-graduate faculty is represented by 'Indicated FTE UGF for UG Instr Overhead'. After this value, 'Total In-Class FTE UGF' and 'FTE UGF for Other Routine Tasks' are subtracted from 'Total FTE UGF' and 'Total Indicated Non Instr FTE UGF' is determined. By comparing this value with 'Desired FTE UGF for research and Projects', 'Indicated UGF Extra Work Load' is calculated. If there is extra work load and it indicates an overhead reduction, the overhead reduced and 'Actual Non Instr FTE UGF' is determined. After Actual FTE UGF for Research and Projects is calculated, it is divided among 'Actual FTE UGF for Projects' and

'Actual FTE UGF for Research' according to the relative weights of 'UGF Financial Pressure' and 'UGF Research Commitment'.

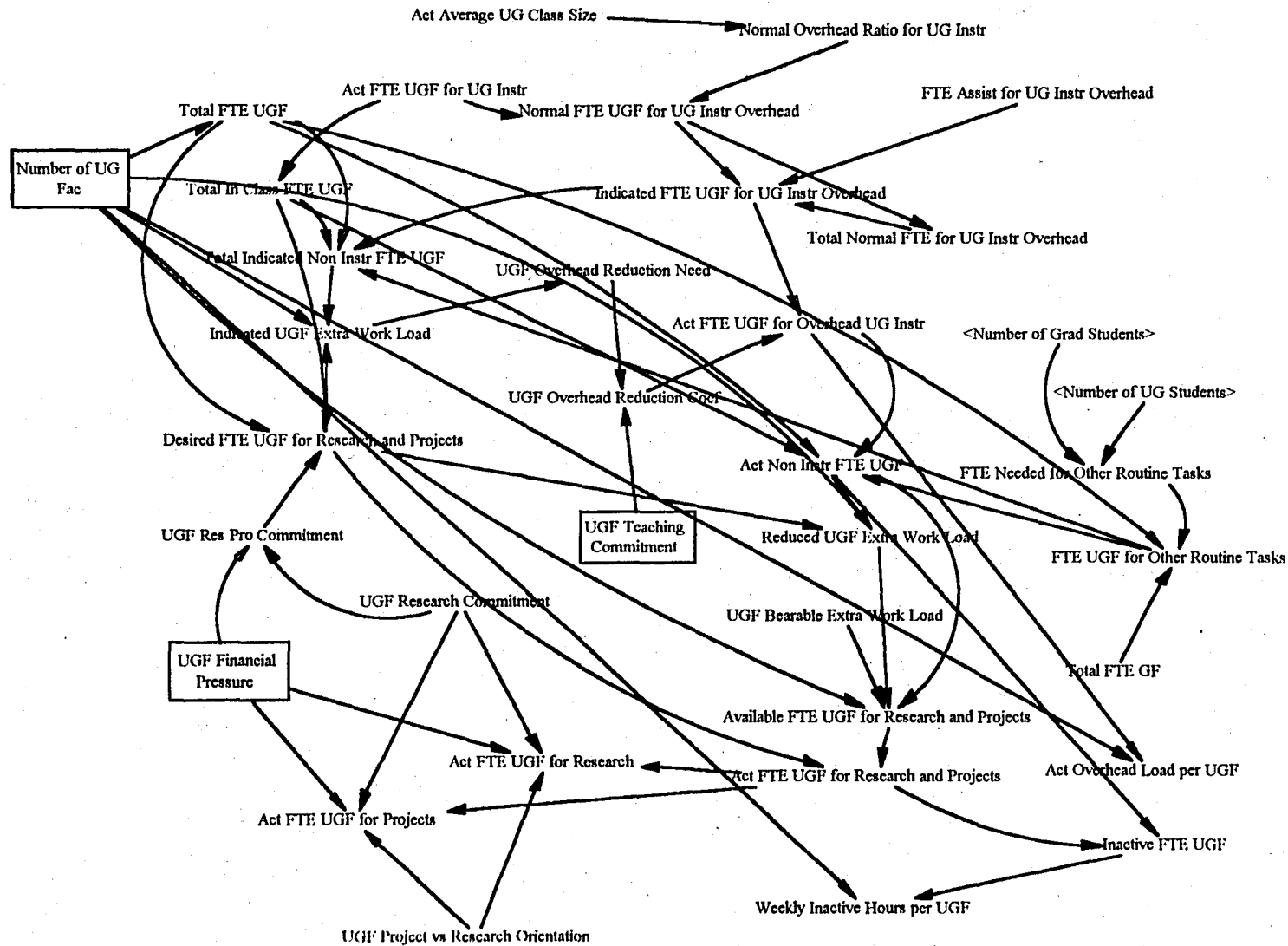


FIGURE 5.6. Structure Diagram of Under-graduate Faculty Overhead Sector

5.2.7. Graduate Faculty Research Sector

In this sector the graduate faculty workforce dedicated to sponsored and unsponsored research activities are determined together with the motivations behind them and the outcomes of these activities. (Figure 5.7).

'Actual FTE GF for Research' is divided among 'Actual FTE GF for Unsponsored Research' and 'Actual FTE GF for Sponsored Research' according to the relative weights of 'GF Unsponsored Research Commitment' and 'GF Sponsored Research Commitment'. These two indicators of commitment are the historical averages of GF Indicated Unsponsored Research Commitment' and 'GF Indicated Sponsored Research Commitment' and take values between zero and one. The variables that determine the values of the indicated commitments are 'GF Desired/Realized Research Papers Published', 'GF Research Culture' and the corresponding research recognitions. 'GF Desired/Realized Research Papers Published' is the ratio between the current historical average of research papers published each semester and the target average papers published. 'GF Research Culture' is the long term attitude of graduate faculty members towards research. It takes values between zero and one. Higher research culture causes higher research commitment. Research recognition represents the long term attitude of the administration towards the related research activities and takes values between zero and one. Administration expresses its recognition by rewards and this increases the research commitment. 'Indicated Unsponsored Research Recognition' depends on the unsponsored research papers productivity of the faculty members, namely 'Period Unsponsored Research Papers Published' over 'Total FTE for Unsponsored Research'. 'Indicated Sponsored Research Recognition depends on the financial productivity, as well as research papers productivity. Thus, 'Funds-Grants Gotten by Sponsored Research', 'Total FTE for Sponsored Research' and 'Financial Concern', (which is an index of the administration's will to get funds and grants through sponsored research), effect 'Indicated Sponsored Research Recognition'. The other variables that effect 'Indicated Sponsored Research Recognition' are 'Period Sponsored Research Papers Published' and 'Total FTE for Sponsored Research'.

After 'Actual FTE GF for Un-sponsored Research' and 'Actual FTE GF for Sponsored Research' are determined, the outcomes of research activities are calculated. These outcomes depend on the related faculty workforces and productivity indices.

5.2.8. Under-graduate Faculty Research Sector

This sector is similar to 'Graduate Faculty Research Sector'. In this sector, the portion of under-graduate faculty workforce dedicated to sponsored and un-sponsored research activities, the motivations behind them and the outcomes of these activities are determined. (Figure 5.8).

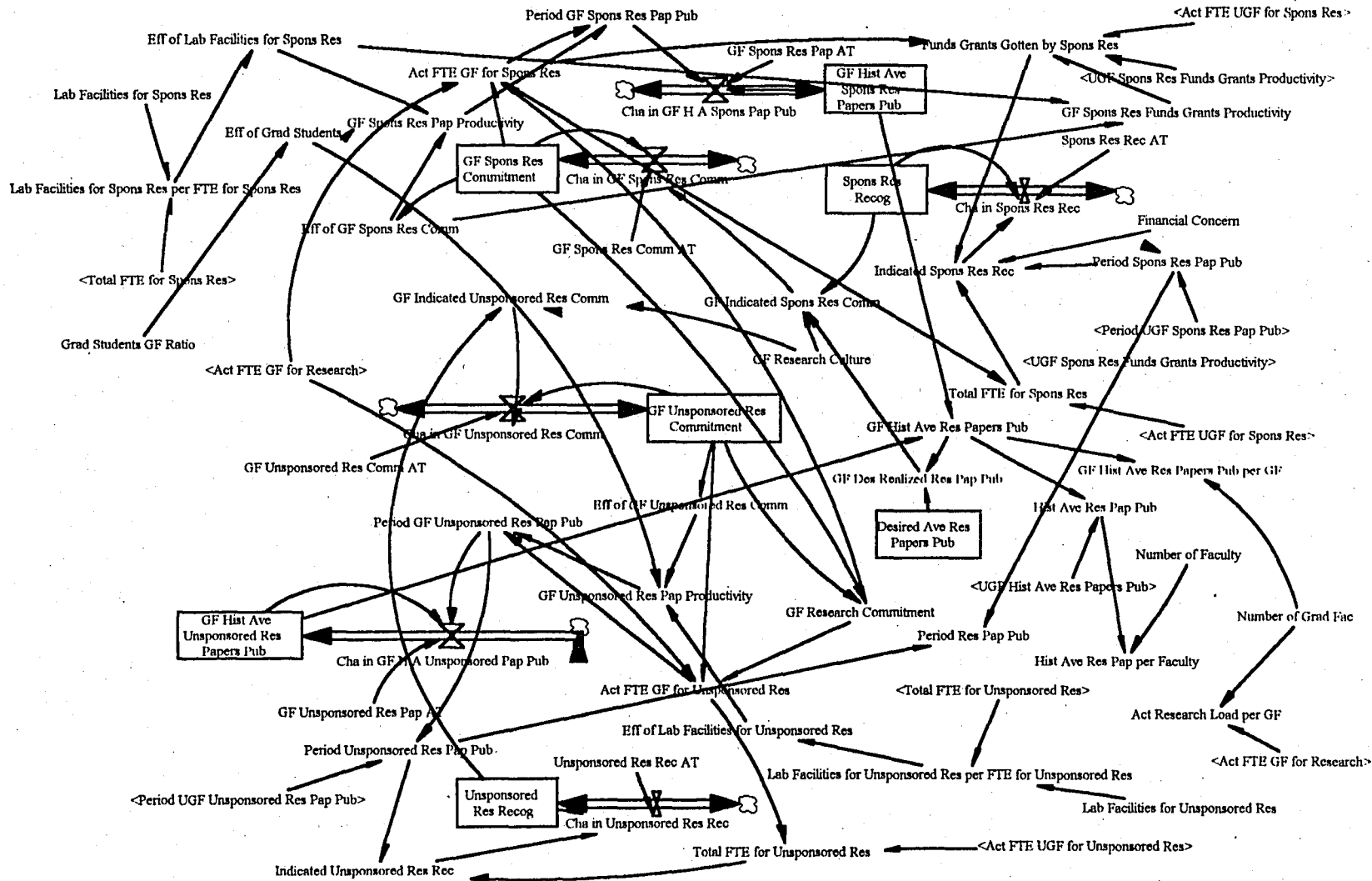


FIGURE 5.7. Structure Diagram of Graduate Faculty Research Sector

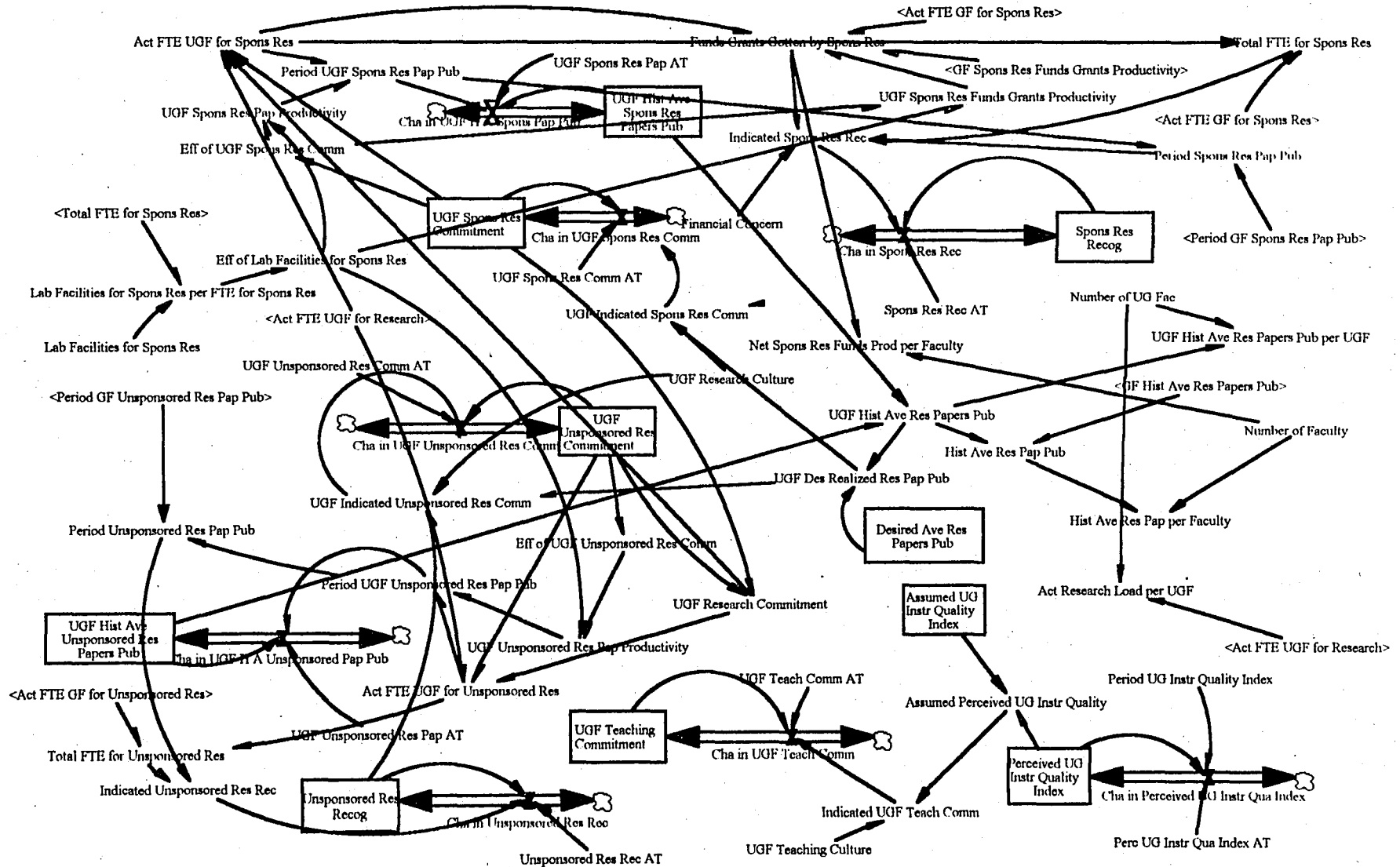


FIGURE 5.8. Structure Diagram of Under-graduate Faculty Research Sector

5.2.9. Graduate Faculty Projects Sector

This is the sector where the portion of the graduate faculty workforce dedicated to income generating projects and unofficial projects, the motivations behind them and the outcomes of the income generating projects activities are determined. (Figure 5.9).

'Actual FTE GF for Projects' is divided among 'Actual FTE GF for Income Generating Projects' and 'Actual FTE GF for Unofficial Projects' according to the relative weights of 'GF IGP Motivation' and 'GF UP Motivation'. 'GF IGP Motivation' and 'GF UP Motivation' are the historical averages of 'Indicated GF IGP Motivation' and 'Indicated GF UP Motivation'. 'Indicated GF IGP Motivation' depends on the ratio of incomes realized through income generating projects and unofficial projects and IGP-UP mentality, which is an index of the long term attitude of the faculty members towards doing projects through non-university channels, in order to obtain income. IGP-UP mentalities, both for graduate and under-graduate faculty members take values between zero and one and higher mentality indicates lower tendency for doing unofficial projects. Another variable that effects 'Indicated GF IGP Motivation' is 'IGP Attractiveness for Administration'. This is an index of the administration's attitude towards income generating projects. 'Indicated GF UP Motivation' is determined by 'IGP-UP Income Ratio' and 'IGP-UP Mentality GF'.

After 'Actual FTE GF for IGP' is determined 'Gross Income Generated by IGP' is calculated as a function of graduate and under-graduate faculty workforce and the related IGP productivity levels. 'Net Funds-Grants Gotten by IGP' is calculated by subtracting 'Income Share for GF on IGP' and 'Income Share for UGF on IGP' from 'Gross Income Generated by IGP'. IGP share per FTE per semester is calculated by multiplying 'IGP Income Level' (which represents the amount of money paid per man-hour of faculty workforce for IGP) by weekly hours per faculty and multiplying this amount by weeks per semester. Number of active weeks per faculty member per semester is 23. Total IGP share for faculty members for the current semester is calculated by multiplying IGP share per FTE per semester by total FTE for IGP for the current semester.

An important sub-system of this sector consists of 'GF Financial Pressure' and the variables that effect it. 'GF Financial Pressure' is the historical average of 'GF Indicated Financial Pressure', which is an index of the financial concern of the graduate faculty members. It depends on the ratio between the historical average of the actual salary and the average salary desired by faculty members.

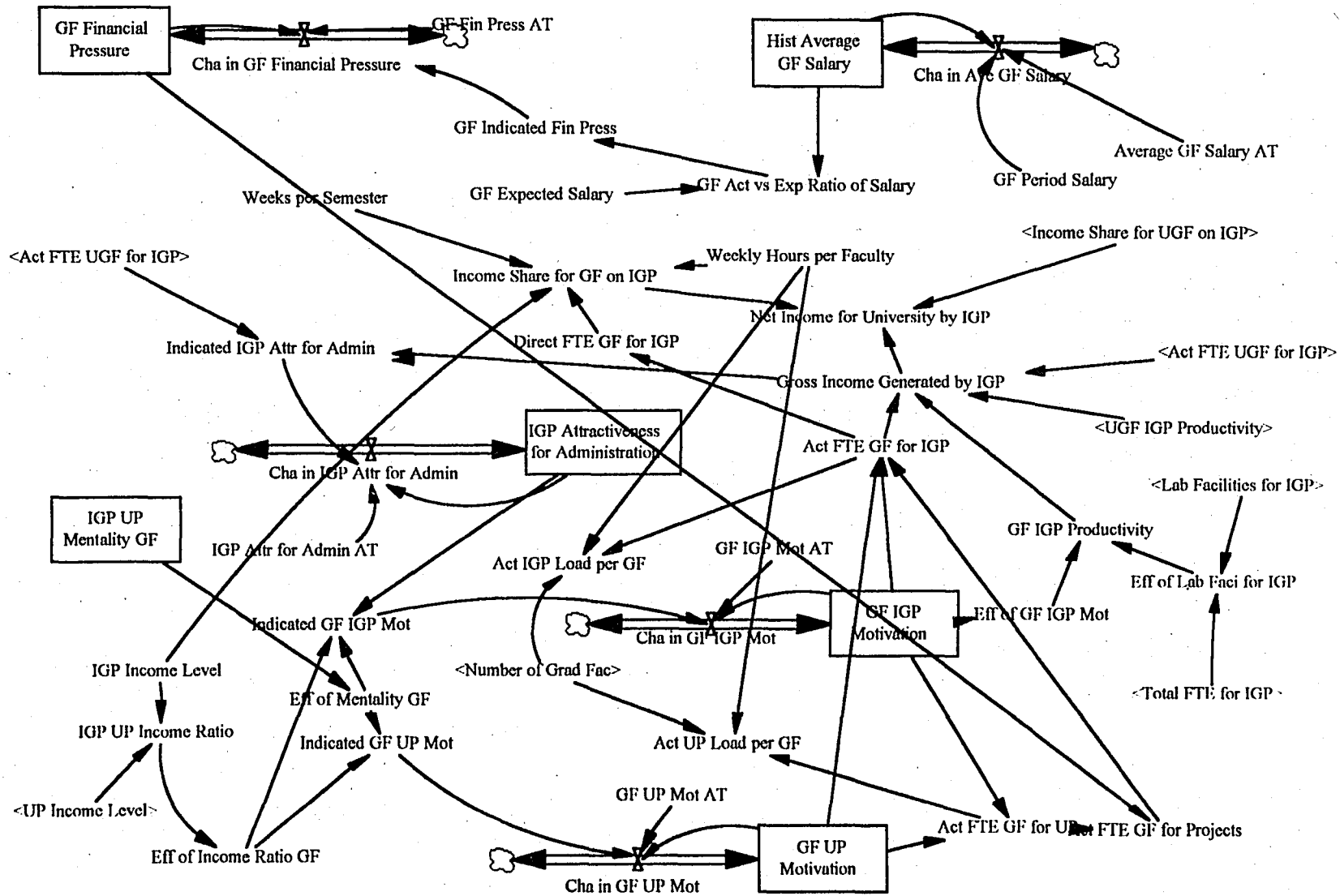


FIGURE 5.9. Structure Diagram of Graduate Faculty Projects Sector

5.2.10. Under-graduate Faculty Projects Sector

This sector is similar to 'Graduate Faculty Projects Sector'. In this sector, the portion of under-graduate faculty workforce dedicated to income generating projects and unofficial projects, the motivations behind them and the funds gotten by income generating projects are determined. (Figure 5.10).

5.2.11 Laboratory Facilities Sector

In this sector the laboratory facilities are updated and then assigned to instruction, research and project activities. The criteria for assigning the facilities are the relative amounts of faculty workforce allocated to each activity. (Figure 5.11).

5.2.12 Assistants Sector

This sector is where the number of assistants, available assistant hours per week and the instruction overhead assigned to these assistants are calculated. (Figure 5.12). 'Number of Assistants' is a function of 'Number of Graduate Students' and 'Assistants/Graduate Students Ratio'. This value is limited by 'Assistant Positions', which is a function of the total number of faculty positions and 'Faculty/Assistant Positions Ratio'.

'FTE Assistants for Instr Overhead' is first converted to faculty FTE by dividing the total assistant hours by weekly hours per faculty. After the FTE assistants for instruction overhead is computed this way, the total available assistant workforce is distributed among 'FTE Assistants for Graduate Instruction Overhead' and 'FTE Assistants for Under-

graduate Instruction Overhead'. According to these values, indicated instruction overhead loads for graduate and under-graduate faculty members are calculated. These values are used as input in 'Graduate Faculty Overhead Sector' and 'Under-graduate Faculty Overhead Sector'.

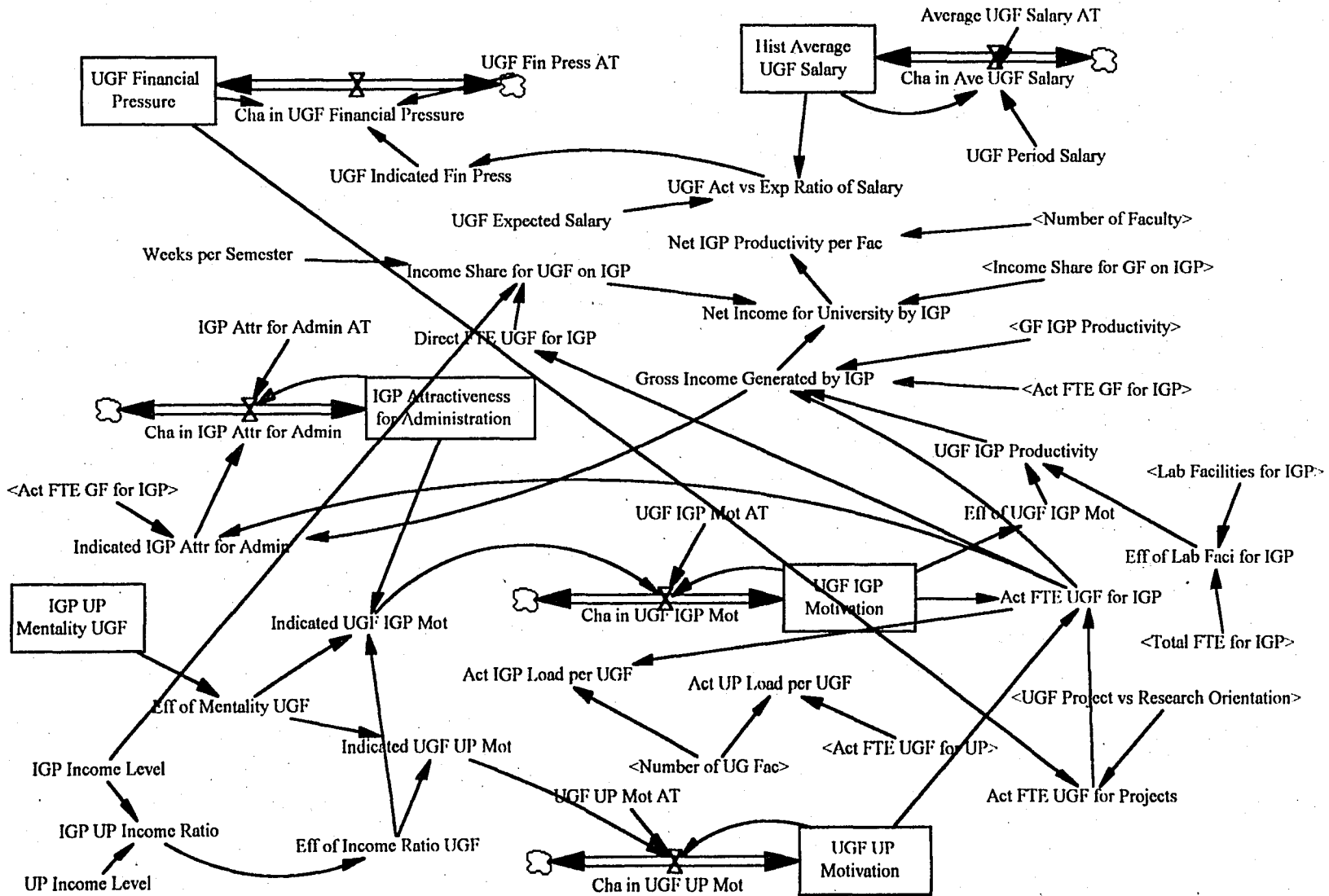


FIGURE 5.10. Structure Diagram of Under-graduate Faculty Projects Sector

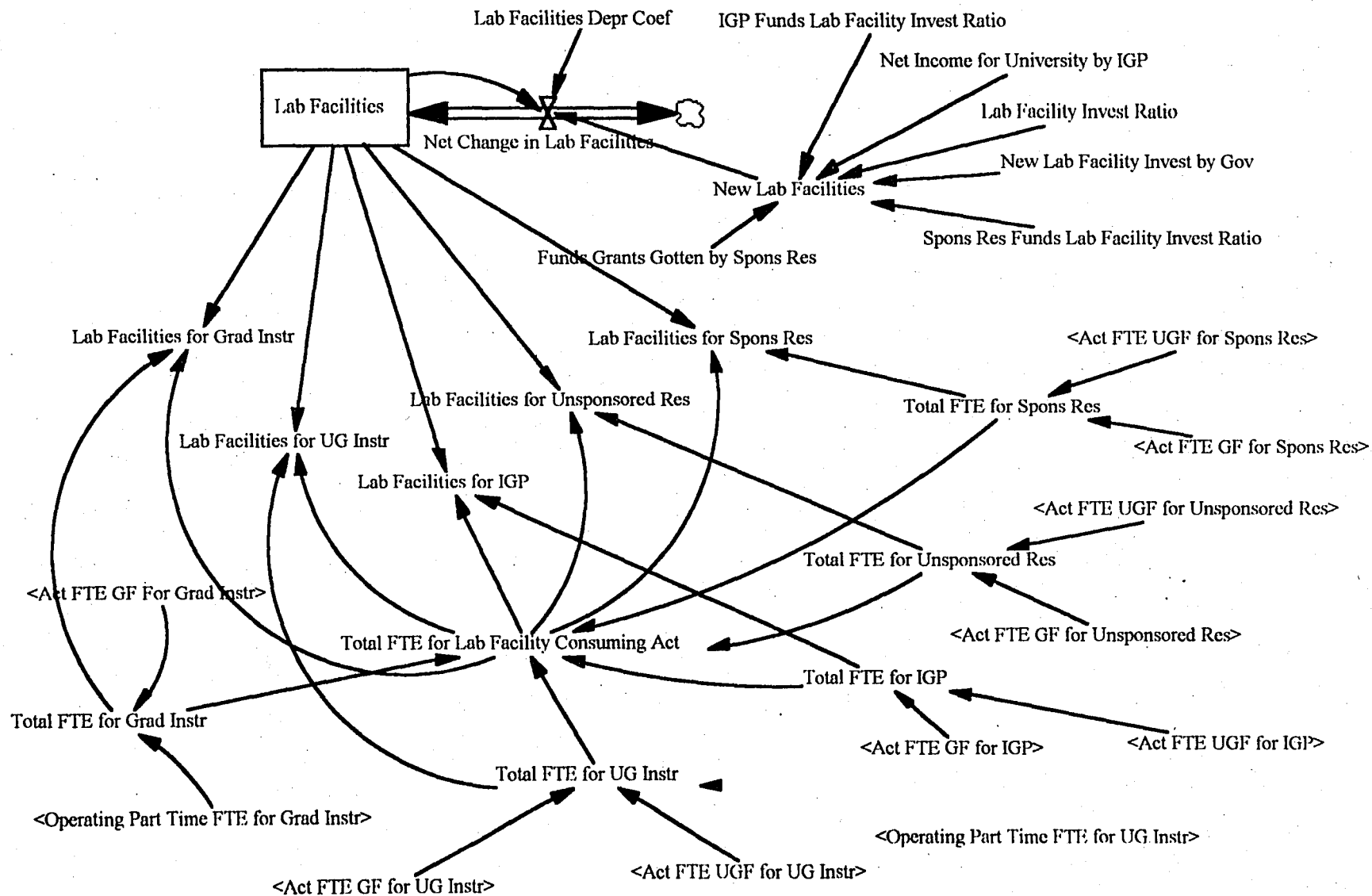


FIGURE 5.11. Structure Diagram of Laboratory Facilities Sector

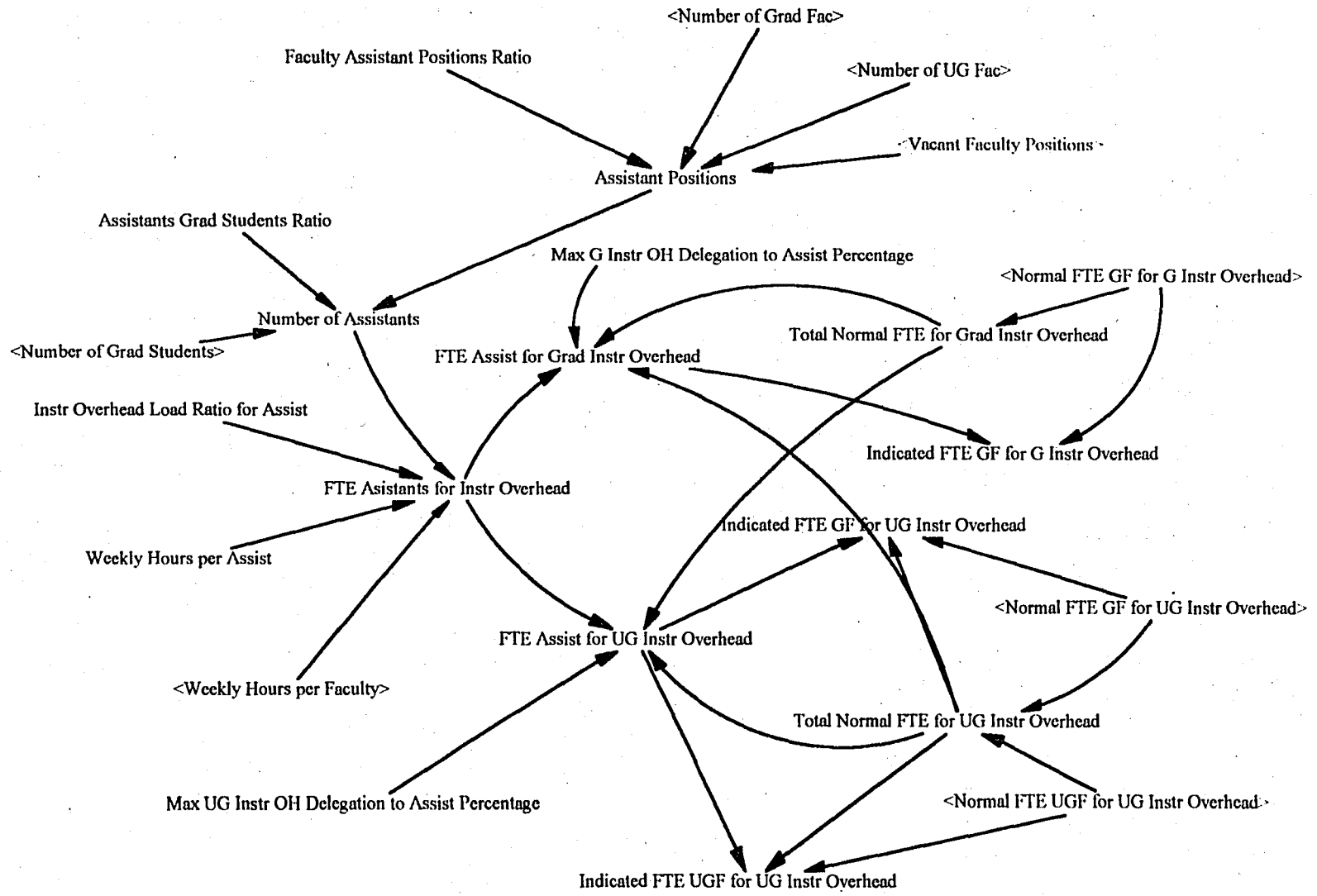


FIGURE 5.12. Structure Diagram of Assistants Sector

5.3. Division (Faculty) Version of the Model

Another version of the presented model was constructed in order to make division-level analyses. This version represents the academic aspects of a faculty system. There are no differences between the causal structures of the university and the faculty versions; the differences are in the mathematical expressions of some constants like 'New Faculty Positions' and the initial values of some stock variables such as the numbers of students and faculty members.

A series of runs were performed with the faculty version in order to verify and validate it. Finally, after the original version of the model was transformed into an interactive model, the faculty version was also made interactive and attached to the simulation game interface that is explained in the 'Game Design' section.

6. MODEL VERIFICATION AND VALIDATION

6.1. Overview

The model presented in the preceding section was verified and validated by a series of standard tests. The first group of tests are verification tests. These tests are intended to determine whether the model works as it is expected to work. After verification of the model, validation tests are done. Validation tests are grouped into two: (a) structure validation tests, which are done in order to determine whether the model has an adequate structure, by testing the behavior of the model under certain conditions; (b) behavior validation tests, which are done in order to determine whether the behavior that the model exhibits resembles to the behavior exhibited by the real system that was modeled. To test the structural validation of the presented model, extreme condition and sensitivity tests were done. Behavior validation was tested by comparing the behavior of the model with the data on Boğaziçi University.

6.2. Verification of the Model

The aim of the verification tests is to determine whether the assumed relationships among the variables are embedded correctly in the computer model and whether the equations and other statements were written as they were intended to be.

To verify the model, the twelve sectors that form the model were simulated one by one, isolated from the other sectors. The behaviors exhibited during these isolated simulation runs are easier to interpret, because the number of variables and feedback loops decrease considerably. A wide range of conditions, both extreme and normal, and different

simulation horizons were used during the isolated simulation runs. the behaviors of the variables within the isolated sector were examined and irrelevant behaviors were traced back in order to correct the wrong causal or mathematical relationships. A built-in analysis feature of Vensim environment, which checks the equivalence of units on both sides of the equations that define the variables, was also used in order to eliminate the mistakes that might be done in the equations. After all the sectors were verified, the causal relationships that link the sectors to each other were verified by running the whole model under different conditions with different simulation horizons. The units equivalence check was repeated for the model as a whole and the verification tests about the model were completed.

6.3. Extreme Condition Tests

The first set of tests that were done in order to validate the model were extreme condition tests. Extreme condition tests are based on the idea that the behaviors of a given model are far more predictable under extreme conditions than they are under normal conditions. Extreme condition tests are done by setting a certain variable to an extremely high or extremely low value and examining the behavior of key variables after simulating the model. The extreme value of the chosen variable implies extreme behaviors by other variables. If the behaviors of one or more key variables are not as they are expected to be, the hypothesis that the model is valid is rejected and the model is revised in order to correct the errors. Otherwise, i.e. if the behaviors of all the key variables are as they were expected to be, the hypothesis can not be rejected. This can be explained better by giving an example: Assume that we set the number of the students to zero in the presented model. We expect the instruction loads of the faculty members, instruction overhead loads and student/faculty ratios to become zero, when we simulate the model. If one or more of these variables are not equal to zero, we reject the hypothesis that the model is valid. If all these variables and the other variables we examine have the values or exhibit the behaviors we expected, we conclude that the hypothesis can not be rejected at that step and go on to other extreme condition tests.

Numerous extreme condition simulation runs were done on the model presented in this study. The results of a selection of these simulation runs are presented in the following sections.

6.3.1. No Under-graduate Students

The model is simulated for 20 periods (semesters) after setting the number of under-graduate students to zero. (Figure B.1.1.1-B.1.1.5). The under-graduate instruction and under-graduate instruction overhead loads for both graduate and under-graduate faculty members becomes zero. Some other variables such as 'Under-graduate Students/Faculty Ratio', 'Under-graduate Graduation' and 'Average Under-graduate Class Size Needed' are also equal to zero, as expected.

6.3.2. No Under-graduate Admission

Another extreme condition was having a certain under-graduate student body, but having the admission equal to zero. (Figure B.1.2.1-B.1.2.5). Under this condition, 'Number of UG Students' and 'UG Graduation' converge to zero. So do the under-graduate instruction and instructions overhead loads of graduate and under-graduate faculty members and under-graduate students/faculty ratio. All these were expected behavior patterns.

6.3.3. Extremely High Under-graduate Admission

The model is simulated under the condition that under-graduate admission is equal to 10000 students per year. (Figure B.1.3.1-B.1.3.5). As expected, under this extreme

condition, the instruction loads of the faculty members reach to absolute maximum levels and the average under-graduate class size reaches the maximum value that is allowed, and still there is a big number of canceled under-graduate instruction hours.

6.3.4. No Under-graduate Faculty

The model is simulated under the condition that the number of under-graduate faculty is zero. (Figure B.1.4.1-B.1.4.3). Under this condition all under-graduate instruction is assigned to graduate faculty. The instruction load on graduate faculty members rises gradually because of the increasing number of under-graduate students and finally at period ten it reaches the absolute maximum level. At this point 'Canceled Under-graduate Lecture Hours' takes a positive value and increased through the rest of the simulation. Under-graduate workforce assigned for research and project activities is equal to zero and this causes all the outputs of these activities, like research papers published, under-graduate faculty members' contribution to income generating projects to be equal to zero, as expected.

6.3.5. No Faculty

Another extreme run is made after setting both 'Number of Under-graduate Faculty' and 'Number of Graduate Faculty' to zero. (Figure B.1.5.1-B.1.5.4). This makes all faculty workforces and all outputs like research papers and funds gotten by IGP an sponsored research equal to zero. All graduate and under-graduate lecture hours are canceled.

6.3.6. Extremely Low Salary

Another extreme simulation run is made after the salaries of faculty members are set to 50 dollars per month. (Figure B.1.6.1-B.1.6.3). This increases the number of leaving faculty members and decreases faculty supplies, (candidates for faculty positions). The number of faculty members decreases rapidly and at period eight it reaches 12, its minimum for this run. (Setting salaries equal to zero causes similar but more steep behaviors. The number of leaving faculty members increases and faculty supplies decreases faster. The number of faculty members decreases faster, as well, reaching a minimum of two.)

6.3.7. No Faculty Supply

Another extreme condition test is done by setting the faculty supplies (candidates) to zero. (Figure B.1.7.1-B.1.7.2). As faculty supplies are zero, 'New Graduate Faculty' and 'New Under-graduate Faculty' become zero. This gradually decreases the number of faculty members, both graduate and under-graduate, because there are leaving faculty members. Finally the number of faculty members becomes zero.

6.3.8. Extremely High Instruction Overhead Ratio

The model is tested after increasing normal instruction overhead hours per lecture hour ratio 10 times. (Figure B.1.8.1-B.1.8.3). As a result, all faculty workforce that is left after graduate and under-graduate lecture hours are assigned are dedicated to instruction overhead. Thus, faculty members can not find time for research and project activities during normal work hours. This leads faculty members to do research and project activities by

working extra hours. But as average extra hours per faculty are limited by bearable extra work load limits, the total time a faculty member dedicates to research and project activities becomes equal to bearable extra work load.

6.4. Base Run of the Model

The 'Base Run' of the model is the simulation run made under typical expected set of parameters and input values. This run is made to display the dynamic behavior of the model under such typical conditions. The behaviors of the variables, observed in this run are used as reference in interpreting the behaviors of the same variables in sensitivity runs.

Base dynamic behaviors of some important variables are shown in Figure 6.1 - 6.6. Figure 6.1 is the dynamic behavior of the variables 'Number of Under-graduate Students' and 'Number of Graduate Students'. The values of both variables increase through time, but while 'Number of Under-graduate Students' increases in a steady pace, the rate of increase in 'Number of Graduate Students' decreases as time passes. In Figure 6.2, it is observed that both 'Number of Graduate Faculty' and 'Number of Under-graduate Faculty' increase in a steady pace.

Figure 6.3 is the dynamic behaviors of the instruction loads on the graduate and under-graduate faculty members. The total instruction loads on graduate and under-graduate faculty members are equal to each other, because no release time is given to graduate faculty members and the instruction need can be satisfied within the operating maximum instruction hours per faculty member.

In Figure 6.4 are the weekly hours spent on research and projects by each graduate faculty member. While the weekly hours spent on research activities decrease slightly, the hours spent on income generating projects increase and the hours spent on unofficial projects decrease considerably. These behaviors are caused by the increase in 'GF IGP Motivation' and the decrease in 'GF UP Motivation'. The dynamic behavior of 'GF IGP

Motivation' and 'GF UP Motivation', together with those of 'GF Unsponsored Research' and 'GF Sponsored Research', are shown in Figure 6.5. The decrease in 'GF UP Motivation' and increase in 'GF IGP Motivation' are caused by the relative values of income obtained from income generating projects and unofficial projects, and the mentality of the faculty members.

The dynamic behaviors of 'Period Research Papers Published', 'Period Unsponsored Research Papers Published', 'Period Sponsored Research Papers Published' are shown in Figure 6.6. Here, all these variables increase steadily after a slight decrease in the first three semesters.

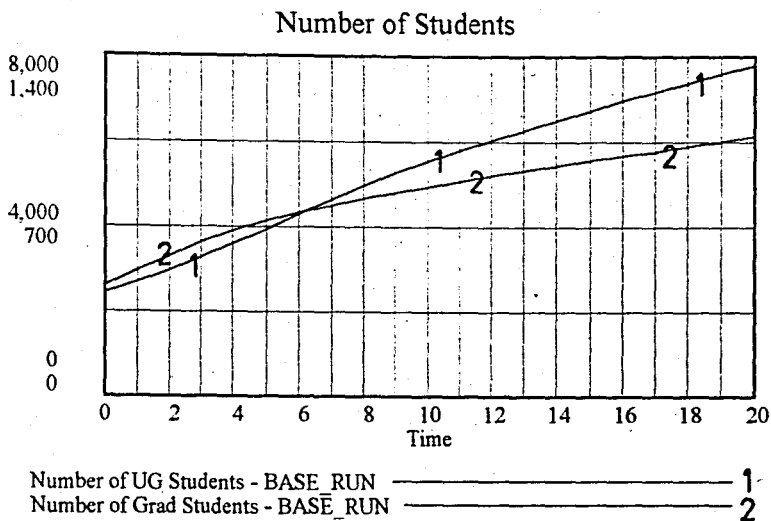


FIGURE 6.1 The Dynamic Behavior of Number of Students in the Base Run

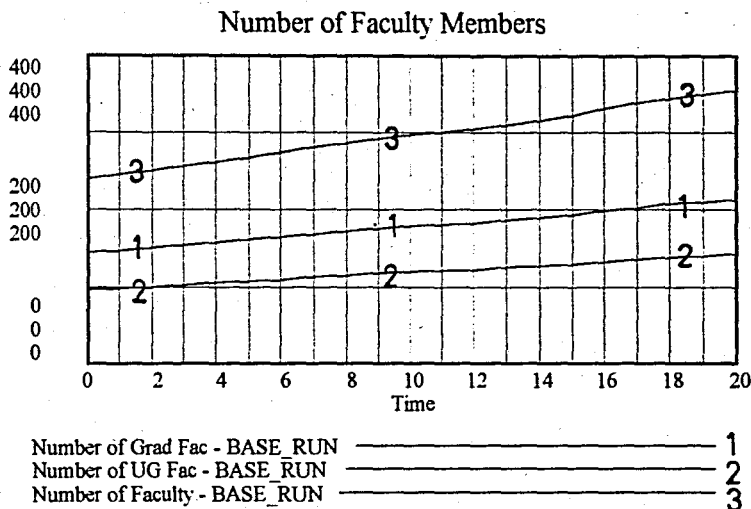


FIGURE 6.2 The Dynamic Behavior of Number of Faculty Members in the Base Run

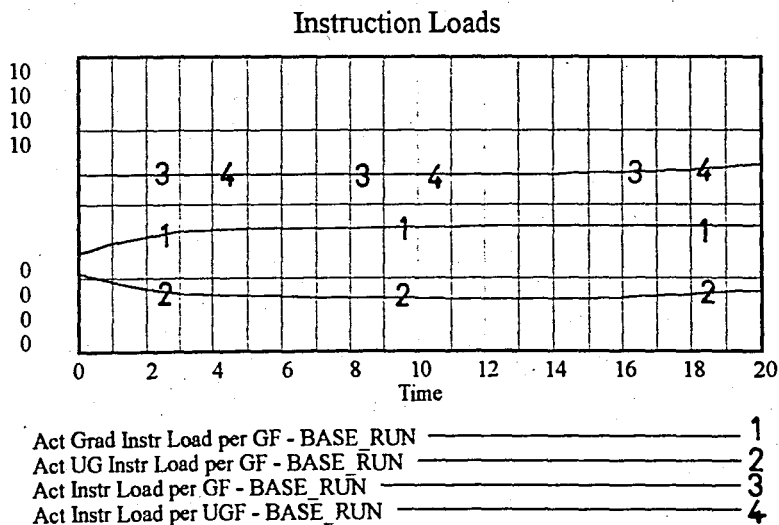


FIGURE 6.3 The Dynamic Behaviors of Instruction Loads in the Base Run

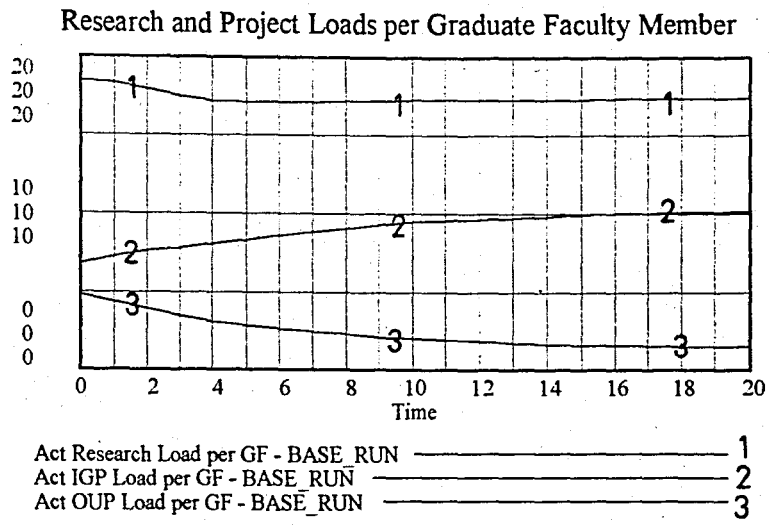


FIGURE 6.4 The Dynamic Behaviors of GF Research and Project Loads in the Base Run

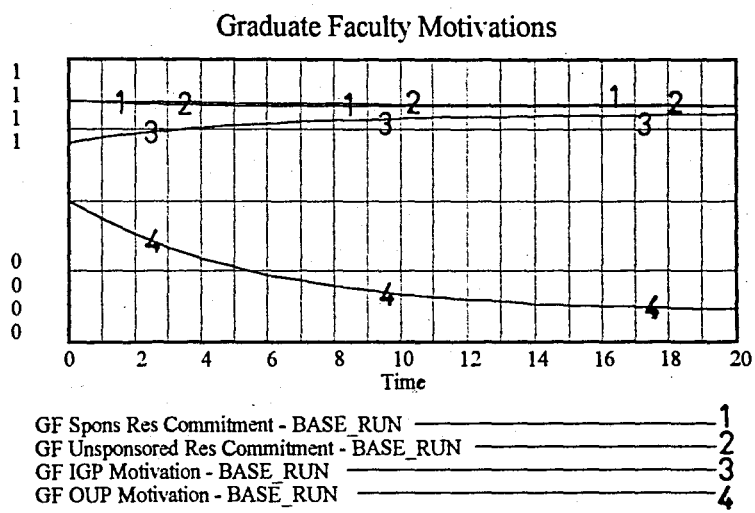


FIGURE 6.5 The Dynamic Behaviors of Graduate Faculty Motivations in the Base Run

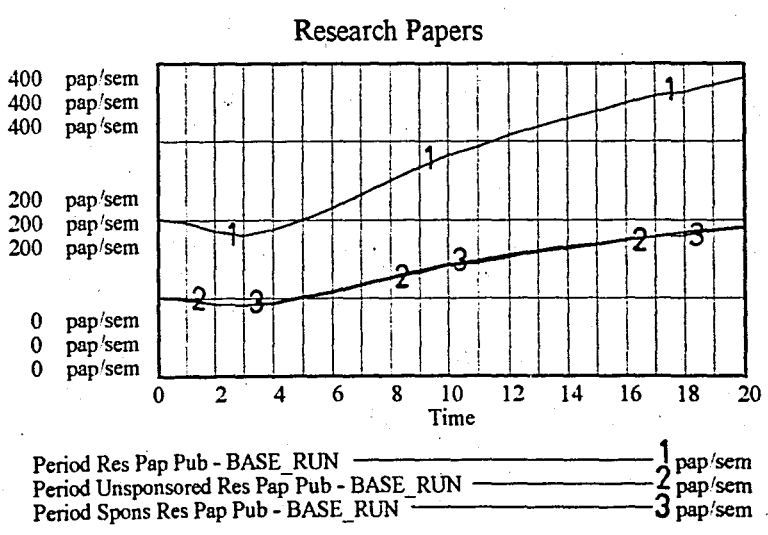


FIGURE 6.6 The Dynamic Behavior of Research Papers per Semester in the Base Run

6.5. Sensitivity Analyses

After the extreme condition tests were completed, a series of sensitivity analyses were made, in order to determine whether the sensitivity of the base model is within acceptable limits.

A set of sensitivity runs are made by simulating the model with different values of a certain variable and examining the behaviors of the key variables to determine if the behaviors of these variables differ within acceptable ranges in each simulation run. If the behaviors of one or more key variables differ more than expected, the hypothesis that the model is valid is rejected. If the differences are within acceptable ranges the hypothesis can not be rejected and other sensitivity runs with different values of some other variables are made.

Numerous sensitivity tests were done in order to determine the validity of the model. Some examples of these sensitivity tests are given below for illustration.

6.5.1. Sensitivity Runs with Different Values of 'GF IGP UP Mentality'

The first set of sensitivity runs are done by giving different values to 'GF IGP UP Mentality', which represents the relative strength of preferring IGP to UP. (Figure B.2.1.1-B.2.1.4). The values are changed from (0.7) to (0.2), (0.5), (0.8) and (1.0). 'GF IGP Motivation' had the initial value 0.7 and 'GF UP Motivation' had the initial value 0.15 in each run. It was observed that, compared to the base runs 'GF IGP Motivation' converges to higher values as the value of the variable 'GF IGP UP Mentality' is set to higher values. 'GF UP Motivation', on the other hand, converges to lower values as 'GF IGP UP Mentality' increases. The allocation of graduate faculty workforce for projects between IGP and UP also change according to the related motivations, in each run.

6.5.2. Sensitivity Runs with Different Values of 'Average Hours per Graduate Student'

Second set of sensitivity runs are done by giving different values to 'Average Hours per Graduate Student', which indicates the average weekly lecture hours needed by each graduate student. (Figure B.2.2.1-B.2.2.3). Four runs are made and the values of 'Average Hours per Graduate Student' during these runs were (3), (7), (15), (25). The value of this variable in the base run was (15). As expected, higher values of 'Average Hours per Graduate Student' cause 'Total FTE Needed for Graduate Instruction' to be higher and that increases the graduate instruction and graduate instruction overhead loads on graduate faculty members.

6.5.3. Sensitivity Runs with Different Values of 'GF Research Papers Productivity'

Another set of sensitivity runs are done by giving different values to the variables 'GF Sponsored Research Papers Productivity' and 'GF Un-sponsored Research Papers Productivity'. (Figure B.2.3.1-B.2.3.3). The values of these variables are calculated by multiplying the maximum possible productivity value by the effects of related commitments, laboratory facilities allocated to research activities and the number of graduate students. The maximum productivity values in the sensitivity runs are (1), (2), (4) and (7). This value is equal to (4) in the base run. It is observed that the related variables like 'Period GF Sponsored Research Papers Published', 'Period GF Un-sponsored Research Papers Published' and 'GF Historical Average Research Papers Published per Graduate Faculty' take higher values as the maximum productivity value of 'GF Sponsored Research Papers Productivity' and 'GF Un-sponsored Research Papers Productivity' takes higher values.

6.6. Behavior Validation of the Model

After the structural validation tests were completed the behavior of the model was compared with the data about Boğaziçi University. (Figure B.3.1.1-B.3.4.2). Most of the real data were taken from the 1994 edition of the yearly document 'Sayılarla Boğaziçi Üniversitesi' ('Boğaziçi University in Numbers') [19]. That document includes a wide range of data on many aspects of Boğaziçi University like students, faculty members, publications and financial figures. Some other data about other aspects of the model, like income generating projects and available faculty and assistant positions were gathered by interviews and used for calibrating the model. However these data could not be used for behavior validation purposes, because they were mostly 'single point data'.

An exact matching between real data and model data points is not required for validating the model, because a System Dynamics model is not designed to include the internal and external details and random factors that are needed in short term forecasting [20]. The purpose of a system dynamics model is to generate the broad dynamic behavior patterns of the system, in the long term. Thus, what is required is the matching of the major patterns of behavior of the model and the real system, (rather than individual data points).

All the data about Boğaziçi University that could be used for behavior validation were compared with the behavior of the model and a broad resemblance between the model behavior and the behavior of the real system, was obtained. (Figure B.3.1.1-B.3.4.2). Thus, it was concluded that the model is behaviorally acceptable.

7. EXPERIMENTS WITH THE MODEL

Some demonstrative simulation experiments were made with the presented model in order to show its simulation capabilities. Two of these experiments and their results are explained below.

7.1. Graduate Study Orientation versus Under-graduate Study Orientation

This simulation experiment is designed to determine the effects of different ratios of under-graduate students / graduate students. (Figure C.1.1-C.1.8). Two simulation runs are made to compare the results of increasing and decreasing under-graduate students / graduate students ratios. The number of under-graduate students is increased slower in the second run than it is in the first run. On the other hand, number of graduate students is increased faster in the second run. The number of under-graduate students and the number of graduate students have the same initial values in both runs. Both simulation runs begin with a under-graduate students / graduate students ratio that is around 5.4. In the first run, which represents a high under-graduate study orientation, the ratio increases gradually and reaches to 12.4. In the second run, which represents a high graduate study orientation, this ratio decreases and finally reaches to 2.

The first effect of the change in student profile is the change in instruction load allocations. The instruction load per under-graduate faculty member takes lower values in the second run because of the slower increase in the number of under-graduate students. The total instruction load per graduate faculty also takes lower values in the second run. Though the faster increase in the number of graduate students causes the graduate instruction load per graduate faculty member to take higher values, the under-graduate instruction load per graduate faculty take substantially lower values because of the slower increase in the number of under-graduate students.

Lower instruction loads cause the faculty workforce dedicated to research and project activities to be higher in the second run and this brings higher research and project outputs, in terms of both research papers and funds gotten by research and project activities, namely project income. As observed from the results of the simulation runs, an important effect of higher graduate study orientation is higher research productivity per faculty member.

7.2. Experiments with Different Under-graduate Class Sizes

Another set of simulation experiments is done in order to determine the effects of different under-graduate class sizes. (Figure C.2.1-C.2.6). The base values for 'Desired Under-graduate Class Size' and 'Maximum Allowable Under-graduate Class Size' are 50 and 100, respectively. The base simulation run was made with these values. In the first experiment the values for 'Desired Under-graduate Class Size' and 'Maximum Allowable Under-graduate Class Size' are 20 and 40, respectively and in the third run they are 80 and 160.

The direct effect of different class sizes are observed on total under-graduate lecture hours needed and total FTE for under-graduate instruction. This in turn effects the instruction loads per graduate and under-graduate faculty member. Lower under-graduate class sizes bring higher under-graduate instruction loads for both graduate and under-graduate faculty members. To alleviate high instruction loads, new faculty members are hired in the short term, which increases the number of faculty. This increasing behavior is very steep in the second run. But if the increase in the number of faculty is not enough to compensate the high instruction need, extremely high instruction loads cause more faculty members to leave and less new faculty members to apply, in the long term (14th semester, in the second run). This causes the number of faculty members to decrease considerably. Low under-graduate class sizes bring up a higher need for part-time faculty workforce. But the need for part-time faculty workforce is limited by a certain percentage of full-time faculty workforce. As full-time faculty workforce decreases because of the high instruction loads,

the upper limit for part-time faculty workforce usage decreases, as well. The discrepancy between needed and delivered under-graduate instruction is tried to be eliminated by increasing the average class size, but if the maximum limit for class size is low (as in the second simulation run), the cancellation of some under-graduate lecture hours is inevitable.

8. GAME DESIGN

8.1. Overview

The interactive dynamic system simulation game based on the model presented in this study is designed to be run through Venapp, the built-in interactive simulation applications module of Vensim environment. Venapp programs are written in a particular scripting language and stored as text files. These files are called 'Vensim Custom Definition' files. It is also possible to store and retrieve the programs as binary files, which are called 'Vensim Custom Format' files. The important point to state here is that both 'Vensim Custom Definition' and 'Vensim Custom Format' files can only be run through Vensim environment and can not be made stand-alone executable programs. Venapp programs do not contain the model they are based on, but load a model or a series of models into Vensim environment and use them. In order to simplify interaction and minimize clutter, Venapp programs are constructed as a series of screens which are linked between themselves. Only one screen can be observed at a time.

The interactive simulation game, developed as a part of this study consists of 15 screens. The main screens are described below.

8.2. Game Screen Descriptions

8.2.1. Title Screen

This screen is the first that appears after the game definition file is loaded. It contains the name of the game and the credits, and the message "Press Any Key to Play the Game".

When a key on keyboard or mouse is pressed this screen is cleared and the link to 'Run Name Screen' is executed.

8.2.2. Run Name Screen

After 'Title Screen' is cleared 'Run Name Screen' is displayed. A message, which asks for a name for the new game output file appears. After the name for the output file is entered, 'Game Initiation Screen' is displayed.

8.2.3. Game Initiation Screen

This screen is divided into five display boxes. At top left corner is 'Game Controls' box. This box includes three buttons, a drop-down box menu and a display object. Two of the buttons are active and the other button is inactive. Active buttons are the 'Start' button, which starts the game by executing the link to 'Main Game Screen', and the 'Exit' button, which executes the link to 'Ask Exit 1 Screen'. The 'End' button is inactive in this screen. The drop-down box menu is used to determine the final time of the simulation in terms of semesters and the display object shows the current time, which is zero initially.

Under 'Game Controls' box, there is another box which contains the user decisions. Since the game has not started yet, the entries in 'Decisions' box are not active and only display the default values for the decision variables. The 'Step' button which provokes the simulation to proceed one period, is also inactive in this screen.

At bottom left corner is 'Detailed Analysis' display box. The button which executes the link to 'Detailed Analysis Screen' is inactive in this screen. At top right corner is 'Main Indicators' display box which includes the values of 30 variables of the model. The

indicators show the initial values of these variables in this screen.

This screen is cleared if one of 'Start' or 'Exit' buttons is pressed. If the 'Start' button is pressed 'Main Game Screen' is displayed. If the 'Exit' button is pressed 'Ask Exit 1 Screen' is displayed.

8.2.4. Main Game Screen

This screen, too, is divided into four display boxes similar to those of 'Game Initiation Screen'. (Figure 8.1). 'Game Control' box includes two active buttons, one inactive button and two display objects. Active buttons are the 'End' button, which executes the link to 'Ask End Screen' and the 'Exit' button, which executes the link to 'Ask Exit 2 Screen'. 'Start' button is inactive. Two display objects show final time and current time.

The decision entries and the 'Advance' button of the 'Decisions' box are active in this screen. The user enters the values he decided on 'New Graduate Students', 'Graduate Faculty Hiring Decision' and 'Under-graduate Faculty Hiring Decision', which represent the number of new graduate and under-graduate faculty members he wants to hire, for the current semester; 'IGP Share for Faculty', which indicates the amount of money that will be paid to each man-hour of faculty workforce from income generating projects and 'Release Time for Graduate Faculty', which indicates the amount of reduction in maximum weekly instruction load of graduate faculty members. When 'Advance' button is pressed the simulation proceeds one period (semester) and the new values are calculated and displayed. When the 'Help' button is pressed the link to 'Main Game Help Screen' is activated. This screen displays information about the decision variables.

The button in the 'Detailed Analysis' box is active and when pressed, it executes the link to 'Detailed Analysis Screen'.

'Main Indicators' box displays the values of the 30 variables at the current time period. The buttons which have the names of the decision and indicator variables display the behavior patterns of the related variables, when pressed. The button 'More Indicators' executes the link to the 'Main Game B Screen', to access another set of 30 variables.

8.2.5. Main Game B Screen

This screen is similar to the 'Main Game Screen'; only the variables displayed in the indicators box are different. With the 30 more variables displayed in this screen, a total of 60 indicator variables are displayed in both Main Game and Main Game B screens. The 'Main Indicators' button executes the link back to 'Main Game Screen'.

8.2.6. Detailed Analysis Screen

This screen includes eight buttons, six of which provoke certain analysis tools. (Figure 8.2). The first button is pressed to select an 'active variable' to be analyzed. The eighth button executes the link to 'Main Game Screen'. The six analysis tools are: 'Causes Tree', which displays the tree of variables that effect the active variable, 'Uses Tree', which displays a tree of variables that are effected by the active variable, 'Loops', which displays the causal loops that include the active variable, 'Graph', which displays the time graph for the active variable, 'Causes Graph', which displays the graphs for the active variable and the variables that effect it, 'Causes Table', which displays a table that includes the values of the active variable and the variables that effect it.

8.2.7. Ask End Screen

This screen is displayed when the 'End' button is pressed in 'Main Game Screen'. It includes a message: "Do You Really Want to End the Game? (You Will Loose the Current Game Data!)" and two buttons: 'Yes', which ends the game and executes the link to 'Run Name Screen' and 'No', which executes the link back to 'Main Game Screen'.

8.2.8. Ask Exit 1 Screen

This screen is displayed when the 'Exit' button is pressed in 'Game Initiation Screen'. It includes a message: "Do You Really Want to Exit? (You Will Leave the Simulation Environment!)" and two buttons: 'Yes', which executes the link to 'Exit Screen' and 'No', which executes the link back to 'Game Initiation Screen'.

GAME CONTROLS

Start End Exit

Final Time 20 Current Time 0

DECISIONS **HELP**

New Grad Students	100
Grad Fac. Hiring Decision	20
Ugrad Fac. Hiring Decision	20
IGP Share for Fac. (\$/hour)	40
Release Time per GF (h/week)	0
Advance with These Decisions	

DETAILED INFO & CAUSAL ANALYSIS

Use this window for precise numerical info. and access to ALL variables of the model.

To Detailed Analysis Screen

MAIN INDICATORS **MORE INDICATORS >>>>**

Number of Grad Students	450	Number of UG Students	2,730
Number of Grad Faculty	155	Number of UG Faculty	90
Number of Faculty	245	Vacant Faculty Positions	135
Indicated GF Supply	32	Indicated UGF Supply	36
New Grad Faculty	0	New UG Faculty	0
GF that Leave	12	UGF that Leave	7
Average Grad Class Size	6	Average UG Class Size	40.80
Instr Load per GF (h/week)	6	Instr Load per UGF (h/week)	9
Grad Instr Load per GF (h/week)	4.03	UG Instr Load per GF (h/week)	1.96
Overhead Load per GF (h/week)	4.64	Overhead Load per UGF (h/week)	12.09
Research Load per GF (h/week)	18.43	Research Load per UGF (h/week)	7.13
IGP Load per GF (h/week)	6.74	IGP Load per UGF (h/week)	6.34
Hours Spent for UP per GF(w)	4.81	Hours Spent for UP per UGF(w)	4.52
Period Research Pap Pub.ed	188	Period Res Pap per Faculty	.7673
Funds Obtained from Spans Res	39,094	Net Income for University by IGP	2,994

FIGURE 8.1. Main Game Screen

<h3 style="text-align: center; border-bottom: 1px solid black;">GAME CONTROLS</h3> <div style="display: flex; justify-content: space-around; margin-bottom: 5px;"> Start End Exit </div> <p>Final Time 20 Current Time 0</p>	<h3 style="text-align: center; border-bottom: 1px solid black;">MAIN INDICATORS</h3> <div style="display: flex; justify-content: space-between; margin-bottom: 10px;"> <div style="border: 1px solid black; padding: 2px; width: 45%;">Number of Grad Students 450</div> <div style="border: 1px solid black; padding: 2px; width: 45%;">Number of UG Students 2,730</div> </div> <div style="text-align: right; margin-bottom: 10px;"> MORE INDICATORS </div>																
<h3 style="text-align: center; border-bottom: 1px solid black;">DECISIONS</h3> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="padding: 5px;">New Grad Students</td> <td style="width: 30px; text-align: center;"><input type="text"/></td> </tr> <tr> <td style="padding: 5px;">Grad Fac. Hiring Decision</td> <td style="text-align: center;"><input type="text"/></td> </tr> <tr> <td style="padding: 5px;">Und.grad Fac. Hiring Decision</td> <td style="text-align: center;"><input type="text"/></td> </tr> <tr> <td style="padding: 5px;">IGP Share for Fac. (\$/hour)</td> <td style="text-align: center;"><input type="text"/></td> </tr> <tr> <td style="padding: 5px;">Release Time per GF (h/week)</td> <td style="text-align: center;"><input type="text"/></td> </tr> <tr> <td colspan="2" style="padding: 5px; text-align: center;">Advance with These Decisions</td> </tr> </table>	New Grad Students	<input type="text"/>	Grad Fac. Hiring Decision	<input type="text"/>	Und.grad Fac. Hiring Decision	<input type="text"/>	IGP Share for Fac. (\$/hour)	<input type="text"/>	Release Time per GF (h/week)	<input type="text"/>	Advance with These Decisions		<h3 style="text-align: center; border-bottom: 1px solid black;">HELP</h3> <div style="text-align: right; margin-bottom: 10px;"> CLOSE HELP </div> <p>*'New Graduate Students' is the number of students that would be admitted in the current semester. Its minimum value is 0.</p> <p>*'Graduate Faculty Hiring Decision' is the number of graduate faculty members that the player wants to hire during the current semester. The number of graduate faculty members that can be hired is limited by 'GF Supply'. Also, the total number of faculty members (graduate and under-graduate) that can be hired is limited by 'Vacant Faculty Positions'.</p> <p>*'Under-graduate Faculty Hiring Decision' is the number of under-graduate faculty members that the player wants to hire during the current semester. The number of under-graduate faculty members that can be hired is limited by 'UGF Supply'. Also, the total number of faculty members (graduate and under-graduate) that can be hired is limited by 'Vacant Faculty Positions'.</p> <p>*'IGP Share for Faculty' is the amount of money paid to a faculty member for one hour of Income Generating Project activities. Its minimum value is 0.</p> <p>*'Release Time for Graduate Faculty' is the weekly hours reduced from the maximum instruction load of each graduate faculty member, in order to give them more time for research. Its minimum value is 0 and maximum value is 4</p>				
New Grad Students	<input type="text"/>																
Grad Fac. Hiring Decision	<input type="text"/>																
Und.grad Fac. Hiring Decision	<input type="text"/>																
IGP Share for Fac. (\$/hour)	<input type="text"/>																
Release Time per GF (h/week)	<input type="text"/>																
Advance with These Decisions																	
<h3 style="text-align: center; border-bottom: 1px solid black;">DETAILED INFO & CAUSAL ANALYSIS</h3> <p style="font-size: small;">Use this window for precise numerical info. and access to ALL variables of the model.</p> <div style="text-align: center; margin-top: 10px;"> To Detailed Analysis Screen </div>	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="padding: 5px;">IGP Load per GF (h/week)</td> <td style="text-align: center; padding: 5px;">6.74</td> <td style="padding: 5px;">IGP Load per UGF (h/week)</td> <td style="text-align: center; padding: 5px;">6.34</td> </tr> <tr> <td style="padding: 5px;">Hours Spent for IP per GF(w)</td> <td style="text-align: center; padding: 5px;">4.81</td> <td style="padding: 5px;">Hours Spent for IP per UGF(w)</td> <td style="text-align: center; padding: 5px;">4.52</td> </tr> <tr> <td style="padding: 5px;">Period Research Pap Pub.ed</td> <td style="text-align: center; padding: 5px;">180</td> <td style="padding: 5px;">Period Res Pap per Faculty</td> <td style="text-align: center; padding: 5px;">.7673</td> </tr> <tr> <td style="padding: 5px;">Funds Obtained from Spons Res</td> <td style="text-align: center; padding: 5px;">39,094</td> <td style="padding: 5px;">Net Income for University by IGP</td> <td style="text-align: center; padding: 5px;">2,994</td> </tr> </table>	IGP Load per GF (h/week)	6.74	IGP Load per UGF (h/week)	6.34	Hours Spent for IP per GF(w)	4.81	Hours Spent for IP per UGF(w)	4.52	Period Research Pap Pub.ed	180	Period Res Pap per Faculty	.7673	Funds Obtained from Spons Res	39,094	Net Income for University by IGP	2,994
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FIGURE 8.2. Main Game Screen while 'Help Option' is On



Detailed Analysis Screen

You can move the output objects by holding the white strip at the top of them.
You can close the output objects by clicking the box at the NorthWest corner.

First Select the Variable You Want to Analyze as 'Active Variable'.

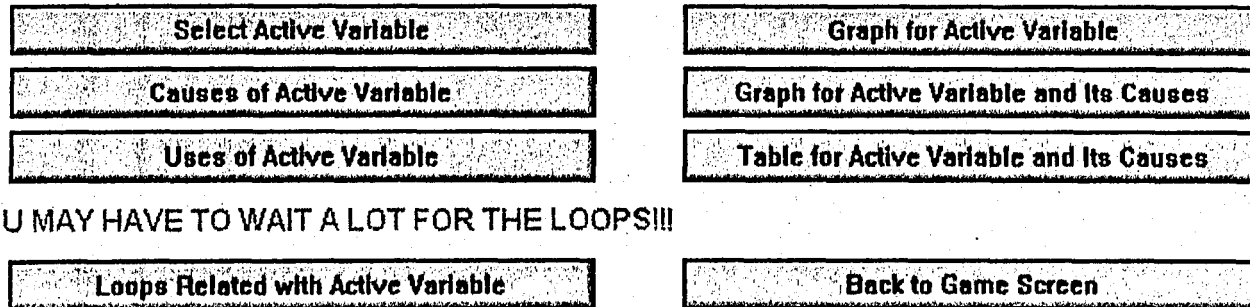


FIGURE 8.3. Detailed Analysis Screen

8.3. Verification and Validation of the Game

A series of verification and validation tests were done on the interactive simulation game. The behavior of the variables in case of extreme player decisions were tested and several sensitivity tests were done. The necessary improvements both in the model and the game were made according to the results of these tests. The resulting game is believed to be a robust and valid interactive simulation environment.

8.4. Game Results

A group of players with different academic degrees and different orientations were invited to play the game. Among the players were graduate students, teaching and research assistants, faculty members and administrators. Some results are presented below for illustration.

8.4.1. Game Results of a Research Oriented Faculty Member

The first player is a faculty member who has high declared research motivation and negative attitude towards income generating projects, even if they are realized through official, university channels.

During the game, in the first six semesters he hires 20 graduate and 20 under-graduate faculty members each semester. After the seventh semester he hires 30 graduate and 20 under-graduate faculty members each semester. He gives considerably release time to graduate faculty (3 h./week). He decreases IGP share for faculty members gradually. (Figure D.1.1)

As a result of his emphasis on graduate study and research, he obtains a remarkable increase in the number of research papers per semester. The average research papers per faculty has increased, as well (Figure D.1.2). On the other hand, decreasing the IGP share for faculty members causes IGP motivations of the faculty members to decrease and unofficial project motivations to increase. These, in turn, causes the weekly hours dedicated to IGP by the faculty members to decrease and the hours dedicated to UP to increase. (D.1.3)

8.4.2. Game Results of a Balance Seeking Faculty Member

Another player is a faculty member who tries to strike a balance between instruction, research and project activities. He tries to adjust his decisions frequently according to the feedback he received from the main indicators of quality and quantity of the outputs of the main activity groups (Figure D.2.1).

He obtains an increase in the number of the research papers per semester and average research papers per faculty member. His results about research papers are close to those of player one (Figure D.2.2).

The important difference between the decisions of player 1 and player 2 is that the latter put the necessary emphasis on IGP activities, which the first neglects. That causes a difference between the income the university receives from IGP (Figure D.2.3).

8.4.3. Game Results of a Teaching Assistant

The third player is a teaching assistant, who is also a graduate student. Her decisions show that she does not place emphasis on graduate study. The graduate admission decision

is between 50 and 105 and under-graduate faculty hiring decision is far higher than graduate faculty hiring decision (Figure D.3.1)

The comparison of the dynamic behavior of the number of graduate students in the game results of player 3 and player 2 portrays the difference in their attitude towards graduate study (Figure D.3.2)

Finally, the behaviors of the indicators of research in player 3's game are given in Figure D.3.3 to make possible the comparison with the results of the other two players. It is seen that player 3's decisions does not have as high a positive effect on research output as the decisions of the other two players.

9. CONCLUSIONS

The main objective of this research was to construct an interactive dynamic simulation model on which a range of problems concerning a university management system can be analyzed and certain policies for overcoming these problems can be tested. In order to construct such a simulation game, a system dynamics model of the academic aspects of a university system was built.

The system dynamics model was built using System Dynamics methodology and Vensim software. Numerous verification and validation tests were done on the model. Among these tests were extreme condition tests, sensitivity analyses and behavior validation tests. The model was calibrated using data from Boğaziçi University and the dynamic behavior patterns of the model were found to be consistent with the major historical time patterns obtained from Boğaziçi University. Observing the results of these tests, it was concluded that the model is structurally and behaviorally acceptable.

After the verification and validation test, some scenario experiments were done to demonstrate the analysis capabilities of the model. Simulation experiments with graduate versus under-graduate study orientation showed that graduate study orientation has considerable positive effect on research output. In other experiments, assuming different desired under-graduate class sizes revealed that keeping class sizes extremely low, under the condition of high student body may cause serious problems in maintaining the faculty body, because of decreasing faculty supply and increasing number of faculty members as a result of heavy instruction loads.

The interactive simulation game, based on the system dynamics model was constructed using Venapp facility of Vensim software. This game version of the model was validated by a series of standard tests and the necessary improvements in the model and the gaming interface were made.

A group of players with different academic degrees and orientations played the game and their game results were compared to explore the capabilities of the interactive gaming version of the model. The comparison of the game results of the players revealed that players with different orientations emphasized different performance measures.

There are several possibilities of further research that can be done on the existing model and the gaming interface. The model can be extended to include more aspects of the university system, such as budget considerations, support staff and in general more detailed representations of variables such as facilities, infrastructure and projects. Causal relations can be enriched by including additional feedback mechanisms. Also, the gaming interface can be enhanced to include various new features. A possible enhancement of the gaming interface is the addition of options to let the player determine the initial conditions of the game or the assumed environmental inputs of the game.

Another research extension would be to build different versions of the game, each emphasizing different aspects of the university management system. Finally, the interactive model can be used as a laboratory to facilitate not only debate but also theoretical research on how to best deal with strategic university management problems.

APPENDIX A

 Graduate Instruction Sector

Absolute Max Inst Hours per GF = Absolute Max Inst Hours per UGF-Release Time for Grad Faculty ~ hours/(week*faculty)

Absolute Max Inst Hours per UGF = 12 ~ hours/(week*faculty)

Absolute Total FTE GF for Inst = (Absolute Max Inst Hours per GF*Number of Grad Fac)/Weekly Hours per Faculty ~ FTE

Act Average Grad Class Size = MAX(MIN(Average Grad Class Size Needed,Max Grad Class Size Allowed),
 Desired Average Grad Class Size) ~ students

Act FTE GF For Grad Instr = MIN(Total FTE Needed for Grad Instr,(Operating Total FTE Grad Faculty for Instr
 +Additional FTE GF for Grad Inst)) ~ FTE

Act FTE GF For Instr = Act FTE GF For Grad Instr+Act FTE GF for UG Instr ~ FTE

Act FTE GF for UG Instr = Implied FTE Grad Faculty for UG Instr-Surplus FTE Grad Fac-Additional FTE GF for UG Inst ~ FTE

Act Grad Instr Load per GF = (Act FTE GF For Grad Instr/Number of Grad Fac)*Weekly Hours per Faculty ~ hours/(week*faculty)

Act Instr Load per GF = Act Grad Instr Load per GF+Act UG Instr Load per GF ~ hours/(week*faculty)

Act UG Instr Load per GF = (Act FTE GF for UG Instr/Number of Grad Fac)*Weekly Hours per Faculty ~ hours/(week*faculty)

Additional FTE GF for Grad Inst = MIN(MAX((Unsatisfied Need for Grad Instr/Weekly Hours per Faculty),0),
 (Absolute Total FTE GF for Inst-Operating Total FTE Grad Faculty for Instr)) ~ FTE

Additional Part Time FTE for Grad Instr = MIN(MAX((Unsatisfied Need for Grad Instr-Additional FTE GF for Grad Inst),0),
 (Additional FTE GF for Grad Inst*Max Part Time Percentage for Grad Instr)) ~ FTE

Average Grad Class Size Needed = MAX((Total Grad Student Hours/(Total Grad Instr Hours Needed-Grad Inst Discrepancy)),
 Desired Average Grad Class Size) ~ students

Average Hours per Grad Student = 15 ~ hours/week

Cancelled Grad Lecture Hours = INTEGER(MAX((Unsatisfied Need for Grad Instr-((Additional FTE GF for Grad Inst
 +Additional Part Time FTE for Grad Instr)*Weekly Hours per Faculty)),0)) ~ hours/week

Closed Grad Programs = INTEGER(MAX(Number of Grad Programs-Indicated Grad Programs Dec,0) /Closed Grad Programs AT)
 ~ programs/semester

Closed Grad Programs AT = 6 ~ semester

Desired Average Grad Class Size = MIN((Eff of Ind on Des Grad Class Size*Indicated Des Grad Class Size) ,Upper Limit Des Grad Class
 Size)
 ~ students

Eff of Ind on Des Grad Class Size = ind vs des grad class size(Indicated Des Grad Class Size) ~ dimensionless

Eff of Instr Load on GF Supply = eff of gf instr load on gf supply(Act Instr Load per GF) ~ dimensionless

Eff of Instr Load on Leaving GF = eff of gf instr load on leaving gf(Act Instr Load per GF) ~ dimensionless

Eff of Salary on GF Supply = eff of gf salary on gf supply(Hist Average GF Salary) ~ dimensionless

Eff of Salary on Leaving GF = eff of gf salary on leaving gf(Hist Average GF Salary) ~ dimensionless

Extra FTE Need for Grad Inst = MAX((Total FTE Needed for Grad Instr-Operating Total FTE Grad Faculty for Instr),0) ~ FTE

GF Hiring Decision = MAX((Cancelled Grad Lecture Hours/Operating Max Inst Hours per Grad Fac),(((Act Instr Load per GF
 *Number of Grad Fac)/(Operating Max Inst Hours per Grad Fac)-(Number of Grad Fac))) ~ faculty

GF Leave AT = 2 ~ semester

GF that Leave = INTEGER((MIN(((Number of Grad Fac/25)+(Eff of Instr Load on Leaving GF*Number of Grad Fac)
 +(Eff of Salary on Leaving GF*Number of Grad Fac)),Number of Grad Fac))/GF Leave AT) ~ faculty/semester

Grad Admission = 300/Grad Admission AT ~ students/semester

Grad Admission AT = 2 ~ semester

Grad Graduation = INTEGER(Number of Grad Students 2/Grad Stu 2 to Gauduation AT) ~ students/semester

Grad Inst Discrepancy = $\text{MAX}(0, (\text{Extra FTE Need for Grad Inst} - \text{Operating Part Time FTE for Grad Instr}) * \text{Weekly Hours per Faculty})$
 ~ hours/week

Grad Stu 1 to 2 = $\text{INTEGER}(\text{Number of Grad Students 1} / \text{Grad Stu 1 to 2 AT})$ ~ students/semester

Grad Stu 1 to 2 AT = 2.8 ~ semester

Grad Stu 2 to Graduation AT = 2.8 ~ semester

Grad Students GF Ratio = $\text{Number of Grad Students} / \text{Number of Grad Fac}$ ~ students/faculty

Hist Ave No of Grad Students AT = 4 ~ semester

Hist Ave Number of Grad Students = $\text{INTEG}(\text{Net Cha in Hist Ave No of Grad Students}, 450)$ ~ students

Hist Average GF Salary = $\text{INTEG}(\text{Cha in Ave GF Salary}, 450)$ ~ dollars/month

Implied FTE Grad Faculty for UG Instr = $\text{MAX}((\text{Operating Total FTE Grad Faculty for Instr} - \text{Total FTE Needed for Grad Instr}), 0)$ ~ FTE

Indicated Des Grad Class Size = $\text{Total Grad Student Hours} / (\text{Operating Total FTE Grad Faculty for Instr} * 0.8 * \text{Weekly Hours per Faculty})$
 ~ students

Indicated GF Hiring = $\text{MIN}(\text{GF Hiring Decision}, \text{Vacant Faculty Positions})$ ~ faculty

Indicated GF Supply = $\text{INTEGER}(200 * (\text{SQRT}(\text{Eff of Instr Load on GF Supply} * \text{Eff of Salary on GF Supply})))$ ~ faculty

Indicated Grad Programs Dec = $\text{Hist Ave Number of Grad Students} / \text{Min Students per Grad Program}$ ~ programs

Indicated Grad Programs Inc = $\text{MIN}((\text{Hist Ave Number of Grad Students} / \text{Normal Students per Grad Program}), \text{Maximum Grad Programs Possible})$ ~ programs

Indicated UGF Hiring = $\text{MIN}(\text{UGF Hiring Decision}, \text{Vacant Faculty Positions})$ ~ faculty

Max Grad Class Size Allowed = $\text{MAX}(25, \text{Desired Average Grad Class Size})$ ~ students

Max Part Time Percentage for Grad Instr = 0.3 ~ dimensionless

Maximum Grad Programs Possible = 50 ~ programs

Min Instr Hours per Grad Program = 12 ~ hours/(week*programs)

Min Students per Grad Program = 10 ~ students/programs

Net Cha in Hist Ave No of Grad Students = $(\text{Number of Grad Students} - \text{Hist Ave Number of Grad Students}) / \text{Hist Ave No of Grad Students AT}$ ~ students/semester

New Faculty Positions = 10 ~ faculty/semester

New Grad Faculty = $\text{INTEGER}(\text{MIN}(\text{MIN}(\text{Indicated GF Hiring}, (\text{Indicated GF Hiring} * \text{Vacant Faculty Positions} / (\text{Total Indicated Faculty Hiring} + 0.0001))), \text{Indicated GF Supply})) / \text{New Grad Faculty AT}$ ~ faculty/semester

New Grad Faculty AT = 2 ~ semester

New Grad Programs = $\text{INTEGER}(\text{MAX}(\text{Indicated Grad Programs Inc} - \text{Number of Grad Programs}, 0) / \text{New Grad Programs AT})$
 ~ programs/semester

New Grad Programs AT = 6 ~ semester

Normal Students per Grad Program = 80 ~ students/programs

Number of Faculty = $\text{Number of Grad Fac} + \text{Number of UG Fac}$ ~ faculty

Number of Grad Fac = $\text{INTEG}(\text{New Grad Faculty} - \text{GF that Leave}, 155)$ ~ faculty

Number of Grad Programs = $\text{INTEG}(\text{New Grad Programs} - \text{Closed Grad Programs}, 25)$ ~ programs

Number of Grad Students = $\text{Number of Grad Students 1} + \text{Number of Grad Students 2}$ ~ students

Number of Grad Students 1 = $\text{INTEG}(\text{Grad Admission} - \text{Grad Stu 1 to 2}, 250)$ ~ students

Number of Grad Students 2 = $\text{INTEG}(-\text{Grad Graduation} + \text{Grad Stu 1 to 2}, 200)$ ~ students

Operating Max Inst Hours per Grad Fac = $\text{Operating Max Inst Hours per UG Fac} - \text{Release Time for Grad Faculty}$ ~ hours/(week*faculty)

Operating Max Inst Hours per UG Fac = 6 ~ hours/(week*faculty)

Operating Part Time FTE for Grad Instr = MAX(0, MIN(Extra FTE Need for Grad Inst, Operating Total FTE Grad Faculty for Instr * Max Part Time Percentage for Grad Instr)) ~ FTE

Operating Total FTE Grad Faculty for Instr = (Number of Grad Fac * Operating Max Inst Hours per Grad Fac) / Weekly Hours per Faculty ~ FTE

Part Time FTE for Grad Instr = Operating Part Time FTE for Grad Instr + Additional Part Time FTE for Grad Instr ~ FTE

Release Time for Grad Faculty = 0 ~ hours/week

Total FTE Needed for Grad Instr = Total Grad Instr Hours Needed / Weekly Hours per Faculty ~ FTE

Total Grad Instr Hours Needed = MAX((Total Grad Student Hours / Desired Average Grad Class Size), (Min Instr Hours per Grad Program * Number of Grad Programs)) ~ hours/week

Total Grad Student Hours = Number of Grad Students * Average Hours per Grad Student ~ students * hours/week

Total Indicated Faculty Hiring = Indicated GF Hiring + Indicated UGF Hiring ~ faculty

Unsatisfied Need for Grad Instr = (Total Grad Student Hours / Act Average Grad Class Size) - (Total Grad Student Hours / Average Grad Class Size Needed) ~ hours/week

Upper Limit Des Grad Class Size = 20 ~ students

Vacant Faculty Positions = INTEG(GF that Leave + New Faculty Positions - New Grad Faculty - New UG Faculty + UGF that Leave, 135) ~ faculty

Under-graduate Instruction Sector

Absolute Max Inst Hours per UGF = 12 ~ hours/(week * faculty)

Absolute Total FTE UGF for Inst = (Absolute Max Inst Hours per UGF * Number of UG Fac) / Weekly Hours per Faculty ~ FTE

Act Average UG Class Size = MIN(Average UG Class Size Needed, Max UG Class Size Allowed) ~ students

Act FTE UGF for UG Instr = Operating Total FTE UG Faculty for Instr - Surplus FTE UG Fac + Additional FTE UGF for UG Instr ~ FTE

Act Instr Load per UGF = (Act FTE UGF for UG Instr / Number of UG Fac) * Weekly Hours per Faculty ~ hours/(week * faculty)

Additional FTE for UG Instr = MIN((Unsatisfied Need for UG Instr / Weekly Hours per Faculty), ((Absolute Total FTE GF for Inst - (Act FTE GF For Grad Instr + (Implied FTE Grad Faculty for UG Instr - Surplus FTE Grad Fac))) - (Absolute Total FTE UGF for Inst - Operating Total FTE UG Faculty for Instr))) ~ FTE

Additional FTE GF for UG Instr = (Additional FTE for UG Instr * (Absolute Total FTE GF for Inst - (Act FTE GF For Grad Instr + (Implied FTE Grad Faculty for UG Instr - Surplus FTE Grad Fac)))) / (((Absolute Total FTE GF for Inst - (Act FTE GF For Grad Instr + (Implied FTE Grad Faculty for UG Instr - Surplus FTE Grad Fac)))) + (Absolute Total FTE UGF for Inst - Operating Total FTE UG Faculty for Instr)) ~ FTE

Additional FTE UGF for UG Instr = Additional FTE for UG Instr - Additional FTE GF for UG Instr ~ FTE

Additional Part Time FTE for UG Instr = MIN((MAX((Unsatisfied Need for UG Instr - Additional FTE for UG Instr), 0)), (Additional FTE for UG Instr * Max Part Time Percentage for UG Instr)) ~ FTE

Average Hours per UG Student = 25 ~ hours/week

Average UG Class Size Needed = (Total UG Student Hours / (Total UG Instr Hours Needed - UG Inst Discrepancy)) ~ students

Cancelled UG Lecture Hours = INTEGER(MAX((Unsatisfied Need for UG Instr - (Additional FTE for UG Instr + Additional Part Time FTE for UG Instr) * Weekly Hours per Faculty), 0)) ~ hours/week

Closed UG Programs = INTEGER(MAX(Number of UG Programs - Indicated UG Programs Dec, 0) / Closed UG Programs AT) ~ programs/semester

Closed UG Programs AT = 6 ~ semester

Desired Average UG Class Size = 50 ~ students

Eff of Instr Load on Leaving UGF = eff of ugf instr load on leaving ugf(Act Instr Load per UGF) ~ dimensionless

Eff of Instr Load on UGF Supply = eff of ugf instr load on ugf supply(Act Instr Load per UGF) ~ dimensionless

Eff of Salary on Leaving UGF = eff of ugf salary on leaving ugf(Hist Average UGF Salary) ~ dimensionless

Eff of Salary on UGF Supply = eff of ugf salary on ugf supply(Hist Average UGF Salary) ~ dimensionless
 Extra FTE Need for UG Inst = Total FTE Needed for UG Instr-Implied Total FTE for UG Instr ~ FTE
 Hist Ave No of UG Students AT = 4 ~ semester
 Hist Ave Number of UG Students = INTEG(Net Cha in Hist Ave No of UG Students,2424) ~ students
 Hist Average UGF Salary =INTEG(Cha in Ave UGF Salary,450) ~ dollars/month
 Implied FTE Grad Faculty for UG Instr =MAX((Operating Total FTE Grad Faculty for Instr-Total FTE Needed for Grad Instr),0) ~ FTE
 Implied Total FTE for UG Instr = Implied FTE Grad Faculty for UG Instr+Operating Total FTE UG Faculty for Instr ~ FTE
 Indicated GF Hiring = MIN(GF Hiring Decision,Vacant Faculty Positions) ~ faculty
 Indicated UG Programs Dec = Hist Ave Number of UG Students/Min Students per UG Program ~ programs
 Indicated UG Programs Inc =MIN((Hist Ave Number of UG Students/Normal Students per UG Program),Max UG Programs Possible) ~ programs
 Indicated UGF Hiring = MIN(UGF Hiring Decision,Vacant Faculty Positions) ~ faculty
 Indicated UGF Supply =INTEG(200*(SQRT(Eff of Instr Load on UGF Supply*Eff of Salary on UGF Supply))) ~ faculty
 Max Part Time Percentage for UG Instr = 0.5 ~ dimensionless
 Max UG Class Size Allowed = 100 ~ students
 Max UG Programs Possible = 65 ~ programs
 Min Instr Hours per UG Prog = 30 ~ hours/(week*programs)
 Min Students per UG Program = 10 ~ students/programs
 Net Cha in Hist Ave No of UG Students = (Number of UG Students-Hist Ave Number of UG Students)/Hist Ave No of UG Students AT ~ students/semester
 New Faculty Positions = 10 ~ faculty/semester
 New UG Faculty = INTEG((MIN(MIN(Indicated UGF Hiring,(Indicated UGF Hiring*Vacant Faculty Positions)/(Total Indicated Faculty Hiring+0.0001))),Indicated UGF Supply))/New UG Faculty AT) ~ faculty/semester
 New UG Faculty AT = 2 ~ semester
 New UG Programs =INTEG(MAX(Indicated UG Programs Inc-Number of UG Programs,0)/New UG Programs AT) ~ programs/semester
 New UG Programs AT = 6 ~ semester
 Normal Students per UG Program = 500 ~ students/programs
 Number of Faculty = Number of Grad Fac+Number of UG Fac ~ faculty
 Number of UG Fac = INTEG(New UG Faculty-UGF that Leave,90) ~ faculty
 Number of UG Programs = INTEG(New UG Programs-Closed UG Programs,25) ~ programs
 Number of UG Students = Number of UG Students 1+Number of UG Students 2+Number of UG Students 3+Number of UG Students 4 ~ students
 Number of UG Students 1 = INTEG(UG Admission-UG Stu 1 to 2,606) ~ students
 Number of UG Students 2 = INTEG(UG Stu 1 to 2-UG Stu 2 to 3,606) ~ students
 Number of UG Students 3 = INTEG(UG Stu 2 to 3-UG Stu 3 to 4,606) ~ students
 Number of UG Students 4 = INTEG(-UG Graduation+UG Stu 3 to 4,606) ~ students
 Operating Max Inst Hours per UG Fac = 6 ~ hours/(week*faculty)
 Operating Part Time FTE for UG Instr = MAX(0,MIN(Extra FTE Need for UG Inst,Implied Total FTE for UG Instr *Max Part Time Percentage for UG Instr)) ~ FTE
 Operating Total FTE UG Faculty for Instr =(Operating Max Inst Hours per UG Fac*Number of UG Fac)/Weekly Hours per Faculty ~ FTE
 Part Time FTE for UG Instr = Operating Part Time FTE for UG Instr+Additional Part Time FTE for UG Instr ~ FTE

Surplus FTE Grad Fac = MIN(MAX(((-Extra FTE Need for UG Inst*Operating Total FTE Grad Faculty for Instr)
/(Operating Total FTE Grad Faculty for Instr+Operating Total FTE UG Faculty for Instr)),0),Implied FTE Grad Faculty for UG Instr)
~ FTE

Surplus FTE UG Fac = MAX((-Extra FTE Need for UG Inst-Surplus FTE Grad Fac),0) ~ FTE

Total FTE Needed for UG Instr = Total UG Instr Hours Needed/Weekly Hours per Faculty ~ FTE

Total Indicated Faculty Hiring = Indicated GF Hiring+Indicated UGF Hiring ~ faculty

Total UG Instr Hours Needed = MAX((Total UG Student Hours/Desired Average UG Class Size)
,(Number of UG Programs*Min Instr Hours per UG Prog)) ~ hours/week

Total UG Student Hours = Number of UG Students*Average Hours per UG Student ~ students*hours/week

UG Admission = (1100+Time*50)/UG Admission AT ~ students/semester

UG Admission AT = 2 ~ students/semester

UG Graduation = INTEGER(Number of UG Students 4/UG Stu 4 to Graduation AT) ~ students/semester

UG Inst Discrepancy = (Extra FTE Need for UG Inst-Operating Part Time FTE for UG Instr)*Weekly Hours per Faculty ~ hours/week

UG Stu 1 to 2 = INTEGER(Number of UG Students 1/UG Stu 1 to 2 AT) ~ students/semester

UG Stu 1 to 2 AT = 2.5 ~ semester

UG Stu 2 to 3 = INTEGER(Number of UG Students 2/UG Stu 2 to 3 AT) ~ students/semester

UG Stu 2 to 3 AT = 2 ~ semester

UG Stu 3 to 4 = INTEGER(Number of UG Students 3/UG Stu 3 to 4 AT) ~ students/semester

UG Stu 3 to 4 AT = 2 ~ semester

UG Stu 4 to Graduation AT = 2 ~ semester

UG Students Fac Ratio = Number of UG Students/Number of Faculty ~ students/faculty

UGF Hiring Decision = MAX(((Cancelled UG Lecture Hours/Operating Max Inst Hours per UG Fac)
,(((Act Instr Load per UGF*Number of UG Fac)/Operating Max Inst Hours per UG Fac)-Number of UG Fac)) ~ faculty

UGF Leave AT = 2 ~ semester

UGF that Leave = INTEGER((MIN(((Number of UG Fac/25)+(Eff of Instr Load on Leaving UGF*Number of UG Fac)
+(Eff of Salary on Leaving UGF*Number of UG Fac)),Number of UG Fac))/UGF Leave AT) ~ faculty/semester

Unsatisfied Need for UG Instr = (Total UG Student Hours/Act Average UG Class Size)
-(Total UG Student Hours/Average UG Class Size Needed) ~ hours/week

Vacant Faculty Positions = INTEG(GF that Leave+New Faculty Positions-New Grad Faculty-New UG Faculty+UGF that Leave,135)
~ faculty

Graduate Instruction Quality Sector

Act Average Grad Class Size = MAX(MIN(Average Grad Class Size Needed,Max Grad Class Size Allowed)
,Desired Average Grad Class Size) ~ students

Act FTE GF for Overhead G Instr = Indicated FTE GF for G Instr Overhead*(1-GF Overhead Reduction Coef) ~ FTE

Act GI Overhead per Grad Stu = ((Act FTE GF for Overhead G Instr+FTE Assist for Grad Instr Overhead)
*Weekly Hours per Faculty)/Number of Grad Students ~ hours/(week*students)

Assumed Grad Instr Quality Index = 0.8 ~ dimensionless

Assumed Perceived Grad Instr Quality = Assumed Grad Instr Quality Index/Perceived Grad Instr Quality Index ~ dimensionless

Assumed Perceived UG Instr Quality = Assumed UG Instr Quality Index/Perceived UG Instr Quality Index ~ dimensionless

Cha in GF Teach Comm = (Indicated GF Teach Comm-GF Teaching Commitment)/GF Teach Comm AT ~ dimensionless/semester
Cha in Perceived Grad Instr Qua Index = (Period Grad Instr Quality Index-Perceived Grad Instr Quality Index)
/Perc Grad Instr Qua Index AT ~ dimensionless/semester

Eff of Act GI Overhead per Grad Stu on GI Quality = eff of overhead per grad stu on gi quality(Act GI Overhead per Grad Stu) ~ dimensionless

Eff of Grad Class Size on GI Quality = eff of grad classsize on gi quality(Act Average Grad Class Size) ~ dimensionless

Eff of Lab Facilities for GI on GI Quality = eff of lab faci on gi quality(Lab Facilities for Grad Instr per Grad Stu) ~ dimensionless

Eff of Reseach on GI Quality = eff of res on gi quality(GF Hist Ave Res Papers Pub per GF) ~ dimensionless

FTE Assist for Grad Instr Overhead = MIN((Total Normal FTE for Grad Instr Overhead *Max G Instr OH Delegation to Assist Percentage), ((FTE Asistants for Instr Overhead *Total Normal FTE for Grad Instr Overhead) / (Total Normal FTE for Grad Instr Overhead +Total Normal FTE for UG Instr Overhead))) ~ FTE

GF Hist Ave Res Papers Pub = GF Hist Ave Unsponsored Res Papers Pub+GF Hist Ave Spons Res Papers Pub ~ papers/semester

GF Hist Ave Res Papers Pub per GF = GF Hist Ave Res Papers Pub/Number of Grad Fac ~ papers/(faculty*semester)

GF Teach Comm AT = 6 ~ semester

GF Teaching Commitment = INTEG(Cha in GF Teach Comm,0.7) ~ dimensionless

GF Teaching Culture = 0.85 ~ dimensionless

Grad Students GF Ratio = Number of Grad Students/Number of Grad Fac ~ students/faculty

Indicated GF Teach Comm = (gf teach com vs des rea instr qua(0.7*(Assumed Perceived Grad Instr Quality) +0.3*(Assumed Perceived UG Instr Quality))+GF Teaching Culture)/2 ~ dimensionless

Lab Facilities for Grad Instr = Lab Facilities*(Total FTE for Grad Instr/Total FTE for Lab Facility Consuming Act) ~ lab units

Lab Facilities for Grad Instr per Grad Stu = Lab Facilities for Grad Instr/Number of Grad Students ~ lab units/students

Number of Grad Fac = INTEG(New Grad Faculty-GF that Leave,155) ~ faculty

Number of Grad Students = Number of Grad Students 1+Number of Grad Students 2 ~ students

Perc Grad Instr Qua Index AT = 10 ~ semester

Perceived Grad Instr Quality Index = INTEG(Cha in Perceived Grad Instr Qua Index,0.8) ~ dimensionless

Period Grad Instr Quality Index =(Eff of Act GI Overhead per Grad Stu on GI Quality+Eff of Grad Class Size on GI Quality +Eff of Reseach on GI Quality+Eff of Lab Facilities for GI on GI Quality)/4 ~ dimensionless

Under-graduate Instruction Quality Sector

Act Average UG Class Size = MIN(Average UG Class Size Needed,Max UG Class Size Allowed) ~ students

Act FTE GF for Overhead UG Instr = Indicated FTE GF for UG Instr Overhead*(1-GF Overhead Reduction Coef) ~ FTE

Act FTE UGF for Overhead UG Instr = Indicated FTE UGF for UG Instr Overhead*(1-UGF Overhead Reduction Coef) ~ FTE

Act UGI Overhead per UG Stu = ((Act FTE GF for Overhead UG Instr+Act FTE UGF for Overhead UG Instr +FTE Assist for UG Instr Overhead)*Weekly Hours per Faculty) /Number of UG Students ~ hours/(week*students)

Assumed Perceived UG Instr Quality = Assumed UG Instr Quality Index/Perceived UG Instr Quality Index ~ dimensionless

Assumed UG Instr Quality Index = 0.8 ~ dimensionless

Cha in Perceived UG Instr Qua Index = (Period UG Instr Quality Index-Perceived UG Instr Quality Index)/Perc UG Instr Qua Index AT ~ dimensionless/semester

Cha in UGF Teach Comm = (Indicated UGF Teach Comm-UGF Teaching Commitment)/UGF Teach Comm AT ~ dimensionless/semester

Eff of Act UGI Overhead per UG Stu on UGI Quality =eff of overhead per ug stu on ugi quality(Act UGI Overhead per UG Stu) ~ dimensionless

Eff of Lab Facilities for UGI on UGI Quality = eff of lab faci on ugi quality(Lab Facilities for UG Instr per UG Stu) ~ dimensionless

Eff of Research on UGI Quality =eff of res on ugi quality(Hist Ave Res Pap per Faculty) ~ dimensionless

Eff of UG Class Size on UGI Quality = eff of ug classsize on ugi quality(Act Average UG Class Size) ~ dimensionless

FTE Assist for UG Instr Overhead = $\text{MIN}((\text{Total Normal FTE for UG Instr Overhead} * \text{Max UG Instr OH Delegation to Assist Percentage}) / ((\text{FTE Assistants for Instr Overhead} * \text{Total Normal FTE for UG Instr Overhead}) / (\text{Total Normal FTE for Grad Instr Overhead} + \text{Total Normal FTE for UG Instr Overhead})))$ ~ FTE

Hist Ave Res Pap per Faculty = $\text{Hist Ave Res Pap Pub} / \text{Number of Faculty}$ ~ papers/(faculty*semester)

Hist Ave Res Pap Pub = $\text{GF Hist Ave Res Papers Pub} + \text{UGF Hist Ave Res Papers Pub}$ ~ papers/semester

Indicated UGF Teach Comm = $(\text{ugf teach com vs des rea instr qua}(\text{Assumed Perceived UG Instr Quality}) - \text{UGF Teaching Culture}) / 2$ ~ dimensionless

Lab Facilities for UG Instr = $\text{Lab Facilities} * (\text{Total FTE for UG Instr} / \text{Total FTE for Lab Facility Consuming Act})$ ~ lab units

Lab Facilities for UG Instr per UG Stu = $\text{Lab Facilities for UG Instr} / \text{Number of UG Students}$ ~ lab units/students

Number of Faculty = $\text{Number of Grad Fac} + \text{Number of UG Fac}$ ~ faculty

Number of UG Students = $\text{Number of UG Students 1} + \text{Number of UG Students 2} + \text{Number of UG Students 3} + \text{Number of UG Students 4}$ ~ students

Perc UG Instr Qua Index AT = 10 ~ semester

Perceived UG Instr Quality Index = $\text{INTEG}(\text{Cha in Perceived UG Instr Qua Index}, 0.8)$ ~ dimensionless

Period UG Instr Quality Index = $(\text{Eff of Act UGI Overhead per UG Stu on UGI Quality} + \text{Eff of Research on UGI Quality} + \text{Eff of UG Class Size on UGI Quality} + \text{Eff of Lab Facilities for UGI on UGI Quality}) / 4$ ~ dimensionless

UG Student Faculty Ratio = $\text{Number of UG Students} / \text{Number of Faculty}$ ~ students/faculty

UGF Teach Comm AT = 6 ~ semester

UGF Teaching Commitment = $\text{INTEG}(\text{Cha in UGF Teach Comm}, 0.7)$ ~ dimensionless

UGF Teaching Culture = 0.85 ~ dimensionless

Graduate Faculty Instruction Overhead Sector

Act Average Grad Class Size = $\text{MAX}(\text{MIN}(\text{Average Grad Class Size Needed}, \text{Max Grad Class Size Allowed}), \text{Desired Average Grad Class Size})$ ~ students

Act Average UG Class Size = $\text{MIN}(\text{Average UG Class Size Needed}, \text{Max UG Class Size Allowed})$ ~ students

Act FTE GF For Grad Instr = $\text{MIN}(\text{Total FTE Needed for Grad Instr}, \text{Operating Total FTE Grad Faculty for Instr} + \text{Additional FTE GF for Grad Inst})$ ~ FTE

Act FTE GF for Overhead G Instr = $\text{Indicated FTE GF for G Instr Overhead} * (1 - \text{GF Overhead Reduction Coef})$ ~ FTE

Act FTE GF for Overhead UG Instr = $\text{Indicated FTE GF for UG Instr Overhead} * (1 - \text{GF Overhead Reduction Coef})$ ~ FTE

Act FTE GF for Projects = $\text{Act FTE GF for Research and Projects} * ((\text{GF Financial Pressure} / (\text{GF Research Commitment} + \text{GF Financial Pressure})) * \text{GF Project vs Research Orientation})$ ~ FTE

Act FTE GF for Research = $\text{Act FTE GF for Research and Projects} * ((\text{GF Research Commitment} / (\text{GF Research Commitment} + \text{GF Financial Pressure})) * (2 - \text{GF Project vs Research Orientation}))$ ~ FTE

Act FTE GF for Research and Projects = $\text{MIN}(\text{Available FTE GF for Research and Projects}, \text{Desired FTE GF for Research and Projects})$ ~ FTE

Act FTE GF for UG Instr = $\text{Implied FTE Grad Faculty for UG Instr} - \text{Surplus FTE Grad Fac} + \text{Additional FTE GF for UG Inst}$ ~ FTE

Act GI Overhead Load per GF = $(\text{Act FTE GF for Overhead G Instr} * \text{Number of Grad Fac}) * \text{Weekly Hours per Faculty}$ ~ hours/(week*faculty)

Act Non Instr FTE GF = $\text{Total FTE GF} - (\text{Total In Class FTE GF} - \text{Act FTE GF for Overhead G Instr} + \text{Act FTE GF for Overhead UG Instr} + \text{FTE GF for Other Routine Tasks})$ ~ FTE

Act Overhead Load per GF = $\text{Act GI Overhead Load per GF} + \text{Act UGI Overhead Load per GF}$ ~ hours/(week*faculty)

Act UGI Overhead Load per GF = $(\text{Act FTE GF for Overhead UG Instr} * \text{Number of Grad Fac}) * \text{Weekly Hours per Faculty}$ ~ hours/(week*faculty)

Available FTE GF for Research and Projects = $\text{Act Non Instr FTE GF} - ((\text{Number of Grad Fac} * \text{MIN}(\text{Reduced GF Extra Work Load}, \text{GF Bearable Extra Work Load})) * \text{Weekly Hours per Faculty})$ ~ FTE

Desired FTE GF for Research and Projects = MAX((Total FTE GF - Total In Class FTE GF)
 *des FTE gf for res pro vs gf res pro comm(GF Res Pro Commitment)), Min FTE GF Required for Research) ~ FTE

FTE GF for Other Routine Tasks = (FTE Needed for Other Routine Tasks * Total FTE GF) / (Total FTE GF + Total FTE UGF) ~ FTE

FTE Needed for Other Routine Tasks = (Number of UG Students * 0.001) - (Number of Grad Students * 0.002) ~ FTE

GF Bearable Extra Work Load = 10 ~ hours/(week*faculty)

GF Financial Pressure = INTEG(Cha in GF Financial Pressure, 0.8) ~ dimensionless

GF Overhead Reduction Coef = (GF Overhead Reduction Need * overhead red coef vs GF teach comm(GF Teaching Commitment))
 ~ dimensionless

GF Overhead Reduction Need = gf redu need vs ind extra work load(Indicated GF Extra Work Load) ~ dimensionless

GF Project vs Research Orientation = 0.8 ~ dimensionless

GF Res Pro Commitment = (GF Financial Pressure + GF Research Commitment) / 2 ~ dimensionless

GF Research Commitment = (GF Unsponsored Res Commitment - GF Spons Res Commitment) / 2 ~ dimensionless

GF Teaching Commitment = INTEG(Cha in GF Teach Comm, 0.7) ~ dimensionless

Inactive FTE GF = MAX((Act Non Instr FTE GF - Act FTE GF for Research and Projects), 0) ~ FTE

Indicated FTE GF for G Instr Overhead = Normal FTE GF for G Instr Overhead - FTE Assist for Grad Instr Overhead ~ FTE

Indicated FTE GF for UG Instr Overhead = Normal FTE GF for UG Instr Overhead
 - ((FTE Assist for UG Instr Overhead * Normal FTE GF for UG Instr Overhead) / Total Normal FTE for UG Instr Overhead) ~ FTE

Indicated GF Extra Work Load = MAX((((Desired FTE GF for Research and Projects - Total Indicated Non Instr FTE GF)
 * Weekly Hours per Faculty) / Number of Grad Fac, 0) ~ hours/(week*faculty)

Min FTE GF Required for Research = (Number of Grad Students * 0.05) ~ FTE

Normal FTE GF for G Instr Overhead = Normal Overhead Ratio for Grad Instr * Act FTE GF For Grad Instr ~ FTE

Normal FTE GF for UG Instr Overhead = Normal Overhead Ratio for UG Instr * Act FTE GF for UG Instr ~ FTE

Normal Overhead Ratio for Grad Instr = 2 * grad class size vs norm overhead ratio(Act Average Grad Class Size) ~ dimensionless

Normal Overhead Ratio for UG Instr = 2 * ug class size vs norm overhead ratio(Act Average UG Class Size) ~ dimensionless

Number of Grad Fac = INTEG(New Grad Faculty - GF that Leave, 155) ~ faculty

Number of Grad Students = Number of Grad Students 1 + Number of Grad Students 2 ~ students

Number of UG Students = Number of UG Students 1 + Number of UG Students 2 + Number of UG Students 3 + Number of UG Students 4
 ~ students

Reduced GF Extra Work Load = (MAX((Desired FTE GF for Research and Projects - Act Non Instr FTE GF), 0) * Weekly Hours per Faculty)
 / Number of Grad Fac ~ hours/(week*faculty)

Total FTE GF = Number of Grad Fac ~ FTE

Total FTE UGF = Number of UG Fac ~ FTE

Total In Class FTE GF = Act FTE GF For Grad Instr + Act FTE GF for UG Instr ~ FTE

Total Indicated Non Instr FTE GF = Total FTE GF - (Total In Class FTE GF + Indicated FTE GF for G Instr Overhead
 + Indicated FTE GF for UG Instr Overhead + FTE GF for Other Routine Tasks) ~ FTE

Weekly Inactive Hours per GF = (Inactive FTE GF / Number of Grad Fac) * Weekly Hours per Faculty ~ hours/(week*faculty)

 Under-graduate Faculty Instruction Overhead Sector

Act Average UG Class Size = MIN(Average UG Class Size Needed, Max UG Class Size Allowed) ~ students

Act FTE UGF for Overhead UG Instr = Indicated FTE UGF for UG Instr Overhead * (1 - UGF Overhead Reduction Coef) ~ FTE

Act FTE UGF for Projects = Act FTE UGF for Research and Projects*((UGF Financial Pressure
(UGF Research Commitment-UGF Financial Pressure))*UGF Project vs Research Orientation) ~ FTE

Act FTE UGF for Research = Act FTE UGF for Research and Projects*((UGF Research Commitment
(UGF Research Commitment+UGF Financial Pressure))*2-UGF Project vs Research Orientation) ~ FTE

Act FTE UGF for Research and Projects = MIN(Available FTE UGF for Research and Projects,Desired FTE UGF for Research and
Projects)
~ FTE

Act FTE UGF for UG Instr = Operating Total FTE UG Faculty for Instr-Surplus FTE UG Fac-Additional FTE UGF for UG Instr ~ FTE

Act Non Instr FTE UGF = Total FTE UGF-(Total In Class FTE UGF+Act FTE UGF for Overhead UG Instr
+FTE UGF for Other Routine Tasks) ~ FTE

Act Overhead Load per UGF = (Act FTE UGF for Overhead UG Instr/Number of UG Fac)*Weekly Hours per Faculty
~ hours/(week*faculty)

Available FTE UGF for Research and Projects = Act Non Instr FTE UGF
+(((MIN(Reduced UGF Extra Work Load,UGF Bearable Extra Work Load)*Number of UG Fac))/Weekly Hours per Faculty) ~ FTE

Desired FTE UGF for Research and Projects =(Total FTE UGF-Total In Class FTE UGF)
*des FTE ugf for res pro vs ugf res pro comm(UGF Res Pro Commitment) ~ FTE

FTE Assist for UG Instr Overhead = MIN((Total Normal FTE for UG Instr Overhead*Max UG Instr OH Delegation to Assist Percentage),
((FTE Asistants for Instr Overhead*Total Normal FTE for UG Instr Overhead)/(Total Normal FTE for Grad Instr Overhead
+Total Normal FTE for UG Instr Overhead))) ~ FTE

FTE Needed for Other Routine Tasks = (Number of UG Students*0.001)+(Number of Grad Students*0.002) ~ FTE

FTE UGF for Other Routine Tasks = (FTE Needed for Other Routine Tasks*Total FTE UGF)/(Total FTE GF+Total FTE UGF) ~ FTE

Inactive FTE UGF =MAX((Act Non Instr FTE UGF-Act FTE UGF for Research and Projects),0) ~ FTE

Indicated FTE UGF for UG Instr Overhead =Normal FTE UGF for UG Instr Overhead
-(FTE Assist for UG Instr Overhead*Normal FTE UGF for UG Instr Overhead)/Total Normal FTE for UG Instr Overhead) ~ FTE

Indicated UGF Extra Work Load =MAX(((Desired FTE UGF for Research and Projects-(Total Indicated Non Instr FTE UGF))
*Weekly Hours per Faculty)/Number of UG Fac),0) ~ hours/(week*faculty)

Normal FTE UGF for UG Instr Overhead = Normal Overhead Ratio for UG Instr*Act FTE UGF for UG Instr ~ FTE

Normal Overhead Ratio for UG Instr = 2*ug class size vs norm overhead ratio(Act Average UG Class Size) ~ dimensionless

Number of Grad Students = Number of Grad Students 1+Number of Grad Students 2 ~ students

Number of UG Fac = INTEG(New UG Faculty-UGF that Leave,90) ~ faculty

Number of UG Students = Number of UG Students 1+Number of UG Students 2+Number of UG Students 3+Number of UG Students 4
~ students

Reduced UGF Extra Work Load =(MAX((Desired FTE UGF for Research and Projects-Act Non Instr FTE UGF),0)
*Weekly Hours per Faculty)/Number of UG Fac ~ hours/(week*faculty)

Total FTE GF =Number of Grad Fac ~ FTE

Total FTE UGF = Number of UG Fac ~ FTE

Total In Class FTE UGF = Act FTE UGF for UG Instr ~ FTE

Total Indicated Non Instr FTE UGF =Total FTE UGF-(Total In Class FTE UGF+Indicated FTE UGF for UG Instr Overhead
+FTE UGF for Other Routine Tasks) ~ FTE

Total Normal FTE for UG Instr Overhead = Normal FTE GF for UG Instr Overhead+Normal FTE UGF for UG Instr Overhead ~ FTE

UGF Bearable Extra Work Load = 10 ~ hours/(week*faculty)

UGF Financial Pressure = INTEG(Cha in UGF Financial Pressure,0,8) ~ dimensionless

UGF Overhead Reduction Coef = (UGF Overhead Reduction Need*overhead red coef vs UGF teach comm(UGF Teaching Commitment))
~ dimensionless

UGF Overhead Reduction Need = ugf redu need vs ind extra work load(Indicated UGF Extra Work Load) ~ dimensionless

UGF Project vs Research Orientation = 0.8 ~ dimensionless

UGF Res Pro Commitment = (UGF Financial Pressure+UGF Research Commitment)/2 ~ dimensionless

UGF Research Commitment = (UGF Un-sponsored Res Commitment-UGF Spons Res Commitment)/2 ~ dimensionless

UGF Teaching Commitment = INTEG(Cha in UGF Teach Comm,0.7) ~ dimensionless

Weekly Inactive Hours per UGF = (Inactive FTE UGF/Number of UG Fac)*Weekly Hours per Faculty ~ hours/(week*faculty)

Graduate Faculty Research Sector

Act FTE GF for Research = Act FTE GF for Research and Projects*((GF Research Commitment / (GF Research Commitment+GF Financial Pressure))*(2-GF Project vs Research Orientation)) ~ FTE

Act FTE GF for Spons Res = Act FTE GF for Research*(GF Spons Res Commitment/(GF Research Commitment*2)) ~ FTE

Act FTE GF for Un-sponsored Res = Act FTE GF for Research*(GF Un-sponsored Res Commitment/(GF Research Commitment*2)) ~ FTE

Act FTE UGF for Spons Res = Act FTE UGF for Research*(UGF Spons Res Commitment/(UGF Research Commitment*2)) ~ FTE

Act FTE UGF for Un-sponsored Res = Act FTE UGF for Research*(UGF Un-sponsored Res Commitment/(UGF Research Commitment*2)) ~ FTE

Act Research Load per GF = (Act FTE GF for Research/Number of Grad Fac)*Weekly Hours per Faculty ~ hours/(week*faculty)

Assumed Perceived UG Instr Quality = Assumed UG Instr Quality Index/Perceived UG Instr Quality Index ~ dimensionless

Cha in GF H A Spons Pap Pub = (Period GF Spons Res Pap Pub-GF Hist Ave Spons Res Papers Pub)/GF Spons Res Pap AT ~ papers/(semester*semester)

Cha in GF H A Un-sponsored Pap Pub = (Period GF Un-sponsored Res Pap Pub-GF Hist Ave Un-sponsored Res Papers Pub) /GF Un-sponsored Res Pap AT ~ papers/(semester*semester)

Cha in GF Spons Res Comm = (GF Indicated Spons Res Comm-GF Spons Res Commitment)/GF Spons Res Comm AT ~ dimensionless/semester

Cha in GF Un-sponsored Res Comm = (GF Indicated Un-sponsored Res Comm-GF Un-sponsored Res Commitment) /GF Un-sponsored Res Comm AT ~ dimensionless/semester

Cha in Spons Res Rec = (Indicated Spons Res Rec-Spons Res Recog)/Spons Res Rec AT ~ dimensionless/semester

Cha in Un-sponsored Res Rec = (Indicated Un-sponsored Res Rec-Un-sponsored Res Recog)/Un-sponsored Res Rec AT ~ dimensionless/semester

Desired Ave Res Papers Pub = 30 ~ papers/semester

Eff of GF Spons Res Comm = GF Spons Res Commitment ~ dimensionless

Eff of GF Un-sponsored Res Comm = GF Un-sponsored Res Commitment ~ dimensionless

Eff of Grad Students = eff of grad stu on res productivity(Grad Students GF Ratio) ~ dimensionless

Eff of Lab Facilities for Spons Res = eff of lab faci on spons res(Lab Facilities for Spons Res per FTE for Spons Res) ~ dimensionless

Eff of Lab Facilities for Un-sponsored Res = eff of lab faci on un-sponsored res (Lab Facilities for Un-sponsored Res per FTE for Un-sponsored Res) ~ dimensionless

Financial Concern = 0.98 ~ dimensionless

Funds Grants Gotten by Spons Res = (Act FTE GF for Spons Res*GF Spons Res Funds Grants Productivity) +(Act FTE UGF for Spons Res*UGF Spons Res Funds Grants Productivity) ~ dollars/semester

GF Des Realized Res Pap Pub = Desired Ave Res Papers Pub/GF Hist Ave Res Papers Pub ~ dimensionless

GF Hist Ave Res Papers Pub = GF Hist Ave Un-sponsored Res Papers Pub+GF Hist Ave Spons Res Papers Pub ~ papers/semester

GF Hist Ave Res Papers Pub per GF = GF Hist Ave Res Papers Pub/Number of Grad Fac ~ papers/(faculty*semester)

GF Hist Ave Spons Res Papers Pub = INTEG(Cha in GF H A Spons Pap Pub,60) ~ papers/semester

GF Hist Ave Un-sponsored Res Papers Pub = INTEG(Cha in GF H A Un-sponsored Pap Pub,60) ~ papers/semester

GF Indicated Spons Res Comm = (0.4*GF Research Culture)+(0.4*(gf res com vs des rea res pap(GF Des Realized Res Pap Pub))) +(0.2*Spons Res Recog) ~ dimensionless

$GF \text{ Indicated Un-sponsored Res Comm} = (0.4 * GF \text{ Research Culture}) + (0.4 * (gf \text{ res com vs des rea res pap}(GF \text{ Des Realized Res Pap Pub})) + (0.2 * \text{Un-sponsored Res Recog}) \quad \sim \text{dimensionless}$

$GF \text{ Research Commitment} = (GF \text{ Un-sponsored Res Commitment} + GF \text{ Spons Res Commitment}) / 2 \quad \sim \text{dimensionless}$

$GF \text{ Research Culture} = 0.9 \quad \sim \text{dimensionless}$

$GF \text{ Spons Res Comm AT} = 6 \quad \sim \text{semester}$

$GF \text{ Spons Res Commitment} = \text{INTEG}(\text{Cha in GF Spons Res Comm}, 0.85) \quad \sim \text{dimensionless}$

$GF \text{ Spons Res Funds Grants Productivity} = ((\text{Eff of Lab Facilities for Spons Res} + \text{Eff of GF Spons Res Comm}) / 2) * 2000 \quad \sim \text{dollars}/(\text{faculty} * \text{semester})$

$GF \text{ Spons Res Pap AT} = 6 \quad \sim \text{semester}$

$GF \text{ Spons Res Pap Productivity} = ((\text{Eff of Lab Facilities for Spons Res} + \text{Eff of GF Spons Res Comm} + \text{Eff of Grad Students}) / 3) * 4 \quad \sim \text{papers}/(\text{faculty} * \text{semester})$

$GF \text{ Un-sponsored Res Comm AT} = 6 \quad \sim \text{semester}$

$GF \text{ Un-sponsored Res Commitment} = \text{INTEG}(\text{Cha in GF Un-sponsored Res Comm}, 0.85) \quad \sim \text{dimensionless}$

$GF \text{ Un-sponsored Res Pap AT} = 6 \quad \sim \text{semester}$

$GF \text{ Un-sponsored Res Pap Productivity} = ((\text{Eff of Lab Facilities for Un-sponsored Res} + \text{Eff of GF Un-sponsored Res Comm} + \text{Eff of Grad Students}) / 3) * 4 \quad \sim \text{papers}/(\text{faculty} * \text{semester})$

$\text{Grad Students GF Ratio} = \text{Number of Grad Students} / \text{Number of Grad Fac} \quad \sim \text{students}/\text{faculty}$

$\text{Hist Ave Res Pap per Faculty} = \text{Hist Ave Res Pap Pub} / \text{Number of Faculty} \quad \sim \text{papers}/(\text{faculty} * \text{semester})$

$\text{Hist Ave Res Pap Pub} = GF \text{ Hist Ave Res Papers Pub} + UGF \text{ Hist Ave Res Papers Pub} \quad \sim \text{papers}/\text{semester}$

$\text{Indicated Spons Res Rec} = 0.2 * (\text{spon res rec vs spon pap pub per FTE for spons res} / (\text{Period Spons Res Pap Pub Total FTE for Spons Res})) + 0.4 * (\text{ind spons res rec vs spons res funds grants prod} / ((\text{Funds Grants Gotten by Spons Res Total FTE for Spons Res}))) + 0.4 * \text{Financial Concern} \quad \sim \text{dimensionless}$

$\text{Indicated Un-sponsored Res Rec} = \text{un-sponsored res rec vs un-sponsored pap pub per FTE for un-sponsored res} / (\text{Period Un-sponsored Res Pap Pub Total FTE for Un-sponsored Res}) \quad \sim \text{dimensionless}$

$\text{Lab Facilities for Spons Res} = \text{Lab Facilities} * (\text{Total FTE for Spons Res} / \text{Total FTE for Lab Facility Consuming Act}) \quad \sim \text{lab units}$

$\text{Lab Facilities for Spons Res per FTE for Spons Res} = \text{Lab Facilities for Spons Res} / \text{Total FTE for Spons Res} \quad \sim \text{lab units}/\text{FTE}$

$\text{Lab Facilities for Un-sponsored Res} = \text{Lab Facilities} * (\text{Total FTE for Un-sponsored Res} / \text{Total FTE for Lab Facility Consuming Act}) \quad \sim \text{lab units}$

$\text{Lab Facilities for Un-sponsored Res per FTE for Un-sponsored Res} = \text{Lab Facilities for Un-sponsored Res} / \text{Total FTE for Un-sponsored Res} \quad \sim \text{lab units}/\text{FTE}$

$\text{Number of Faculty} = \text{Number of Grad Fac} + \text{Number of UG Fac} \quad \sim \text{faculty}$

$\text{Number of Grad Fac} = \text{INTEG}(\text{New Grad Faculty} - GF \text{ that Leave}, 155) \quad \sim \text{faculty}$

$\text{Period GF Spons Res Pap Pub} = \text{INTEGER}(\text{Act FTE GF for Spons Res} * GF \text{ Spons Res Pap Productivity}) \quad \sim \text{papers}/\text{semester}$

$\text{Period GF Un-sponsored Res Pap Pub} = \text{INTEGER}(\text{Act FTE GF for Un-sponsored Res} * GF \text{ Un-sponsored Res Pap Productivity}) \quad \sim \text{papers}/\text{semester}$

$\text{Period Res Pap Pub} = \text{Period Spons Res Pap Pub} + \text{Period Un-sponsored Res Pap Pub} \quad \sim \text{papers}/\text{semester}$

$\text{Period Spons Res Pap Pub} = \text{Period GF Spons Res Pap Pub} + \text{Period UGF Spons Res Pap Pub} \quad \sim \text{papers}/\text{semester}$

$\text{Period UGF Spons Res Pap Pub} = \text{INTEGER}(\text{Act FTE UGF for Spons Res} * UGF \text{ Spons Res Pap Productivity}) \quad \sim \text{papers}/\text{semester}$

$\text{Period UGF Un-sponsored Res Pap Pub} = \text{INTEGER}(\text{Act FTE UGF for Un-sponsored Res} + UGF \text{ Un-sponsored Res Pap Productivity}) \quad \sim \text{papers}/\text{semester}$

$\text{Period Un-sponsored Res Pap Pub} = \text{Period GF Un-sponsored Res Pap Pub} + \text{Period UGF Un-sponsored Res Pap Pub} \quad \sim \text{papers}/\text{semester}$

$\text{Spons Res Rec AT} = 10 \quad \sim \text{semester}$

$\text{Spons Res Recog} = \text{INTEG}(\text{Cha in Spons Res Rec}, 0.6) \quad \sim \text{dimensionless}$

$\text{Total FTE for Spons Res} = \text{Act FTE GF for Spons Res} + \text{Act FTE UGF for Spons Res} \quad \sim \text{FTE}$

Total FTE for Unsponsored Res = Act FTE GF for Unsponsored Res - Act FTE UGF for Unsponsored Res ~ FTE

UGF Hist Ave Res Papers Pub = UGF Hist Ave Unsponsored Res Papers Pub - UGF Hist Ave Spons Res Papers Pub ~ papers/semester

UGF Spons Res Funds Grants Productivity = ((Eff of Lab Facilities for Spons Res + Eff of UGF Spons Res Comm)/2)*2000
~ dollars/(faculty*semester)

Unsponsored Res Rec AT = 10 ~ semester

Unsponsored Res Recog = INTEG(Cha in Unsponsored Res Rec, 0.7) ~ dimensionless

Under-graduate Faculty Research Sector

Act FTE GF for Spons Res = Act FTE GF for Research*(GF Spons Res Commitment/(GF Research Commitment*2)) ~ FTE

Act FTE GF for Unsponsored Res = Act FTE GF for Research*(GF Unsponsored Res Commitment/(GF Research Commitment*2))
~ FTE

Act FTE UGF for Research = Act FTE UGF for Research and Projects*((UGF Research Commitment
(UGF Research Commitment+UGF Financial Pressure))*(2-UGF Project vs Research Orientation)) ~ FTE

Act FTE UGF for Spons Res = Act FTE UGF for Research*(UGF Spons Res Commitment/(UGF Research Commitment*2)) ~ FTE

Act FTE UGF for Unsponsored Res = Act FTE UGF for Research*(UGF Unsponsored Res Commitment/(UGF Research Commitment*2))
~ FTE

Act Research Load per UGF = (Act FTE UGF for Research/Number of UG Fac)*Weekly Hours per Faculty ~ hours/(week*faculty)

Assumed Perceived UG Instr Quality = Assumed UG Instr Quality Index Perceived UG Instr Quality Index ~ dimensionless

Assumed UG Instr Quality Index = 0.8 ~ dimensionless

Cha in Perceived UG Instr Qua Index = (Period UG Instr Quality Index - Perceived UG Instr Quality Index)/Perc UG Instr Qua Index AT
~ dimensionless/semester

Cha in Spons Res Rec = (Indicated Spons Res Rec - Spons Res Recog)/Spons Res Rec AT
~ dimensionless/semester

Cha in UGF H A Spons Pap Pub = (Period UGF Spons Res Pap Pub - UGF Hist Ave Spons Res Papers Pub)/UGF Spons Res Pap AT
~ papers/(semester*semester)

Cha in UGF H A Unsponsored Pap Pub = (Period UGF Unsponsored Res Pap Pub - UGF Hist Ave Unsponsored Res Papers Pub)
/UGF Unsponsored Res Pap AT ~ papers/(semester*semester)

Cha in UGF Spons Res Comm = (UGF Indicated Spons Res Comm - UGF Spons Res Commitment)/UGF Spons Res Comm AT
~ dimensionless/semester

Cha in UGF Teach Comm = (Indicated UGF Teach Comm - UGF Teaching Commitment)/UGF Teach Comm AT ~
dimensionless/semester

Cha in UGF Unsponsored Res Comm = (UGF Indicated Unsponsored Res Comm - UGF Unsponsored Res Commitment)
/UGF Unsponsored Res Comm AT ~ dimensionless/semester

Cha in Unsponsored Res Rec = (Indicated Unsponsored Res Rec - Unsponsored Res Recog)/Unsponsored Res Rec AT
~ dimensionless/semester

Desired Ave Res Papers Pub = 30 ~ papers/semester

Eff of Lab Facilities for Spons Res = eff of lab faci on spons res (Lab Facilities for Spons Res per FTE for Spons Res) ~ dimensionless

Eff of UGF Spons Res Comm = UGF Spons Res Commitment ~ dimensionless

Eff of UGF Unsponsored Res Comm = UGF Unsponsored Res Commitment ~ dimensionless

Financial Concern = 0.98 ~ dimensionless

Funds Grants Gotten by Spons Res = (Act FTE GF for Spons Res*GF Spons Res Funds Grants Productivity)+(Act FTE UGF for Spons Res
*UGF Spons Res Funds Grants Productivity) ~ dollars/semester

GF Hist Ave Res Papers Pub = GF Hist Ave Unsponsored Res Papers Pub - GF Hist Ave Spons Res Papers Pub ~ papers/semester

GF Spons Res Funds Grants Productivity = ((Eff of Lab Facilities for Spons Res + Eff of GF Spons Res Comm)/2)*2000
~ dollars/(faculty*semester)

Hist Ave Res Pap per Faculty = Hist Ave Res Pap Pub/Number of Faculty ~ papers/(faculty*semester)

Hist Ave Res Pap Pub = GF Hist Ave Res Papers Pub + UGF Hist Ave Res Papers Pub ~ papers/semester

Indicated Spons Res Rec = $0.2 * (\text{spn res rec vs spn pap pub per FTE for spns res} / (\text{Period Spons Res Pap Pub Total FTE for Spons Res}))$
 $+ 0.4 * (\text{ind spns res rec vs spns res funds grants prod} / (\text{Funds Grants Gotten by Spons Res Total FTE for Spons Res}))$
 $+ 0.4 * \text{Financial Concern}$ ~ dimensionless

Indicated UGF Teach Comm = $(\text{ugf teach com vs des rea instr qua} / (\text{Assumed Perceived UG Instr Quality})) + \text{UGF Teaching Culture}$ / 2
 ~ dimensionless

Indicated Un-sponsored Res Rec = $\text{un-sponsored res rec vs un-sponsored pap pub per FTE for un-sponsored res} / (\text{Period Un-sponsored Res Pap Pub Total FTE for Un-sponsored Res})$ ~ dimensionless

Lab Facilities for Spons Res = $\text{Lab Facilities} * (\text{Total FTE for Spons Res} / \text{Total FTE for Lab Facility Consuming Act})$ ~ lab units

Lab Facilities for Spons Res per FTE for Spons Res = $\text{Lab Facilities for Spons Res} / \text{Total FTE for Spons Res}$ ~ lab units/FTE

Net Spons Res Funds Prod per Faculty = $\text{Funds Grants Gotten by Spons Res} / \text{Number of Faculty}$ ~ dollars/(faculty*semester)

Number of Faculty = $\text{Number of Grad Fac} + \text{Number of UG Fac}$ ~ faculty

Number of UG Fac = $\text{INTEG}(\text{New UG Faculty} - \text{UGF that Leave}, 90)$ ~ faculty

Perc UG Instr Qua Index AT = 10 ~ semester

Perceived UG Instr Quality Index = $\text{INTEG}(\text{Cha in Perceived UG Instr Qua Index}, 0.8)$ ~ dimensionless

Period GF Spons Res Pap Pub = $\text{INTEG}(\text{Act FTE GF for Spons Res} * \text{GF Spons Res Pap Productivity})$ ~ papers/semester

Period GF Un-sponsored Res Pap Pub = $\text{INTEG}(\text{Act FTE GF for Un-sponsored Res} * \text{GF Un-sponsored Res Pap Productivity})$
 ~ papers/semester

Period Spons Res Pap Pub = $\text{Period GF Spons Res Pap Pub} + \text{Period UGF Spons Res Pap Pub}$ ~ papers/semester

Period UG Instr Quality Index = $(\text{Eff of Act UGI Overhead per UG Stu on UGI Quality} + \text{Eff of Research on UGI Quality} + \text{Eff of UG Class Size on UGI Quality} + \text{Eff of Lab Facilities for UGI on UGI Quality}) / 4$ ~ dimensionless

Period UGF Spons Res Pap Pub = $\text{INTEG}(\text{Act FTE UGF for Spons Res} * \text{UGF Spons Res Pap Productivity})$ ~ papers/semester

Period UGF Un-sponsored Res Pap Pub = $\text{INTEG}(\text{Act FTE UGF for Un-sponsored Res} * \text{UGF Un-sponsored Res Pap Productivity})$
 ~ papers/semester

Period Un-sponsored Res Pap Pub = $\text{Period GF Un-sponsored Res Pap Pub} + \text{Period UGF Un-sponsored Res Pap Pub}$ ~ papers/semester

Spons Res Rec AT = 10 ~ semester

Spons Res Recog = $\text{INTEG}(\text{Cha in Spons Res Rec}, 0.6)$ ~ dimensionless

Total FTE for Spons Res = $\text{Act FTE GF for Spons Res} + \text{Act FTE UGF for Spons Res}$ ~ FTE

Total FTE for Un-sponsored Res = $\text{Act FTE GF for Un-sponsored Res} + \text{Act FTE UGF for Un-sponsored Res}$ ~ FTE

UGF Des Realized Res Pap Pub = $\text{Desired Ave Res Papers Pub} / \text{UGF Hist Ave Res Papers Pub}$ ~ dimensionless

UGF Hist Ave Res Papers Pub = $\text{UGF Hist Ave Un-sponsored Res Papers Pub} + \text{UGF Hist Ave Spons Res Papers Pub}$ ~ papers/semester

UGF Hist Ave Res Papers Pub per UGF = $\text{UGF Hist Ave Res Papers Pub} / \text{Number of UG Fac}$ ~ papers/(faculty*semester)

UGF Hist Ave Spons Res Papers Pub = $\text{INTEG}(\text{Cha in UGF H A Spons Pap Pub}, 12)$ ~ papers/semester

UGF Hist Ave Un-sponsored Res Papers Pub = $\text{INTEG}(\text{Cha in UGF H A Un-sponsored Pap Pub}, 10)$ ~ papers/semester

UGF Indicated Spons Res Comm = $(0.4 * \text{UGF Research Culture}) + (0.4 * (\text{ugf res com vs des rea res pap} / (\text{UGF Des Realized Res Pap Pub})))$
 $+ (0.2 * \text{Spons Res Recog})$ ~ dimensionless

UGF Indicated Un-sponsored Res Comm = $(0.4 * \text{UGF Research Culture}) + (0.4 * (\text{ugf res com vs des rea res pap} / (\text{UGF Des Realized Res Pap Pub}))) + (0.2 * \text{Un-sponsored Res Recog})$ ~ dimensionless

UGF Research Commitment = $(\text{UGF Un-sponsored Res Commitment} + \text{UGF Spons Res Commitment}) / 2$ ~ dimensionless

UGF Research Culture = 0.3 ~ dimensionless

UGF Spons Res Comm AT = 6 ~ semester

UGF Spons Res Commitment = $\text{INTEG}(\text{Cha in UGF Spons Res Comm}, 0.5)$ ~ dimensionless

UGF Spons Res Funds Grants Productivity = ((Eff of Lab Facilities for Spons Res + Eff of UGF Spons Res Comm) / 2) * 2000
 ~ dollars / (faculty * semester)

UGF Spons Res Pap AT = 6 ~ semester

UGF Spons Res Pap Productivity = ((Eff of Lab Facilities for Spons Res + Eff of UGF Spons Res Comm) / 2) * 2.5
 ~ papers / (faculty * semester)

UGF Teach Comm AT = 6 ~ semester

UGF Teaching Commitment = INTEG(Cha in UGF Teach Comm, 0.7) ~ dimensionless

UGF Teaching Culture = 0.85 ~ dimensionless

UGF Un-sponsored Res Comm AT = 6 ~ semester

UGF Un-sponsored Res Commitment = INTEG(Cha in UGF Un-sponsored Res Comm, 0.5) ~ dimensionless

UGF Un-sponsored Res Pap AT = 6 ~ semester

UGF Un-sponsored Res Pap Productivity = ((Eff of Lab Facilities for Spons Res + Eff of UGF Un-sponsored Res Comm) / 2) * 2.5
 ~ papers / (faculty * semester)

Un-sponsored Res Rec AT = 10 ~ semester

Un-sponsored Res Recog = INTEG(Cha in Un-sponsored Res Rec, 0.7) ~ dimensionless

 Graduate Faculty Projects Sector

Act FTE GF for IGP = Act FTE GF for Projects * (GF IGP Motivation / (GF IGP Motivation + GF UP Motivation)) ~ FTE

Act FTE GF for UP = Act FTE GF for Projects * (GF UP Motivation / (GF IGP Motivation + GF UP Motivation)) ~ FTE

Act FTE GF for Projects = Act FTE GF for Research and Projects
 * ((GF Financial Pressure / (GF Research Commitment + GF Financial Pressure)) * GF Project vs Research Orientation) ~ FTE

Act FTE UGF for IGP = Act FTE UGF for Projects * (UGF IGP Motivation / (UGF IGP Motivation + UGF UP Motivation)) ~ FTE

Act IGP Load per GF = (Act FTE GF for IGP / Number of Grad Fac) * Weekly Hours per Faculty ~ hours / (week * faculty)

Act UP Load per GF = (Act FTE GF for UP / Number of Grad Fac) * Weekly Hours per Faculty ~ hours / (week * faculty)

Average GF Salary AT = 2 ~ semester

Cha in Ave GF Salary = (GF Period Salary - Hist Average GF Salary) / Average GF Salary AT ~ dollars / (month * semester)

Cha in GF Financial Pressure = (GF Indicated Fin Press - GF Financial Pressure) / GF Fin Press AT ~ dimensionless / semester

Cha in GF IGP Mot = (Indicated GF IGP Mot - GF IGP Motivation) / GF IGP Mot AT ~ dimensionless / semester

Cha in GF UP Mot = (Indicated GF UP Mot - GF UP Motivation) / GF UP Mot AT ~ dimensionless / semester

Cha in IGP Attr for Admin = (Indicated IGP Attr for Admin - IGP Attractiveness for Administration) / IGP Attr for Admin AT
 ~ dimensionless / semester

Direct FTE GF for IGP = 0.25 * Act FTE GF for IGP ~ FTE

Eff of GF IGP Mot = eff of gf IGP mot vs gf IGP mot (GF IGP Motivation) ~ dimensionless

Eff of Income Ratio GF = gf UP IGP income ratio vs eff of it (IGP UP Income Ratio) ~ dimensionless

Eff of Lab Faci for IGP = eff of lab faci on IGP (Lab Facilities for IGP / Total FTE for IGP) ~ dimensionless

Eff of Mentality GF = gf IGP UP ment vs eff of it (IGP UP Mentality GF) ~ dimensionless

GF Act vs Exp Ratio of Salary = Hist Average GF Salary / GF Expected Salary ~ dimensionless

GF Expected Salary = 1200 ~ dollars / month

GF Fin Press AT = 6 ~ semester

GF Financial Pressure = INTEG(Cha in GF Financial Pressure, 0.8) ~ dimensionless

GF IGP Mot AT = 6 ~ semester

GF IGP Motivation = INTEG(Cha in GF IGP Mot,0.7) ~ dimensionless

GF IGP Productivity = ((Eff of GF IGP Mot-Eff of Lab Faci for IGP)/2)*8000 ~ dollars/(faculty*semester)

GF Indicated Fin Press =gf act exp rat salary vs ind fin press(GF Act vs Exp Ratio of Salary) ~ dimensionless

GF UP Mot AT = 6 ~ semester

GF UP Motivation = INTEG(Cha in GF UP Mot,0.5) ~ dimensionless

GF Period Salary = 450 ~ dollars/month

Gross Income Generated by IGP = (UGF IGP Productivity*Act FTE UGF for IGP)-(GF IGP Productivity*Act FTE GF for IGP)
~ dollars/semester

Hist Average GF Salary =INTEG(Cha in Ave GF Salary,450) ~ dollars/month

IGP Attr for Admin AT = 2 ~ semester

IGP Attractiveness for Administration = INTEG(Cha in IGP Attr for Admin,0.8) ~ dimensionless

IGP Income Level = 20 ~ dollars/hours

IGP UP Income Ratio =IGP Income Level/ UP Income Level ~ dimensionless

IGP UP Mentality GF = 0.7 ~ dimensionless

Income Share for GF on IGP = IGP Income Level*Direct FTE GF for IGP*Weekly Hours per Faculty *Weeks per Semester
~ dollars/semester

Income Share for UGF on IGP = IGP Income Level*Direct FTE UGF for IGP*Weekly Hours per Faculty*Weeks per Semester
~ dollars/semester

Indicated GF IGP Mot =(((SQRT((1-Eff of Income Ratio GF)*Eff of Mentality GF))))*0.9)-(IGP Attractiveness for Administration*0.1)
~ dimensionless

Indicated GF UP Mot =SQRT(Eff of Income Ratio GF*(1-Eff of Mentality GF)) ~ dimensionless

Indicated IGP Attr for Admin = IGP attr for adm vs funds FTE for IGP ratio
(Gross Income Generated by IGP/(Act FTE UGF for IGP+Act FTE GF for IGP)) ~ dimensionless

Lab Facilities for IGP = Lab Facilities*(Total FTE for IGP/Total FTE for Lab Facility Consuming Act) ~ lab units

Net Funds Grants Gotten by IGP = Gross Income Generated by IGP-(Income Share for UGF on IGP+Income Share for GF on IGP)
~ dollars/semester

Number of Grad Fac = INTEG(New Grad Faculty-GF that Leave,155) ~ faculty

UP Income Level =40 ~ dollars/hours

Total FTE for IGP = Act FTE GF for IGP+Act FTE UGF for IGP ~ FTE

UGF IGP Productivity = ((Eff of UGF IGP Mot-Eff of Lab Faci for IGP)/2)*8000 ~ dollars/(faculty*semester)

Weekly Hours per Faculty = 40 ~ hours/(week*FTE)

Weeks per Semester = 23 ~ weeks/semester

Under-graduate Faculty Projects Sector

Act FTE GF for IGP = Act FTE GF for Projects*(GF IGP Motivation/(GF IGP Motivation+GF UP Motivation)) ~ FTE

Act FTE UGF for IGP = Act FTE UGF for Projects*(UGF IGP Motivation/(UGF IGP Motivation+UGF UP Motivation)) ~ FTE

Act FTE UGF for UP = Act FTE UGF for Projects*(UGF UP Motivation/(UGF IGP Motivation+UGF UP Motivation)) ~ FTE

Act FTE UGF for Projects = Act FTE UGF for Research and Projects
*((UGF Financial Pressure/(UGF Research Commitment+UGF Financial Pressure))*UGF Project vs Research Orientation) ~ FTE

Act IGP Load per UGF = (Act FTE UGF for IGP/Number of UG Fac)*Weekly Hours per Faculty ~ hours/(week*faculty)

Act UP Load per UGF = (Act FTE UGF for UP/Number of UG Fac)*Weekly Hours per Faculty ~ hours/(week*faculty)

Average UGF Salary AT = 2 ~ semester

Cha in Ave UGF Salary = (UGF Period Salary-Hist Average UGF Salary)/Average UGF Salary AT ~ dollars (month*semester)

Cha in IGP Attr for Admin =(Indicated IGP Attr for Admin-IGP Attractiveness for Administration) IGP Attr for Admin AT
~ dimensionless/semester

Cha in UGF Financial Pressure = (UGF Indicated Fin Press-UGF Financial Pressure) UGF Fin Press AT ~ dimensionless/semester

Cha in UGF IGP Mot = (Indicated UGF IGP Mot-UGF IGP Motivation)/UGF IGP Mot AT ~ dimensionless/semester

Cha in UGF UP Mot = (Indicated UGF UP Mot-UGF UP Motivation)/UGF UP Mot AT ~ dimensionless/semester

Direct FTE UGF for IGP = 0.25*Act FTE UGF for IGP ~ FTE

Eff of Income Ratio UGF = ugf UP IGP income ratio vd eff of it(IGP UP Income Ratio) ~ dimensionless

Eff of Lab Faci for IGP = eff of lab faci on IGP(Lab Facilities for IGP/Total FTE for IGP) ~ dimensionless

Eff of Mentality UGF = ugf IGP UP ment vs eff of it(IGP UP Mentality UGF) ~ dimensionless

Eff of UGF IGP Mot = eff of ugf IGP mot vs ugf IGP mot(UGF IGP Motivation) ~ dimensionless

GF IGP Productivity = ((Eff of GF IGP Mot+Eff of Lab Faci for IGP)/2)*8000 ~ dollars/(faculty*semester)

Gross Income Generated by IGP = (UGF IGP Productivity*Act FTE UGF for IGP)+(GF IGP Productivity*Act FTE GF for IGP)
~ dollars/semester

Hist Average UGF Salary =INTEG(Cha in Ave UGF Salary,450) ~ dollars/month

IGP Attr for Admin AT = 2 ~ semester

IGP Attractiveness for Administration = INTEG(Cha in IGP Attr for Admin,0.8) ~ dimensionless

IGP Income Level = 20 ~ dollars/hours

IGP UP Income Ratio =IGP Income Level/ UP Income Level ~ dimensionless

IGP UP Mentality UGF= 0.7 ~ dimensionless

Income Share for GF on IGP = IGP Income Level*Direct FTE GF for IGP*Weekly Hours per Faculty *Weeks per Semester
~ dollars/semester

Income Share for UGF on IGP = IGP Income Level*Direct FTE UGF for IGP*Weekly Hours per Faculty*Weeks per Semester
~ dollars/semester

Indicated IGP Attr for Admin = IGP attr for adm vs funds FTE for IGP ratio
(Gross Income Generated by IGP/(Act FTE UGF for IGP+Act FTE GF for IGP)) ~ dimensionless

Indicated UGF IGP Mot =(((SQRT((1-Eff of Income Ratio UGF)*Eff of Mentality UGF)))*0.9)+(IGP Attractiveness for
Administration*0.1)
~ dimensionless

Indicated UGF UP Mot =SQRT(Eff of Income Ratio UGF*(1-Eff of Mentality UGF)) ~ dimensionless

Lab Facilities for IGP = Lab Facilities*(Total FTE for IGP/Total FTE for Lab Facility Consuming Act) ~ lab units

Net Funds Grants Gotten by IGP = Gross Income Generated by IGP-(Income Share for UGF on IGP+Income Share for GF on IGP)
~ dollars/semester

Net IGP Productivity per Fac = Net Funds Grants Gotten by IGP/Number of Faculty ~ dollars/(faculty*semester)

Number of Faculty = Number of Grad Fac+Number of UG Fac ~ faculty

Number of UG Fac = INTEG(New UG Faculty-UGF that Leave,90) ~ faculty

UP Income Level =40 ~ dollars/hours

Total FTE for IGP = Act FTE GF for IGP+Act FTE UGF for IGP ~ FTE

UGF Act vs Exp Ratio of Salary =Hist Average UGF Salary/UGF Expected Salary ~ dimensionless

UGF Expected Salary = 1200 ~ dollars/month

UGF Fin Press AT = 6 ~ semester

UGF Financial Pressure = INTEG(Cha in UGF Financial Pressure,0.8) ~ dimensionless

UGF IGP Mot AT = 6 ~ semester

UGF IGP Motivation = INTEG(Cha in UGF IGP Mot,0.7) ~ dimensionless

UGF IGP Productivity = ((Eff of UGF IGP Mot+Eff of Lab Faci for IGP)/2)*8000 ~ dollars/(faculty*semester)

UGF Indicated Fin Press = ugf act exp rat salary vs ind fin press(UGF Act vs Exp Ratio of Salary) ~ dimensionless

UGF UP Mot AT = 6 ~ semester

UGF UP Motivation = INTEG(Cha in UGF UP Mot,0.5) ~ dimensionless

UGF Period Salary = 450 ~ dollars/month

UGF Project vs Research Orientation = 0.8 ~ dimensionless

Weeks per Semester = 23 ~ weeks/semester

 Laboratory Facilities Sector

Act FTE GF For Grad Instr = MIN(Total FTE Needed for Grad Instr
 ,(Operating Total FTE Grad Faculty for Instr+Additional FTE GF for Grad Inst)) ~ FTE

Act FTE GF for IGP = Act FTE GF for Projects*(GF IGP Motivation/(GF IGP Motivation+GF UP Motivation)) ~ FTE

Act FTE GF for Spons Res = Act FTE GF for Research*(GF Spons Res Commitment/(GF Research Commitment*2)) ~ FTE

Act FTE GF for UG Instr = Implied FTE Grad Faculty for UG Instr-Surplus FTE Grad Fac+Additional FTE GF for UG Inst ~ FTE

Act FTE GF for Un-sponsored Res = Act FTE GF for Research*(GF Un-sponsored Res Commitment/(GF Research Commitment*2)) ~ FTE

Act FTE UGF for IGP = Act FTE UGF for Projects*(UGF IGP Motivation/(UGF IGP Motivation+UGF UP Motivation)) ~ FTE

Act FTE UGF for Spons Res = Act FTE UGF for Research*(UGF Spons Res Commitment/(UGF Research Commitment*2)) ~ FTE

Act FTE UGF for UG Instr = Operating Total FTE UG Faculty for Instr-Surplus FTE UG Fac+Additional FTE UGF for UG Inst ~ FTE

Act FTE UGF for Un-sponsored Res = Act FTE UGF for Research*(UGF Un-sponsored Res Commitment/(UGF Research Commitment*2)) ~ FTE

Funds Grants Gotten by Spons Res = (Act FTE GF for Spons Res*GF Spons Res Funds Grants Productivity)
 +(Act FTE UGF for Spons Res*UGF Spons Res Funds Grants Productivity) ~ dollars/semester

IGP Funds Lab Facility Invest Ratio = 0.4 ~ dimensionless

Lab Facilities = INTEG(Net Change in Lab Facilities,400) ~ lab units

Lab Facilities Depr Coef = 0.02 ~ dimensionless/semester

Lab Facilities for Grad Instr = Lab Facilities*(Total FTE for Grad Instr/Total FTE for Lab Facility Consuming Act) ~ lab units

Lab Facilities for IGP = Lab Facilities*(Total FTE for IGP/Total FTE for Lab Facility Consuming Act) ~ lab units

Lab Facilities for Spons Res = Lab Facilities*(Total FTE for Spons Res/Total FTE for Lab Facility Consuming Act) ~ lab units

Lab Facilities for UG Instr = Lab Facilities*(Total FTE for UG Instr/Total FTE for Lab Facility Consuming Act) ~ lab units

Lab Facilities for Un-sponsored Res = Lab Facilities*(Total FTE for Un-sponsored Res/Total FTE for Lab Facility Consuming Act)
 ~ lab units

Lab Facility Invest Ratio = 0.0005 ~ lab units/dollars
 Net Change in Lab Facilities = New Lab Facilities
 -(Lab Facilities*Lab Facilities Depr Coef) ~ lab units/semester

Net Funds Grants Gotten by IGP = Gross Income Generated by IGP-(Income Share for UGF on IGP+Income Share for GF on IGP)
 ~ dollars/semester

New Lab Facilities = Lab Facility Invest Ratio*(Net Funds Grants Gotten by IGP*IGP Funds Lab Facility Invest Ratio)
 +(Funds Grants Gotten by Spons Res*Spons Res Funds Lab Facility Invest Ratio)-(New Lab Facility Invest by Gov) ~ lab units semester

New Lab Facility Invest by Gov = 80000 ~ dollars/semester

Part Time FTE for Grad Instr = MAX(0, MIN(Extra FTE Need for Grad Inst, Operating Total FTE Grad Faculty for Instr *Max Part Time Percentage for Grad Instr)) ~ FTE

Part Time FTE for UG Instr = MAX(0, MIN(Extra FTE Need for UG Inst, Implied Total FTE for UG Instr *Max Part Time Percentage for UG Instr)) ~ FTE

Spons Res Funds Lab Facility Invest Ratio = 0.4 ~ dimensionless

Total FTE for Grad Instr = Act FTE GF For Grad Instr + Part Time FTE for Grad Instr ~ FTE

Total FTE for IGP = Act FTE GF for IGP + Act FTE UGF for IGP ~ FTE

Total FTE for Lab Facility Consuming Act = Total FTE for Grad Instr + Total FTE for UG Instr - Total FTE for Un-sponsored Res + Total FTE for Spons Res + Total FTE for IGP ~ FTE

Total FTE for Spons Res = Act FTE GF for Spons Res + Act FTE UGF for Spons Res ~ FTE

Total FTE for UG Instr = Act FTE GF for UG Instr + Act FTE UGF for UG Instr + Part Time FTE for UG Instr ~ FTE

Total FTE for Un-sponsored Res = Act FTE GF for Un-sponsored Res + Act FTE UGF for Un-sponsored Res ~ FTE

 .Assistants Sector

Assistant Positions = (Number of Grad Fac + Number of UG Fac + Vacant Faculty Positions) * Faculty Assistant Positions Ratio ~ assistants

Assistants Grad Students Ratio = 0.25 ~ assistants/students

Faculty Assistant Positions Ratio = 1 ~ assistants/faculty

FTE Asistants for Instr Overhead = (Number of Assistants * Weekly Hours per Assist * Instr Overhead Load Ratio for Assist) / Weekly Hours per Faculty ~ FTE

FTE Assist for Grad Instr Overhead = MIN((Total Normal FTE for Grad Instr Overhead * Max G Instr OH Delegation to Assist Percentage) / ((FTE Assistants for Instr Overhead * Total Normal FTE for Grad Instr Overhead) / (Total Normal FTE for Grad Instr Overhead + Total Normal FTE for UG Instr Overhead))) ~ FTE

FTE Assist for UG Instr Overhead = MIN((Total Normal FTE for UG Instr Overhead * Max UG Instr OH Delegation to Assist Percentage) / ((FTE Assistants for Instr Overhead + Total Normal FTE for UG Instr Overhead) / (Total Normal FTE for Grad Instr Overhead + Total Normal FTE for UG Instr Overhead))) ~ FTE

Indicated FTE GF for G Instr Overhead = Normal FTE GF for G Instr Overhead - FTE Assist for Grad Instr Overhead ~ FTE

Indicated FTE GF for UG Instr Overhead = Normal FTE GF for UG Instr Overhead - ((FTE Assist for UG Instr Overhead * Normal FTE GF for UG Instr Overhead) / Total Normal FTE for UG Instr Overhead) ~ FTE

Indicated FTE UGF for UG Instr Overhead = Normal FTE UGF for UG Instr Overhead - ((FTE Assist for UG Instr Overhead * Normal FTE UGF for UG Instr Overhead) / Total Normal FTE for UG Instr Overhead) ~ FTE

Instr Overhead Load Ratio for Assist = 0.5 ~ dimensionless

Max G Instr OH Delegation to Assist Percentage = 0.3 ~ dimensionless

Max UG Instr OH Delegation to Assist Percentage = 0.4 ~ dimensionless

Normal FTE GF for G Instr Overhead = Normal Overhead Ratio for Grad Instr * Act FTE GF For Grad Instr ~ FTE

Normal FTE GF for UG Instr Overhead = Normal Overhead Ratio for UG Instr * Act FTE GF for UG Instr ~ FTE

Normal FTE UGF for UG Instr Overhead = Normal Overhead Ratio for UG Instr * Act FTE UGF for UG Instr ~ FTE

Number of Assistants = MIN(Assistant Positions, (Assistants Grad Students Ratio * Number of Grad Students)) ~ assistants

Number of Grad Fac = INTEG(New Grad Faculty - GF that Leave, 155) ~ faculty

Number of Grad Students = Number of Grad Students 1 + Number of Grad Students 2 ~ students

Number of UG Fac = INTEG(New UG Faculty - UGF that Leave, 90) ~ faculty

Total Normal FTE for Grad Instr Overhead = Normal FTE GF for G Instr Overhead ~ FTE

Total Normal FTE for UG Instr Overhead = Normal FTE GF for UG Instr Overhead + Normal FTE UGF for UG Instr Overhead ~ FTE

Vacant Faculty Positions = INTEG(GF that Leave+New Faculty Positions-New Grad Faculty-New UG Faculty-UGF that Leave,135)
~ faculty

Weekly Hours per Assist = 20 ~ hours/(week*assistants)

Weekly Hours per Faculty = 40 ~ hours/(week*FTE)

APPENDIX B

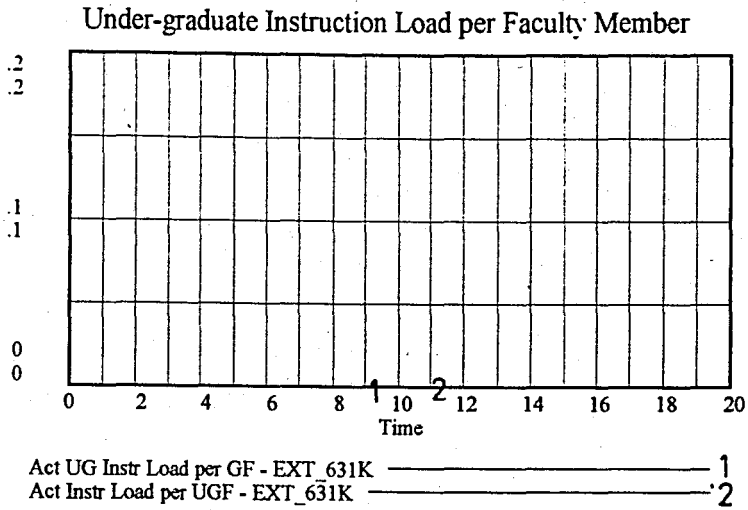


FIGURE B.1.1.1. The Behaviors of UG Instruction Loads in Case of No UG Students

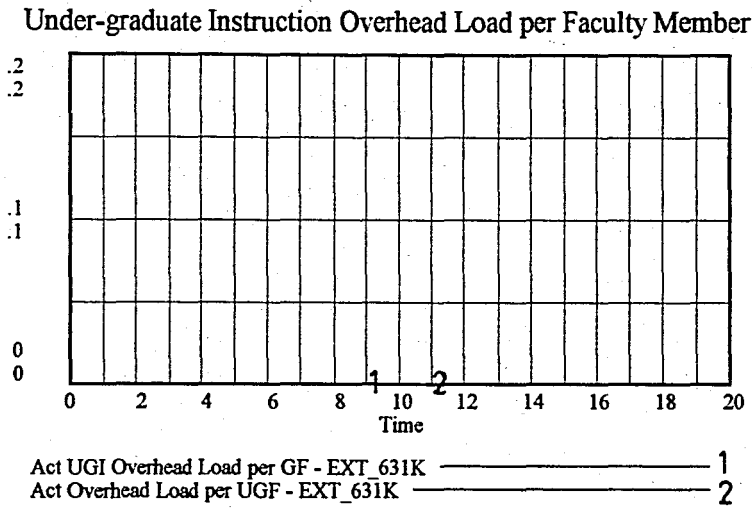


FIGURE B.1.1.2. The Behaviors of UGI Overhead Loads in Case of No UG Students

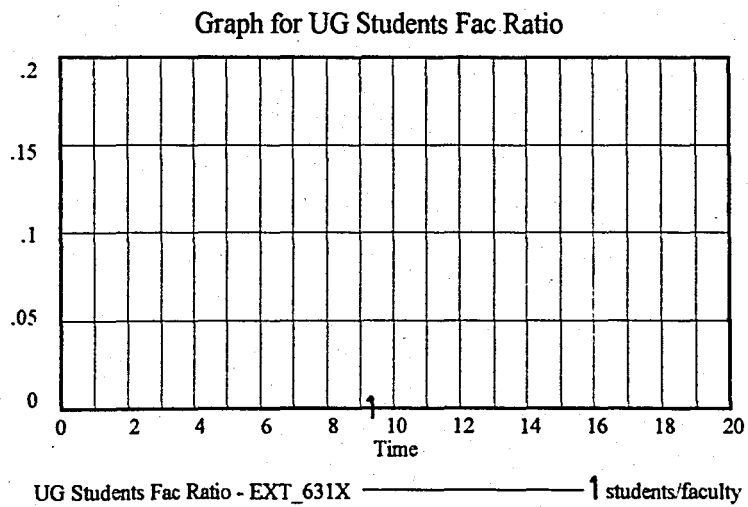


FIGURE B.1.1.3. The Behavior of UG Student / Faculty Ratio in case of Case of No UG Students

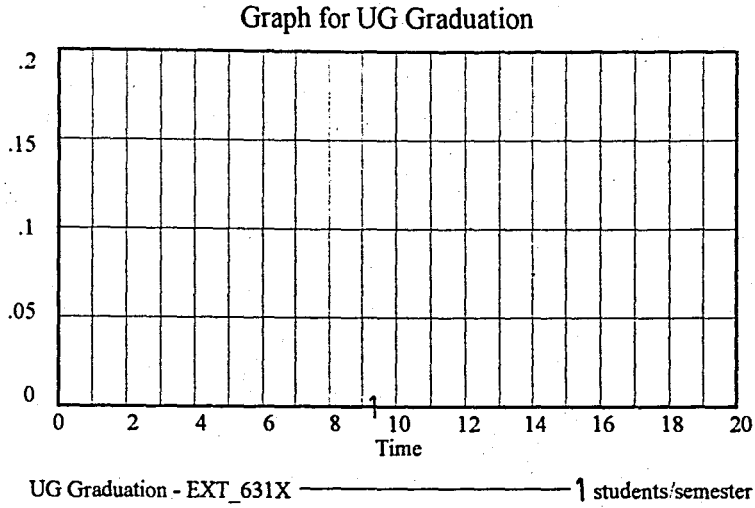


FIGURE B.1.1.4. The Behavior of UG Graduation in Case of No UG Students

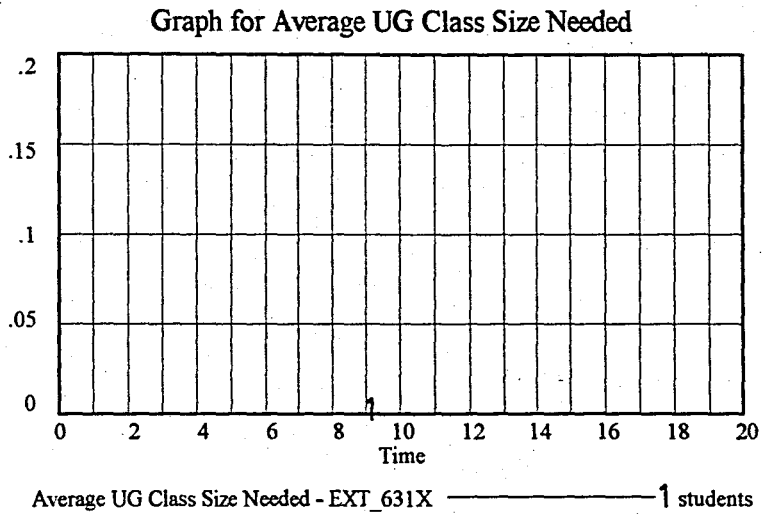


FIGURE B.1.1.5. The Behavior of Average UG Class Size Needed in Case of No UG Students

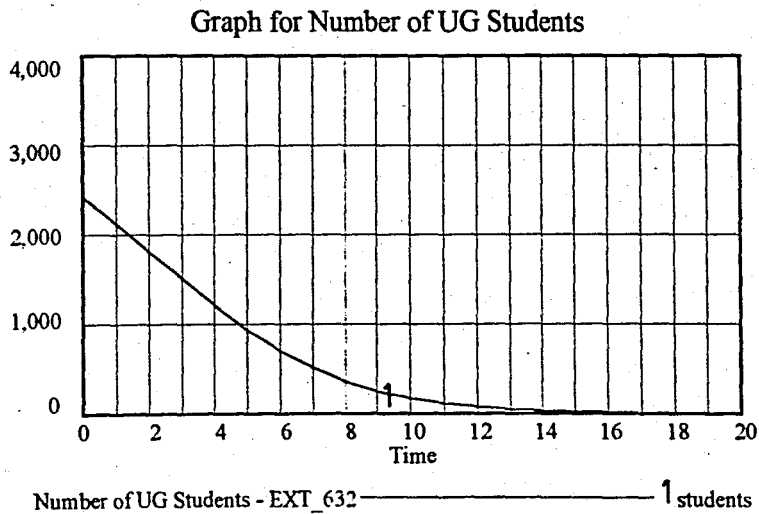


FIGURE B.1.2.1. The Behavior of Number of UG Students in Case of No UG Admission

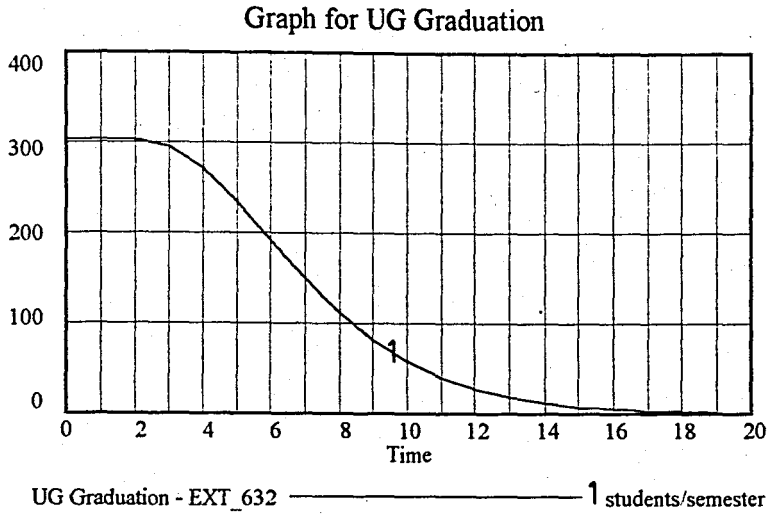


FIGURE B.1.2.2. The Behavior of UG Graduation in Case of No UG Admission

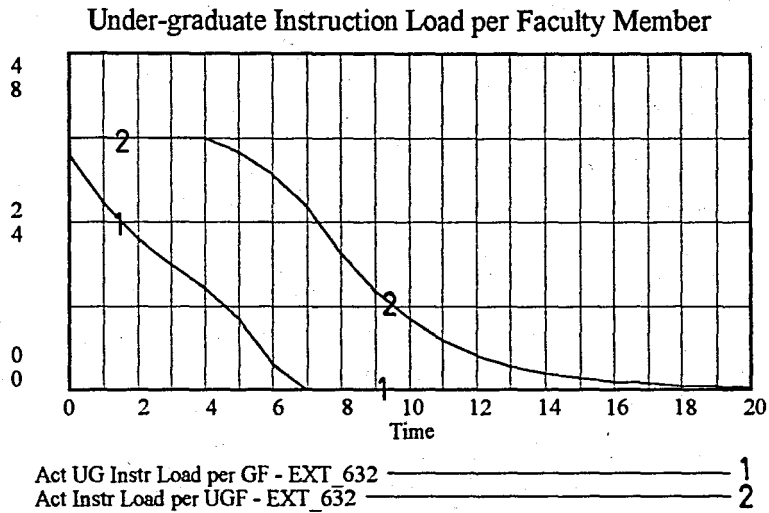


FIGURE B.1.2.3. The Behavior of UG Instruction Loads in Case of No UG Admission

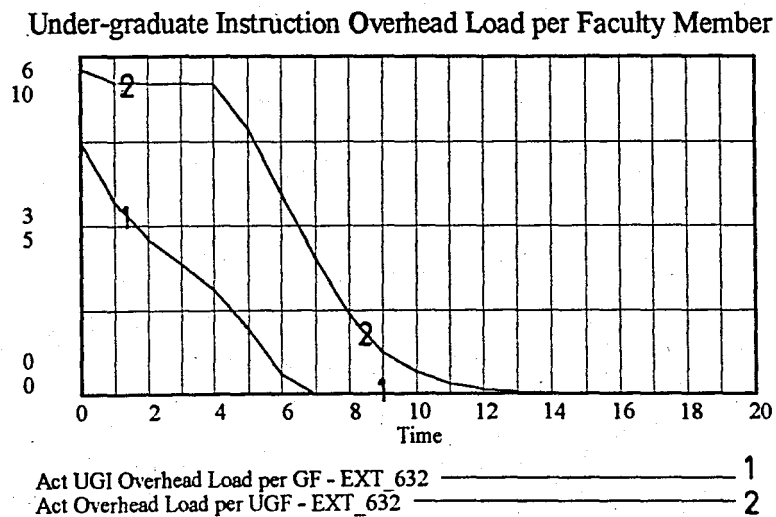


FIGURE B.1.2.4. The Behavior of UGI Overhead Loads in Case of No UG Admission

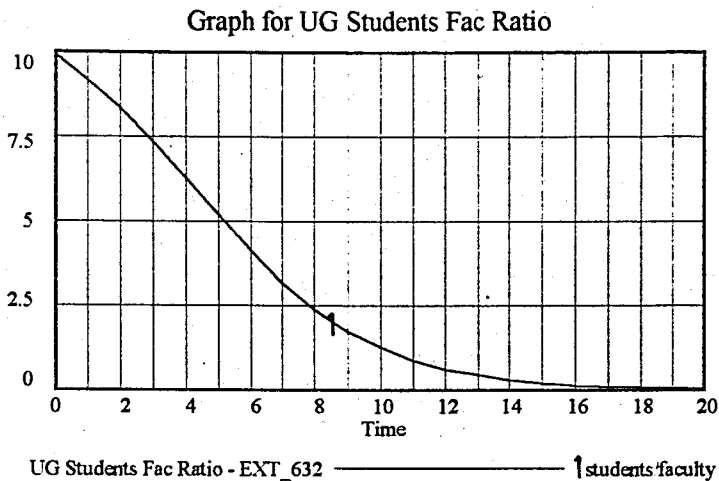


FIGURE B.1.2.5. The Behavior of UG Student / Faculty Ratio in Case of No UG Admission

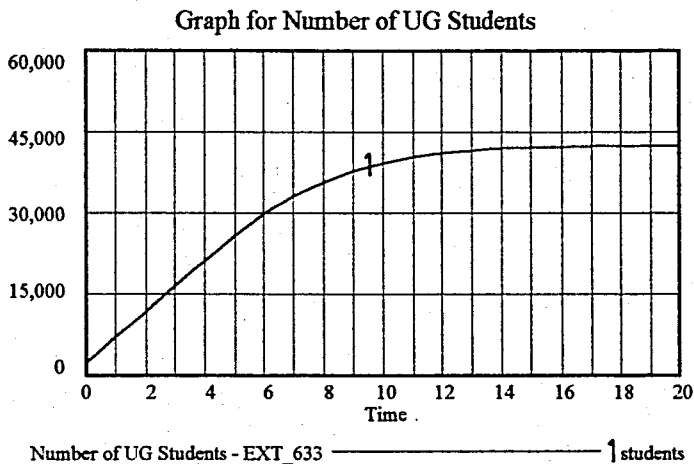


FIGURE B.1.3.1. The Behavior of Number of UG Students in Case of Extremely High Under-graduate Admission (10,000/year)

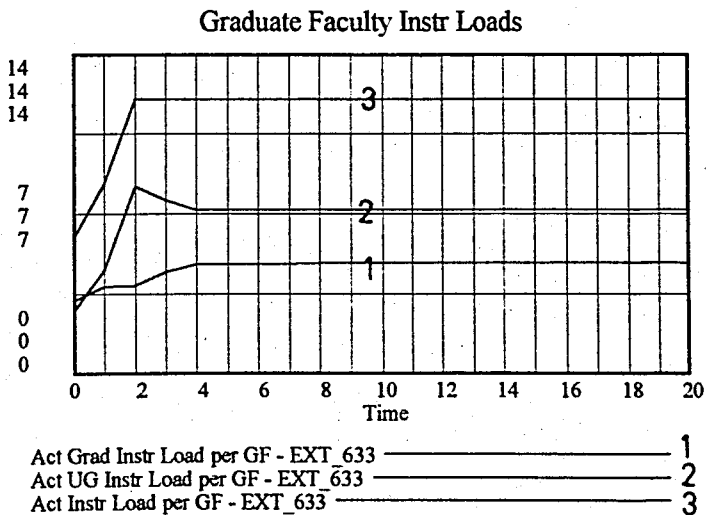


FIGURE B.1.3.2. The Behavior of Instruction Loads per Graduate Faculty in Case of Extremely High Under-graduate Admission (10,000/year)

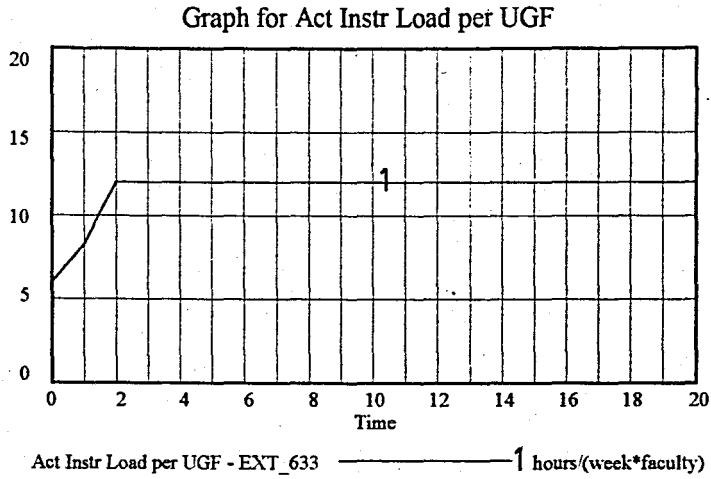


FIGURE B.1.3.3. The Behavior of UG Instruction Load per UG Faculty in Case of Extremely High Under-graduate Admission (10,000/year)

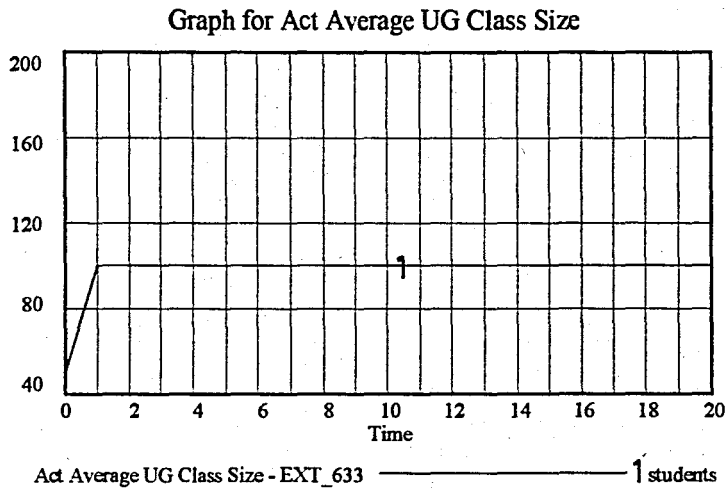


FIGURE B.1.3.4. The Behavior of Average UG Class Size in Case of Extremely High Under-graduate Admission (10,000/year)

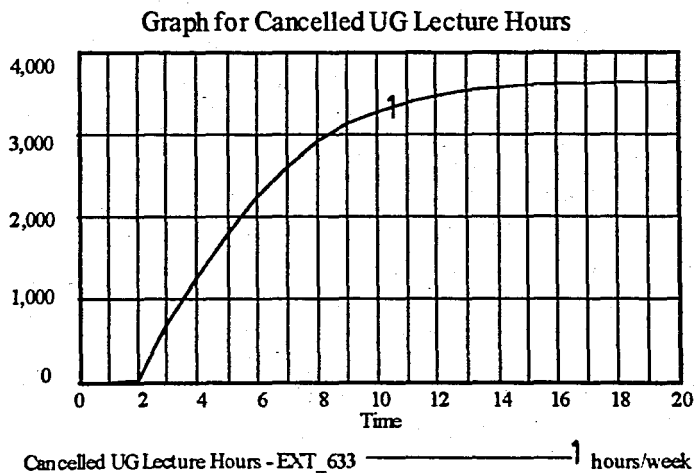


FIGURE B.1.3.5. The Behavior of Canceled UG Lecture Hours in Case of Extremely High Under-graduate Admission (10,000/year)

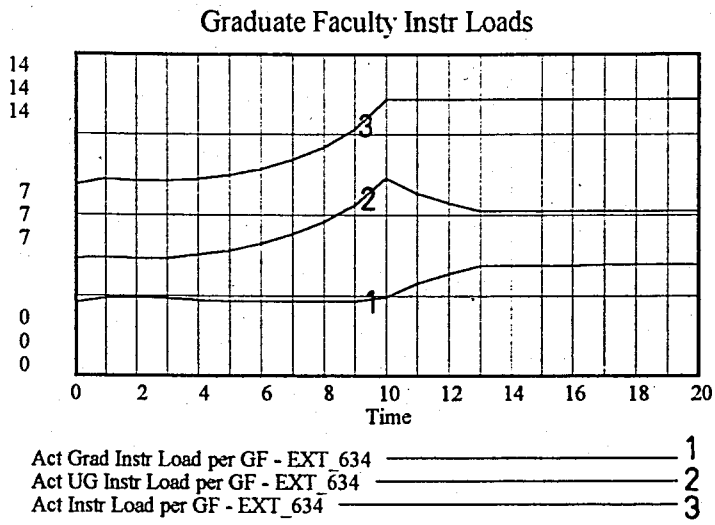


FIGURE B.1.4.1. The Behavior of GF Instruction Loads in Case of No Under-graduate Faculty

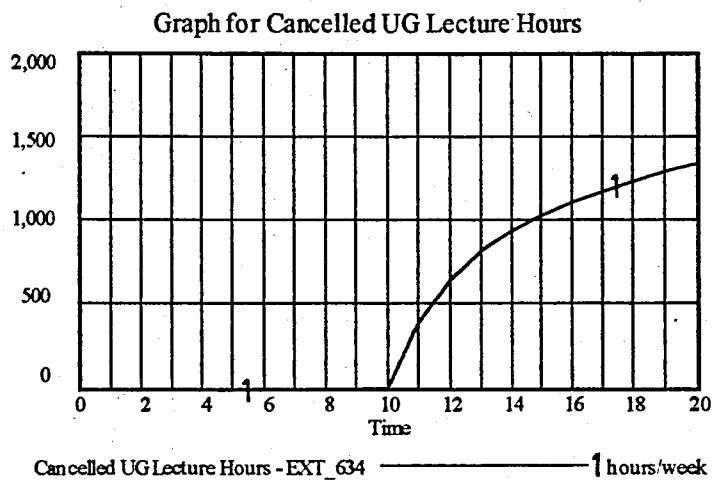


FIGURE B.1.4.2. The Behavior of Canceled UG Lecture Hours in Case of No Under-graduate Faculty

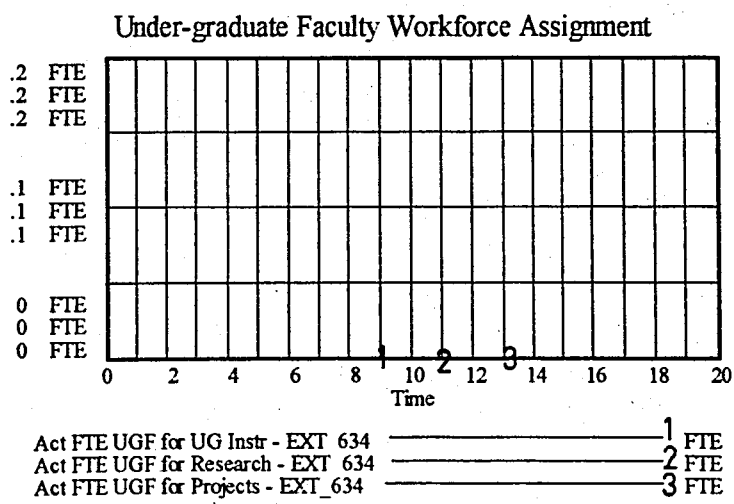


FIGURE B.1.4.3. The Behavior of UGF Loads in Case of No Under-graduate Faculty

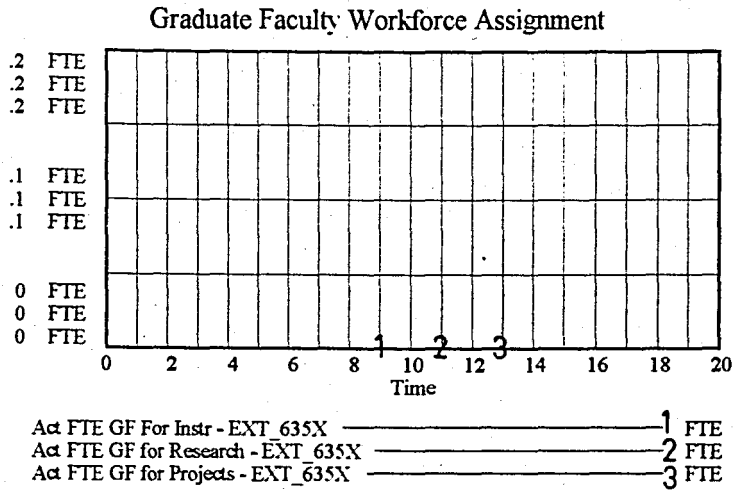


FIGURE B.1.5.1. The Behavior of Graduate Faculty Loads in Case of No Faculty

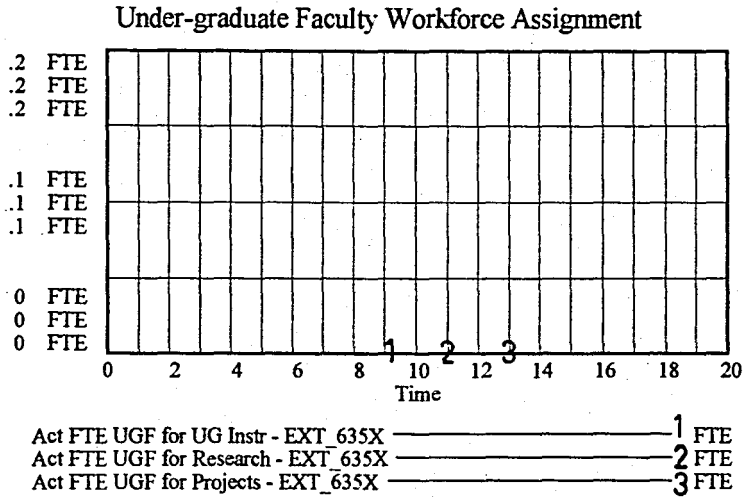


FIGURE B.1.5.2. The Behavior of Under-graduate Faculty Loads in Case of No Faculty

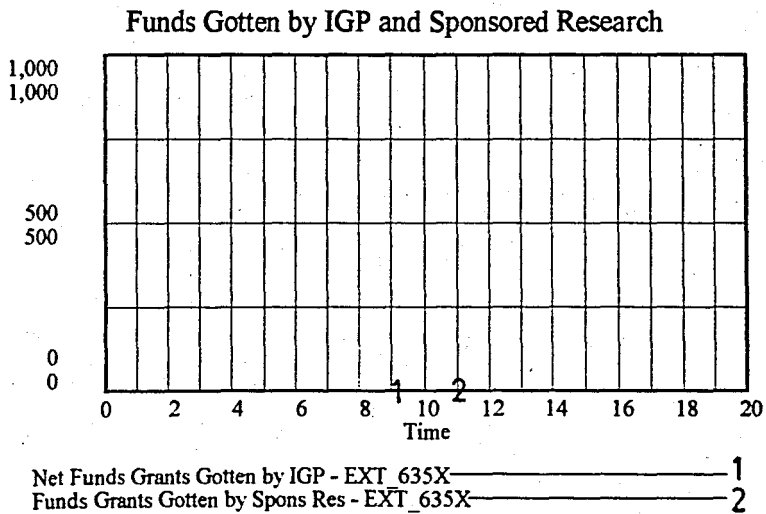


FIGURE B.1.5.3. The Behavior of Funds Gotten from IGP and Sponsored Research in Case of No Faculty

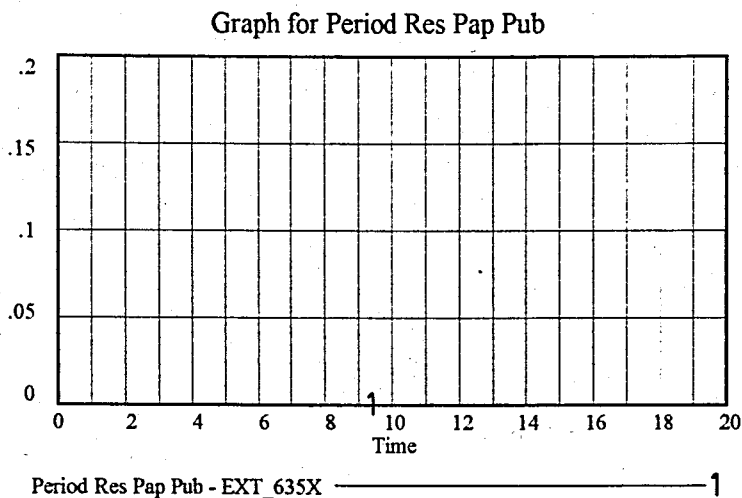


FIGURE B.1.5.4. The Behavior of Period Research Papers Published in Case of No Faculty

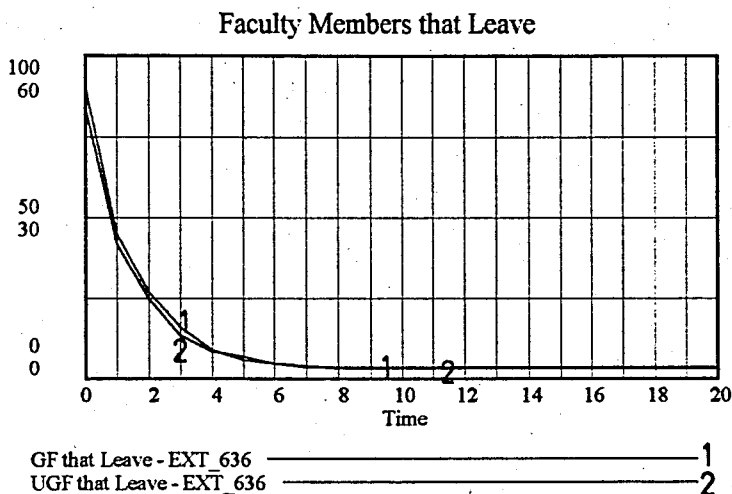


FIGURE B.1.6.1. The Behavior of Faculty Members that Leave in Case of Extremely Low Salary (\$50/m.)

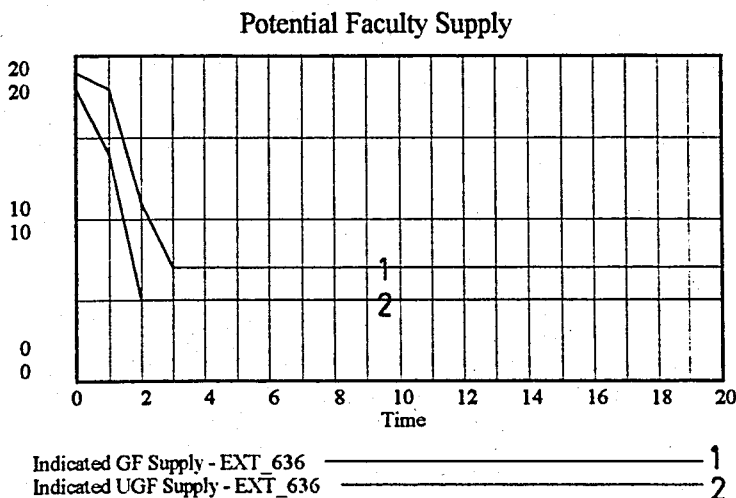


FIGURE B.1.6.2. The Behavior of Faculty Supply in Case of Extremely Low Salary (\$50/m.)

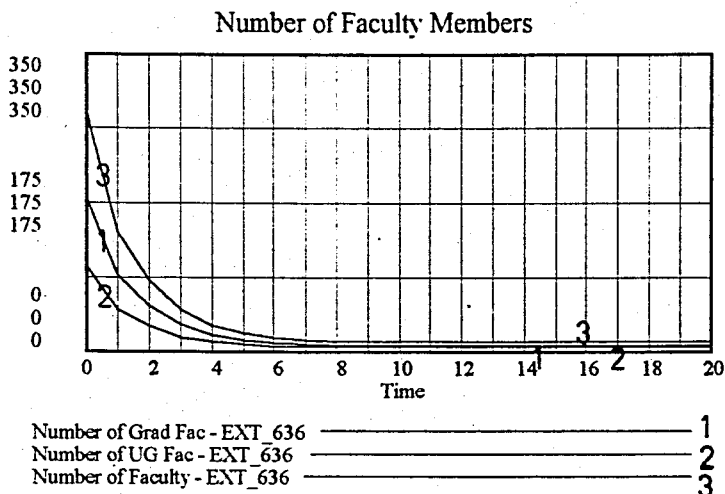


FIGURE B.1.6.3. The Behavior of Number of Faculty in Case of Extremely Low Salary (\$50/m.)

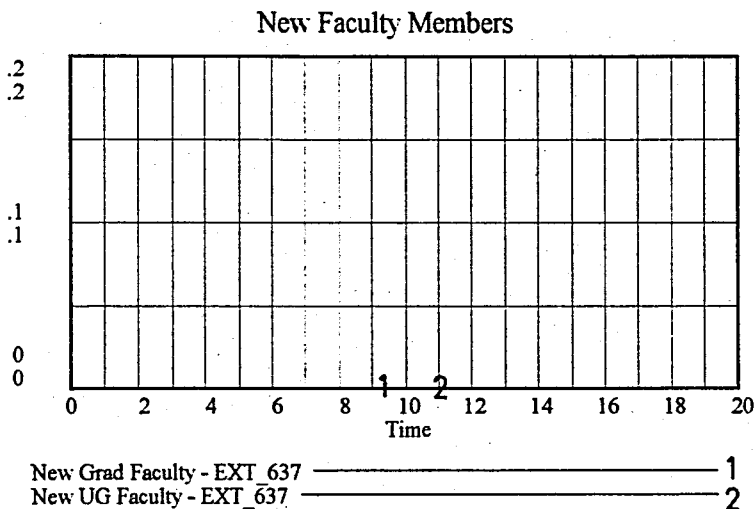


FIGURE B.1.7.1. The Behavior of New Faculty Members in Case of Zero Faculty Supply

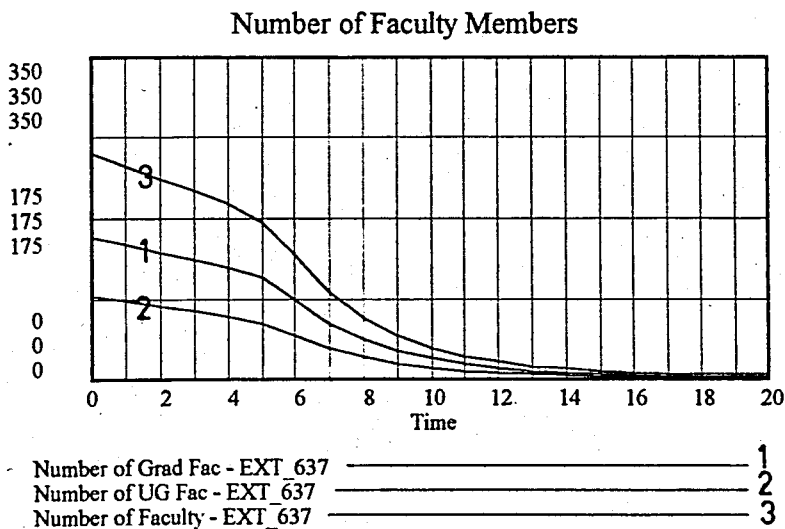


FIGURE B.1.7.2. The Behavior of Number of Faculty in Case of Zero Faculty Supply

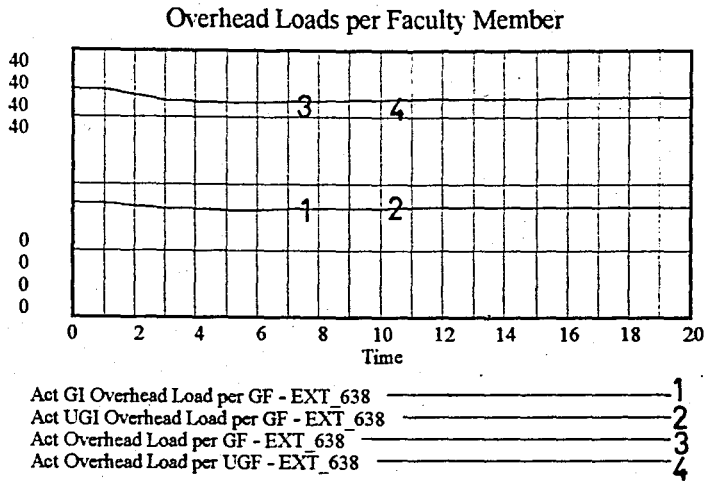


FIGURE B.1.8.1. The Behavior of Instruction Overhead Loads in Case of Extremely High Instruction Overhead Ratio(10 times the base value)

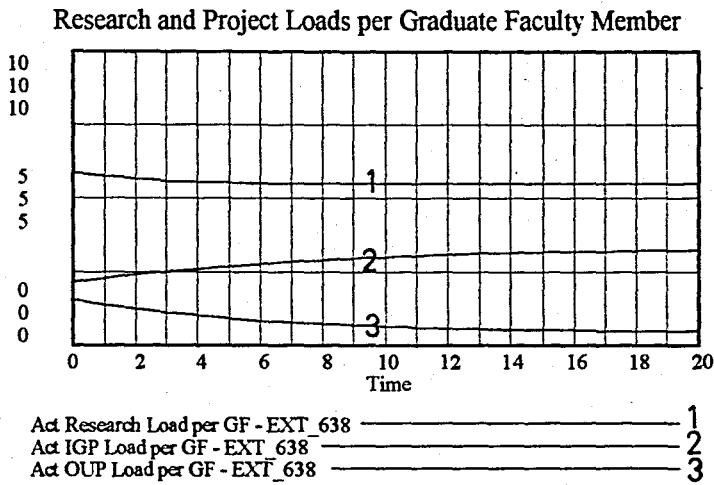


FIGURE B.1.8.2. The Behavior of GF Research and Project Loads in Case of Extremely High Instruction Overhead Ratio(10 times the base value)

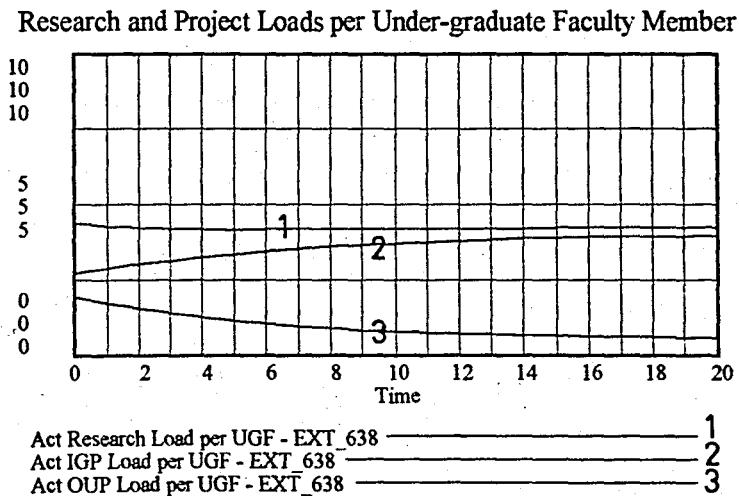


FIGURE B.1.8.3. The Behavior of UGF Research and Project Loads in Case of Extremely High Instruction Overhead Ratio (10 times the base value)

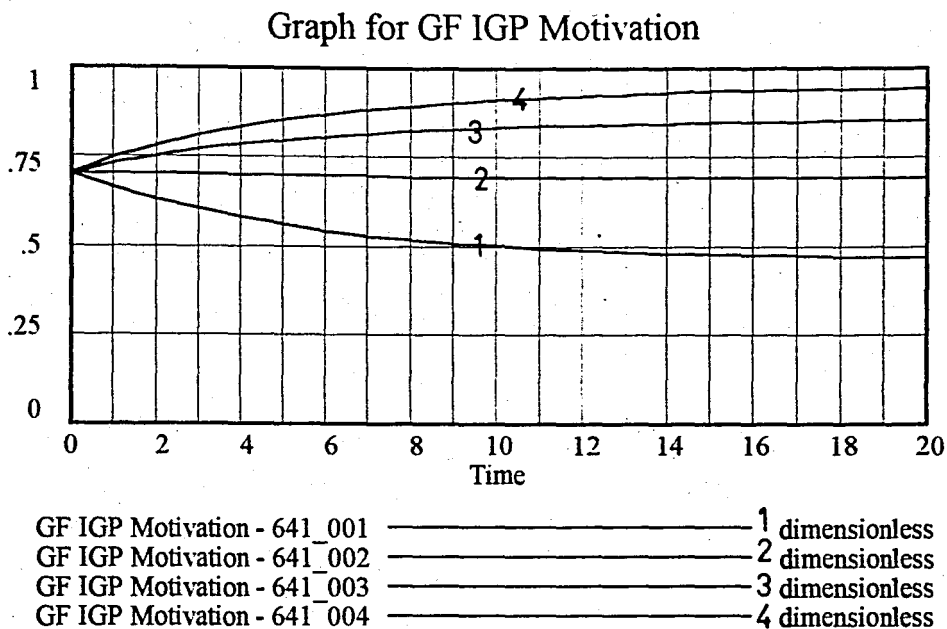


FIGURE B.2.1.1. The Behavior of GF IGP Motivation for Different Values of GF IGP UP Mentality; (decreased to 0.2 in run 001, to 0.5 in run 002 and increased to 0.8 in run 003, 1.0 in run 004 from 0.7 in the base run.)

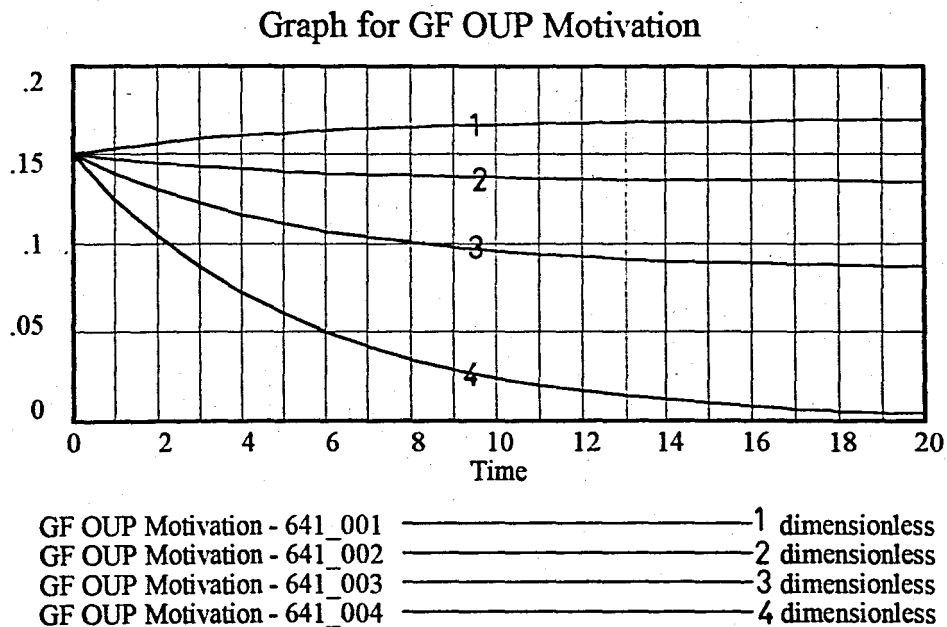


FIGURE B.2.1.2. The Behavior of GF UP Motivation for Different Values of GF IGP UP Mentality; (decreased to 0.2 in run 001, to 0.5 in run 002 and increased to 0.8 in run 003, 1.0 in run 004 from 0.7 in the base run.)

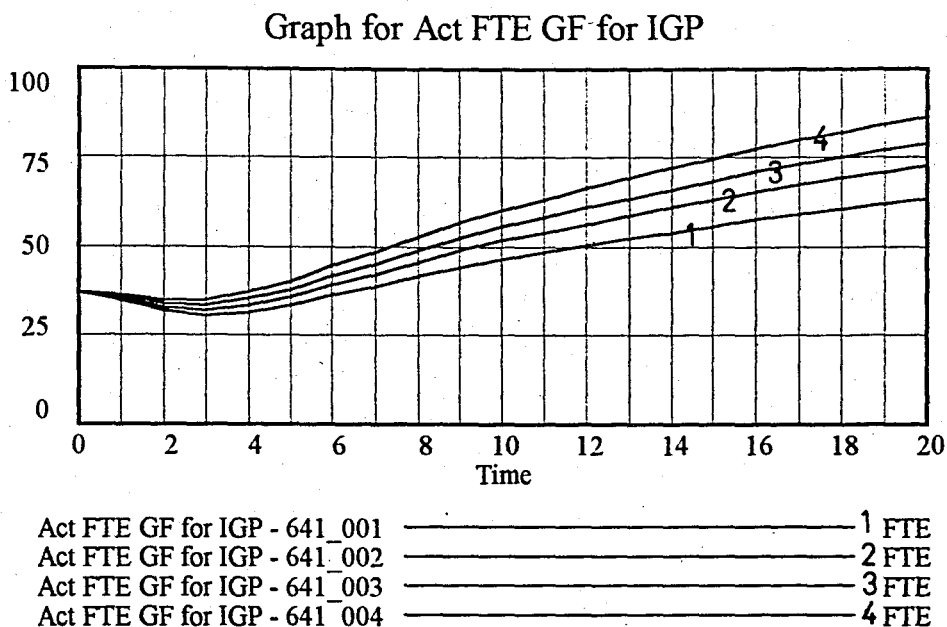


FIGURE B.2.1.3. The Behavior of Actual FTE GF for IGP for Different Values of GF IGP UP Mentality; (decreased to 0.2 in run 001, to 0.5 in run 002 and increased to 0.8 in run 003, 1.0 in run 004 from 0.7 in the base run.)

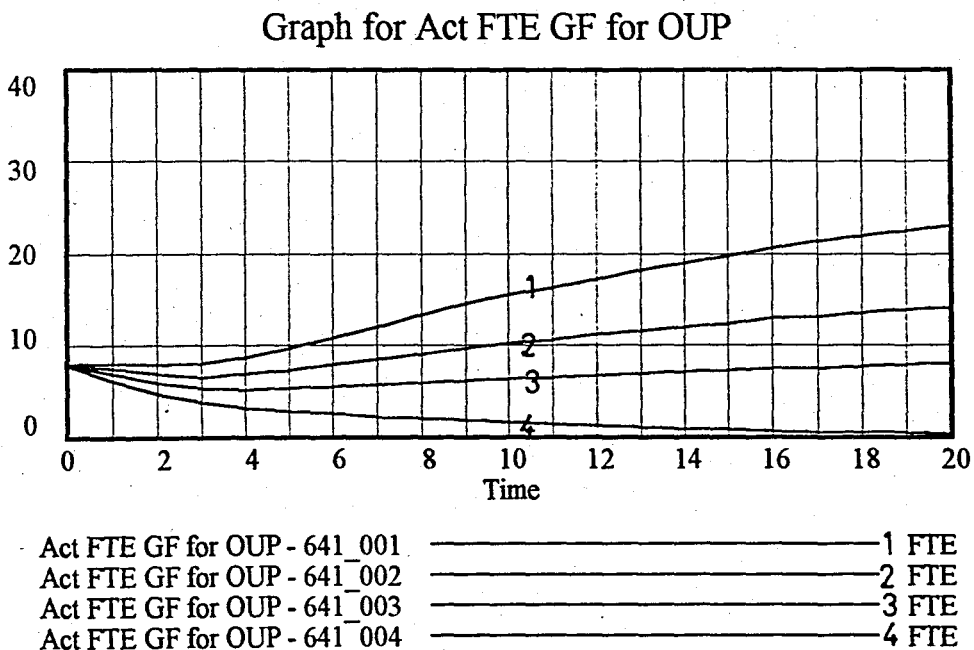


FIGURE B.2.1.4. The Behavior of Actual FTE GF for UP for Different Values of GF IGP UP Mentality; (decreased to 0.2 in run 001, to 0.5 in run 002 and increased to 0.8 in run 003, 1.0 in run 004 from 0.7 in the base run.)

Graph for Total FTE Needed for Grad Instr

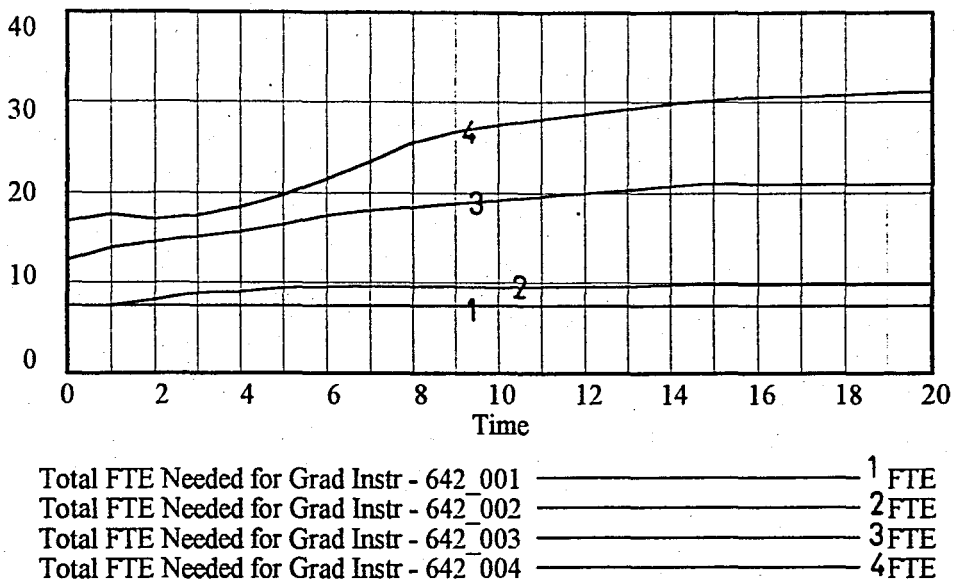


FIGURE B.2.2.1. The Behavior of Total FTE Needed for Grad Instruction for Different Values of Average Hours per Graduate Student; (decreased to 3 in run 001, to 7 in run 002 and increased to 20 in run 004 from 15 in the base run and run 003.)

Graph for Act Grad Instr Load per GF

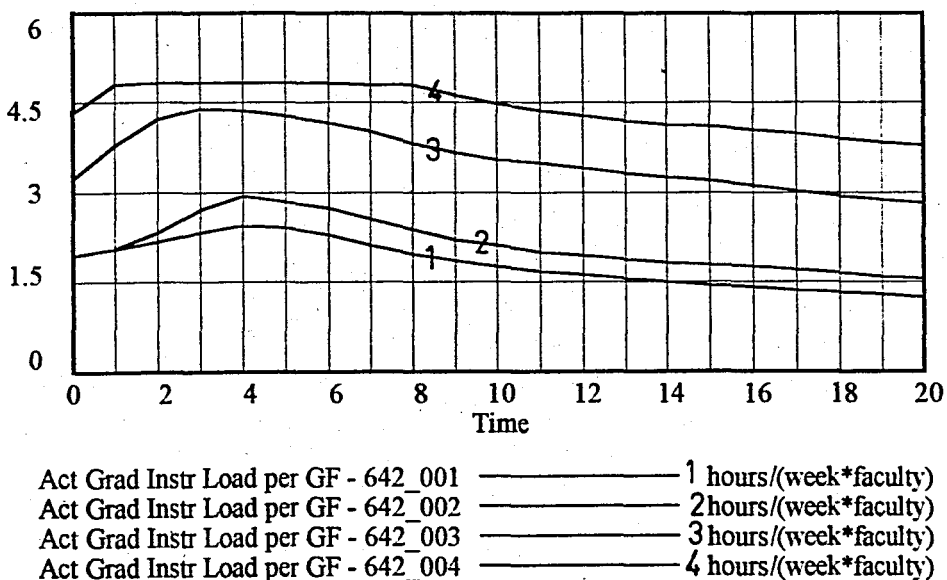


FIGURE B.2.2.2. The Behavior of Graduate Instruction Load per GF for Different Values of Average Hours per Graduate Student; (decreased to 3 in run 001, to 7 in run 002 and increased to 20 in run 004 from 15 in the base run and run 003.)

Graph for Act GI Overhead Load per GF

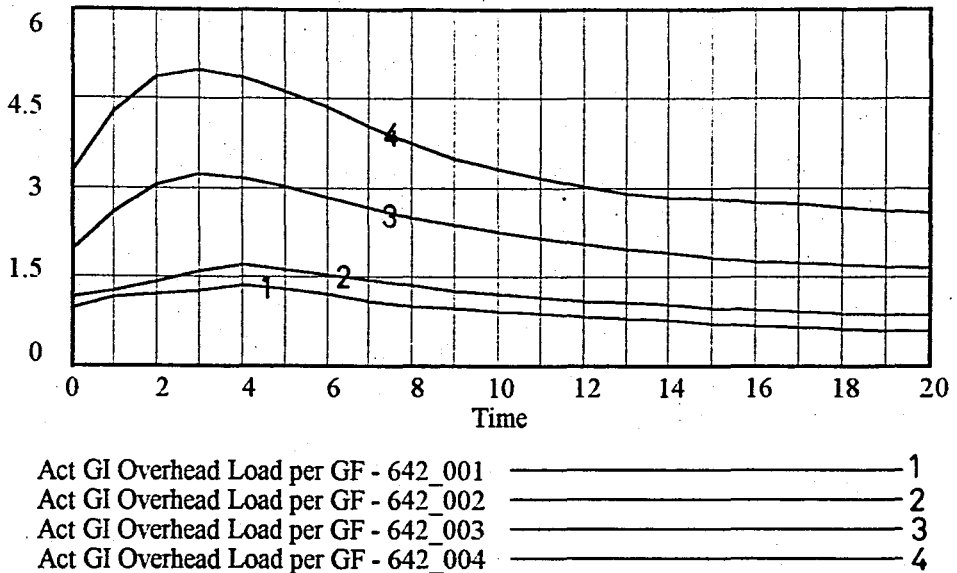


FIGURE B.2.2.3. The Behavior of Grad Instruction Overhead Load per GF for Different Values of Average Hours per Graduate Student; (decreased to 3 in run 001, to 7 in run 002 and increased to 20 in run 004 from 15 in the base run and run 003.)

Graph for Period GF Spons Res Pap Pub

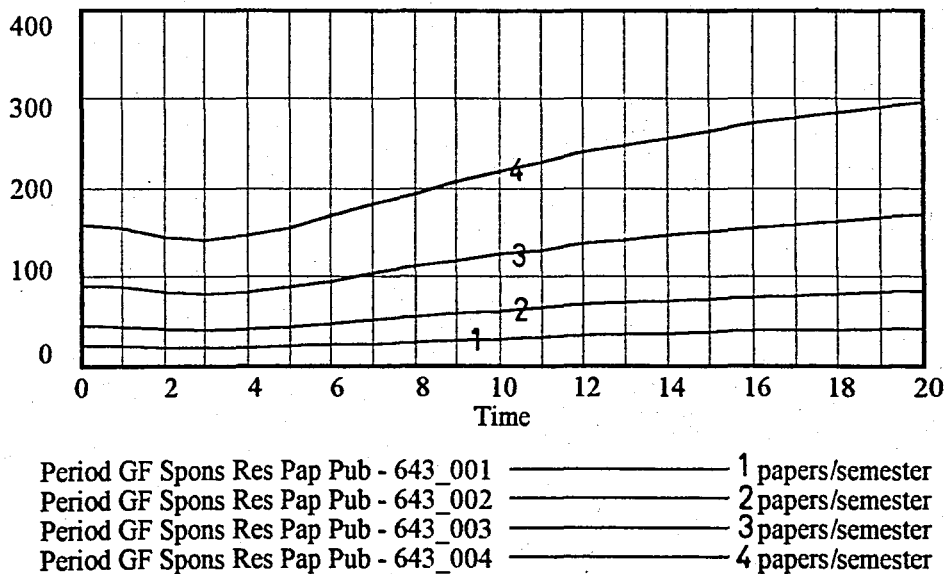


FIGURE B.2.3.1. The Behavior of Period GF Sponsored Research Papers for Different Values of GF Research Papers Productivity; (decreased to 1 in run 001, to 2 in run 002 and increased to 7 in run 004 from 4 in the base run and run 003.)

Graph for Period GF Unsponsored Res Pap Pub

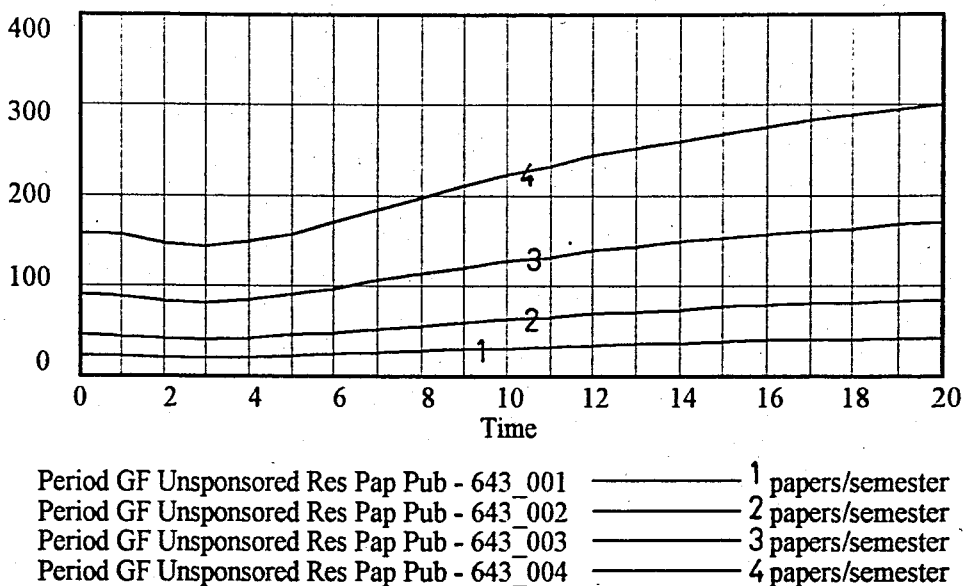


FIGURE B.2.3.2. The Behavior of Period GF Unsponsored Research Papers for Different Values of GF Research Papers Productivity; (decreased to 1 in run 001, to 2 in run 002 and increased to 7 in run 004 from 4 in the base run and run 003.)

Graph for GF Hist Ave Res Papers Pub per GF

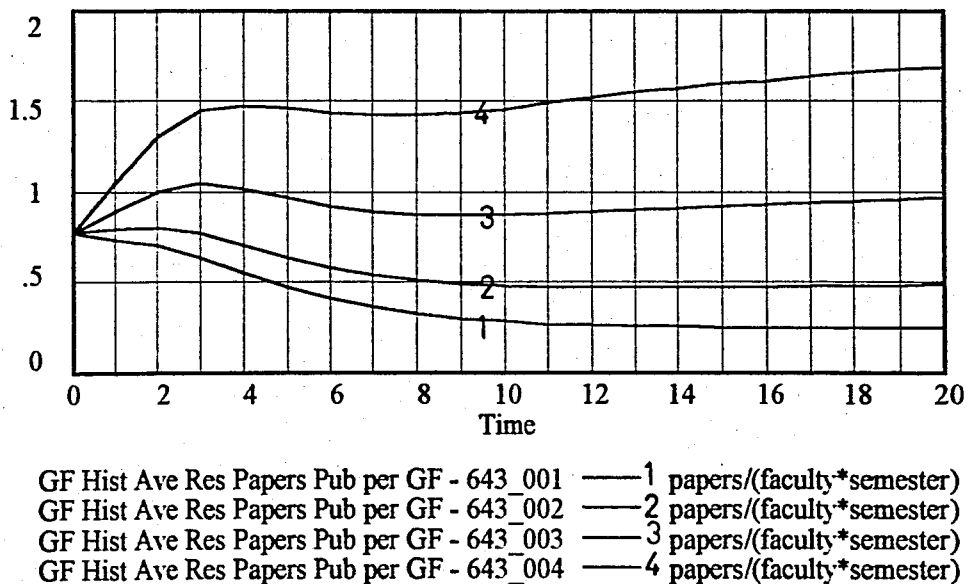


FIGURE B.2.3.3. The Behavior of GF Historical Average Research Papers per GF for Different Values of GF Research Papers Productivity; (decreased to 1 in run 001, to 2 in run 002 and increased to 7 in run 004 from 4 in the base run and run 003.)

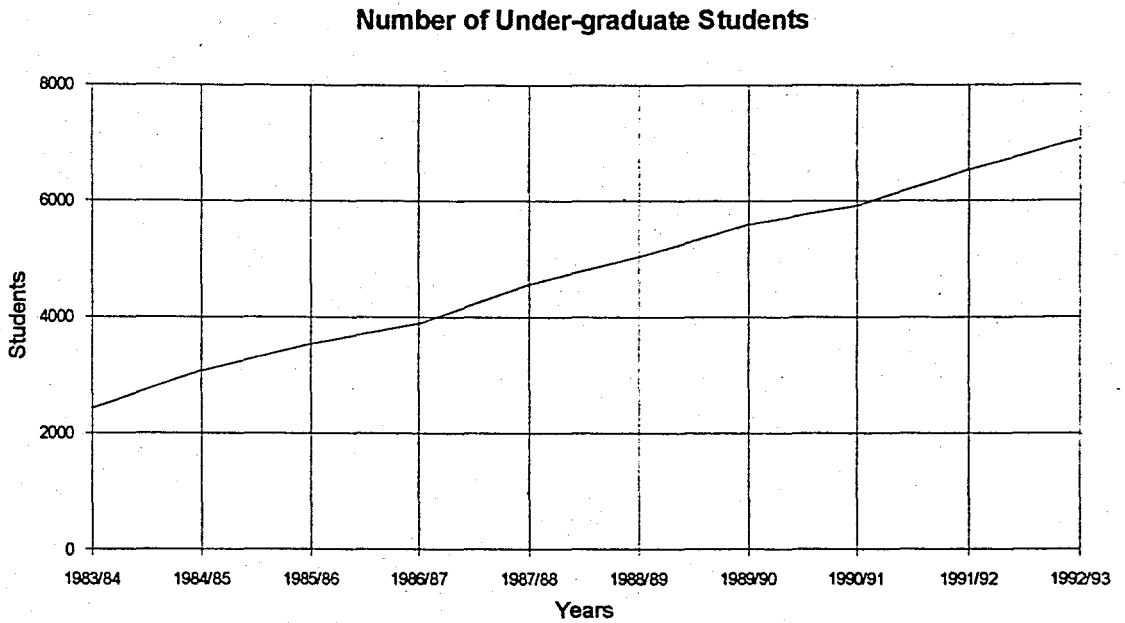


FIGURE B.3.1.1. Real System Behavior According to Data from Boğaziçi University

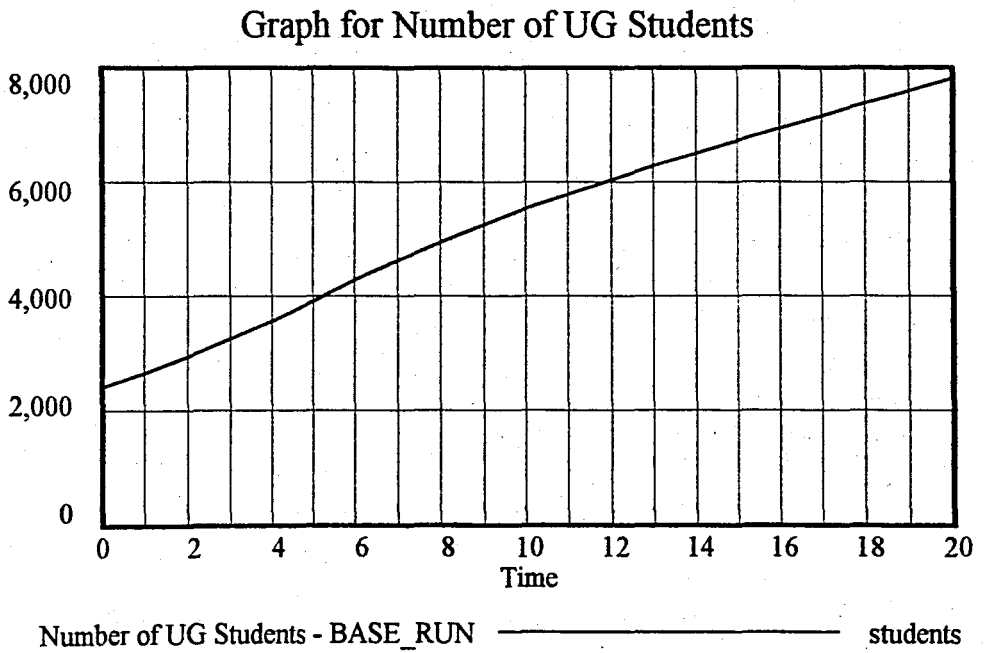


FIGURE B.3.1.2. Model Behavior

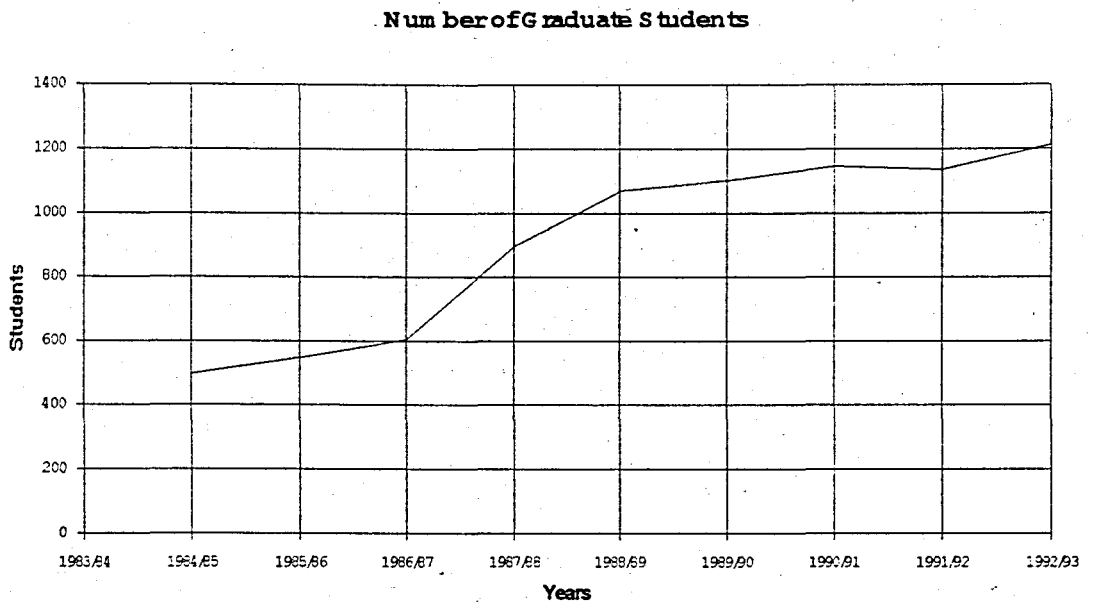


FIGURE B.3.2.1. Real System Behavior According to Data from Boğaziçi University

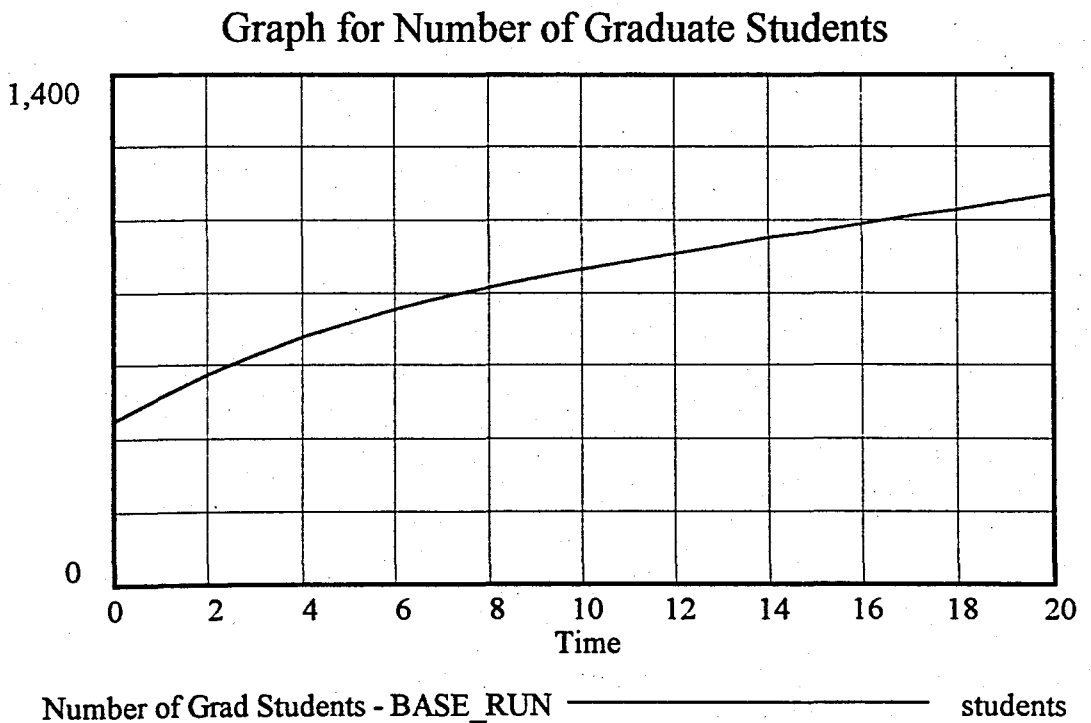


FIGURE B.3.2.2. Model Behavior

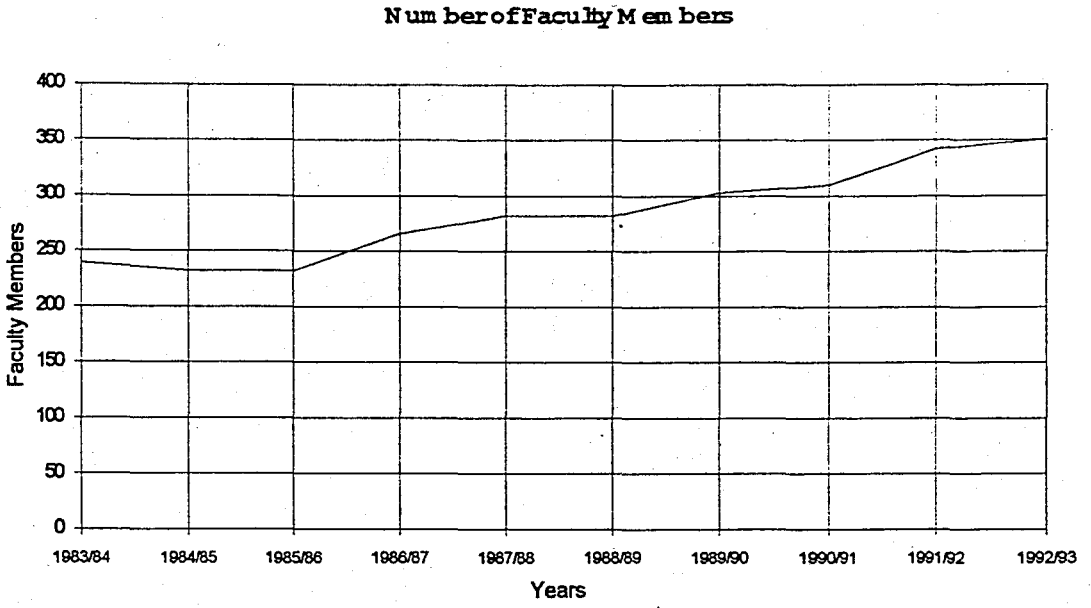


FIGURE B.3.3.1. Real System Behavior According to Data from Boğaziçi University

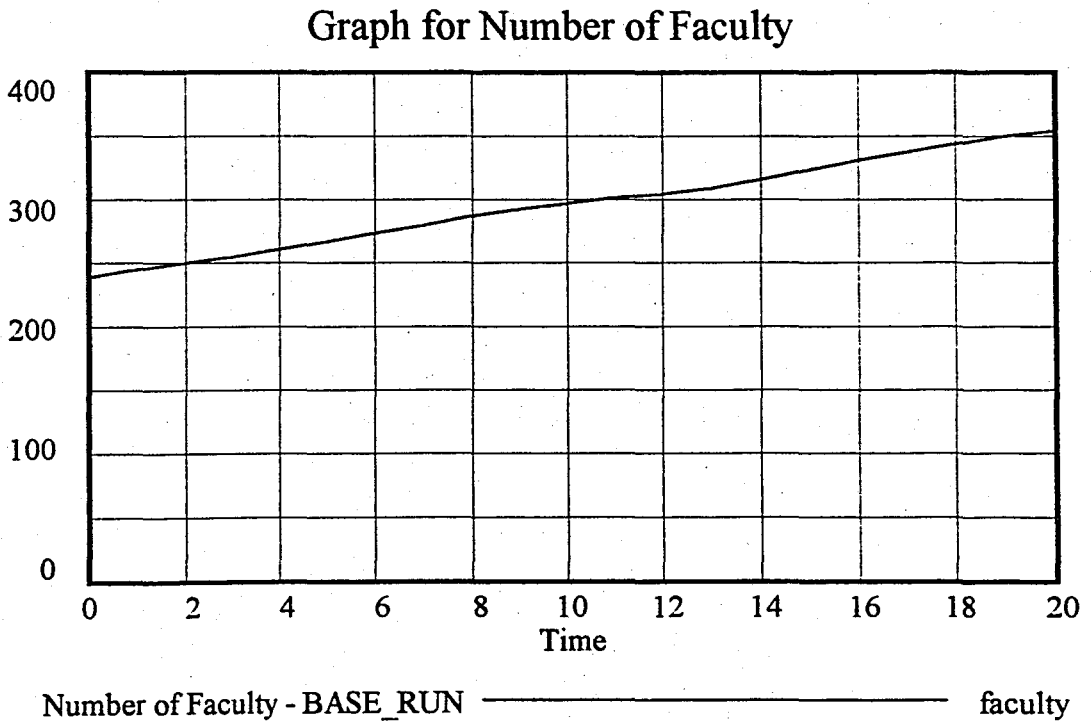


FIGURE B.3.3.2. Model Behavior

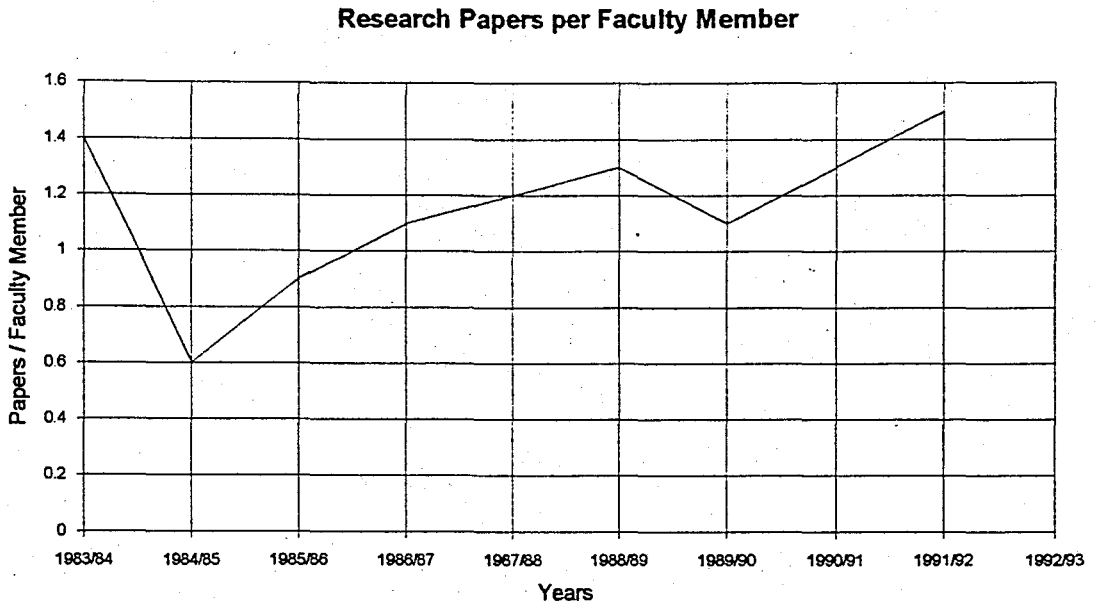


FIGURE B.3.4.1. Real System Behavior According to Data from Boğaziçi University

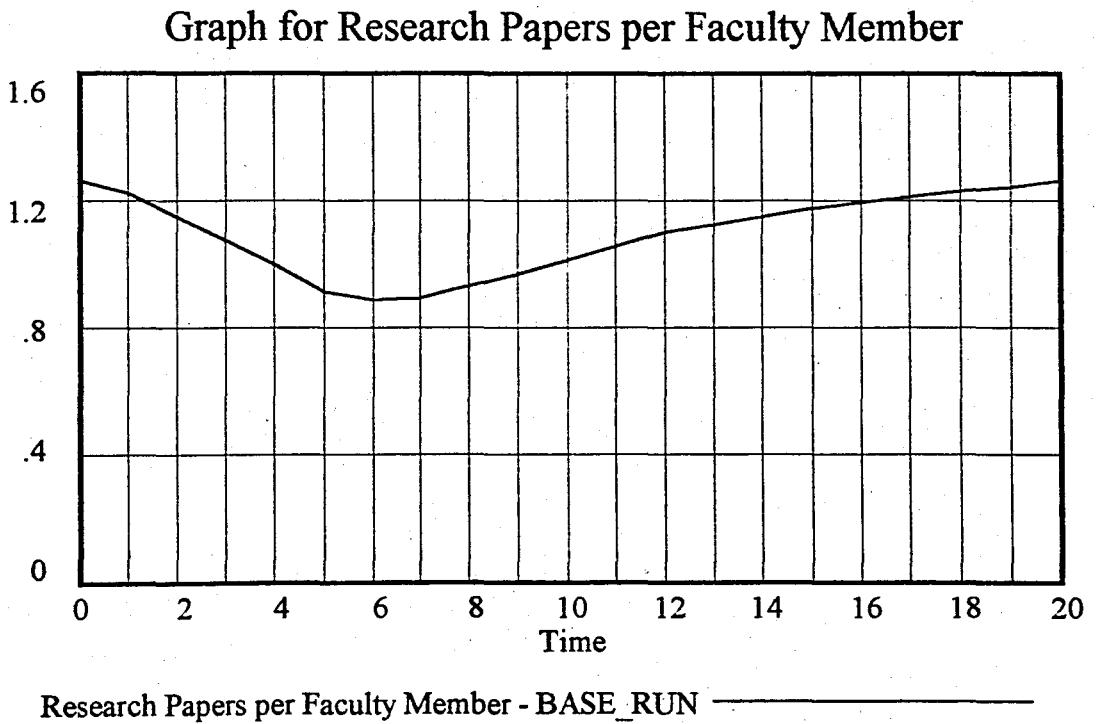


FIGURE B.3.4.2. Model Behavior

APPENDIX C

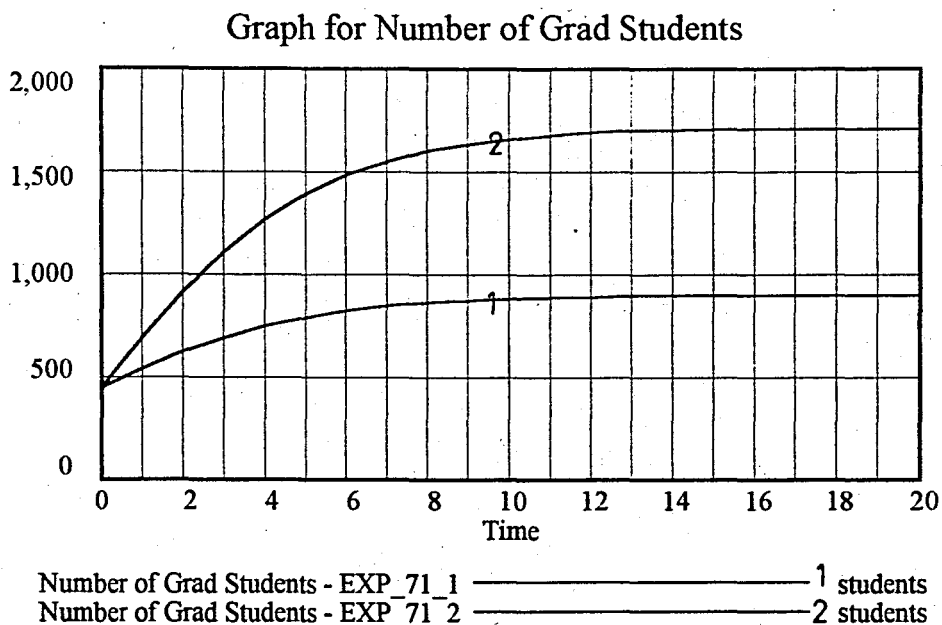


FIGURE C.1.1. Experiments with Graduate versus Under-graduate Study Orientation (Higher Under-graduate and Lower Graduate Admission in run 1 versus Lower Under-graduate and Higher Graduate Admission in run 2)

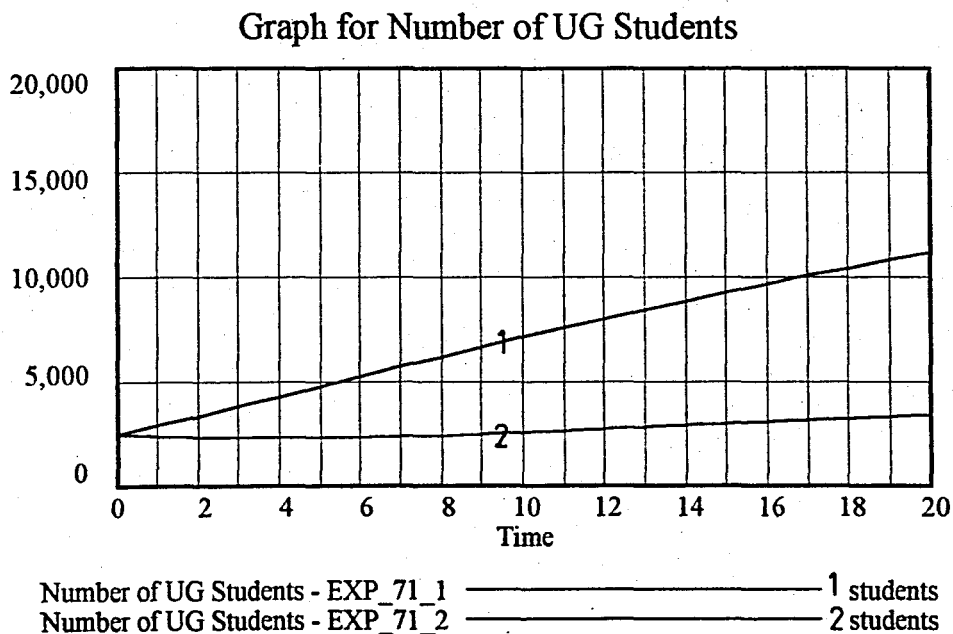


FIGURE C.1.2. Experiments with Graduate versus Under-graduate Study Orientation (Higher Under-graduate and Lower Graduate Admission in run 1 versus Lower Under-graduate and Higher Graduate Admission in run 2)

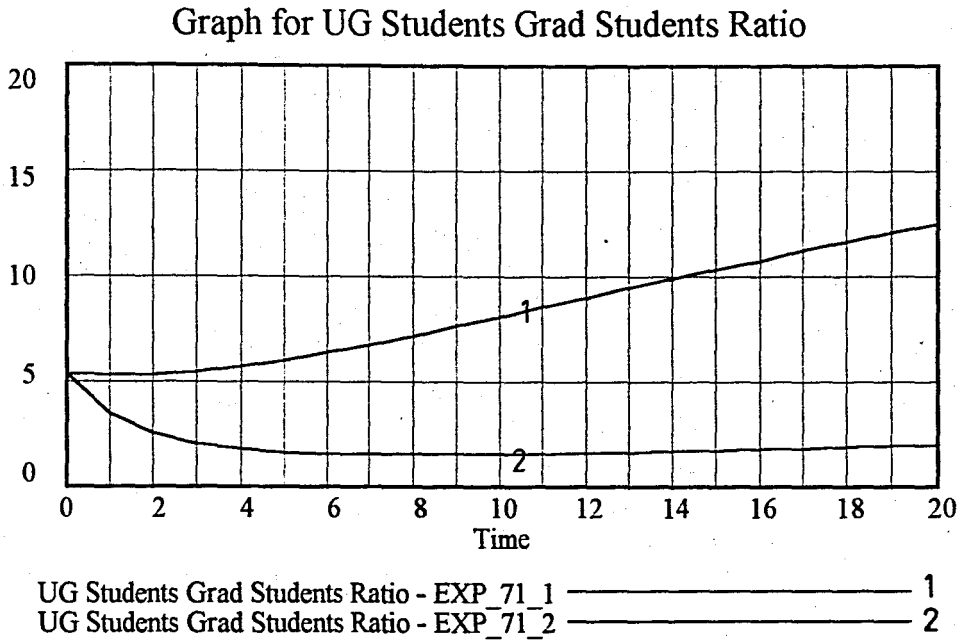


FIGURE C.1.3. Experiments with Graduate versus Under-graduate Study Orientation (Higher Under-graduate and Lower Graduate Admission in run 1 versus Lower Under-graduate and Higher Graduate Admission in run 2)

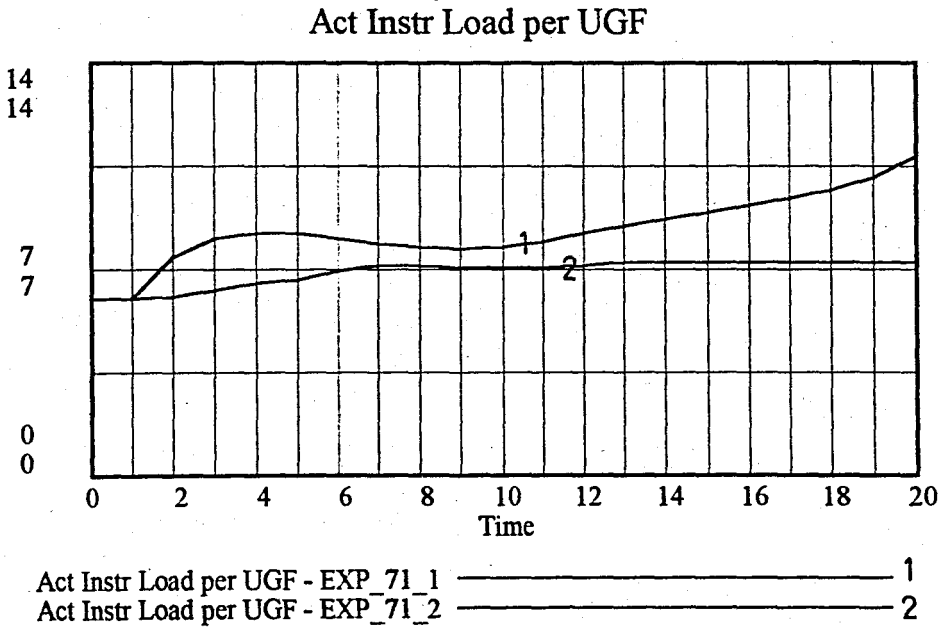


FIGURE C.1.4. Experiments with Graduate versus Under-graduate Study Orientation (Higher Under-graduate and Lower Graduate Admission in run 1 versus Lower Under-graduate and Higher Graduate Admission in run 2)

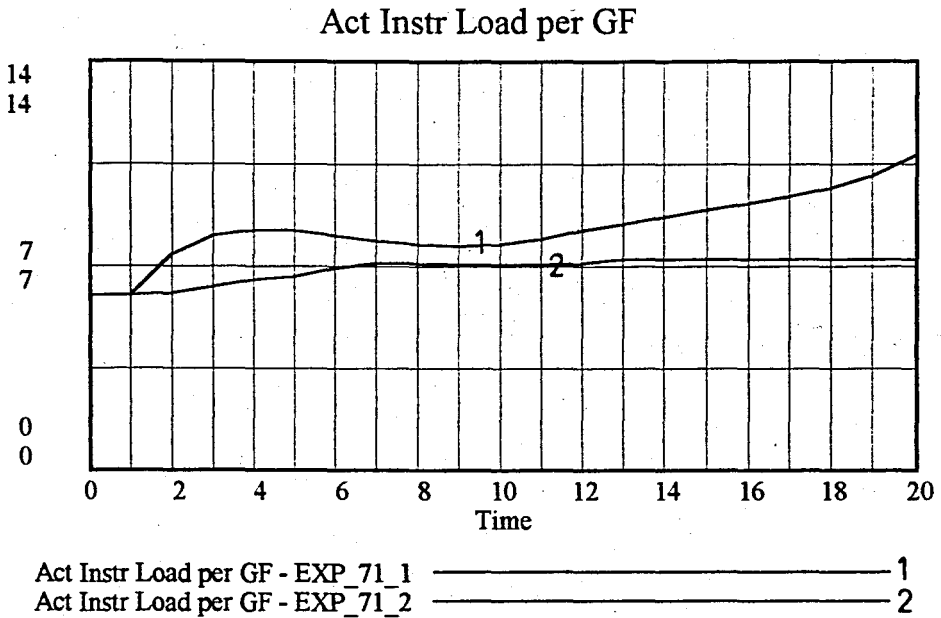


FIGURE C.1.5. Experiments with Graduate versus Under-graduate Study Orientation (Higher Under-graduate and Lower Graduate Admission in run 1 versus Lower Under-graduate and Higher Graduate Admission in run 2)

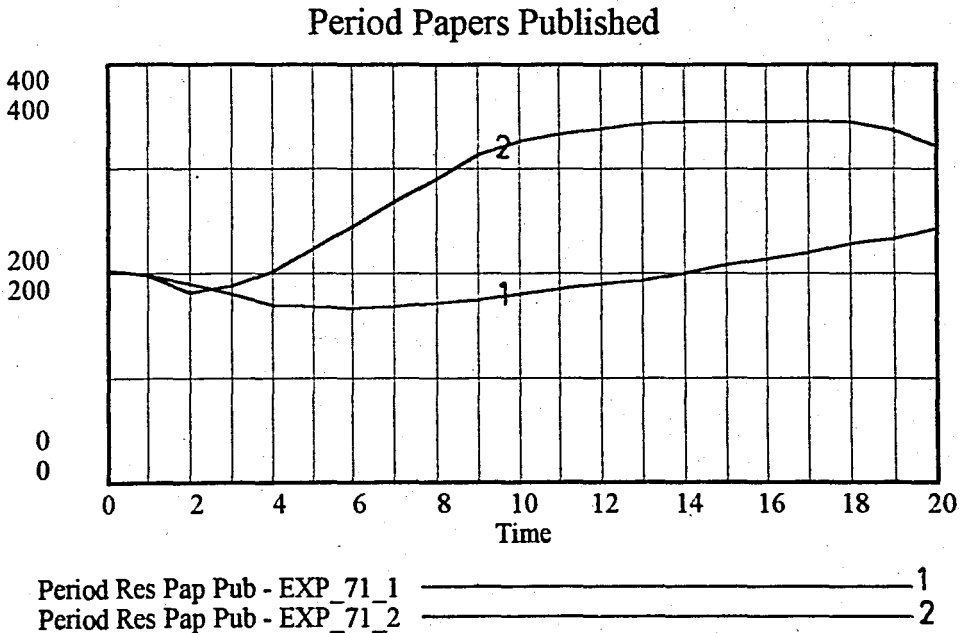


FIGURE C.1.6. Experiments with Graduate versus Under-graduate Study Orientation (Higher Under-graduate and Lower Graduate Admission in run 1 versus Lower Under-graduate and Higher Graduate Admission in run 2)

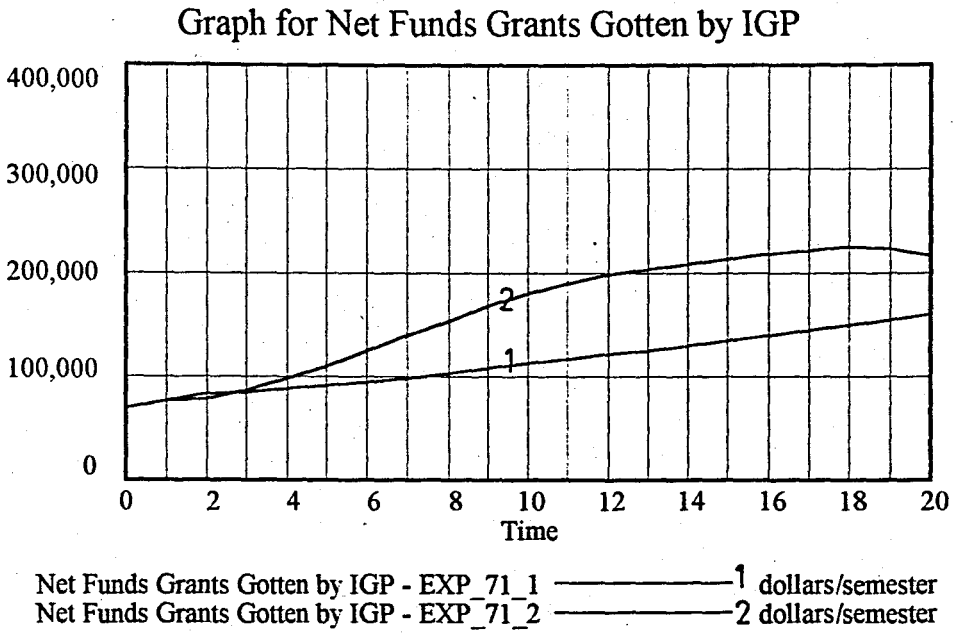


FIGURE C.1.7. Experiments with Graduate versus Under-graduate Study Orientation (Higher Under-graduate and Lower Graduate Admission in run 1 versus Lower Under-graduate and Higher Graduate Admission in run 2)

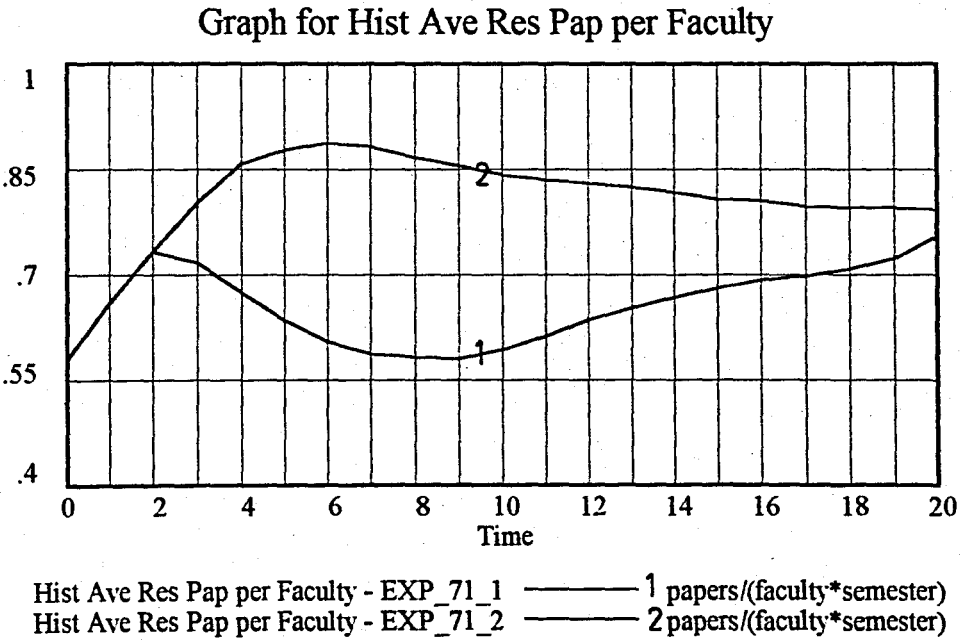
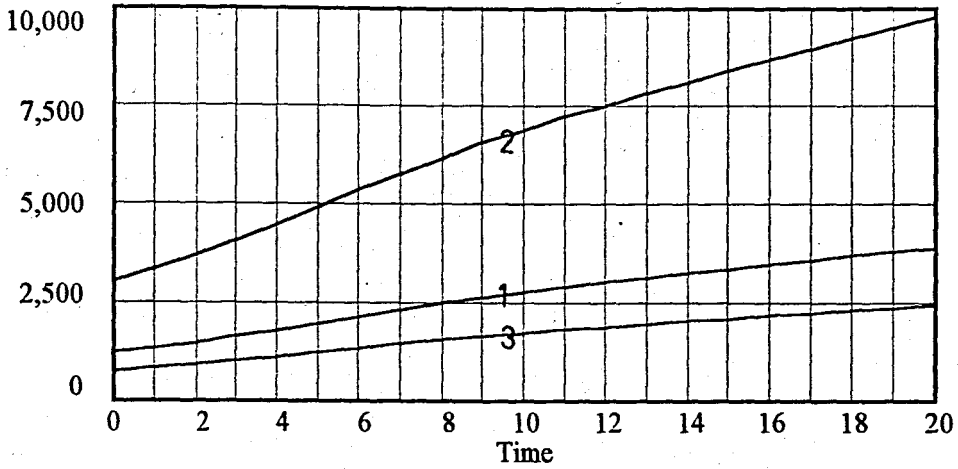


FIGURE C.1.8. Experiments with Graduate versus Under-graduate Study Orientation (Higher Under-graduate and Lower Graduate Admission in run 1 versus Lower Under-graduate and Higher Graduate Admission in run 2)

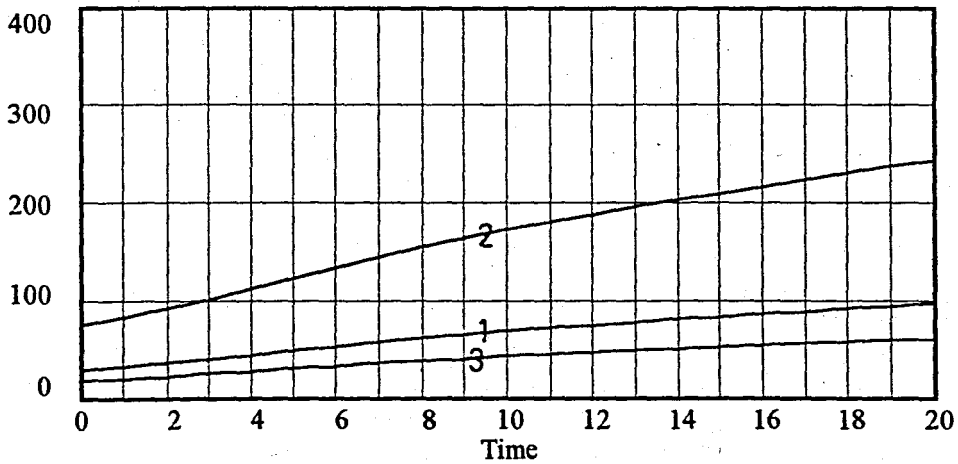
Graph for Total UG Instr Hours Needed



Total UG Instr Hours Needed - EXP_72_1 ————— 1 hours/week
 Total UG Instr Hours Needed - EXP_72_2 ————— 2 hours/week
 Total UG Instr Hours Needed - EXP_72_3 ————— 3 hours/week

FIGURE C.2.1. Experiments with Different 'Desired' and 'Maximum' UG Class Sizes (Desired=20, Maximum=40 in run 2; Desired=80, Maximum=160 in run 3 Desired=50, Maximum=100 in the base run and run 1)

Graph for Total FTE Needed for UG Instr



Total FTE Needed for UG Instr - EXP_72_1 ————— 1 FTE
 Total FTE Needed for UG Instr - EXP_72_2 ————— 2 FTE
 Total FTE Needed for UG Instr - EXP_72_3 ————— 3 FTE

FIGURE C.2.2. Experiments with Different 'Desired' and 'Maximum' UG Class Sizes (Desired=20, Maximum=40 in run 2; Desired=80, Maximum=160 in run 3 Desired=50, Maximum=100 in the base run and run 1)

Graph for Act UG Instr Load per GF

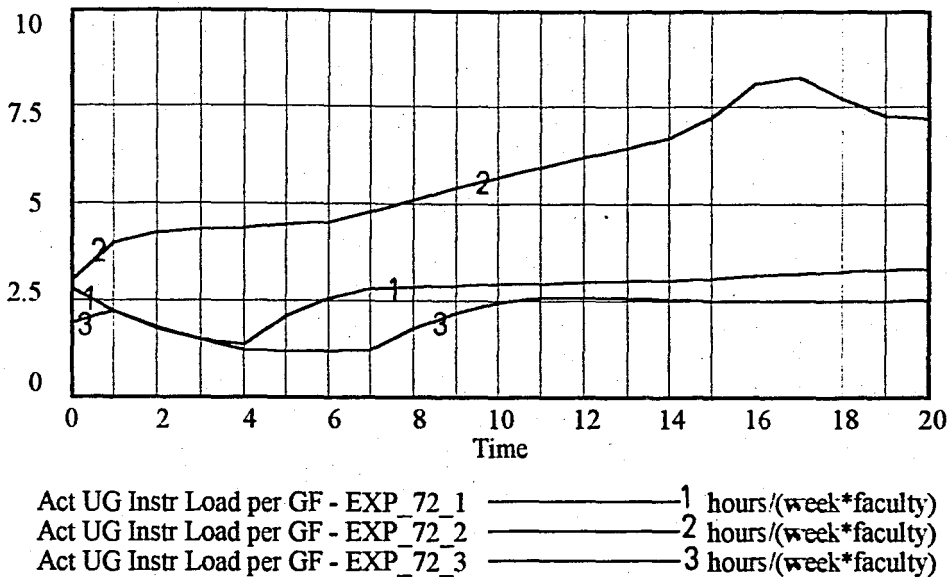


FIGURE C.2.3. Experiments with Different 'Desired' and 'Maximum' UG Class Sizes (Desired=20, Maximum=40 in run 2; Desired=80, Maximum=160 in run 3 Desired=50, Maximum=100 in the base run and run 1)

Graph for Act Instr Load per UGF

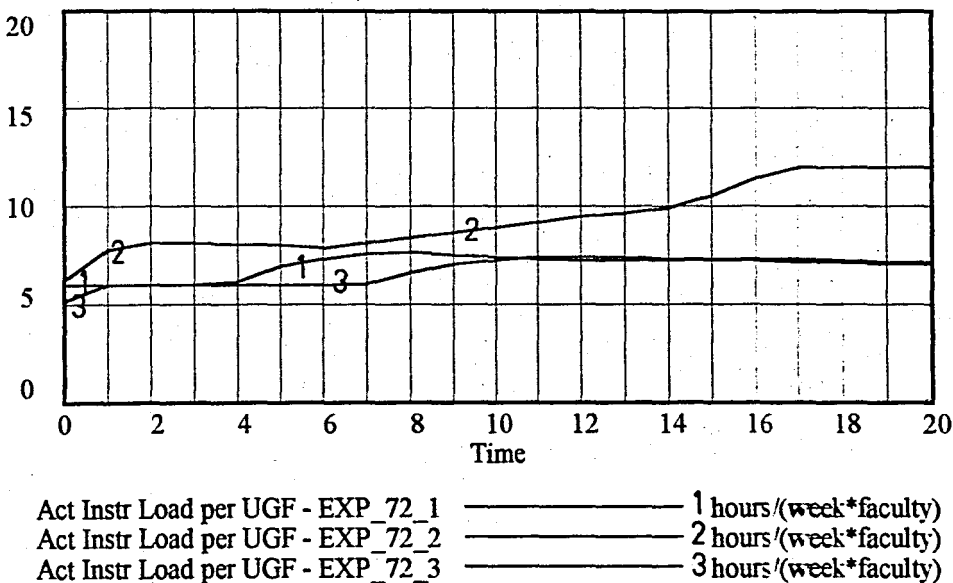


FIGURE C.2.4. Experiments with Different 'Desired' and 'Maximum' UG Class Sizes (Desired=20, Maximum=40 in run 2; Desired=80, Maximum=160 in run 3 Desired=50, Maximum=100 in the base run and run 1)

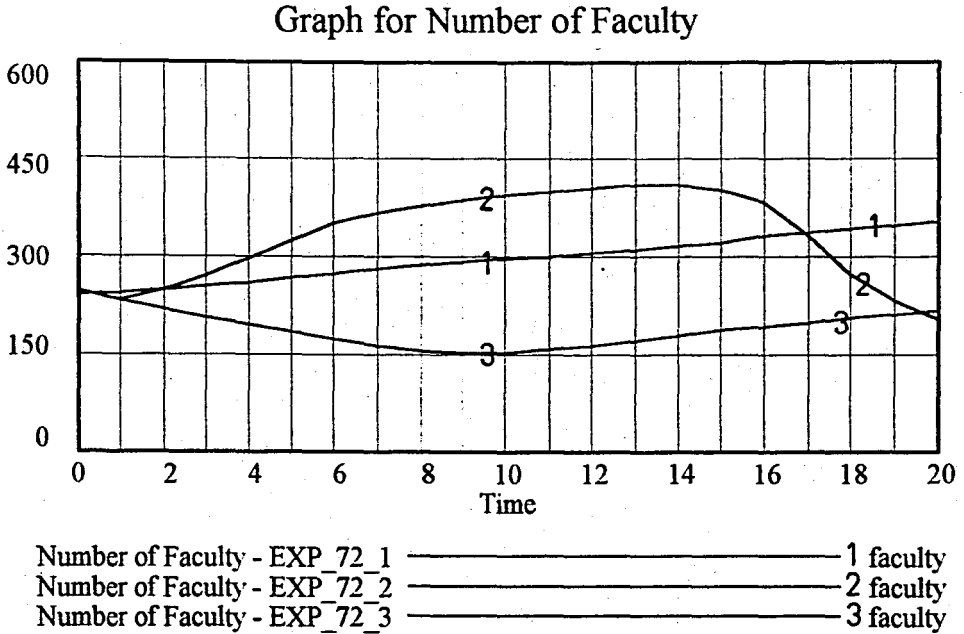


FIGURE C.2.5. Experiments with Different 'Desired' and 'Maximum' UG Class Sizes (Desired=20, Maximum=40 in run 2; Desired=80, Maximum=160 in run 3 Desired=50, Maximum=100 in the base run and run 1)

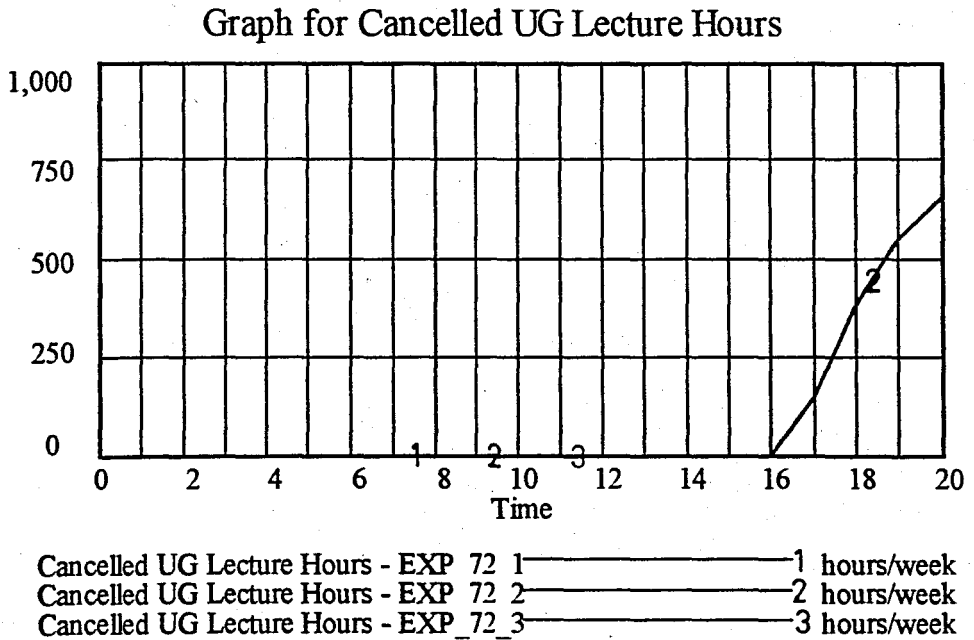


FIGURE C.2.6. Experiments with Different 'Desired' and 'Maximum' UG Class Sizes (Desired=20, Maximum=40 in run 2; Desired=80, Maximum=160 in run 3 Desired=50, Maximum=100 in the base run and run 1)

APPENDIX D

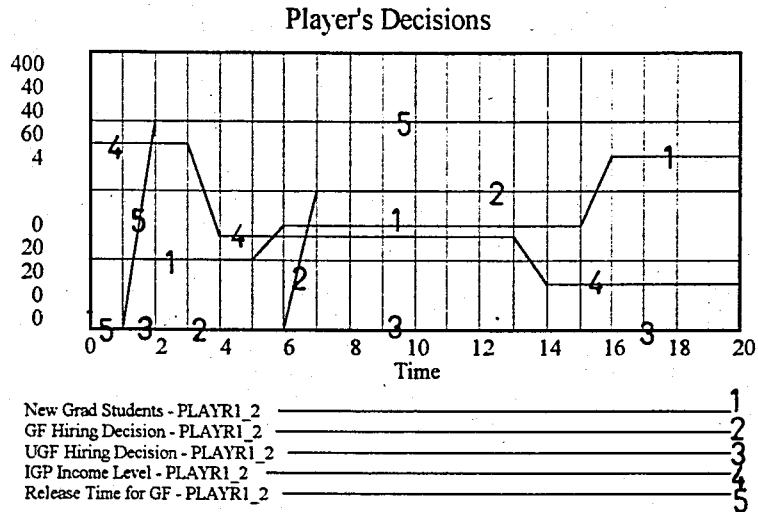


FIGURE D.1.1. Research Oriented Faculty Member's Decisions in His Second Game

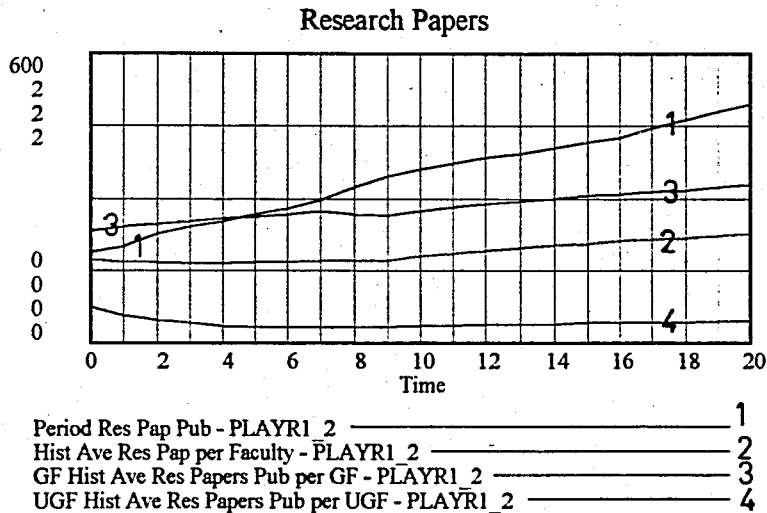


FIGURE D.1.2. Behavior Patterns from Research Oriented Faculty Member's Second Game

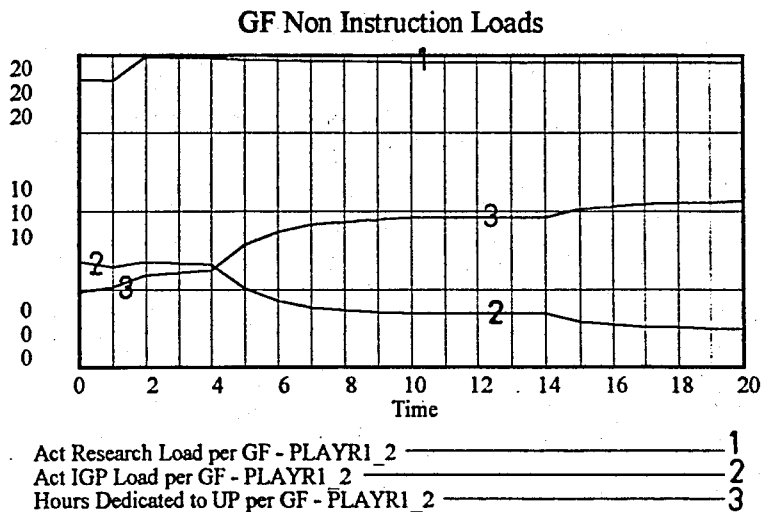


FIGURE D.1.3. Behavior Patterns from Research Oriented Faculty Member's Second Game

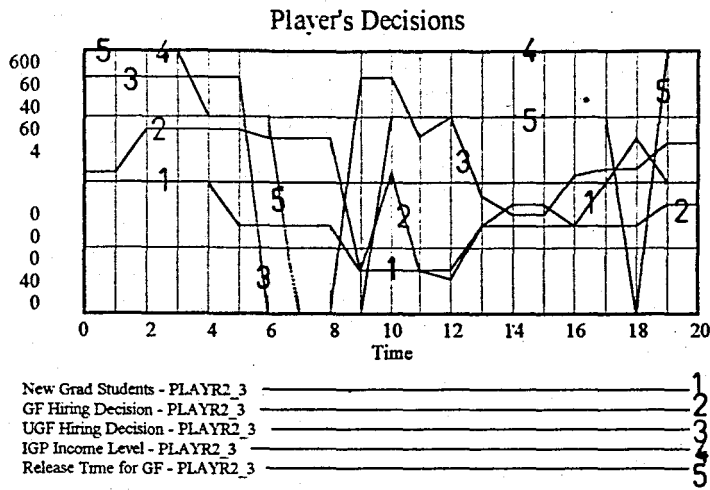


FIGURE D.2.1. Balance Seeking Faculty Member's Decisions in His Third Game

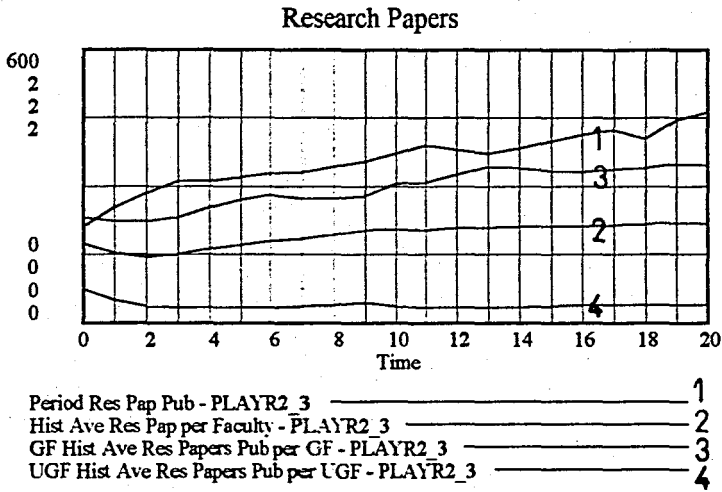


FIGURE D.2.2. Behavior Patterns from Balance Seeking Faculty Member's Third Game

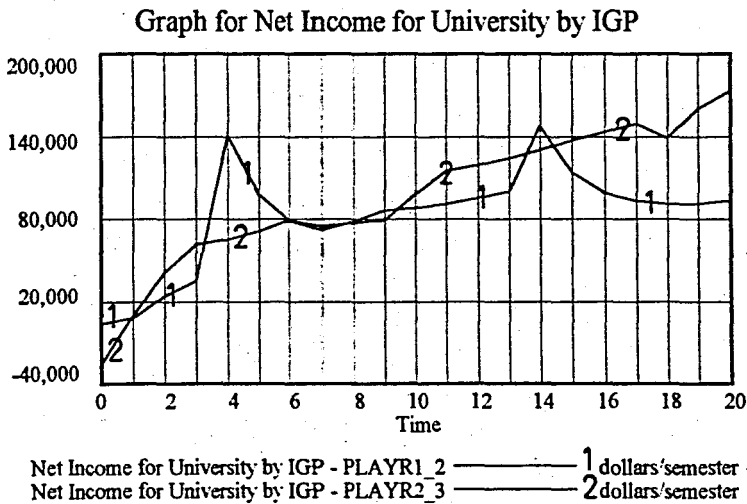


FIGURE D.2.3. Net IGP Income for University Obtained by the Research Oriented Faculty Member (Playr1_2) and the Balance Seeking Faculty Member(Playr2_3)

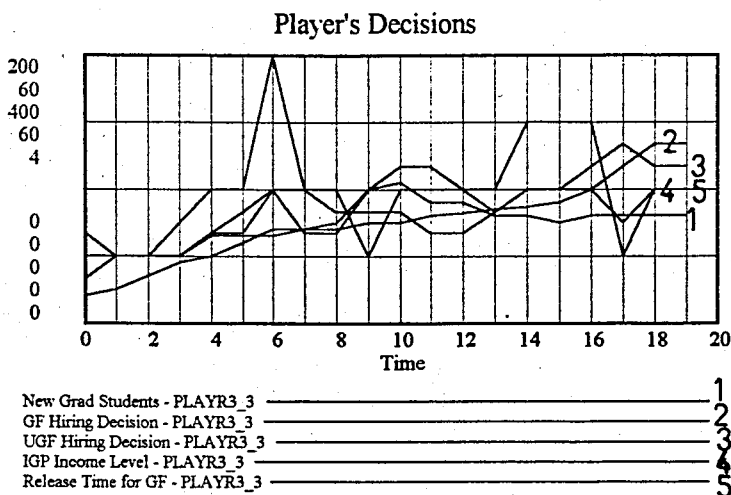


FIGURE D.3.1. Graduate Student-Teaching Assistant's Decisions in Her Third Game

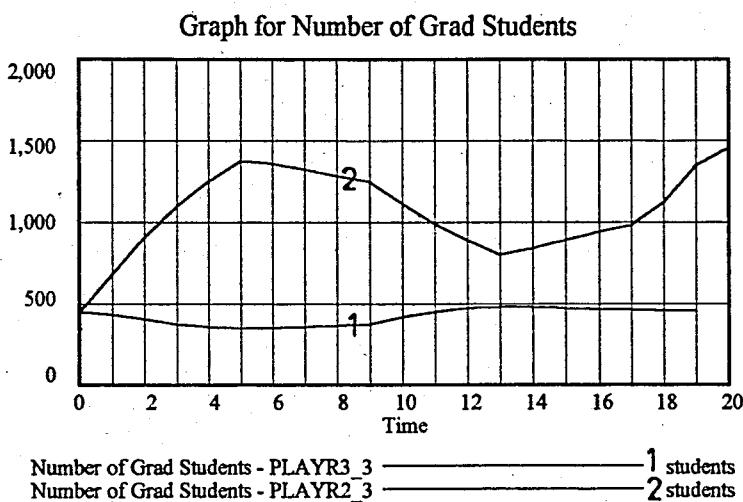


FIGURE D.3.2. Behavior of Number of Graduate Students in the Games Played by the Balance Seeking Faculty Member (Playr2_3) and the Teaching Assistant (Playr3_3)

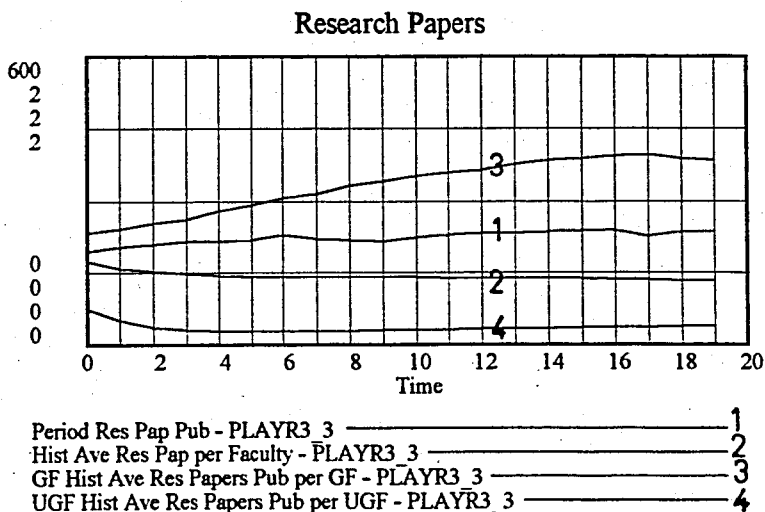


FIGURE D.3.3. Behavior Patterns from Graduate Student-Teaching Assistant's Third Game

APPENDIX E

:SCREEN TITLE.

```

COMMAND,"",0,0,0,0,,,SPECIAL>LOADMODEL,unigame.vmf
COMMAND,"",0,0,0,0,,,SPECIAL>CLEARRUNS
COMMAND,"",0,0,0,0,,,SPECIAL>SETTITLE,The University Game by Vedat G. Diker
TEXTONLY,"The University Game",0,25,100,0,C||30,B|125-50-75,
TEXTONLY,"by Vedat G. Diker",0,44,100,0,C||17||0-0-255,
TEXTONLY,"Boğaziçi University",0,58,100,0,C||15||0-0-0,
TEXTONLY,"Industrial Engineering Department",0,63,100,0,C||15||0-0-0,
TEXTONLY,"Istanbul, August 1995",0,68,100,0,C||15||0-0-0,
TEXTONLY,"Important! This game was designed to be used with SVGA display.",0,78,100,0,C||12|b,255-0-0,
TEXTONLY,"You may get distorted layouts with other displays.",0,82,100,0,C||12|b,255-0-0,
TEXTONLY,"Press any Key to Play the Game",0,90,100,0,C||13||0-0-0,
ANYKEY,"",0,0,0,0,,,,NAMERUN

```

:SCREEN NAMERUN.

```

COMMAND,"",0,0,0,0,,,SIMULATE>RUNNAME?Name for new game output (NOT UNI_001!!)
COMMAND,"",0,0,0,0,,,GAME>GAMEINTERVAL|1.0
COMMAND,"",0,0,0,0,,,MENU>GAMEO
CLOSESCREEN,"",0,0,0,0,,,GAMEINI

```

:SCREEN GAMEINI

```

COMMAND,"",0,0,0,0,,,SIMULATE>SETVAL|FINAL TIME=20
RECTANGLE,"",1,2,31,4,C|||0-0-255|,
TEXTONLY," GAME CONTROLS",0,2,31,3,C|Times New Roman|16||125-50-75|,
RECTANGLE,"",1,6,31,13,C|||0-0-255|,
BUTTON,"Start",3,7,7,5,L, Ss, ,MAINGAME
RECTANGLE,"",13,7,7,5,L|||75-125-55|,
TEXTONLY," End ",14,8,5,0,C|System 10 b|75-125-55|,
BUTTON," Exit ",23,7,7,0,L, Xx, , ASKEXIT1
TEXTONLY,"Set Final Time",2,14,8,0,L, b|255-0-0|,
LISTVAR,"FINAL TIME",12,13,6,5,L|System 10|b|255-0-0|,|10|50|10|14|20|30|50
TEXTONLY,"Current Time",19,14,8,0,L, b|0-0-0|,
SHOWVAR,"TIME",30,14,4,0,L|System 10 b|255-0-0|,
RECTANGLE,"",33,2,66,6,C|||0-0-255|,
TEXTONLY," MAIN INDICATORS ",33,2,0,4,L|Times New Roman|20||50-0-200|,
RECTANGLE,"",33,8,66,91,C|||0-0-255|,
RECTANGLE,"",77,3,21,4,L|||b|75-125-55|,
TEXTONLY,"MORE INDICATORS >>>>>",77,3,21,4,C|||b|75-125-55|
RECTANGLE,"",34,9,31,5,
TEXTONLY,"Number of Grad Students",34,9,23,5,L|||b|,
SHOWVAR,"Number of Grad Students",64,10,0,3,R|System|10|b|0-0-255|,
RECTANGLE,"",67,9,31,5,
TEXTONLY,"Number of UG Students",67,9,23,5,L|||b|,
SHOWVAR,"Number of UG Students",97,10,0,3,R|System|10|b|0-0-255|,
RECTANGLE,"",34,15,31,5,
TEXTONLY,"Number of Grad Faculty",34,15,23,5,L|||b|,
SHOWVAR,"Number of Grad Fac",64,16,0,3,R|System|10|b|0-0-255|,
RECTANGLE,"",67,15,31,5,
TEXTONLY,"Number of UG Faculty",67,15,23,5,L|||b|,
SHOWVAR,"Number of UG Fac",97,16,0,3,R|System|10|b|0-0-255|,
RECTANGLE,"",34,21,31,5,
TEXTONLY,"Number of Faculty",64,21,23,5,L|||b|,
SHOWVAR,"Number of Faculty",64,22,0,3,R|System|10|b|0-0-255|,
RECTANGLE,"",67,21,31,5,
TEXTONLY,"Vacant Faculty Positions",67,21,23,5,L|||b|,
SHOWVAR,"Vacant Faculty Positions",97,22,0,3,R|System|10|b|0-0-255|,
RECTANGLE,"",34,27,31,5,
TEXTONLY,"Indicated GF Supply",34,27,23,5,L|||b|,
SHOWVAR,"Indicated GF Supply",64,28,0,3,R|System|10|b|0-0-255|,
RECTANGLE,"",67,27,31,5,
TEXTONLY,"Indicated UGF Supply",67,27,23,5,L|||b|,
SHOWVAR,"Indicated UGF Supply",97,28,0,3,R|System|10|b|0-0-255|,
RECTANGLE,"",34,33,31,5,
TEXTONLY,"New Grad Faculty",34,33,23,5,L|||b|,
SHOWVAR,"New Grad Faculty",64,34,0,3,R|System|10|b|0-0-255|,
RECTANGLE,"",67,33,31,5,
TEXTONLY,"New UG Faculty",67,33,23,5,L|||b|,
SHOWVAR,"New UG Faculty",97,34,0,3,R|System|10|b|0-0-255|,
RECTANGLE,"",34,39,31,5,
TEXTONLY,"GF that Leave",34,39,23,5,L|||b|,
SHOWVAR,"GF that Leave",64,40,0,3,R|System|10|b|0-0-255|,
RECTANGLE,"",67,39,31,5,

```

TEXTONLY, "UGF that Leave", 67, 39, 23, 5, L||b,
 SHOWVAR, "UGF that Leave", 97, 40, 0, 3, R\System\10\b\0-0-255},
 RECTANGLE, "", 34, 45, 31, 5
 TEXTONLY, "Average Grad Class Size", 34, 45, 23, 5, L||b,
 SHOWVAR, "Act Average Grad Class Size", 64, 46, 0, 3, R\System\10\b\0-0-255},
 RECTANGLE, "", 67, 45, 31, 5
 TEXTONLY, "Average UG Class Size", 67, 45, 23, 5, L||b,
 SHOWVAR, "Act Average UG Class Size", 97, 46, 0, 3, R\System\10\b\0-0-255},
 RECTANGLE, "", 34, 51, 31, 5
 TEXTONLY, "Instr Load per GF (h/week)", 34, 51, 23, 5, L||b,
 SHOWVAR, "Act Instr Load per GF", 64, 52, 0, 3, R\System\10\b\0-0-255},
 RECTANGLE, "", 67, 51, 31, 5
 TEXTONLY, "Instr Load per UGF (h/week)", 67, 51, 23, 5, L||b,
 SHOWVAR, "Act Instr Load per UGF", 97, 52, 0, 3, R\System\10\b\0-0-255},
 RECTANGLE, "", 34, 57, 31, 5
 TEXTONLY, "Grad Instr Load per GF (h/week)", 34, 57, 23, 5, L||b,
 SHOWVAR, "Act Grad Instr Load per GF", 64, 58, 0, 3, R\System\10\b\0-0-255},
 RECTANGLE, "", 67, 57, 31, 5
 TEXTONLY, "UG Instr Load per GF (h/week)", 67, 57, 23, 5, L||b,
 SHOWVAR, "Act UG Instr Load per GF", 97, 58, 0, 3, R\System\10\b\0-0-255},
 RECTANGLE, "", 34, 63, 31, 5
 TEXTONLY, "Overhead Load per GF (h/week)", 34, 63, 23, 5, L||b,
 SHOWVAR, "Act Overhead Load per GF", 64, 64, 0, 3, R\System\10\b\0-0-255},
 RECTANGLE, "", 67, 63, 31, 5
 TEXTONLY, "Overhead Load per UGF (h/week)", 67, 63, 23, 5, L||b,
 SHOWVAR, "Act Overhead Load per UGF", 97, 64, 0, 3, R\System\10\b\0-0-255},
 RECTANGLE, "", 34, 69, 31, 5
 TEXTONLY, "Research Load per GF (h/week)", 34, 69, 23, 5, L||b,
 SHOWVAR, "Act Research Load per GF", 64, 70, 0, 3, R\System\10\b\0-0-255},
 RECTANGLE, "", 67, 69, 31, 5
 TEXTONLY, "Research Load per UGF (h/week)", 67, 69, 23, 5, L||b,
 SHOWVAR, "Act Research Load per UGF", 97, 70, 0, 3, R\System\10\b\0-0-255},
 RECTANGLE, "", 34, 75, 31, 5
 TEXTONLY, "IGP Load per GF (h/week)", 34, 75, 23, 5, L||b,
 SHOWVAR, "Act IGP Load per GF", 64, 76, 0, 3, R\System\10\b\0-0-255},
 RECTANGLE, "", 67, 75, 31, 5
 TEXTONLY, "IGP Load per UGF (h/week)", 67, 75, 23, 5, L||b,
 SHOWVAR, "Act IGP Load per UGF", 97, 76, 0, 3, R\System\10\b\0-0-255},
 RECTANGLE, "", 34, 81, 31, 5
 TEXTONLY, "Hours Spent for UP per GF(w)", 34, 81, 23, 5, L||b,
 SHOWVAR, "Hours Dedicated to UP per GF", 64, 82, 0, 3, R\System\10\b\0-0-255},
 RECTANGLE, "", 67, 81, 31, 5
 TEXTONLY, "Hours Spent for UP per UGF(w)", 67, 81, 23, 5, L||b,
 SHOWVAR, "Hours Dedicated to UP per UGF", 97, 82, 0, 3, R\System\10\b\0-0-255},
 RECTANGLE, "", 34, 87, 31, 5
 TEXTONLY, "Period Research Pap Pub.ed", 34, 87, 23, 5, L||b,
 SHOWVAR, "Period Res Pap Pub", 64, 88, 0, 3, R\System\10\b\0-0-255},
 RECTANGLE, "", 67, 87, 31, 5
 TEXTONLY, "Period Res Pap per Faculty", 67, 87, 23, 5, L||b,
 SHOWVAR, "Period Res Pap Pub per Faculty", 97, 88, 0, 3, R\System\10\b\0-0-255},
 RECTANGLE, "", 34, 93, 31, 5
 TEXTONLY, "Funds Obtained from Spons Res", 34, 93, 23, 5, L||b,
 SHOWVAR, "Funds Grants Gotten by Spons Res", 64, 94, 0, 3, R\System\10\b\0-0-255},
 RECTANGLE, "", 67, 93, 31, 5
 TEXTONLY, "Net Income for University by IGP", 67, 93, 23, 5, L||b,
 SHOWVAR, "Net Income for University by IGP", 97, 94, 0, 3, R\System\10\b\0-0-255},
 RECTANGLE, "", 1, 72, 31, 10, C|||0-0-255},
 TEXTONLY, "DETAILED INFO &", 1, 72, 30, 5, L|Times New Roman|14||5-180-70|,
 TEXTONLY, "CAUSAL ANALYSIS", 1, 77, 30, 5, L|Times New Roman|14||5-180-70|,
 RECTANGLE, "", 1, 82, 31, 17, C|||0-0-255},
 TEXTONLY, "Use this window for precise numerical info.", 2, 83, 30, 4, C|Arial|9||125-50-75|,
 TEXTONLY, "and access to ALL variables of the model.", 2, 87, 30, 4, C|Arial|9||125-50-75|,
 RECTANGLE, "", 3, 92, 27, 5, C|||75-125-55|,
 TEXTONLY, "To Detailed Analysis Screen", 3, 92, 27, 5, C|System|10\b|75-125-55|,
 RECTANGLE, "", 1, 21, 31, 49, C|||75-125-55|,
 RECTANGLE, "", 2, 22, 29, 5, C|||0-0-255|,
 TEXTONLY, "DECISIONS", 1, 22, 23, 5, L|Times New Roman|16\b|75-125-55|,
 RECTANGLE, "", 24, 22, 7, 5, C|||75-125-55|,
 TEXTONLY, "HELP", 25, 23, 0, 5, L|12\b|75-125-55|,,
 RECTANGLE, "", 2, 27, 29, 42, C|||0-0-255|,
 RECTANGLE, "", 3, 28, 21, 5, L|||75-125-55|,
 TEXTONLY, "New Grad Students", 3, 29, 21, 3, L||b|75-125-55|,
 RECTANGLE, "", 25, 28, 5, 5, L|||75-125-55|,
 RECTANGLE, "", 3, 35, 21, 5, L|||75-125-55|,
 TEXTONLY, "Grad Fac Hiring Decision", 3, 36, 21, 3, L||b|75-125-55|,
 RECTANGLE, "", 25, 35, 5, 5, L|||75-125-55|,
 RECTANGLE, "", 3, 42, 21, 5, L|||75-125-55|.

TEXTONLY, "Und.grad Fac. Hiring Decision", 3, 43, 21, 3, L||b|75-125-55|,
 RECTANGLE, "", 25, 42, 5, 5, L||75-125-55|,
 RECTANGLE, "", 3, 49, 21, 5, L||75-125-55|,
 TEXTONLY, "IGP Share for Fac. (S hour)", 3, 50, 21, 3, L||b|75-125-55|,
 RECTANGLE, "", 25, 49, 5, 5, L||75-125-55|,
 RECTANGLE, "", 3, 56, 21, 5, L||75-125-55|,
 TEXTONLY, "Release Time per GF (h week)", 3, 57, 21, 3, L||b|75-125-55|,
 RECTANGLE, "", 25, 56, 5, 5, L||75-125-55|,
 RECTANGLE, "", 3, 63, 27, 5, L||75-125-55|,
 TEXTONLY, "Advance with These Decisions", 3, 63, 27, 5, C|System|10|b|75-125-55|,

:SCREEN ASKEXIT1

TEXTONLY, "Do You Really Want to Exit?", 0, 30, 100, 0, C|Times New Roman|22|b|0-0-255|,
 TEXTONLY, "(You Will Leave the Simulation Environment!)", 0, 40, 100, 0, C|Times New Roman|18|b|255-0-0|,
 BUTTON, " Yes ", 40, 49, 10, 0, C, ., EXIT
 BUTTON, " No ", 60, 49, 10, 0, C, ., GAMEIN

:SCREEN EXIT

COMMAND, "", 75, 90, 0, 0, C, Xx, MENU>EXIT,

:SCREEN MAINGAME

RECTANGLE, "", 1, 2, 31, 4, C||0-0-255|,
 TEXTONLY, " GAME C O N T R O L S ", 0, 2, 31, 3, C|Times New Roman|16||125-50-75|,
 RECTANGLE, "", 1, 6, 31, 13, C||0-0-255|,
 RECTANGLE, "", 3, 7, 7, 5, C||75-125-55|,
 TEXTONLY, " Start ", 3, 8, 7, 0, C|System|10|b|75-125-55|,
 BUTTON, " End ", 13, 7, 7, 0, L, Ee, , ASKEND
 BUTTON, " Exit ", 23, 7, 7, 0, L, Xx, , ASKEXIT2
 TEXTONLY, " Final Time", 2, 14, 8, 0, L||b|0-0-0|,
 SHOWVAR, "FINAL TIME", 12, 13, 3, 5, L|System|10|b|0-0-0|,
 TEXTONLY, "Current Time", 19, 14, 8, 0, L||b|0-0-255|,
 SHOWVAR, "TIME", 30, 14, 4, 0, L|System|10|b|255-0-0|,
 RECTANGLE, "", 33, 2, 66, 6, C||0-0-255|,
 TEXTONLY, " MAIN I N D I C A T O R S ", 33, 2, 0, 4, L|Times New Roman|20||50-0-200|,
 RECTANGLE, "", 33, 8, 66, 91, C||0-0-255|,
 BUTTON, "MORE INDICATORS >>>>>", 77, 3, 21, 4, L||b|, ., MAINGAMEB
 RECTANGLE, "", 34, 9, 31, 5,
 BUTTON, "Number of Grad Students", 34, 9, 23, 5, L||b|, ., SPECIAL>SETWBITEM|Number of Grad Students
&WORKBENCH>GRAPH
 SHOWVAR, "Number of Grad Students", 64, 10, 0, 3, R|System|10|b|0-0-255|,
 RECTANGLE, "", 67, 9, 31, 5,
 BUTTON, "Number of UG Students", 67, 9, 23, 5, L||b|, ., SPECIAL>SETWBITEM|Number of UG Students &WORKBENCH>GRAPH
 SHOWVAR, "Number of UG Students", 97, 10, 0, 3, R|System|10|b|0-0-255|,
 RECTANGLE, "", 34, 15, 31, 5
 BUTTON, "Number of Grad Faculty", 34, 15, 23, 5, L||b|, ., SPECIAL>SETWBITEM|Number of Grad Fac &WORKBENCH>GRAPH
 SHOWVAR, "Number of Grad Fac", 64, 16, 0, 3, R|System|10|b|0-0-255|,
 RECTANGLE, "", 67, 15, 31, 5
 BUTTON, "Number of UG Faculty", 67, 15, 23, 5, L||b|, ., SPECIAL>SETWBITEM|Number of UG Fac &WORKBENCH>GRAPH
 SHOWVAR, "Number of UG Fac", 97, 16, 0, 3, R|System|10|b|0-0-255|,
 RECTANGLE, "", 34, 21, 31, 5
 BUTTON, "Number of Faculty", 34, 21, 23, 5, L||b|, ., SPECIAL>SETWBITEM|Number of Faculty &WORKBENCH>GRAPH
 SHOWVAR, "Number of Faculty", 64, 22, 0, 3, R|System|10|b|0-0-255|,
 RECTANGLE, "", 67, 21, 31, 5
 BUTTON, "Vacant Faculty Positions", 67, 21, 23, 5, L||b|, ., SPECIAL>SETWBITEM|Vacant Faculty Positions
&WORKBENCH>GRAPH
 SHOWVAR, "Vacant Faculty Positions", 97, 22, 0, 3, R|System|10|b|0-0-255|,
 RECTANGLE, "", 34, 27, 31, 5
 BUTTON, "Indicated GF Supply", 34, 27, 23, 5, L||b|, ., SPECIAL>SETWBITEM|Indicated GF Supply &WORKBENCH>GRAPH
 SHOWVAR, "Indicated GF Supply", 64, 28, 0, 3, R|System|10|b|0-0-255|,
 RECTANGLE, "", 67, 27, 31, 5
 BUTTON, "Indicated UGF Supply", 67, 27, 23, 5, L||b|, ., SPECIAL>SETWBITEM|Indicated UGF Supply &WORKBENCH>GRAPH
 SHOWVAR, "Indicated UGF Supply", 97, 28, 0, 3, R|System|10|b|0-0-255|,
 RECTANGLE, "", 34, 33, 31, 5
 BUTTON, "New Grad Faculty", 34, 33, 23, 5, L||b|, ., SPECIAL>SETWBITEM|New Grad Faculty &WORKBENCH>GRAPH
 SHOWVAR, "New Grad Faculty", 64, 34, 0, 3, R|System|10|b|0-0-255|,
 RECTANGLE, "", 67, 33, 31, 5
 BUTTON, "New UG Faculty", 67, 33, 23, 5, L||b|, ., SPECIAL>SETWBITEM|New UG Faculty &WORKBENCH>GRAPH
 SHOWVAR, "New UG Faculty", 97, 34, 0, 3, R|System|10|b|0-0-255|,
 RECTANGLE, "", 34, 39, 31, 5
 BUTTON, "GF that Leave", 34, 39, 23, 5, L||b|, ., SPECIAL>SETWBITEM|GF that Leave &WORKBENCH>GRAPH
 SHOWVAR, "GF that Leave", 64, 40, 0, 3, R|System|10|b|0-0-255|,

RECTANGLE, "", 67, 39, 31, 5
 BUTTON, "UGF that Leave", 67, 39, 23, 5, L||b|, , SPECIAL>SETWBITEM|UGF that Leave &WORKBENCH>GRAPH
 SHOWVAR, "UGF that Leave", 97, 40, 0, 3, R|System|10|b|0-0-255|,
 RECTANGLE, "", 34, 45, 31, 5
 BUTTON, "Average Grad Class Size", 34, 45, 23, 5, L||b|, , SPECIAL>SETWBITEM|Act Average Grad Class Size
&WORKBENCH>GRAPH
 SHOWVAR, "Act Average Grad Class Size", 64, 46, 0, 3, R|System|10|b|0-0-255|,
 RECTANGLE, "", 67, 45, 31, 5
 BUTTON, "Average UG Class Size", 67, 45, 23, 5, L||b|, , SPECIAL>SETWBITEM|Act Average UG Class Size
&WORKBENCH>GRAPH
 SHOWVAR, "Act Average UG Class Size", 97, 46, 0, 3, R|System|10|b|0-0-255|,
 RECTANGLE, "", 34, 51, 31, 5
 BUTTON, "Instr Load per GF (h/week)", 34, 51, 23, 5, L||b|, , SPECIAL>SETWBITEM|Act Instr Load per GF
&WORKBENCH>GRAPH
 SHOWVAR, "Act Instr Load per GF", 64, 52, 0, 3, R|System|10|b|0-0-255|,
 RECTANGLE, "", 67, 51, 31, 5
 BUTTON, "Instr Load per UGF (h/week)", 67, 51, 23, 5, L||b|, , SPECIAL>SETWBITEM|Act Instr Load per UGF
&WORKBENCH>GRAPH
 SHOWVAR, "Act Instr Load per UGF", 97, 52, 0, 3, R|System|10|b|0-0-255|,
 RECTANGLE, "", 34, 57, 31, 5
 BUTTON, "Grad Instr Load per GF (h/week)", 34, 57, 23, 5, L||b|, , SPECIAL>SETWBITEM|Act Grad Instr Load per GF
&WORKBENCH>GRAPH
 SHOWVAR, "Act Grad Instr Load per GF", 64, 58, 0, 3, R|System|10|b|0-0-255|,
 RECTANGLE, "", 67, 57, 31, 5
 BUTTON, "UG Instr Load per GF (h/week)", 67, 57, 23, 5, L||b|, , SPECIAL>SETWBITEM|Act UG Instr Load per GF
&WORKBENCH>GRAPH
 SHOWVAR, "Act UG Instr Load per GF", 97, 58, 0, 3, R|System|10|b|0-0-255|,
 RECTANGLE, "", 34, 63, 31, 5
 BUTTON, "Overhead Load per GF (h/week)", 34, 63, 23, 5, L||b|, , SPECIAL>SETWBITEM|Act Overhead Load per GF
&WORKBENCH>GRAPH
 SHOWVAR, "Act Overhead Load per GF", 64, 64, 0, 3, R|System|10|b|0-0-255|,
 RECTANGLE, "", 67, 63, 31, 5
 BUTTON, "Overhead Load per UGF (h/week)", 67, 63, 23, 5, L||b|, , SPECIAL>SETWBITEM|Act Overhead Load per UGF
&WORKBENCH>GRAPH
 SHOWVAR, "Act Overhead Load per UGF", 97, 64, 0, 3, R|System|10|b|0-0-255|,
 RECTANGLE, "", 34, 69, 31, 5
 BUTTON, "Research Load per GF (h/week)", 34, 69, 23, 5, L||b|, , SPECIAL>SETWBITEM|Act Research Load per GF
&WORKBENCH>GRAPH
 SHOWVAR, "Act Research Load per GF", 64, 70, 0, 3, R|System|10|b|0-0-255|,
 RECTANGLE, "", 67, 69, 31, 5
 BUTTON, "Research Load per UGF (h/week)", 67, 69, 23, 5, L||b|, , SPECIAL>SETWBITEM|Act Research Load per UGF
&WORKBENCH>GRAPH
 SHOWVAR, "Act Research Load per UGF", 97, 70, 0, 3, R|System|10|b|0-0-255|,
 RECTANGLE, "", 34, 75, 31, 5
 BUTTON, "IGP Load per GF (h/week)", 34, 75, 23, 5, L||b|, , SPECIAL>SETWBITEM|Act IGP Load per GF &WORKBENCH>GRAPH
 SHOWVAR, "Act IGP Load per GF", 64, 76, 0, 3, R|System|10|b|0-0-255|,
 RECTANGLE, "", 67, 75, 31, 5
 BUTTON, "IGP Load per UGF (h/week)", 67, 75, 23, 5, L||b|, , SPECIAL>SETWBITEM|Act IGP Load per UGF
&WORKBENCH>GRAPH
 SHOWVAR, "Act IGP Load per UGF", 97, 76, 0, 3, R|System|10|b|0-0-255|,
 RECTANGLE, "", 34, 81, 31, 5
 BUTTON, "Hours Spent for UP per GF(w)", 34, 81, 23, 5, L||b|, , SPECIAL>SETWBITEM|Hours Dedicated to UP per GF
&WORKBENCH>GRAPH
 SHOWVAR, "Hours Dedicated to UP per GF", 64, 82, 0, 3, R|System|10|b|0-0-255|,
 RECTANGLE, "", 67, 81, 31, 5
 BUTTON, "Hours Spent for UP per UGF(w)", 67, 81, 23, 5, L||b|, , SPECIAL>SETWBITEM|Hours Dedicated to UP per UGF
&WORKBENCH>GRAPH
 SHOWVAR, "Hours Dedicated to UP per UGF", 97, 82, 0, 3, R|System|10|b|0-0-255|,
 RECTANGLE, "", 34, 87, 31, 5
 BUTTON, "Period Research Pap Pub.ed", 34, 87, 23, 5, L||b|, , SPECIAL>SETWBITEM|Period Res Pap Pub &WORKBENCH>GRAPH
 SHOWVAR, "Period Res Pap Pub", 64, 88, 0, 3, R|System|10|b|0-0-255|,
 RECTANGLE, "", 67, 87, 31, 5
 BUTTON, "Period Res Pap per Faculty", 67, 87, 23, 5, L||b|, , SPECIAL>SETWBITEM|Period Res Pap Pub per Faculty
&WORKBENCH>GRAPH
 SHOWVAR, "Period Res Pap Pub per Faculty", 97, 88, 0, 3, R|System|10|b|0-0-255|,
 RECTANGLE, "", 34, 93, 31, 5
 BUTTON, "Funds Obtained from Spons Res", 34, 93, 23, 5, L||b|, , SPECIAL>SETWBITEM|Funds Grants Gotten by Spons Res
&WORKBENCH>GRAPH
 SHOWVAR, "Funds Grants Gotten by Spons Res", 64, 94, 0, 3, R|System|10|b|0-0-255|,
 RECTANGLE, "", 67, 93, 31, 5
 BUTTON, "Net Income for University by IGP", 67, 93, 23, 5, L||b|, , SPECIAL>SETWBITEM|Net Income for University by IGP
&WORKBENCH>GRAPH
 SHOWVAR, "Net Income for University by IGP", 97, 94, 0, 3, R|System|10|b|0-0-255|,
 RECTANGLE, "", 1, 72, 31, 10, C|||0-0-255|,
 TEXTONLY, "DETAILED INFO &", 1, 72, 30, 5, L|Times New Roman|14|5-180-70|,
 TEXTONLY, "CAUSAL ANALYSIS", 1, 77, 30, 5, L|Times New Roman|14|5-180-70|,
 RECTANGLE, "", 1, 82, 31, 17, C|||0-0-255|,

TEXTONLY, "Use this window for precise numerical info.", 2, 83, 30, 4, C|Arial9|125-50-75|,
 TEXTONLY, "and access to ALL variables of the model.", 2, 87, 30, 4, C|Arial9|125-50-75|,
 BUTTON, "To Detailed Analysis Screen", 3, 92, 27, 5, L, Xx, , DETAILEDANALYSIS
 RECTANGLE, "", 1, 21, 31, 49, C|||255-0-0|,
 RECTANGLE, "", 2, 22, 29, 5, C|||0-0-255|,
 TEXTONLY, " D E C I S I O N S", 1, 22, 23, 5, L|Times New Roman 16|b|255-0-0|,
 BUTTON, "HELP", 24, 22, 7, 5, L|12|b|, , MAINGHELP
 RECTANGLE, "", 2, 27, 29, 42, C|||0-0-255|,
 BUTTON, "New Grad Students", 3, 28, 21, 5, L||b|, , SPECIAL>SETWBITEM|New Grad Students &WORKBENCH>GRAPH
 MODVAR, "New Grad Students", 25, 28, 5, 5, L, [0|]
 BUTTON, "Grad Fac. Hiring Decision", 3, 35, 21, 5, L||b|, , SPECIAL>SETWBITEM|GF Hiring Decision &WORKBENCH>GRAPH
 MODVAR, "GF Hiring Decision", 25, 35, 5, 5, L,
 BUTTON, "U.grad Fac. Hiring Decision", 3, 42, 21, 5, L||b|, , SPECIAL>SETWBITEM|UGF Hiring Decision &WORKBENCH>GRAPH
 MODVAR, "UGF Hiring Decision", 25, 42, 5, 5, L,
 BUTTON, "IGP Share for Fac. (S/hour)", 3, 49, 21, 5, L||b|, , SPECIAL>SETWBITEM|IGP Income Level &WORKBENCH>GRAPH
 MODVAR, "IGP Income Level", 25, 49, 5, 5, L, [0|]
 BUTTON, "Release Time per GF (h/week)", 3, 56, 21, 5, L, b|, , SPECIAL>SETWBITEM|Release Time for GF
 &WORKBENCH>GRAPH
 MODVAR, "Release Time for GF", 25, 56, 5, 5, L, [0|4|]
 BUTTON, "Advance with These Decisions", 3, 63, 27, 5, L, Ss, GAME>GAMEON,MAINGAME

:SCREEN MAINGHELP

RECTANGLE, "", 1, 2, 31, 4, C|||75-125-55|,
 TEXTONLY, " G A M E C O N T R O L S", 0, 2, 31, 3, C Times New Roman|16||75-125-55|,
 RECTANGLE, "", 1, 6, 31, 13, C|||75-125-55|,
 RECTANGLE, "", 3, 7, 7, 5, C|||75-125-55|,
 TEXTONLY, " Start ", 3, 8, 7, 0, C|System|10|b|75-125-55|,
 RECTANGLE, "", 13, 7, 7, 5, C|||75-125-55|,
 TEXTONLY, " End ", 14, 8, 5, 0, C|System|10|b|75-125-55|,
 RECTANGLE, "", 23, 7, 7, 5, C|||75-125-55|,
 TEXTONLY, " Exit ", 24, 8, 5, 0, C|System|10|b|75-125-55|,
 TEXTONLY, " Final Time", 2, 14, 8, 0, L||b|75-125-55|,
 SHOWVAR,"FINAL TIME",12,13,3,5,L|System|10|b|75-125-55|,
 TEXTONLY, "Current Time", 19, 14, 8, 0, L||b|75-125-55|,
 SHOWVAR,"TIME", 30, 14, 4, 0, L|System|10|b|75-125-55|,
 RECTANGLE, "", 33, 2, 66, 6, C|||75-125-55|,
 TEXTONLY, " M A I N I N D I C A T O R S ", 33, 2, 0, 4, L|Times New Roman|20||75-125-55|,
 RECTANGLE, "", 33, 8, 66, 91, C|||75-125-55|,
 RECTANGLE, "", 77, 3, 21, 4, C|||75-125-55|,
 TEXTONLY, "MORE INDICATORS >>>>>", 77, 3, 21, 4, L||b|75-125-55|, , ,
 RECTANGLE, "", 34, 9, 31, 5, L||b|75-125-55|,
 TEXTONLY, "Number of Grad Students", 34, 9, 23, 5, L||b|75-125-55|,
 SHOWVAR,"Number of Grad Students", 64, 10, 0, 3, R|System|10|b|75-125-55|,
 RECTANGLE, "", 67, 9, 31, 5, L||b|75-125-55|,
 TEXTONLY, "Number of UG Students", 67, 9, 23, 5, L||b|75-125-55|,
 SHOWVAR,"Number of UG Students", 97, 10, 0, 3, R|System|10|b|75-125-55|,
 RECTANGLE, "", 34, 16, 64, 5, C|||255-0-0|,
 TEXTONLY, " H E L P ", 35, 16, 0, 4, L|Times New Roman|20|50-0-200|,
 BUTTON, "CLOSE HELP", 80, 16, 15, 5, L||b|, , MAINGAME
 RECTANGLE, "", 34, 21, 64, 53, C|||255-0-0|,
 TEXTONLY, " * 'New Graduate Students' is the number of students that would be admitted in the", 37, 22, 0, 0, L|Arial|9||125-50-75|,
 TEXTONLY, "current semester. Its minimum value is 0.", 36, 25, 0, 0, L|Arial|9||125-50-75|,
 TEXTONLY, " * 'Graduate Faculty Hiring Decision' is the number of graduate faculty members that the", 36, 29, 0, 0, L|Arial|9||125-50-75|,
 TEXTONLY, "player wants to hire during the current semester. The number of graduate faculty members", 36, 32, 0, 0, L|Arial|9||125-50-75|,
 TEXTONLY, "that can be hired is limited by 'GF Supply'. Also, the total number of faculty members", 36, 35, 0, 0, L|Arial|9||125-50-75|,
 TEXTONLY, "(graduate and under-graduate) that can be hired is limited by 'Vacant Faculty Positions'.", 36, 38, 0, 0, L|Arial|9||125-50-75|,
 TEXTONLY, " * 'Under-graduate Faculty Hiring Decision' is the number of under-graduate faculty", 36, 42, 0, 0, L|Arial|9||125-50-75|,
 TEXTONLY, "members that the player wants to hire during the current semester. The number of under-", 36, 45, 0, 0, L|Arial|9||125-50-75|,
 TEXTONLY, "graduate faculty members that can be hired is limited by 'UGF Supply'. Also, the total", 36, 48, 0, 0, L|Arial|9||125-50-75|,
 TEXTONLY, "number of faculty members (graduate and under-graduate) that can be hired is limited by", 36, 51, 0, 0, L|Arial|9||125-50-75|,
 TEXTONLY, "'Vacant Faculty Positions'.", 36, 54, 0, 0, L|Arial|9||125-50-75|,
 TEXTONLY, " * 'IGP Share for Faculty' is the amount of money paid to a faculty member for one", 36, 58, 0, 0, L|Arial|9||125-50-75|,
 TEXTONLY, "hour of Income Generating Project activities. Its minimum value is 0.", 36, 61, 0, 0, L|Arial|9||125-50-75|,
 TEXTONLY, " * 'Release Time for Graduate Faculty' is the weekly hours reduced from the maximum", 36, 65, 0, 0, L|Arial|9||125-50-75|,
 TEXTONLY, "instruction load of each graduate faculty member, in order to give them more time for ", 36, 68, 0, 0, L|Arial|9||125-50-75|,
 TEXTONLY, "research. Its minimum value is 0 and maximum value is 4.", 36, 71, 0, 0, L|Arial|9||125-50-75|,
 RECTANGLE, "", 34, 75, 31, 5, L||b|75-125-55|,
 TEXTONLY, "IGP Load per GF (h/week)", 34, 75, 23, 5, L||b|75-125-55|,
 SHOWVAR,"Act IGP Load per GF", 64, 76, 0, 3, R|System|10|b|75-125-55|,
 RECTANGLE, "", 67, 75, 31, 5, L||b|75-125-55|,

TEXTONLY, "IGP Load per UGF (h/week)", 67, 75, 23, 5, L||b75-125-55|,
 SHOWVAR, "Act IGP Load per UGF", 97, 76, 0, 3, R|System|10b75-125-55|,
 RECTANGLE, "", 34, 81, 31, 5, L||b75-125-55|,
 TEXTONLY, "Hours Spent for UP per GF(w)", 34, 81, 23, 5, L||b75-125-55|,
 SHOWVAR, "Hours Dedicated to UP per GF", 64, 82, 0, 3, R|System|10b75-125-55|,
 RECTANGLE, "", 67, 81, 31, 5, L||b75-125-55|,
 TEXTONLY, "Hours Spent for UP per UGF(w)", 67, 81, 23, 5, L||b75-125-55|,
 SHOWVAR, "Hours Dedicated to UP per UGF", 97, 82, 0, 3, R|System|10b75-125-55|,
 RECTANGLE, "", 34, 87, 31, 5, L||b75-125-55|,
 TEXTONLY, "Period Research Pap Pub.ed", 34, 87, 23, 5, L||b75-125-55|,
 SHOWVAR, "Period Res Pap Pub", 64, 88, 0, 3, R|System|10b75-125-55|,
 RECTANGLE, "", 67, 87, 31, 5, L||b75-125-55|,
 TEXTONLY, "Period Res Pap per Faculty", 67, 87, 23, 5, L||b75-125-55|,
 SHOWVAR, "Period Res Pap Pub per Faculty", 97, 88, 0, 3, R|System|10b75-125-55|,
 RECTANGLE, "", 34, 93, 31, 5, L||b75-125-55|,
 TEXTONLY, "Funds Obtained from Spons Res", 34, 93, 23, 5, L||b75-125-55|,
 SHOWVAR, "Funds Grants Gotten by Spons Res", 64, 94, 0, 3, R|System|10b75-125-55|,
 RECTANGLE, "", 67, 93, 31, 5, L||b75-125-55|,
 TEXTONLY, "Net Income for University by IGP", 67, 93, 23, 5, L||b75-125-55|,
 SHOWVAR, "Net Income for University by IGP", 97, 94, 0, 3, R|System|10b75-125-55|,
 RECTANGLE, "", 1, 72, 31, 10, C||75-125-55|,
 TEXTONLY, "DETAILED INFO &", 1, 72, 30, 5, L|Times New Roman|14|75-125-55|,
 TEXTONLY, "CAUSAL ANALYSIS", 1, 77, 30, 5, L|Times New Roman|14|75-125-55|,
 RECTANGLE, "", 1, 82, 31, 17, C||75-125-55|,
 TEXTONLY, "Use this window for precise numerical info.", 2, 83, 30, 4, C|Arial|9|75-125-55|,
 TEXTONLY, "and access to ALL variables of the model.", 2, 87, 30, 4, C|Arial|9|75-125-55|,
 RECTANGLE, "", 3, 92, 27, 5, C||75-125-55|,
 TEXTONLY, "To Detailed Analysis Screen", 3, 92, 27, 5, C|System|10|b75-125-55|,
 RECTANGLE, "", 1, 21, 31, 49, C||75-125-55|,
 RECTANGLE, "", 2, 22, 29, 5, C||75-125-55|,
 TEXTONLY, "DECISIONS", 1, 22, 23, 5, L|Times New Roman|16|b75-125-55|,
 RECTANGLE, "", 24, 22, 7, 5, C||75-125-55|,
 TEXTONLY, "HELP", 25, 23, 0, 5, L|12|b75-125-55|,, ,
 RECTANGLE, "", 2, 27, 29, 42, C||75-125-55|,
 RECTANGLE, "", 3, 28, 21, 5, L||75-125-55|,
 TEXTONLY, "New Grad Students", 3, 29, 21, 3, L||b75-125-55|,
 RECTANGLE, "", 25, 28, 5, 5, L||75-125-55|,
 RECTANGLE, "", 3, 35, 21, 5, L||75-125-55|,
 TEXTONLY, "Grad Fac. Hiring Decision", 3, 36, 21, 3, L||b75-125-55|,
 RECTANGLE, "", 25, 35, 5, 5, L||75-125-55|,
 RECTANGLE, "", 3, 42, 21, 5, L||75-125-55|,
 TEXTONLY, "Und.grad Fac. Hiring Decision", 3, 43, 21, 3, L||b75-125-55|,
 RECTANGLE, "", 25, 42, 5, 5, L||75-125-55|,
 RECTANGLE, "", 3, 49, 21, 5, L||75-125-55|,
 TEXTONLY, "IGP Share for Fac. (S/hour)", 3, 50, 21, 3, L||b75-125-55|,
 RECTANGLE, "", 25, 49, 5, 5, L||75-125-55|,
 RECTANGLE, "", 3, 56, 21, 5, L||75-125-55|,
 TEXTONLY, "Release Time per GF (h/week)", 3, 57, 21, 3, L||b75-125-55|,
 RECTANGLE, "", 25, 56, 5, 5, L||75-125-55|,
 RECTANGLE, "", 3, 63, 27, 5, L||75-125-55|,
 TEXTONLY, "Advance with These Decisions", 3, 63, 27, 5, C|System|10|b75-125-55|,

:SCREEN MAINGAMEB

RECTANGLE, "", 1, 2, 31, 4, C||0-0-255|,
 TEXTONLY, " GAME CONTROL S", 0, 2, 31, 3, C|Times New Roman|16|125-50-75|,
 RECTANGLE, "", 1, 6, 31, 13, C||0-0-255|,
 RECTANGLE, "", 3, 7, 7, 5, C||75-125-55|,
 TEXTONLY, " Start ", 3, 8, 7, 0, C|System|10|b75-125-55|,
 BUTTON, " End ", 13, 7, 7, 0, L, Ee, , ASKENDB
 BUTTON, " Exit ", 23, 7, 7, 0, L, Xx, , ASKEXIT2B
 TEXTONLY, " Final Time", 2, 14, 8, 0, L||b0-0-0|,
 SHOWVAR, "FINAL TIME", 12, 13, 3, 5, L|System|10|b0-0-0|,
 TEXTONLY, "Current Time", 19, 14, 8, 0, L||b0-0-255|,
 SHOWVAR, "TIME", 30, 14, 4, 0, L|System|10|b255-0-0|,
 RECTANGLE, "", 33, 2, 66, 6, C||0-0-255|,
 TEXTONLY, " MORE INDICATORS ", 54, 2, 0, 4, L|Times New Roman|20||50-0-200|,
 RECTANGLE, "", 33, 8, 66, 91, C||0-0-255|,
 BUTTON, "<<<<< MAIN INDICATORS", 34, 3, 21, 4, L||b|, , , MAINGAME
 RECTANGLE, "", 34, 9, 31, 5,
 BUTTON, "Instr Overhead per Gr. Stu (h/w)", 34, 9, 23, 5, L||b|, , SPECIAL>SETWBITEM|Act GI Overhead per Grad Stu
 &WORKBENCH>GRAPH
 SHOWVAR, "Act GI Overhead per Grad Stu", 64, 10, 0, 3, R|System|10|b0-0-255|,
 RECTANGLE, "", 67, 9, 31, 5,
 BUTTON, "Instr Overhead per UG Stu (h/w)", 67, 9, 23, 5, L||b|, , SPECIAL>SETWBITEM|Act UGI Overhead per UG Stu
 &WORKBENCH>GRAPH

SHOWVAR, "Act UGI Overhead per UG Stu", 97, 10, 0, 3, R[System\10\b\0-0-255],
 RECTANGLE, "", 34, 15, 31, 5
 BUTTON, "UG Stu./Grad Stu. Ratio", 34, 15, 23, 5, L|||b|, , SPECIAL>SETWBITEM\UG Students Grad Students Ratio
 &WORKBENCH>GRAPH
 SHOWVAR, "UG Students Grad Students Ratio", 64, 16, 0, 3, R[System\10\b\0-0-255],
 RECTANGLE, "", 67, 15, 31, 5
 BUTTON, "Number of Assistants", 67, 15, 23, 5, L|||b|, , SPECIAL>SETWBITEM\Number of Assistants &WORKBENCH>GRAPH
 SHOWVAR, "Number of Assistants", 97, 16, 0, 3, R[System\10\b\0-0-255],
 RECTANGLE, "", 34, 21, 31, 5
 BUTTON, "Grad Stu./Grad Faculty Ratio", 34, 21, 23, 5, L|||b|, , SPECIAL>SETWBITEM\Grad Students GF Ratio
 &WORKBENCH>GRAPH
 SHOWVAR, "Grad Students GF Ratio", 64, 22, 0, 3, R[System\10\b\0-0-255],
 RECTANGLE, "", 67, 21, 31, 5
 BUTTON, "UG Stu./Faculty Ratio", 67, 21, 23, 5, L|||b|, , SPECIAL>SETWBITEM\UG Students Fac Ratio &WORKBENCH>GRAPH
 SHOWVAR, "UG Students Fac Ratio", 97, 22, 0, 3, R[System\10\b\0-0-255],
 RECTANGLE, "", 34, 27, 31, 5
 BUTTON, "Grad Stu.1/Grad Faculty", 34, 27, 23, 5, L|||b|, , SPECIAL>SETWBITEM\Grad Stu1 GF Ratio &WORKBENCH>GRAPH
 SHOWVAR, "Grad Stu1 GF Ratio", 64, 28, 0, 3, R[System\10\b\0-0-255],
 RECTANGLE, "", 67, 27, 31, 5
 BUTTON, "Grad Stu.2/Grad Faculty", 67, 27, 23, 5, L|||b|, , SPECIAL>SETWBITEM\Grad Stu2 GF Ratio &WORKBENCH>GRAPH
 SHOWVAR, "Grad Stu2 GF Ratio", 97, 28, 0, 3, R[System\10\b\0-0-255],
 RECTANGLE, "", 34, 33, 31, 5
 BUTTON, "Grad Stu./FTE for Grad Instr", 34, 33, 23, 5, L|||b|, , SPECIAL>SETWBITEM\Grad Stu FTE for GI
 &WORKBENCH>GRAPH
 SHOWVAR, "Grad Stu FTE for GI", 64, 34, 0, 3, R[System\10\b\0-0-255],
 RECTANGLE, "", 67, 33, 31, 5
 BUTTON, "UG Stu./FTE for UG Instr", 67, 33, 23, 5, L|||b|, , SPECIAL>SETWBITEM\UG Stu FTE for UGI &WORKBENCH>GRAPH
 SHOWVAR, "UG Stu FTE for UGI", 97, 34, 0, 3, R[System\10\b\0-0-255],
 RECTANGLE, "", 34, 39, 31, 5
 BUTTON, "Cancelled Grad Courses (/week)", 34, 39, 23, 5, L|||b|, , SPECIAL>SETWBITEM\Cancelled Grad Courses
 &WORKBENCH>GRAPH
 SHOWVAR, "Cancelled Grad Courses", 64, 40, 0, 3, R[System\10\b\0-0-255],
 RECTANGLE, "", 67, 39, 31, 5
 BUTTON, "Cancelled UG Courses (/week)", 67, 39, 23, 5, L|||b|, , SPECIAL>SETWBITEM\Cancelled UG Courses
 &WORKBENCH>GRAPH
 SHOWVAR, "Cancelled UG Courses", 97, 40, 0, 3, R[System\10\b\0-0-255],
 RECTANGLE, "", 34, 45, 31, 5
 BUTTON, "Part Time Fac % for Gr. Instr", 34, 45, 23, 5, L|||b|, , SPECIAL>SETWBITEM\Part Time Percentage for Grad Instr
 &WORKBENCH>GRAPH
 SHOWVAR, "Part Time Percentage for Grad Instr", 64, 46, 0, 3, R[System\10\b\0-0-255],
 RECTANGLE, "", 67, 45, 31, 5
 BUTTON, "Part Time Fac % for UG Instr", 67, 45, 23, 5, L|||b|, , SPECIAL>SETWBITEM\Part Time Percentage for UG Instr
 &WORKBENCH>GRAPH
 SHOWVAR, "Part Time Percentage for UG Instr", 97, 46, 0, 3, R[System\10\b\0-0-255],
 RECTANGLE, "", 34, 51, 31, 5
 BUTTON, "Grad Fac Spons Res Commitm.", 34, 51, 23, 5, L|||b|, , SPECIAL>SETWBITEM\GF Spons Res Commitment
 &WORKBENCH>GRAPH
 SHOWVAR, "GF Spons Res Commitment", 64, 52, 0, 3, R[System\10\b\0-0-255],
 RECTANGLE, "", 67, 51, 31, 5
 BUTTON, "UG Fac Spons Res Commitm.", 67, 51, 23, 5, L|||b|, , SPECIAL>SETWBITEM\UGF Spons Res Commitment
 &WORKBENCH>GRAPH
 SHOWVAR, "UGF Spons Res Commitment", 97, 52, 0, 3, R[System\10\b\0-0-255],
 RECTANGLE, "", 34, 57, 31, 5
 BUTTON, "Grad Fac Unspons Res Commitm.", 34, 57, 23, 5, L|||b|, , SPECIAL>SETWBITEM\GF Unsponsored Res Commitment
 &WORKBENCH>GRAPH
 SHOWVAR, "GF Unsponsored Res Commitment", 64, 58, 0, 3, R[System\10\b\0-0-255],
 RECTANGLE, "", 67, 57, 31, 5
 BUTTON, "UG Fac Unspons Res Commitm.", 67, 57, 23, 5, L|||b|, , SPECIAL>SETWBITEM\UGF Unsponsored Res Commitment
 &WORKBENCH>GRAPH
 SHOWVAR, "UGF Unsponsored Res Commitment", 97, 58, 0, 3, R[System\10\b\0-0-255],
 RECTANGLE, "", 34, 63, 31, 5
 BUTTON, "Grad Fac IGP Motivation", 34, 63, 23, 5, L|||b|, , SPECIAL>SETWBITEM\GF IGP Motivation &WORKBENCH>GRAPH
 SHOWVAR, "GF IGP Motivation", 64, 64, 0, 3, R[System\10\b\0-0-255],
 RECTANGLE, "", 67, 63, 31, 5
 BUTTON, "UG Fac IGP Motivation", 67, 63, 23, 5, L|||b|, , SPECIAL>SETWBITEM\UGF IGP Motivation &WORKBENCH>GRAPH
 SHOWVAR, "UGF IGP Motivation", 97, 64, 0, 3, R[System\10\b\0-0-255],
 RECTANGLE, "", 34, 69, 31, 5
 BUTTON, "Grad Fac UP Motivation", 34, 69, 23, 5, L|||b|, , SPECIAL>SETWBITEM\GF UP Motivation &WORKBENCH>GRAPH
 SHOWVAR, "GF UP Motivation", 64, 70, 0, 3, R[System\10\b\0-0-255],
 RECTANGLE, "", 67, 69, 31, 5
 BUTTON, "UG Fac UP Motivation", 67, 69, 23, 5, L|||b|, , SPECIAL>SETWBITEM\GF UP Motivation &WORKBENCH>GRAPH
 SHOWVAR, "GF UP Motivation", 97, 70, 0, 3, R[System\10\b\0-0-255],
 RECTANGLE, "", 34, 75, 31, 5
 BUTTON, "Grad Fac Teaching Commitment", 34, 75, 23, 5, L|||b|, , SPECIAL>SETWBITEM\GF Teaching Commitment
 &WORKBENCH>GRAPH
 SHOWVAR, "GF Teaching Commitment", 64, 76, 0, 3, R[System\10\b\0-0-255],
 RECTANGLE, "", 67, 75, 31, 5

BUTTON, "UG Fac Teaching Commitment ", 67, 75, 23, 5, L||b|, , SPECIAL>SETWBITEM(UGF Teaching Commitment &WORKBENCH>GRAPH
SHOWVAR, "UGF Teaching Commitment ", 97, 76, 0, 3, R\System\10\b\0-0-255|,
RECTANGLE, "", 34, 81, 31, 5
BUTTON, "Grad Fac Res Pap Productivity", 34, 81, 23, 5, L||b|, , SPECIAL>SETWBITEM(GF Res Pap Productivity &WORKBENCH>GRAPH
SHOWVAR, "GF Res Pap Productivity", 64, 82, 0, 3, R\System\10\b\0-0-255|,
RECTANGLE, "", 67, 81, 31, 5
BUTTON, "UG Fac Res Pap Productivity", 67, 81, 23, 5, L||b|, , SPECIAL>SETWBITEM(UGF Res Pap Productivity &WORKBENCH>GRAPH
SHOWVAR, "UGF Res Pap Productivity", 97, 82, 0, 3, R\System\10\b\0-0-255|,
RECTANGLE, "", 34, 87, 31, 5
BUTTON, "GF Sp.R. Fund Prod(\$/fac*sem.)", 34, 87, 23, 5, L||b|, , SPECIAL>SETWBITEM(GF Spons Res Funds Grants Productivity &WORKBENCH>GRAPH
SHOWVAR, "GF Spons Res Funds Grants Productivity", 64, 88, 0, 3, R\System\10\b\0-0-255|,
RECTANGLE, "", 67, 87, 31, 5
BUTTON, "UGF Sp.R. Fund Prod(\$/fac*sem.)", 67, 87, 23, 5, L||b|, , SPECIAL>SETWBITEM(UGF Spons Res Funds Grants Productivity &WORKBENCH>GRAPH
SHOWVAR, "UGF Spons Res Funds Grants Productivity ", 97, 88, 0, 3, R\System\10\b\0-0-255|,
RECTANGLE, "", 34, 93, 31, 5
BUTTON, "Grad Fac IGP Prod (\$/fac*semtr.)", 34, 93, 23, 5, L||b|, , SPECIAL>SETWBITEM(UGF IGP Productivity &WORKBENCH>GRAPH
SHOWVAR, "UGF IGP Productivity", 64, 94, 0, 3, R\System\10\b\0-0-255|,
RECTANGLE, "", 67, 93, 31, 5
BUTTON, "UG Fac IGP Prod (\$/fac*semtr.)", 67, 93, 23, 5, L||b|, , SPECIAL>SETWBITEM(UGF IGP Productivity &WORKBENCH>GRAPH
SHOWVAR, "UGF IGP Productivity", 97, 94, 0, 3, R\System\10\b\0-0-255|,
RECTANGLE, "", 1, 72, 31, 10, C|||0-0-255|,
TEXTONLY, "DETAILED INFO &", 1, 72, 30, 5, L|Times New Roman|14||5-180-70|,
TEXTONLY, "CAUSAL ANALYSIS", 1, 77, 30, 5, L|Times New Roman|14||5-180-70|,
RECTANGLE, "", 1, 82, 31, 17, C|||0-0-255|,
TEXTONLY, "Use this window for precise numerical info.", 2, 83, 30, 4, C|Arial|9||125-50-75|,
TEXTONLY, "and access to ALL variables of the model.", 2, 87, 30, 4, C|Arial|9||125-50-75|,
BUTTON, "To Detailed Analysis Screen", 3, 92, 27, 5, L, Xx, , BDANALYSIS
RECTANGLE, "", 1, 21, 31, 49, C|||255-0-0|,
RECTANGLE, "", 2, 22, 29, 5, C|||0-0-255|,
TEXTONLY, " DECISIONS", 1, 22, 23, 5, L|Times New Roman|16\b\255-0-0|,
BUTTON, "HELP", 24, 22, 7, 5, L|12\b|, , MAINGBHELP
RECTANGLE, "", 2, 27, 29, 42, C|||0-0-255|,
BUTTON, "New Grad Students", 3, 28, 21, 5, L||b|, , SPECIAL>SETWBITEM(New Grad Students &WORKBENCH>GRAPH
MODVAR, "New Grad Students", 25, 28, 5, 5, L, [0|]
BUTTON, "Grad Fac. Hiring Decision", 3, 35, 21, 5, L||b|, , SPECIAL>SETWBITEM(GF Hiring Decision &WORKBENCH>GRAPH
MODVAR, "GF Hiring Decision", 25, 35, 5, 5, L,
BUTTON, "U.grad Fac. Hiring Decision", 3, 42, 21, 5, L||b|, , SPECIAL>SETWBITEM(UGF Hiring Decision &WORKBENCH>GRAPH
MODVAR, "UGF Hiring Decision", 25, 42, 5, 5, L,
BUTTON, "IGP Share for Fac. (\$/hour)", 3, 49, 21, 5, L||b|, , SPECIAL>SETWBITEM(IGP Income Level &WORKBENCH>GRAPH
MODVAR, "IGP Income Level", 25, 49, 5, 5, L, [0|]
BUTTON, "Release Time per GF (h/week)", 3, 56, 21, 5, L||b|, , SPECIAL>SETWBITEM(Release Time for GF &WORKBENCH>GRAPH
MODVAR, "Release Time for GF", 25, 56, 5, 5, L, [0|4|]
BUTTON, "Advance with These Decisions", 3, 63, 27, 5, L, Ss, GAME>GAMEON,MAINGAMEB

:SCREEN MAINGBHELP

RECTANGLE, "", 1, 2, 31, 4, C|||75-125-55|,
TEXTONLY, " GAME CONTROL S", 0, 2, 31, 3, C|Times New Roman|16||75-125-55|,
RECTANGLE, "", 1, 6, 31, 13, C|||75-125-55|,
RECTANGLE, "", 3, 7, 7, 5, C|||75-125-55|,
TEXTONLY, " Start ", 3, 8, 7, 0, C|System\10\b\75-125-55|,
RECTANGLE, "", 13, 7, 7, 5, C|||75-125-55|,
TEXTONLY, " End ", 14, 8, 5, 0, C|System\10\b\75-125-55|,
RECTANGLE, "", 23, 7, 7, 5, C|||75-125-55|,
TEXTONLY, " Exit ", 24, 8, 5, 0, C|System\10\b\75-125-55|,
TEXTONLY, " Final Time", 2, 14, 8, 0, L||b\75-125-55|,
SHOWVAR, "FINAL TIME", 12, 13, 3, 5, L|System\10\b\75-125-55|,
TEXTONLY, "Current Time", 19, 14, 8, 0, L||b\75-125-55|,
SHOWVAR, "TIME", 30, 14, 4, 0, L|System\10\b\75-125-55|,
RECTANGLE, "", 33, 2, 66, 6, C|||75-125-55|,
TEXTONLY, " MORE INDICATORS ", 54, 2, 0, 4, L|Times New Roman|20||75-125-55|,
RECTANGLE, "", 33, 8, 66, 91, C|||75-125-55|,
RECTANGLE, "", 34, 3, 21, 4, C|||75-125-55|,
TEXTONLY, "<<<<< MAIN INDICATORS", 34, 3, 21, 4, L||b\75-125-55|, , 4
RECTANGLE, "", 34, 9, 31, 5, L||b\75-125-55|,
TEXTONLY, "Instr Overhead per Gr. Stu (h'w)", 34, 9, 23, 5, L||b\75-125-55|,
SHOWVAR, "Act GI Overhead per Grad Stu", 64, 10, 0, 3, R\System\10\b\75-125-55|,
RECTANGLE, "", 67, 9, 31, 5, L||b\75-125-55|,

TEXTONLY, "Instr Overhead per UG Stu (h'w)", 67, 9, 23, 5, L||b|75-125-55|,
 SHOWVAR, "Act UGI Overhead per UG Stu", 97, 10, 0, 3, R|System|10|b|75-125-55|,
 RECTANGLE, "", 34, 16, 64, 5, C|||255-0-0|,
 TEXTONLY, " H E L P ", 35, 16, 0, 4, L|Times New Roman|20|50-0-200|,
 BUTTON, "CLOSE HELP", 80, 16, 15, 5, L||b|, , , MAINGAMEB
 RECTANGLE, "", 34, 21, 64, 53, C|||255-0-0|,
 TEXTONLY, " * 'New Graduate Students' is the number of students that would be admitted in the", 37, 22, 0, 0, L|Arial 9|125-50-75|,
 TEXTONLY, "current semester. Its minimum value is 0.", 36, 25, 0, 0, L|Arial 9|125-50-75|,
 TEXTONLY, " * 'Graduate Faculty Hiring Decision' is the number of graduate faculty members that the", 36, 29, 0, 0, L|Arial 9|125-50-75|,
 TEXTONLY, "player wants to hire during the current semester. The number of graduate faculty members", 36, 32, 0, 0, L|Arial 9|125-50-75|,
 TEXTONLY, "that can be hired is limited by 'GF Supply'. Also, the total number of faculty members", 36, 35, 0, 0, L|Arial 9|125-50-75|,
 TEXTONLY, "(graduate and under-graduate) that can be hired is limited by 'Vacant Faculty Positions'.", 36, 38, 0, 0, L|Arial 9|125-50-75|,
 TEXTONLY, " * 'Under-graduate Faculty Hiring Decision' is the number of under-graduate faculty", 36, 42, 0, 0, L|Arial 9|125-50-75|,
 TEXTONLY, "members that the player wants to hire during the current semester. The number of under-", 36, 45, 0, 0, L|Arial 9|125-50-75|,
 TEXTONLY, "graduate faculty members that can be hired is limited by 'UGF Supply'. Also, the total", 36, 48, 0, 0, L|Arial 9|125-50-75|,
 TEXTONLY, "number of faculty members (graduate and under-graduate) that can be hired is limited by", 36, 51, 0, 0, L|Arial 9|125-50-75|,
 TEXTONLY, "Vacant Faculty Positions.", 36, 54, 0, 0, L|Arial 9|125-50-75|,
 TEXTONLY, " * 'IGP Share for Faculty' is the amount of money paid to a faculty member for one", 36, 58, 0, 0, L|Arial 9|125-50-75|,
 TEXTONLY, "hour of Income Generating Project activities. Its minimum value is 0.", 36, 61, 0, 0, L|Arial 9|125-50-75|,
 TEXTONLY, " * 'Release Time for Graduate Faculty' is the weekly hours reduced from the maximum", 36, 65, 0, 0, L|Arial 9|125-50-75|,
 TEXTONLY, "instruction load of each graduate faculty member, in order to give them more time for ", 36, 68, 0, 0, L|Arial 9|125-50-75|,
 TEXTONLY, "research. Its minimum value is 0 and maximum value is 4.", 36, 71, 0, 0, L|Arial 9|125-50-75|,
 RECTANGLE, "", 34, 75, 31, 5, L||b|75-125-55|,
 TEXTONLY, "Grad Fac Teaching Commitment", 34, 75, 23, 5, L||b|75-125-55|,
 SHOWVAR, "GF Teaching Commitment", 64, 76, 0, 3, R|System|10|b|75-125-55|,
 RECTANGLE, "", 67, 75, 31, 5, L||b|75-125-55|,
 TEXTONLY, "UG Fac Teaching Commitment", 67, 75, 23, 5, L||b|75-125-55|,
 SHOWVAR, "UGF Teaching Commitment ", 97, 76, 0, 3, R|System|10|b|75-125-55|,
 RECTANGLE, "", 34, 81, 31, 5, L||b|75-125-55|,
 TEXTONLY, "Grad Fac Res Pap Productivity", 34, 81, 23, 5, L||b|75-125-55|,
 SHOWVAR, "GF Res Pap Productivity", 64, 82, 0, 3, R|System|10|b|75-125-55|,
 RECTANGLE, "", 67, 81, 31, 5, L||b|75-125-55|,
 TEXTONLY, "UG Fac Res Pap Productivity", 67, 81, 23, 5, L||b|75-125-55|,
 SHOWVAR, "UGF Res Pap Productivity", 97, 82, 0, 3, R|System|10|b|75-125-55|,
 RECTANGLE, "", 34, 87, 31, 5, L||b|75-125-55|,
 TEXTONLY, "GF Sp.R. Fund Prod(\$/fac*sem.)", 34, 87, 23, 5, L||b|75-125-55|,
 SHOWVAR, "GF Spons Res Funds Grants Productivity", 64, 88, 0, 3, R|System|10|b|75-125-55|,
 RECTANGLE, "", 67, 87, 31, 5, L||b|75-125-55|,
 TEXTONLY, "UGF Sp.R. Fund Prod(\$/fac*sem.)", 67, 87, 23, 5, L||b|75-125-55|,
 SHOWVAR, "UGF Spons Res Funds Grants Productivity", 97, 88, 0, 3, R|System|10|b|75-125-55|,
 RECTANGLE, "", 34, 93, 31, 5, L||b|75-125-55|,
 TEXTONLY, "Grad Fac IGP Prod (\$/fac*semtr.)", 34, 93, 23, 5, L||b|75-125-55|,
 SHOWVAR, "UGF IGP Productivity", 64, 94, 0, 3, R|System|10|b|75-125-55|,
 RECTANGLE, "", 67, 93, 31, 5, L||b|75-125-55|,
 TEXTONLY, "UG Fac IGP Prod (\$/fac*semtr.)", 67, 93, 23, 5, L||b|75-125-55|,
 SHOWVAR, "UGF IGP Productivity", 97, 94, 0, 3, R|System|10|b|75-125-55|,
 RECTANGLE, "", 1, 72, 31, 10, C|||75-125-55|,
 TEXTONLY, "D E T A I L E D I N F O & ", 1, 72, 30, 5, L|Times New Roman|14|75-125-55|,
 TEXTONLY, "C A U S A L A N A L Y S I S", 1, 77, 30, 5, L|Times New Roman|14|75-125-55|,
 RECTANGLE, "", 1, 82, 31, 17, C|||75-125-55|,
 TEXTONLY, "Use this window for precise numerical info.", 2, 83, 30, 4, C|Arial 9|75-125-55|,
 TEXTONLY, "and access to ALL variables of the model.", 2, 87, 30, 4, C|Arial 9|75-125-55|,
 RECTANGLE, "", 3, 92, 27, 5, C|||75-125-55|,
 TEXTONLY, "To Detailed Analysis Screen", 3, 92, 27, 5, C|System|10|b|75-125-55|,
 RECTANGLE, "", 1, 21, 31, 49, C|||75-125-55|,
 RECTANGLE, "", 2, 22, 29, 5, C|||75-125-55|,
 TEXTONLY, " D E C I S I O N S", 1, 22, 23, 5, L|Times New Roman|16|b|75-125-55|,
 RECTANGLE, "", 24, 22, 7, 5, C|||75-125-55|,
 TEXTONLY, "HELP", 25, 23, 0, 5, L||12|b|75-125-55|, , ,
 RECTANGLE, "", 2, 27, 29, 42, C|||75-125-55|,
 RECTANGLE, "", 3, 28, 21, 5, L||75-125-55|,
 TEXTONLY, "New Grad Students", 3, 29, 21, 3, L||b|75-125-55|,
 RECTANGLE, "", 25, 28, 5, 5, L||75-125-55|,
 RECTANGLE, "", 3, 35, 21, 5, L||75-125-55|,
 TEXTONLY, "Grad Fac. Hiring Decision", 3, 36, 21, 3, L||b|75-125-55|,
 RECTANGLE, "", 25, 35, 5, 5, L||75-125-55|,
 RECTANGLE, "", 3, 42, 21, 5, L||75-125-55|,
 TEXTONLY, "Und.grad Fac. Hiring Decision", 3, 43, 21, 3, L||b|75-125-55|,
 RECTANGLE, "", 25, 42, 5, 5, L||75-125-55|,
 RECTANGLE, "", 3, 49, 21, 5, L||75-125-55|,
 TEXTONLY, "IGP Share for Fac. (\$/hour)", 3, 50, 21, 3, L||b|75-125-55|,
 RECTANGLE, "", 25, 49, 5, 5, L||75-125-55|,

RECTANGLE, "", 3, 56, 21, 5, L|||75-125-55},
 TEXTONLY, "Release Time per GF (h/week)", 3, 57, 21, 3, L||b 75-125-55.
 RECTANGLE, "", 25, 56, 5, 5, L|||75-125-55},
 RECTANGLE, "", 3, 63, 27, 5, L|||75-125-55},
 TEXTONLY, "Advance with These Decisions", 3, 63, 27, 5, C|System 10 b 75-125-55},

:SCREEN ASKEXIT2

TEXTONLY, "Do You Really Want to Exit?", 0, 30, 100, 0, C|Times New Roman 22;b|0-0-255},
 TEXTONLY, "(You Will Leave the Simulation Environment!)", 0, 40, 100, 0, C|Times New Roman|18;b|255-0-0},
 BUTTON, " Yes ", 40, 49, 10, 0, C, ,,EXIT
 BUTTON, " No ", 60, 49, 10, 0, C, ,,MAINGAME

:SCREEN ASKEND

TEXTONLY, "Do You Really Want to End the Game?", 0, 30, 100, 0, C|Times New Roman|22;b|0-0-255},
 TEXTONLY, "(You Will Loose the Current Game Data!)", 0, 40, 100, 0, C|Times New Roman|18;b|255-0-0},
 BUTTON, " Yes ", 40, 49, 10, 0, C, ,,NAMERUN
 BUTTON, " No ", 60, 49, 10, 0, C, ,,MAINGAME

:SCREEN ASKEXIT2B

TEXTONLY, "Do You Really Want to Exit?", 0, 30, 100, 0, C|Times New Roman 22;b|0-0-255},
 TEXTONLY, "(You Will Leave the Simulation Environment!)", 0, 40, 100, 0, C|Times New Roman|18;b|255-0-0},
 BUTTON, " Yes ", 40, 49, 10, 0, C, ,,EXIT
 BUTTON, " No ", 60, 49, 10, 0, C, ,,MAINGAMEB

:SCREEN ASKENDB

TEXTONLY, "Do You Really Want to End the Game?", 0, 30, 100, 0, C|Times New Roman|22;b|0-0-255},
 TEXTONLY, "(You Will Loose the Current Game Data!)", 0, 40, 100, 0, C|Times New Roman|18;b|255-0-0},
 BUTTON, " Yes ", 40, 49, 10, 0, C, ,,NAMERUN
 BUTTON, " No ", 60, 49, 10, 0, C, ,,MAINGAMEB

:SCREEN DETAILEDANALYSIS

TEXTONLY, "Detailed Analysis Screen", 0, 7, 100, 0, C|Times New Roman 22;b|5-180-70},
 TEXTONLY, "You can move the output objects by holding the white strip at the top of them.", 0, 15, 100, 0, C|Times New Roman|12;b|125-50-75},
 TEXTONLY, "You can close the output objects by clicking the box at the NorthWest corner.", 0, 18, 100, 0, C|Times New Roman|12;b|125-50-75},
 TEXTONLY, "First Select the Variable You Want to Analyze as 'Active Variable'.", 0, 24, 100, 0, C|Times New Roman|14;b|255-0-0},
 BUTTON, "Select Active Variable", 7, 66, 40, 0, L, , SPECIAL>VARSELECT|New Active Variable?,
 BUTTON, "Graph for Active Variable", 53, 66, 40, 0, L, , WORKBENCH>STRIP GRAPH
 BUTTON, "Causes of Active Variable", 7, 72, 40, 0, L, , WORKBENCH>CAUSES TREE
 BUTTON, "Graph for Active Variable and Its Causes", 53, 72, 40, 0, L, , WORKBENCH>CAUSES STRIP
 BUTTON, "Uses of Active Variable", 7, 78, 40, 0, L, , WORKBENCH>USES TREE
 BUTTON, "Table for Active Variable and Its Causes", 53, 78, 40, 0, L, , WORKBENCH>CAUSES TAB
 TEXTONLY, "!!! YOU MAY HAVE TO WAIT A LOT FOR THE LOOPS!!!", 27, 85, 0, 0, C|Arial|12;b|255-0-0},
 BUTTON, "Loops Related with Active Variable", 7, 90, 40, 0, L, , WORKBENCH>LOOPS
 BUTTON, "Back to Game Screen", 53, 90, 40, 0, L, ,,MAINGAME

:SCREEN BDANALYSIS

TEXTONLY, "Detailed Analysis Screen", 0, 7, 100, 0, C|Times New Roman 22;b|5-180-70},
 TEXTONLY, "You can move the output objects by holding the white strip at the top of them.", 0, 15, 100, 0, C|Times New Roman|12;b|125-50-75},
 TEXTONLY, "You can close the output objects by clicking the box at the NorthWest corner.", 0, 18, 100, 0, C|Times New Roman|12;b|125-50-75},
 TEXTONLY, "First Select the Variable You Want to Analyze as 'Active Variable'.", 0, 24, 100, 0, C|Times New Roman|14;b|255-0-0},
 BUTTON, "Select Active Variable", 7, 66, 40, 0, L, , SPECIAL>VARSELECT|New Active Variable?,
 BUTTON, "Graph for Active Variable", 53, 66, 40, 0, L, , WORKBENCH>STRIP GRAPH
 BUTTON, "Causes of Active Variable", 7, 72, 40, 0, L, , WORKBENCH>CAUSES TREE
 BUTTON, "Graph for Active Variable and Its Causes", 53, 72, 40, 0, L, , WORKBENCH>CAUSES STRIP
 BUTTON, "Uses of Active Variable", 7, 78, 40, 0, L, , WORKBENCH>USES TREE
 BUTTON, "Table for Active Variable and Its Causes", 53, 78, 40, 0, L, , WORKBENCH>CAUSES TAB
 TEXTONLY, "!!! YOU MAY HAVE TO WAIT A LOT FOR THE LOOPS!!!", 27, 85, 0, 0, C|Arial|12;b|255-0-0},
 BUTTON, "Loops Related with Active Variable", 7, 90, 40, 0, L, , WORKBENCH>LOOPS
 BUTTON, "Back to Game Screen", 53, 90, 40, 0, L, ,,MAINGAMEB

APPENDIX F

THE UNIVERSITY GAME

What is The University Game

The University Game is an interactive dynamic simulation model. The model, which the game is based on, is a system dynamics model of the academic aspects of a university management system. In particular the model focuses on those university problems that are dynamic and persistent in nature and as such must be addressed by high level, strategic policy making mechanisms within the university. These strategic policy making mechanisms are typically the rector, the deans and the major policy making councils at the university and divisional levels. The player plays the part of a university policy-maker, who is trying to seek a delicate balance among the main academic functions of the university, in order to get better output from these activities, both in terms of quality and quantity. Examples of output measures include number of research papers published, income generated for the university from projects and sponsored research, average class size, student/faculty ratios, etc.

The player does not have too many decision opportunities, because most of the decisions are imposed by the environment the university exists in. For example, the number of new students to be admitted to under-graduate study, salaries paid to faculty members, vacant positions and many other conditions are imposed on the player. The objective of the player is to make five decisions, so as to improve the indicators about the quality and quantity of the performance of the university, within the limitations imposed by outside factors.

Logical Flow of the Game

The game is designed as a series of screens which are connected to each other. The opening screen displays the title of the game and the credits. After a key on the mouse or the keyboard is pressed this screen is cleared and a name for the file which will keep the data of the new game is asked. Though the player can give any name to this file (provided that it has the extension `.vdf` and it is at most eight characters long), it will be better to give

file names which indicate the player and the order of the games; for example, **JSmith01.vdf**, **JSmith02.vdf**, **JSmith03.vdf**, so on. This will simplify the process of evaluating the results.

After a name is given to the data file, the game initiation screen appears. Here, the player decides the length of the simulation. The simulation is done in terms of semesters, i.e., one time unit is equal to one semester. The simulation can last 10 to 50 semesters and the player selects the value for the final time from the drop-down box. The player can also enter the prompt box a value which is not displayed in the drop-down box, provided that the value is between 10 and 50 inclusively.

After the final time is decided, the game is initiated by pressing the **Start** button in the **Game Controls** box, that is displayed at the top left corner of the screen. The player can leave the simulation environment by pressing the **Exit** button.

After the **Start** button is pressed the main game screen appears. On the top left corner of the screen are the game controls. Here, the final time and the current time are displayed. There are two buttons. One of them is the **Exit** button and the other is the **End** button which can be used to end the current game at any time of the simulation, without leaving the simulation environment.

Under the game controls, the **Decision** box is displayed. The player enters his decisions in the boxes to the right of the buttons with the names of the decision variables on them. After the decisions are made, the **Advance ...** button should be pressed. When this button is pressed the simulation advances one interval (semester) and the new values of the variables are calculated.

On the right side of the screen, are the **main indicators** of the model. The numbers in blue are the values of the variables written in the buttons, at the current time interval. Pressing the buttons, the dynamic behavior patterns of the variables can be displayed. The **More Indicators** button will turn the page to display some more indicators. It is possible to display the main indicators again, by pressing the **Main Indicators** button. There is a total of 60 indicators on two pages.

On the bottom left corner is the **More Info and Causal Analysis** box. The button in this box makes possible the detailed analysis of ALL the variables included in the model. On the **Detailed Analysis Screen** are eight buttons. The top left button must be clicked first, to select a variable to analyze. The other three buttons on the left and the buttons on the right are used to display analysis objects like behavior patterns, tables fish-bone graphs and feedback loop diagrams. The button on the bottom right takes the player back to the main game screen.

Hints and Warnings

The values displayed in the decision boxes at the beginning of the game are some initial **neutral** values, **not** the optimal values. The player should make decisions even at the first step of the simulation and revise his decisions at each step, by making use of the provided analysis tools.

In making the faculty hiring decisions, the player should keep in mind that there are leaving faculty members at each time interval.

A good balance should be struck in the **IGP (Income Generating Projects) Share for Faculty** decision, because setting this value too low would cause the faculty members not to take part in projects that are realized through university channels and to tend to do unofficial projects (UP). On the other hand, setting this value too high would cause the net funds gotten by IGP activities to decrease considerably.

A faculty member who does both graduate and under-graduate teaching and who has significant research skills and interest is defined as a **graduate** faculty member. An **under-graduate** faculty member is one who does only under-graduate teaching and is involved in minor research. **Release time for Graduate Faculty Members** is the amount of decrease that is to be made on the maximum instruction loads of the graduate faculty members (assumed to be six hours/week), in order to provide them extra time for activities like research and projects. Giving a positive value to this decision variable may increase the research and project outputs by graduate faculty members, but can, on the other hand, increase the instruction loads on the under-graduate faculty members.

Note that the assumed environment imposes that the number of under-graduate students are increasing gradually. The desired average class size for under-graduate instruction is 35 and the desired average class size for graduate instruction is 6. In the internal computations, it is also assumed that the maximum class sizes for under-graduate and graduate instruction are 100 and 25, respectively. The maximum possible graduate faculty supply is equal to 65 and the maximum possible under-graduate faculty supply is equal to 75; salary and instruction loads cause the indicated faculty supplies to be less than these values.

The game starts with approximate initial values of first semester of 1983.

The lower and upper limits for decisions are as follows:

New Graduate Students	min:	0	
Graduate Faculty Hiring Decision	min:	(-) No. of Graduate Faculty	
Under-graduate Faculty Hiring Decision	min:	(-) No. of Under-grad Faculty	
IGP Share for Faculty	min:	0	
Release Time for Graduate Faculty	min:	0	max: 4

Finally, please keep in mind that there is no winning or losing in such systemic games. The purpose is **not** to be on some 'highest scores' list, but to **learn** during the game. And for this purpose, the player should try to base his decisions on the information feedback displayed through the game. The expectation is that the player's understanding of the problem issues will gradually increase over some period of time, after playing the game numerous times.

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