MODELING THE DYNAMICS OF ACADEMIC PUBLICATIONS AND CITATIONS

Nisa Önsel, Yaman Barlas

Industrial Engineering Department

Bogazici University

34342 Bebek Istanbul Turkey

+90 212 359 73 43

nisa.guler@boun.edu.tr, ybarlas@boun.edu.tr

Abstract

In promotion, tenure or funding decisions, publication performances of researchers in scientific institutions are evaluated using some performance measures. However, there is a concern that measuring research performance, if not properly done, may damage science. Researchers tend to change their research practices when they are asked to be good at some particular measure. In this study, a dynamic model is developed for analyzing the changes in publication practices of researchers towards improving the performance measures used. Reputation, skill level, total time devoted to research activities, fraction of papers accepted by the journals, publication and citation pressures on researchers are the basic variables in the model. The model is constructed and calibrated using Boğaziçi University Engineering Faculty data. Validation of the model is established by standard structure and behavior tests. Scenario and policy analysis are performed with the simulation model. Pushing researchers to publish in high numbers causes spurious publications with low citations. Allowing researchers to spend more time on research activities is found to be an effective policy. Encouraging mostly the high quality research results in more high-quality publications compared to low-quality ones, hence increased citations. The model provides a platform on which many other policies can be tested.

Key Words: academic publications, citations, dynamic system simulation, scientometrics.

INTRODUCTION

Publications of researchers are expected to be read and used by other researchers in their new research. Price (1964) conceptualizes this accumulation as generating, distributing and consuming the scientific knowledge. Since publications are the main output of the research activities, they have been subjected to evaluation to have an idea regarding the quality of the research and researchers. For this purpose "scientometrics", the science of measuring and analyzing science has emerged.

Currently, there are different quantitative procedures applied in different countries for measuring research performance (Moed, 2008; Barker, 2007; Butler, 2004; Frolic, 2006;

Moed, 2005, p.29-30; Taubes, 193). The research performance measures are necessary for various purposes like tenure promotion and funding decisions.

The number of publications is inadequate in showing the quality of the work. Because of this reason, number of citations was included in the analysis of science (Garfield, 1970). Garfield claimed that act of citing is an expression of the importance of the cited material because authors refer to previous material to support, illustrate or elaborate on a particular point. He considers the total number of such expressions the most objective measure of the material's importance to current research (Garfield, 1979, p.24). Moed (2005, p.202) points out that citation analysis is a very good measure of the quality of scientific work to be used in sociological studies of science. There are some issues like self citation, negative citation, citation networks, possible tendencies of people to abuse the citations (Taubes, 1993).

Although the main weight is assigned to publication and citation numbers, measures like peer reviews, research income, performance of postgraduate students are evaluated in research performance measurement as well. Studies on finding an optimal combination of the performance indicators by a compact, objective and reliable performance measuring formula are not complete yet. The source of absence of consensus is the complexity of the issue. Every indicator has its pluses and minuses (Coccia, 2008).

One problem in measuring research performance is the possible negative effects of the measurement on researchers' practices. The concern is that, if we put pressure on researchers to publish, then they would change their research practices towards publishing for numbers. Hamilton (1990) provided the statistic that 10% of the journals receive 90% of the citations. The growing number of journals and the high number of uncited articles confirm the suspicion that academic culture encourages spurious publication. The famous saying "Publish or perish" shows the amount of pressure on researchers. In literature, we see many examples of changing research practices of researchers towards changed performance measurement criteria (Moed, 2008; Butler, 2002; Butler, 2004; Besancenot, 2007).

The studies and concerns summarized show the importance of a comprehensive analysis of the problem. In this study, we focus on the question of what performance measures may improve the research output performance and what measures may harm it. For this purpose, a dynamic simulation model is constructed. Our main assumption is that publication pressure forces researchers to publish more and more, and citation pressure steers them towards journals with high journal impact factor where the publications are anticipated to receive high number of citations. By using the dynamic simulation model, we seek to observe the long run publication behavior of faculty members under some assumptions and to see the effects of some managerial policies on the researchers' publication practices.

MODEL DESCRIPTION

The parameters and initial values of all stocks are estimated based on real publication data of Boğaziçi University Engineering Faculty (BUEF) between 1981-2006. World data is

obtained from ISI Web of Science. The detailed documentation of the model can be found in (Onsel, 2011).

Overview of the Model

The model is composed of 5 sectors. The sectors correspond to 'publication', 'research time', 'publication and citation pressures', 'reputation', and 'citation'.

The causal loop diagram provided in Figure 1 shows the relations between the key variables in the model. *Research time* is the time that is devoted to research activities. High research time causes high publishing rates, hence low *publication pressure*. But *publication pressure* causes *research time* to increase. The research activities are classified into three types according to the quality of the research (A, B and C). *Publication pressure* is formed by comparing the *publication per faculty per year* value with the world average. It forces the faculty to do C type, low quality research. On the other hand, *citation pressure* is formed by comparing the number of *citations per publication* with the world average and it causes the faculty to do A type, high quality research. The faculty simulated has a certain *reputation* and *skill* level. *Reputation* and the number of *citations per publication* positively affect each other. When *reputation* is high, fraction of submitted papers accepted by the journals is high. High *acceptance fraction* provides high publishing rates, hence low *publication pressure*. *Skill* level, which is an exogenous variable, has a positive effect on publishing rates and citation receiving rates.

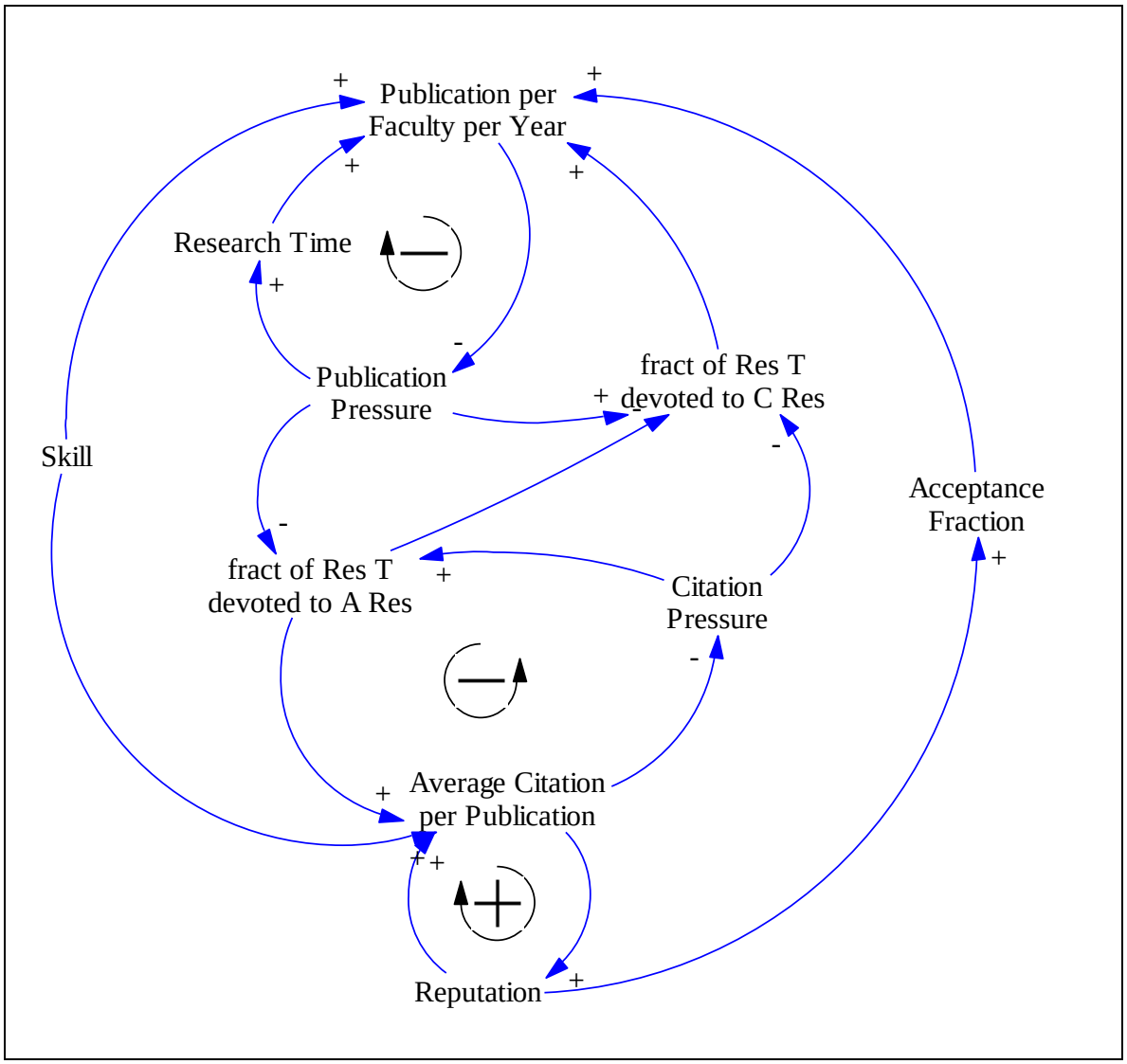

Figure 1: Causal-loop diagram of the overall model.

Publication Sector

After having been written, a paper is submitted to a journal. The peers read the paper and decide on whether accepting or rejecting the paper. The *Paper Submitted* stock stands for representing the papers that are under peer review (Figure 4). For approximately one and a half year after being published, publications do not receive many citations. In these years, the publications are called "newborn publications". When the *maturing time* passes, the papers become citable papers and enter the *Publication* stock. When a publication becomes very old and receives no more citation, that publication is assumed to be obsolete. Obsolete publications stay in the *Obsolete Publication* stock forever. The findings of Lariviere (2008) are adopted for modeling the aging structure of the papers.

Not every paper has the same quality. The high quality papers mature fast, receive more citations, and become obsolete late. In the model, this quality categorization is dealt with by separating the papers into three types. *A type papers* are high quality, *B type papers* are medium quality and *C type papers* are low quality ones. The quality classification is based on the average number of citations received by papers. The number of citations received in each age of the three types of publications of year 1995-2000 is seen in Figure 2-3.

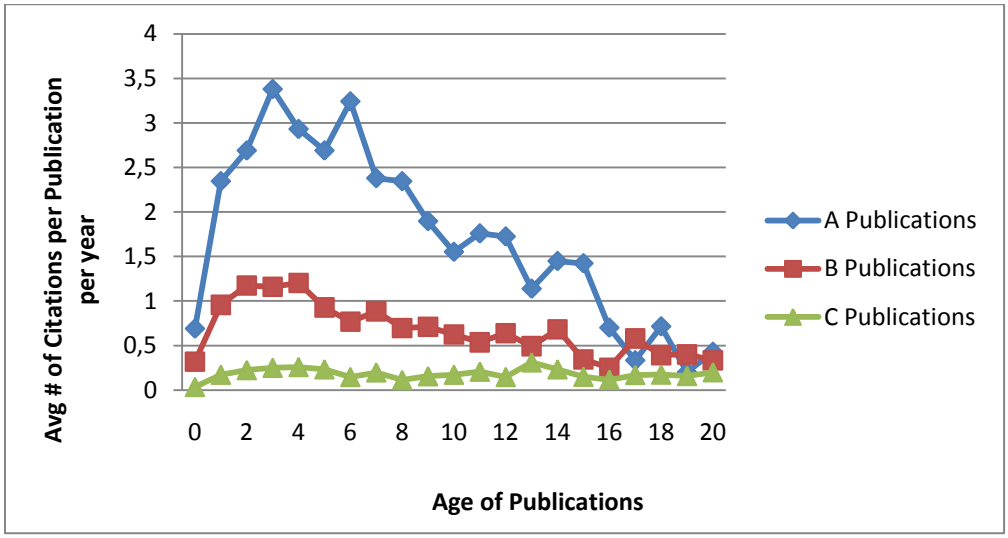

Figure 2: Avg # of citations received by 1985-1995 publications of Boğazici University Engineering Faculty in each age of the publications.

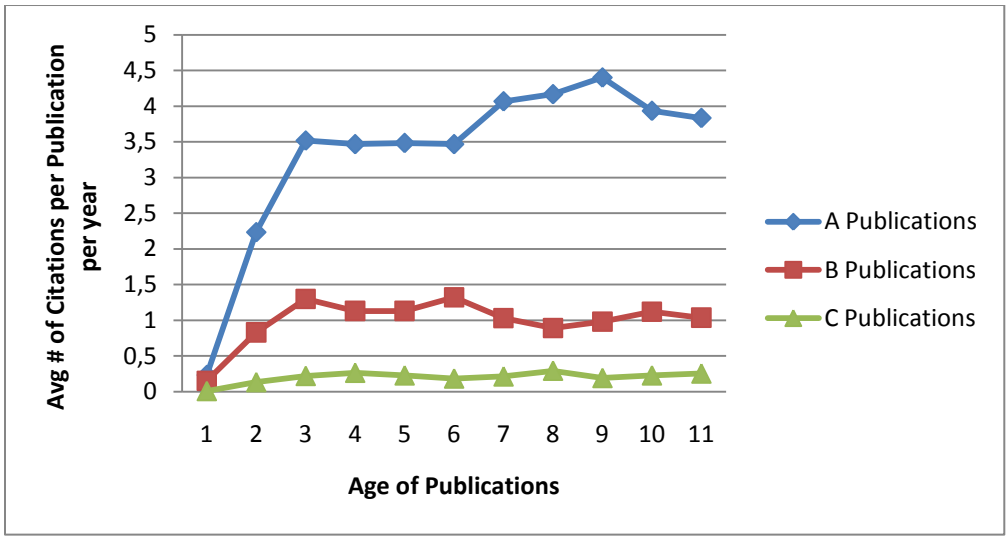

Figure 3: Avg # of citations received by 1995-2000 publications of Boğazici University Engineering Faculty in each age of the publications.

The parameters *Mature time* and *Obsolescence time* (that provide the shape of citation receiving rate according to age of the publications) and the *required time* which is the time required to write one paper, are given in Table 1.

Table 1: The parameter set used in the model for three publication types

	A Type Publications	B Type Publications	C Type Publications
Required Time	0.8 years/paper	0.4 years/paper	0.2 years/paper
Mature Time	1.4 years	1.2 years	1.8 years
Obsolescence Time	18 years	18 years	20 years

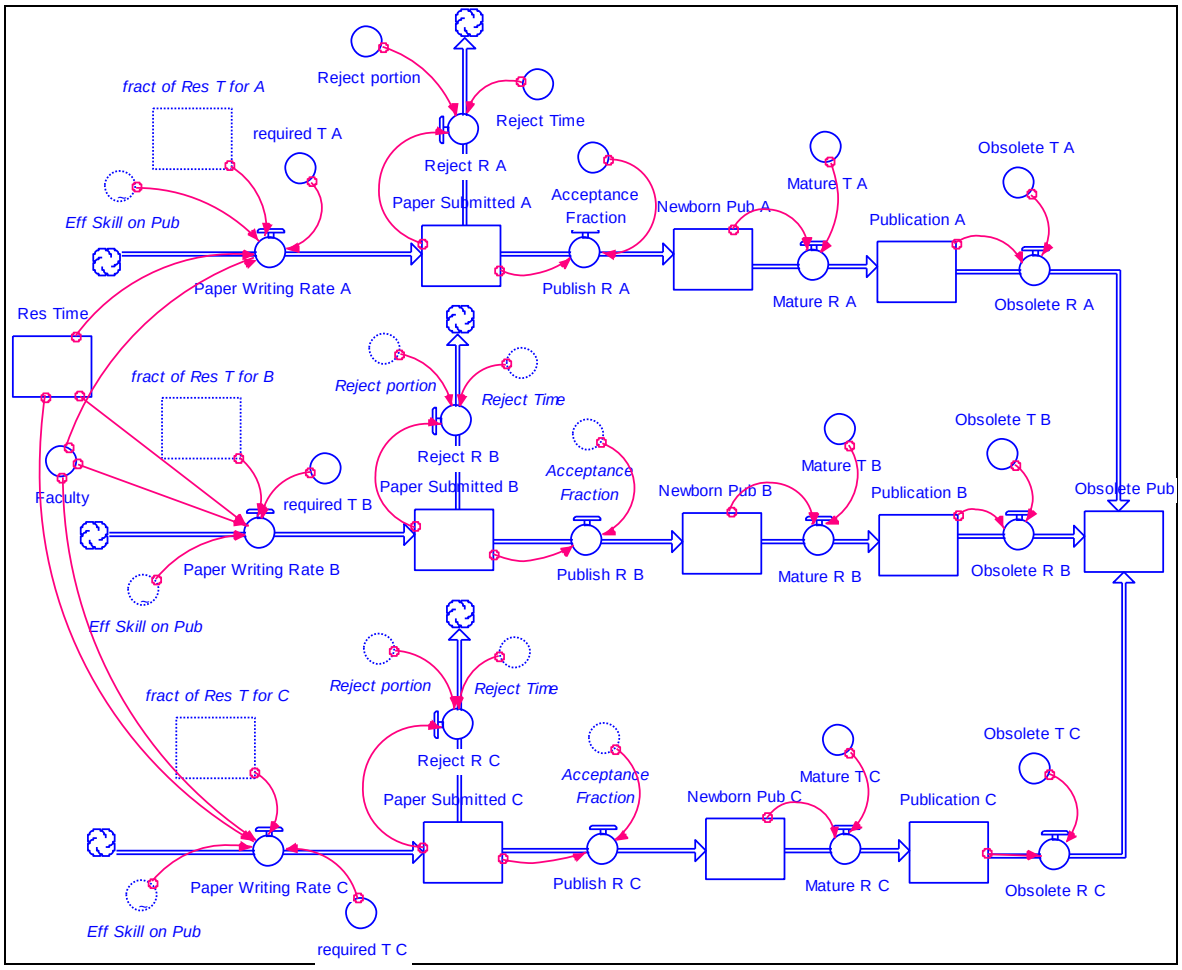

Figure 4: Stock-flow structure of publication sector.

Research Time Sector

The *Research Time* is the average time of the faculty members that is devoted to research activities. The research activities end with writing papers and submitting them to academic journals. Normal level of *Research Time* is taken as 0.3 year per faculty per year according to the estimations based on BUEF data. *Research time* increases or decreases depending on the publication pressure felt by the faculty members (Figure 5).

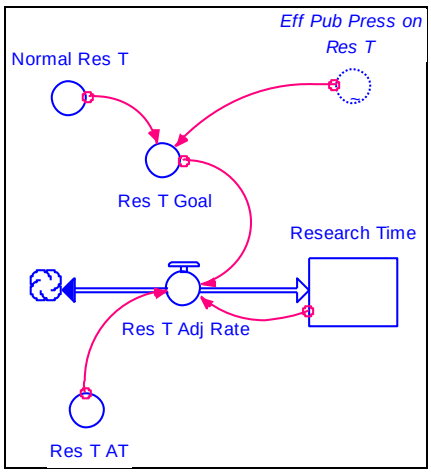

Figure 5: Stock flow diagram of Research Time sector

Publication and Citation Pressures Sector

It is assumed that there are two main research performance measures. If the *average number of publications per faculty per year* is less than the world average, faculty members feel a *publication pressure*. On the other hand, if the *average number of citations per publication* is less than the world average, faculty members feel a *citation pressure*. The higher the gap between faculty's and the world's performance measures, the stronger the pressure felt by faculty members. The world average number of publications per faculty per year in engineering fields in recent years is taken from a previous study (Kucuk, 2007). It is assumed to be constant throughout the simulation period. The world average number of citations received by the publications in engineering fields in the world is obtained from ISI Web of Science for years 1981-2006.

It is assumed that, if there is publication pressure on the faculty, they tend to ignore quality and try to write as many papers as they can. This pressure pushes them to use their research time more in writing *C type papers* and less in writing *A type papers*, because *C type papers* are written in a shorter time. On the other hand, if there is citation pressure, it pushes the faculty members to use their research time more in writing *A type papers*. When there is no strong pressure of either type, *B type papers* are written. The effect functions for citation pressure and publication pressure on research time allocation are provided in Figure 6.

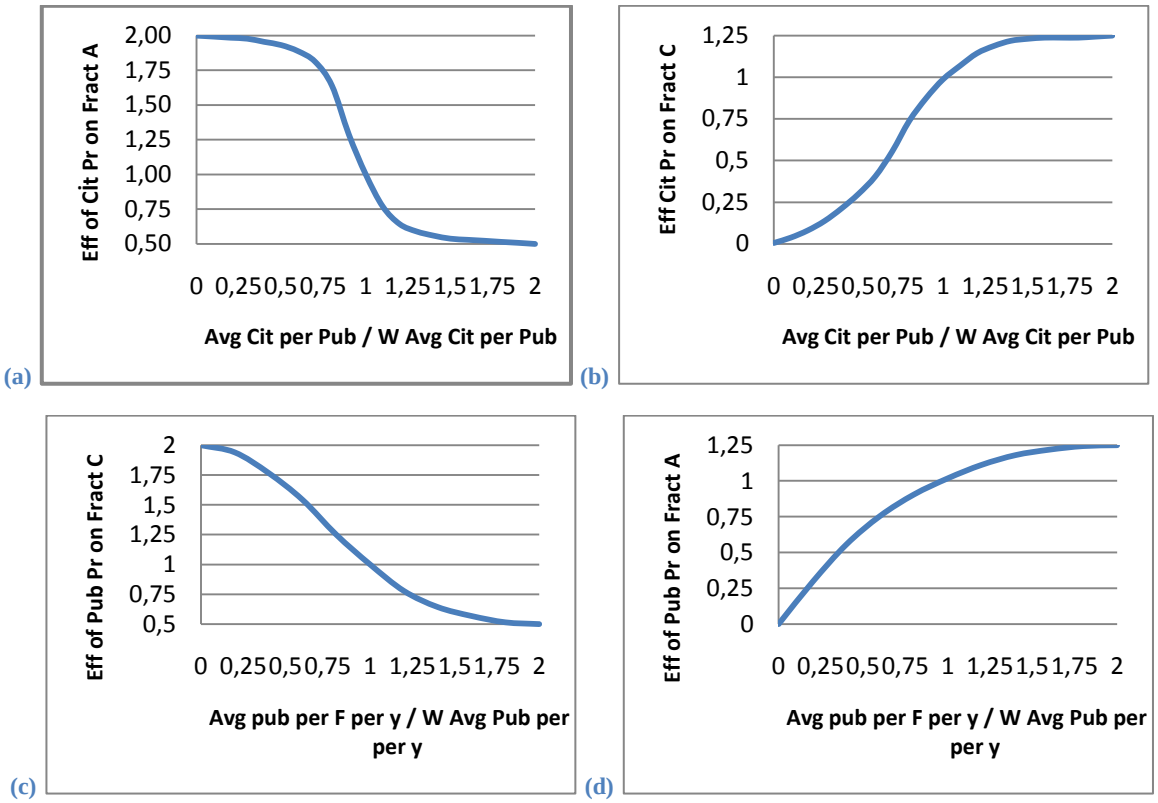

Figure 6: (a) Effect of citation pressure on fract of Res T for A. (b) Effect of citation pressure on fract of Res T for C. (c) Effect of publication pressure on fract of Res T for C. (d) Effect of publication pressure on fract of Res T for A.

Fraction of research time that is allocated to A/B/C type research is controlled by stocks. *Normal level of fraction of research time allocated to A type research* is 0.3 and *normal level of fraction of research time allocated to C type research* is 0.25.

*fract A goal= Normal fract A * Eff Citation Pressure on fract A * Eff Publication Pressure on fract A*

*fract C goal= Normal fract C * Eff Citation Pressure on fract C * Eff Publication Pressure on fract C*

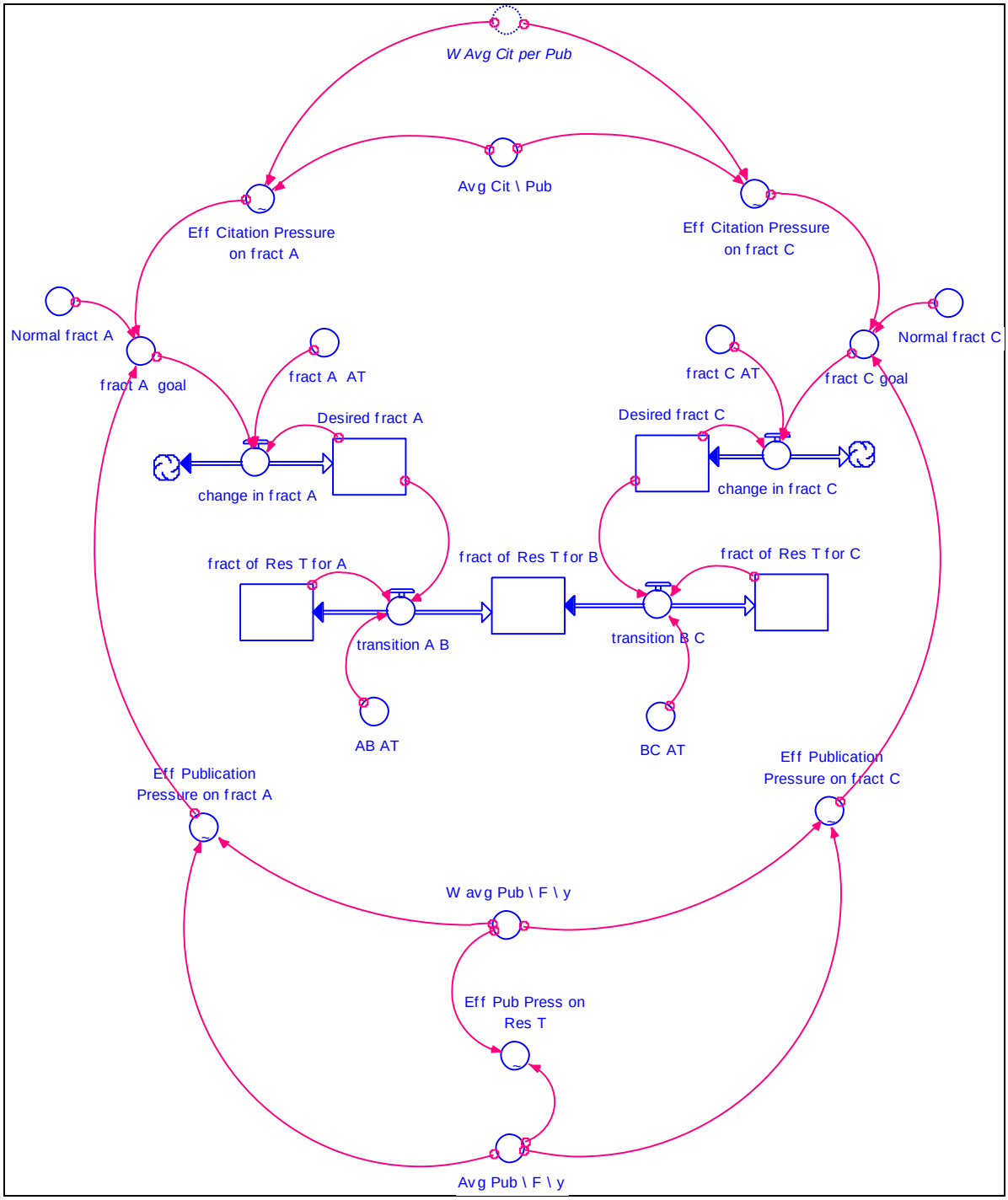

Figure 7: Stock-flow structure of citation and publication pressures sector.

Reputation Sector

To have reputation in academic world means to be known for doing good research. This good esteem makes the publications read and cited by other researchers. The more citations

your publications receive, the more visible you are in the academic world. Therefore, *average number of citations per publication* and *reputation* has a direct effect on each other. External citations are the ones received from researchers outside the faculty. The reputation of the faculty is essential in receiving external citations. However, internal citations are received from the colleagues of the author. Reputation is not essential in receiving internal citations (Figure 8).

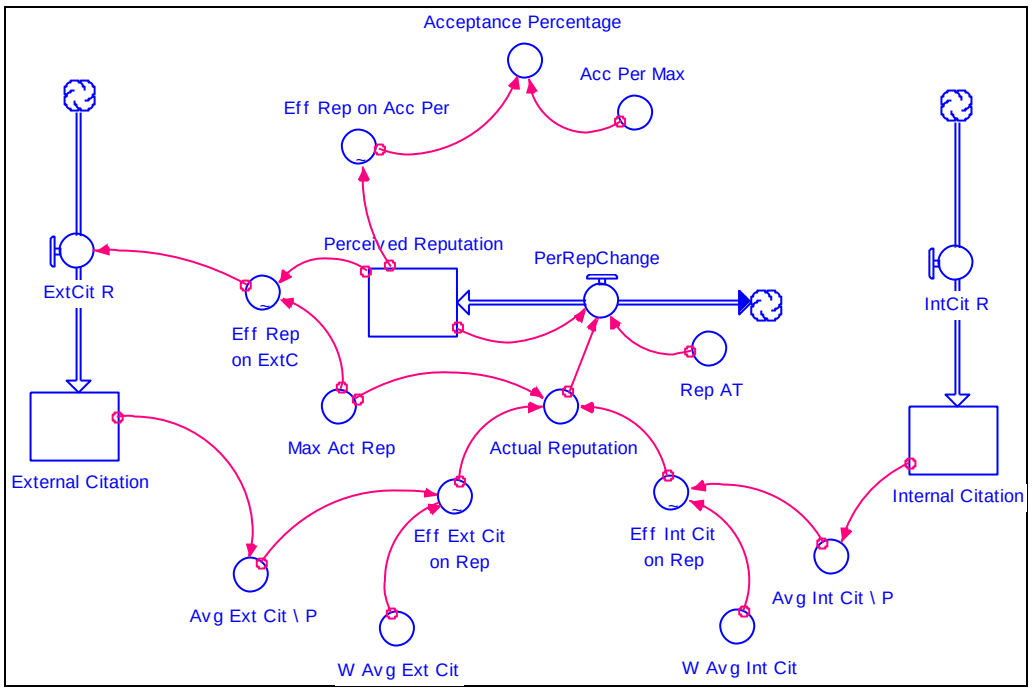

Figure 8: The stock flow structure of reputation sector

Actual Reputation= Max Act Rep * (Eff Ext Cit on Rep+ Eff Int Cit on Rep)

Effect of external citation on reputation and *effect of internal citation on reputation* are seen in Figure 9.

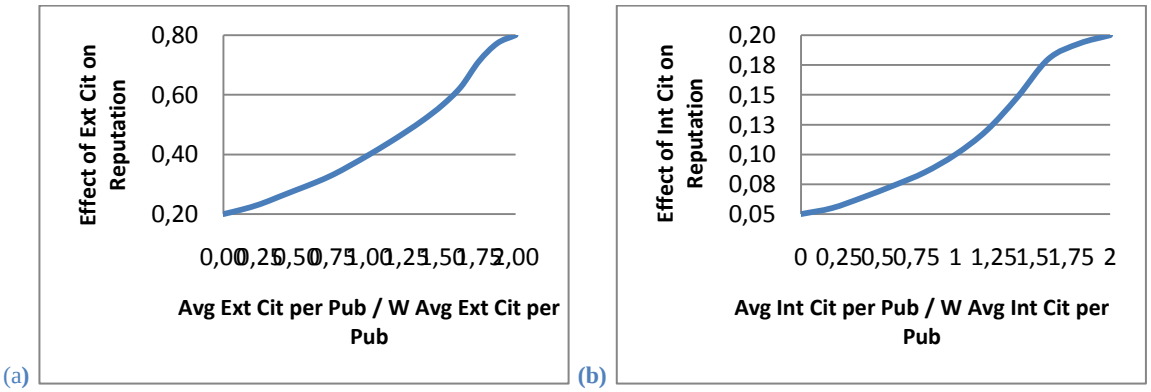

Figure 9: Effect of External and Internal Citation on Reputation

The scale of *reputation* is 0-100. In the model, initial *Perceived Reputation* is taken as "40" based on the calculations with BUEF data.

It is assumed that, reputation increases *acceptance fraction*. *Acceptance Fraction* is a value between 0.64 and 0.32. Its initial value is 0.43 in the model.

Citation Sector

The citations received by the publications accumulate in *External Citation* and *Internal Citation* stocks. External citations come from researchers outside the Bogazici faculty. Internal citations are the ones given by Bogazici faculty. The number of citations received by a paper depends on the paper's quality so *cit/pub/y* parameters are different for *A*, *B* and *C type publications* (Figure 10).

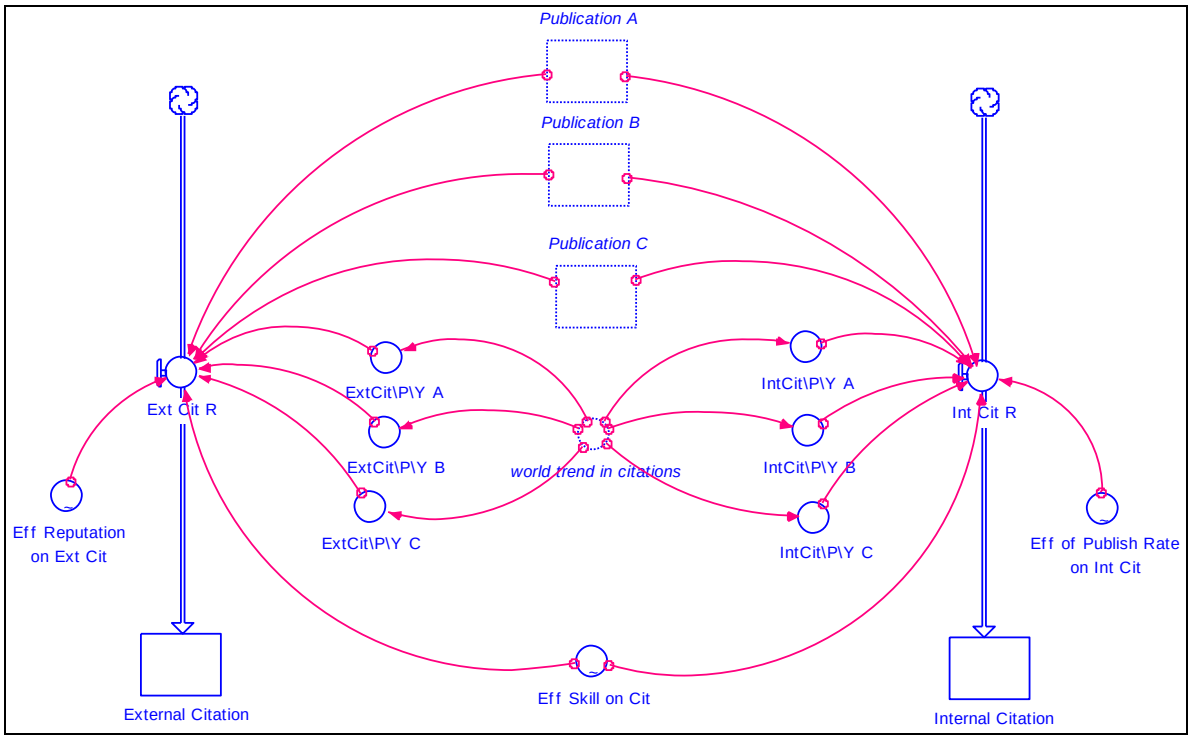

Figure 10: Stock flow diagram of the citation sector

Glanzel (2004) characterized the conditional expectation of internal citations for given number of external citation by a law. Employing his suggestions, we analyzed the BUEF data and determined the initial *ext cit/p/y* and *int cit /p/y* parameters for each type of publications.

Table 2: Ext cit /p/y and Int cit /p/y parameters for year 1995

	Type A	Type B	Type C
Int cit /p/y	0.49	0.21	0.06
Ext Cit /p/y	5.45	1.00	0.12

The number of citations received by the publications are increasing every year with a trend. The world trend is calculated by using the real world citation data.

reputation has a positive effect on *external citation receiving rate* (Figure 11).

Skill level of faculty is a combination of many qualities such as background, financial support, accessibility to research materials, etc. To keep the model simple, this variable is included in the model as an exogenous variable. Skill level has a positive effect on *publish rates* and *citation receiving rates*.

(a)

(b)

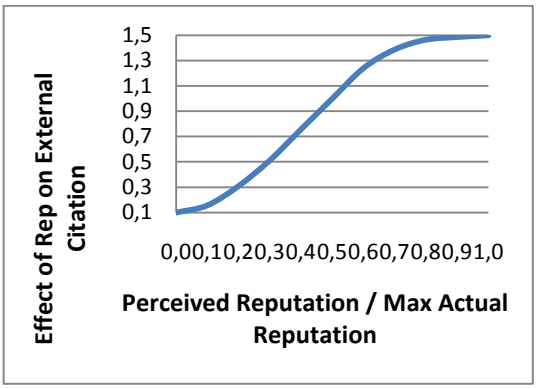

Figure 11: (a) Effect of Skill on Citations (b) Effect of Reputation on External Citations

ANALYSIS AND VALIDATION OF THE MODEL

Analysis of the Base Behaviour

Behaviors of faculty members in terms of publications and citations are simulated. Length of simulation is 45 years, from 1995 to 2040.

Initially, both of the citation pressure and publication pressure are strong. The *avg cit/pub* value is 2.84 where *world avg cit/pub* is 4.38. *avg pub/f/y* value is 0.28 *where world avg pub/f/y* is 1.57. The most significant response of researchers to this condition is the increase in *research time* in a very short time. With the increasing *research time*, publish rates increase. *Publish rate B* and *publish rate C* increase more than *publish rate A*. Due to the decrease in citation pressure, *A type publications* reach equilibrium at a low level (Figure 12).

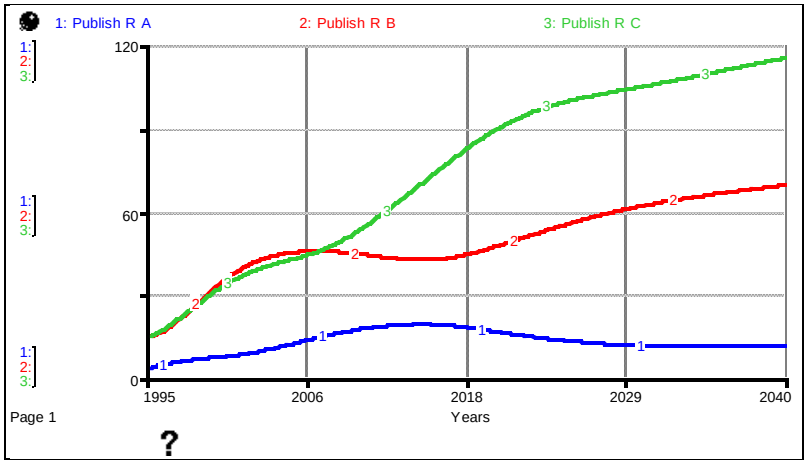

Figure 12: Publish Rates in the base run.

The rapid increase in publish rates in the first years yields a rapid increase in *avg pub/f/y* (Figure 13). As a result, publication pressure decreases. In 2016, research time starts decreasing. The decrease in research time slows down the increase in *avg pub/f/y*.

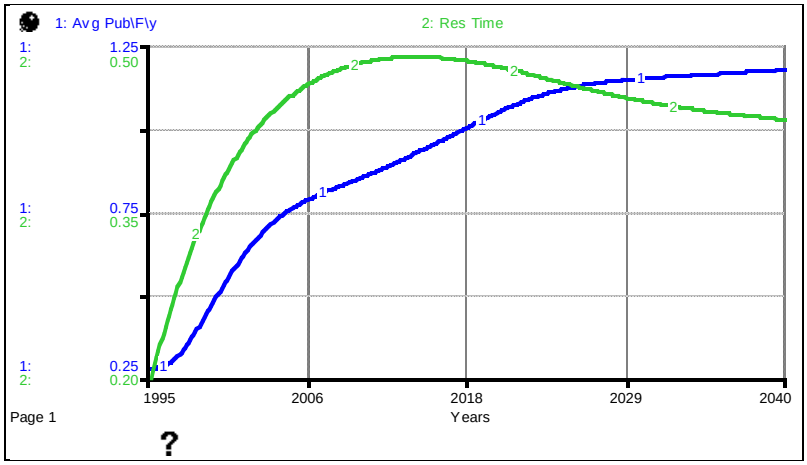

Figure 13: Avg Pub/F/y and Research time in the base run.

The fractions of research time allocated to *A, B* and *C type research* are seen in Figure 14. *fract of Res T for A* oscillates around 0.29 at the beginning. After 2012, with the decreasing citation pressure, the motivation for *A type research* decreases and this fact leads to a stabilization of *fract of Res T for A* in a low level. *fract of Res T for B* oscillates around 0.45. The pressures are easing off and this allows researchers to make *B type publications*. *fract of Res T for C* is at the lowest level in the beginning. It increases due to the publication pressure. However, the increase is not very dramatic because although publication pressure exists from the beginning to the end, its strength keeps decreasing in the simulation period.

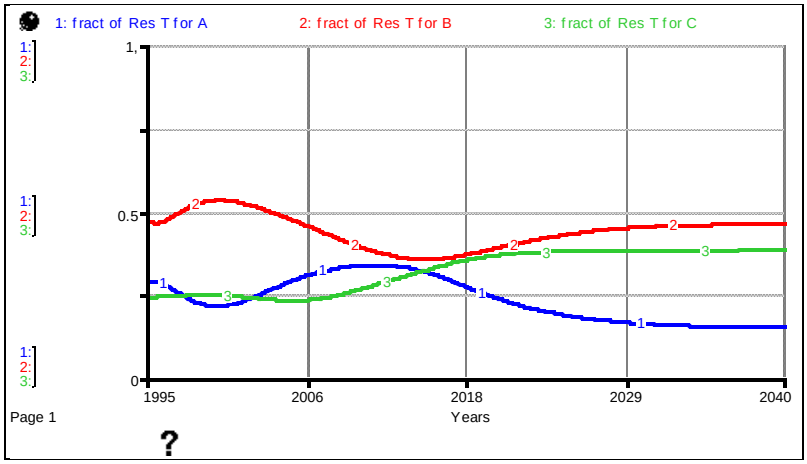

Figure 14: Research Time allocation in the base run.

Avg cit/pub value of the faculty catches the world average in year 2015. From then on, citation pressure decreases significantly. The values of *avg cit/pub* parameters are seen in Figure 15.

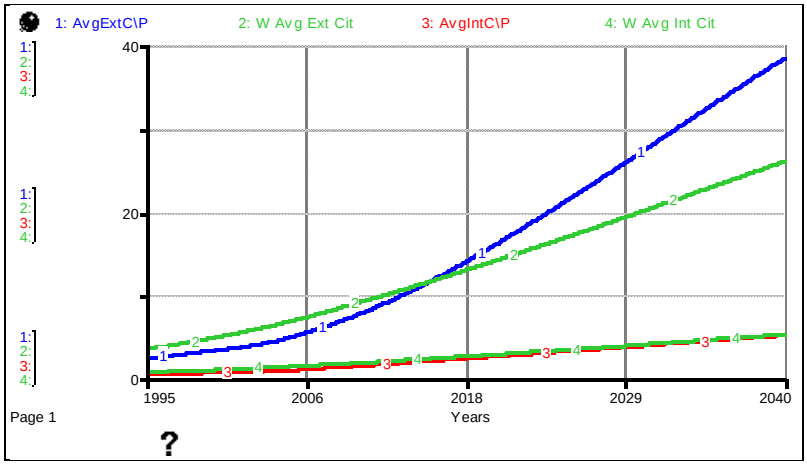

Figure 15: Citation per publication values in the base run.

Initially *reputation* is 40 out of 100 in the simulation. Reputation increases during the simulation period. Starting in 2007, with *avg cit/pub* coming closer to the *world avg cit/pub*, increase in reputation accelerates. *Acceptance fraction* reaches level 0.54 where it starts at level 0.43 in the beginning (Figure 16).

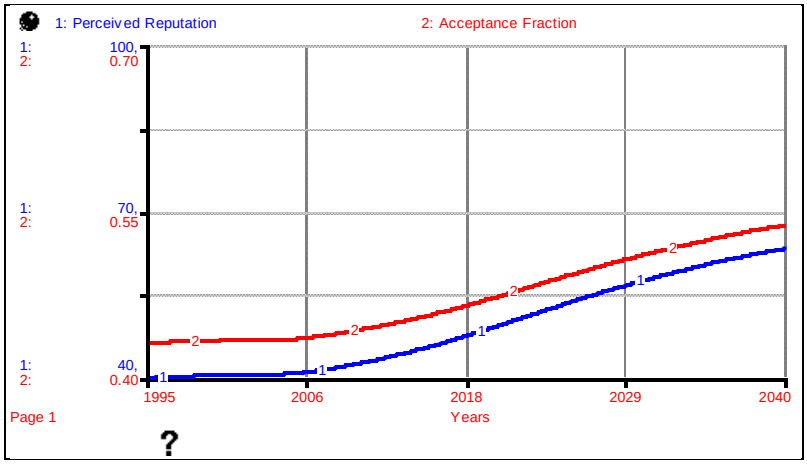

Figure 16: Reputation and Acceptance Fraction in the base run.

Base behavior obtained from the model for the first 11 years is highly compatible with the real behavior of BUEF, as will be shown below. Considering this fact, we trust in our base assumptions. If these basic assumptions about behaviors of faculty members do not change, in the long run the faculty will be in the position presented. In terms of citations, the faculty will be in a very good place with much higher *average citation per publication* values. In terms of publication productivity, faculty will be in a much better place as well. Faculty members will spend about 44 percent of their time in research activities and these research activities will be dedicated mostly to *B type research*. The faculty will be more visible in the academia with increased *reputation* level.

Validation of the Model

The purpose of model validation is to assure that the model is an acceptable description of the real system behavior with respect to a problem (Barlas, 1996). Model validation is assured in two steps. Firstly, structure tests are applied to check whether the structure of the model is a meaningful description of the real relations that exist in the system. Secondly, behaviour validity tests are carried out to assess how accurately the model can reproduce the major behavior patterns exhibited by the real system (Barlas, 1996).

In the model, all parameters and variables have real life counterparts. The equations and logical relationships are compatible with our knowledge about real system. There is no dimensional inconsistency in equations. All the model equations are valid under extreme conditions. By assigning extreme values to selected parameters, extreme-condition tests are carried out via simulation and model-generated behavior is compared to the observed (or anticipated) behavior of the real system. With most of the parameters, sensitivity analysis are carried out as well. The details of the tests are documented in (Onsel, 2011).

By using the real data belonging to BUEF, behaviors generated in the model and real behaviors of faculty are compared for the first eleven years (1995-2006). The model is able to reproduce the major behavior patterns exhibited by the real system (Figures 17-20).

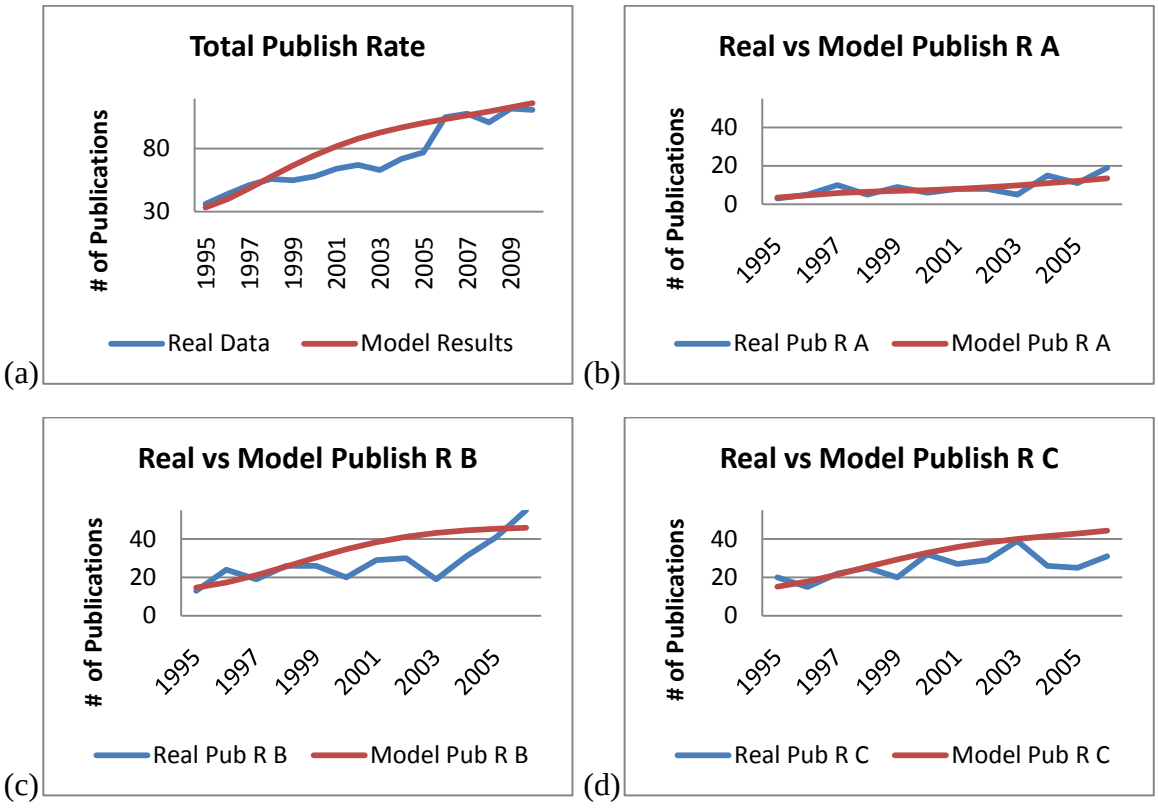

Figure 17: (a) Real vs Model-generated Total Publish Rate. (b) Real vs Model-generated Publish Rate A. (c) Real vs Model-generated Publish Rate B. (b) Real vs Model-generated Publish Rate C.

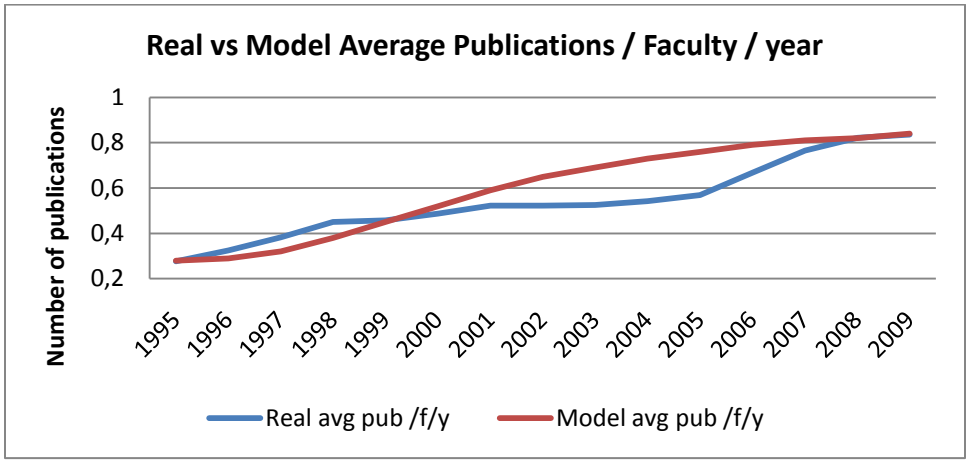

Figure 18: Real vs Model Average Publications / Faculty / year

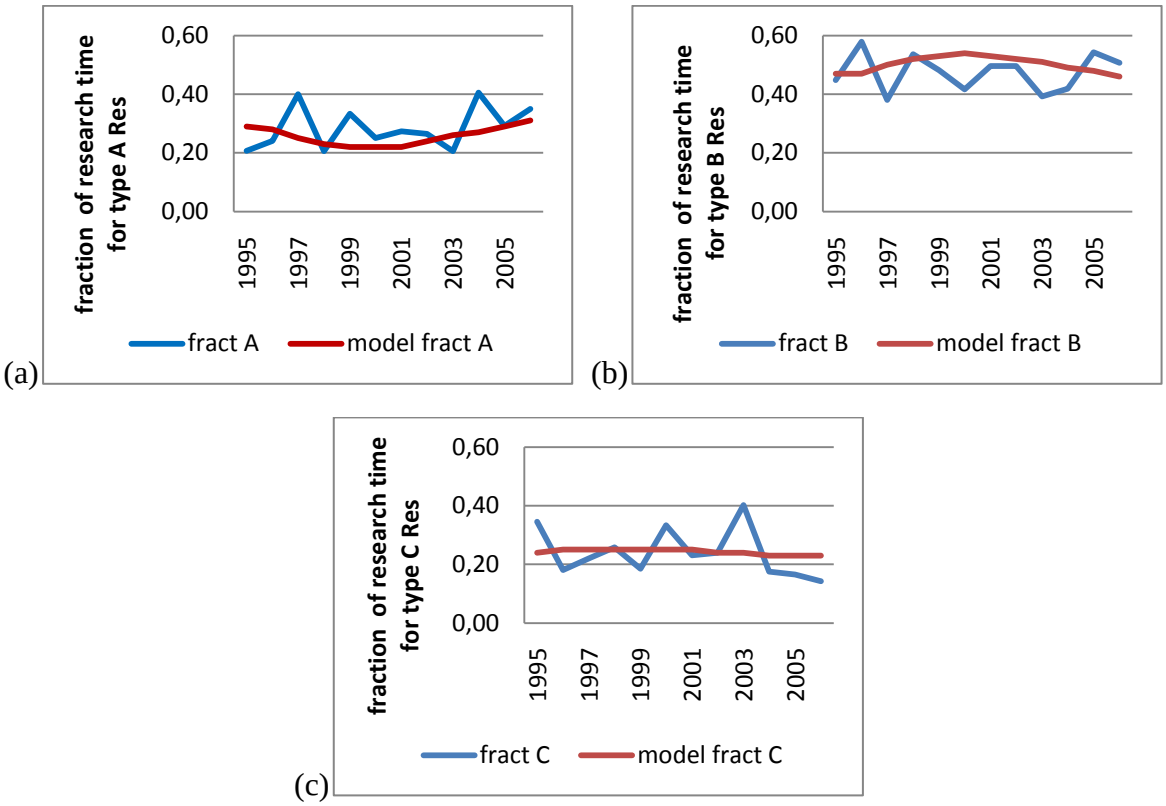

Figure 19: (a) Fraction of Research Time for type A research. (b) Fraction of Research Time for type B research. (c) Fraction of Research Time for type C research.

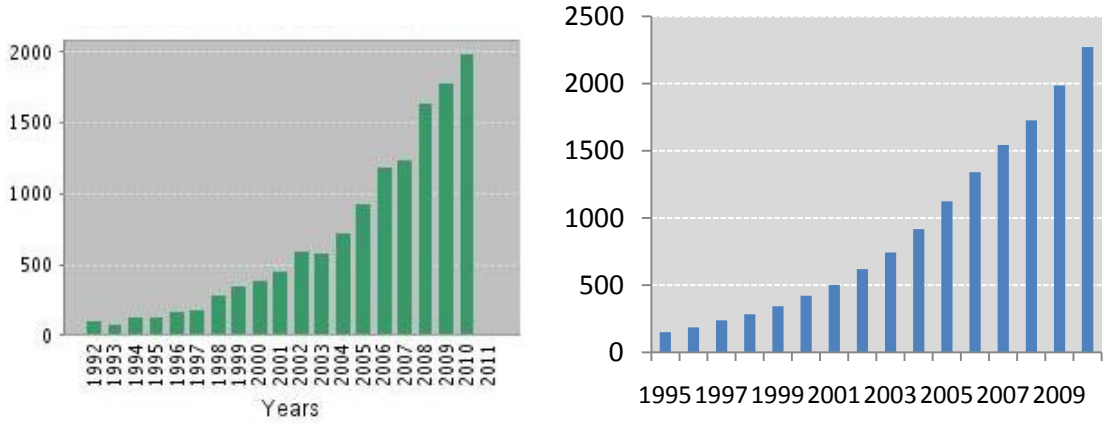

Figure 20: (a) Real yearly citation rate. (b) Model-generated yearly citation rate.

SCENARIO AND POLICY ANALYSIS

The model is used as an experimental platform for studying the problem defined above, under different scenario and policy settings. While implementing the scenarios and policies

below, the first 11 years of the simulation are unchanged, since those years are based on real past behavior of faculty.

Scenario 1: Skill level improving over time

Skill is an exogeneous variable in the model. However, assuming a dynamic change in skill level as a result of internal effects is reasonable. The internal effects can be experience gained by publishing, age, hiring new high skilled faculty members etc. In this scenario, *skill* level is increased from 50 to 65 gradually, between 2006-2040.

High *skill* level provides high *paper writing rates*, hence high *publish rates*. *average number of publication per faculty per year* increases and publication pressure decreases (Figure 21). When faculty members realize that they are publishing more than before even though they are spending less time on each publication, they lower the *research time*.

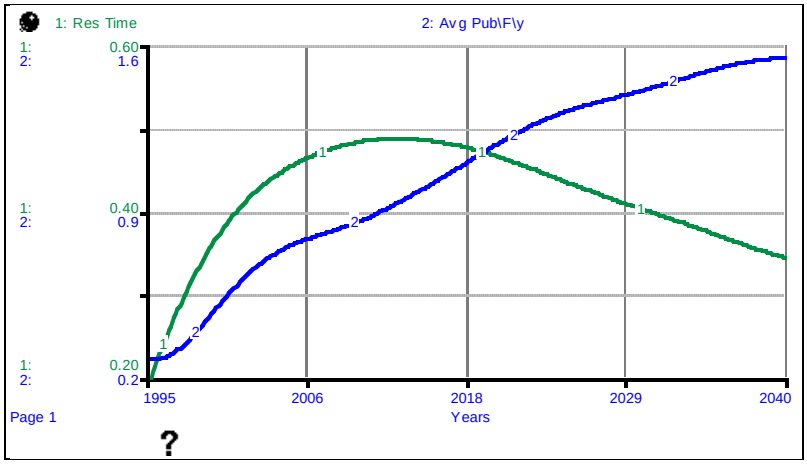

Figure 21: Research time and average publication per faculty per year in scenario 1.

Average citation per publication values increase significantly because of the direct positive effect of skill on citation receiving rates. Citation pressure decreases. Research time allocation concentrates on *B type research* because of the weakness of the pressures (Figure 22).

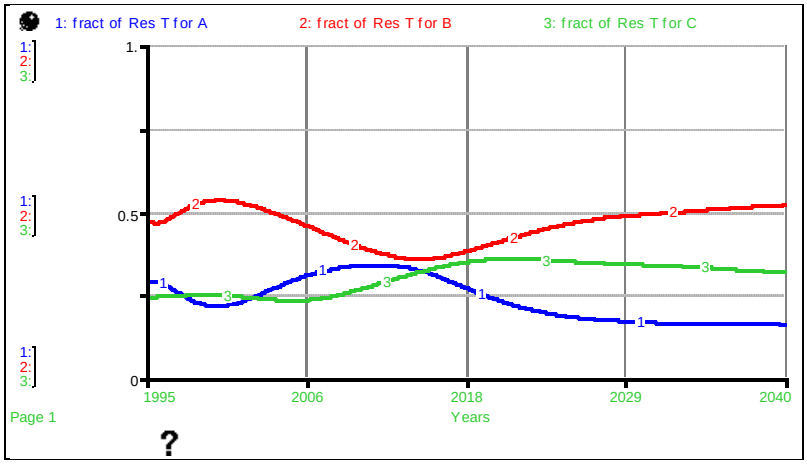

Figure 22: Research Time allocation in scenario 1

Scenario 2: Worsened Skill level

Skill level is decreased from 50 to 40 gradually. *Publish rates* stabilize in lower levels due to low paper writing rates. *avg pub/f/y* is low and there is a strong publication pressure. Faculty members keep the *research time* at a high level (Figure 23).

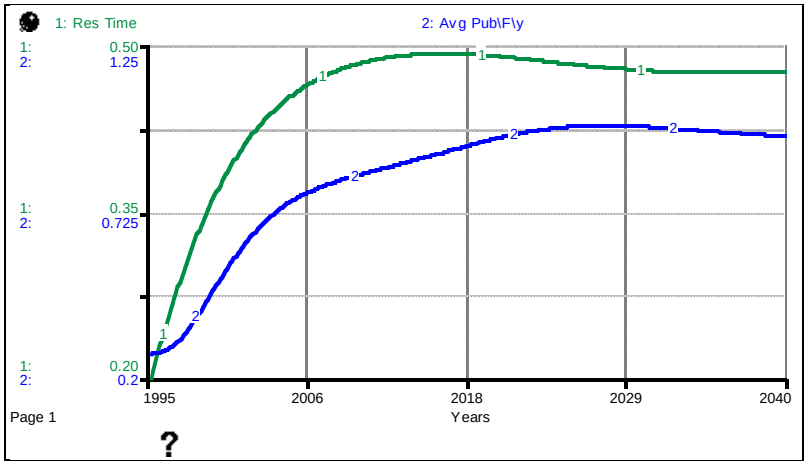

Figure 23: Research time and average publication per faculty per year in scenario 2.

With the high publication pressure, Research time is mostly allocated to *B* and *C type research.*

The final values of selected variables in base run, scenario 1 and scenario 2 are presented in Table 3.

Table 3: The final values of selected variables in the base run, scenario 1 and scenario 2.

	Base	Scenario 1	Scenario 2
Fract of Research T (A-B-C)	0.15–0.46–0.39	0.16–0.52–0.32	0.15–0.43–0.42
Research Time	0.43	0.34	0.48
Avg Pub / F / Y	1.18	1.55	0.96
Avg Cit/Pub (int+ext)	43	57	38
Publish R (A+B+C= Total Pub R)	11+70+116=197	17+107+133=257	9+51+100=160

4.2 Policy Analysis

Policy analysis aims at finding out policies, which will take the faculty to better positions in terms of quality and performance in the long run. Final values of the selected variables in the base run and under the policies tested are presented in Table 4.

Policy 1: Upgrading the publication benchmark

The *world avg pub/f/y* parameter is gradually increased from 1.57 to 3 (which is compared with *avg pub/f/y* while forming publication pressure). Publication pressure increases. *Research time* increases and since the publication pressure is strong throughout the simulation, it never decreases (Figure 24).

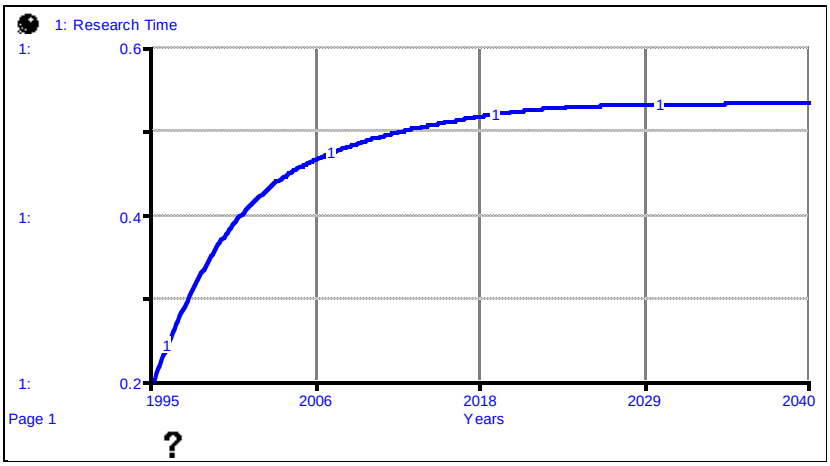

Figure 24: Research Time under Policy 1.

Compared to the base run, the faculty publishes almost the same quantity of *A type* and *B type publications*; in addition, they publish many more *C type publications* (Figure 25).

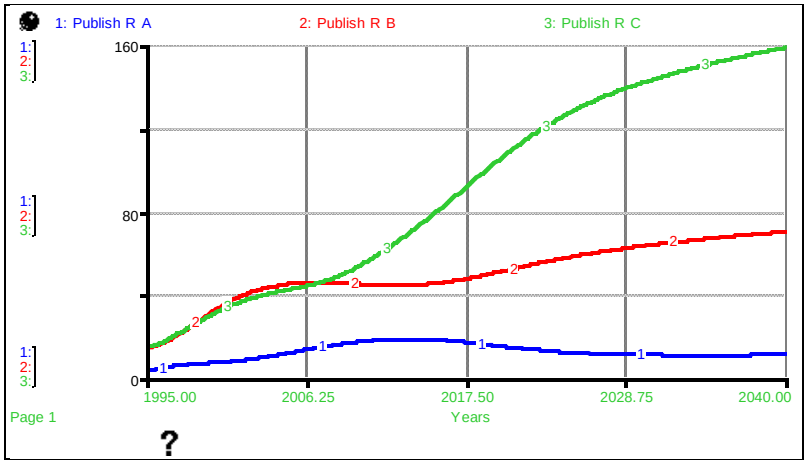

Figure 25: Publish Rates under Policy 1.

Policy 2: Stronger Publication Pressure

Strength of publication pressure on research time allocation is increased. The slopes of *effect of publication pressure on fract A* and *effect of publication pressure on fract C* in the model are steeper in this policy. *Publish Rate A* stabilizes at 7 publications per year which is very poor compared to its value in the base run. The total publish rate is almost equal to its value in the base run (Figure 26). *Avg cit/pub* is very low compared to the base run.

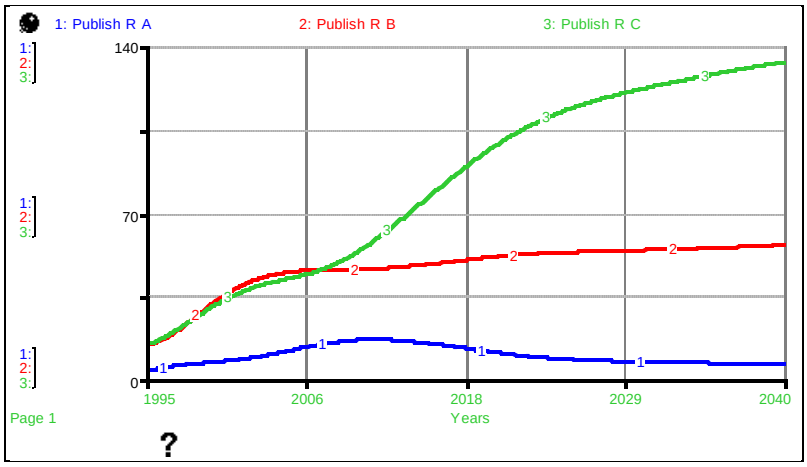

Figure 26: Publish Rates under Policy 2.

Reputation and *acceptance fraction* are low as well. This policy does not bring what it is intended to do. In order to increase *avg pub/f/y* level, making publication pressure stronger than citation pressure only results in a decrease in *citation receiving rates* while total *publish rate* stays the same.

Policy 3: Research Time is affected more from publication pressure.

This policy allows the faculty members to increase their research time to higher levels than they do in the base run when publication pressure is strong. *Research time* increases providing high *publish rates*. With decreased publication pressure, it becomes possible to allocate more time to *A type research* so *fract of Res t for A* is high. *fract of Res t for B* has a higher value than it has in the base run as well (Figure 27). Under the previous two policies, researchers had to give up writing *A type papers* because of high publication pressure. However, under this policy they increase research time and write all three types of papers in higher quantities (Figure 28)

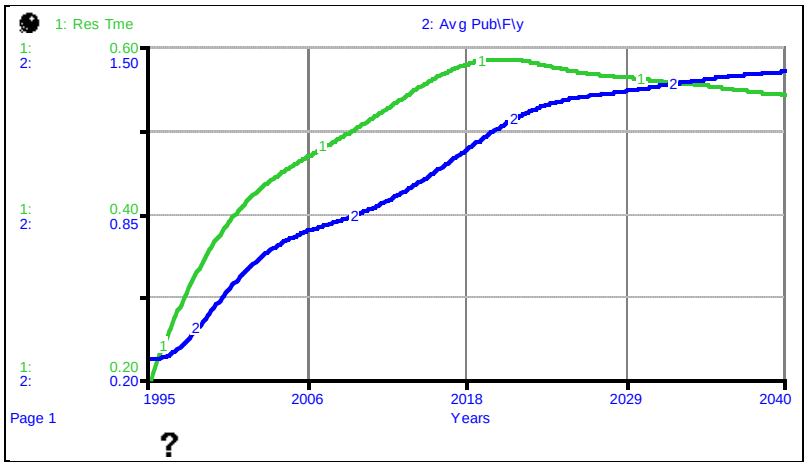

Figure 27: Research Time and Avg Pub/F/y under Policy 3.

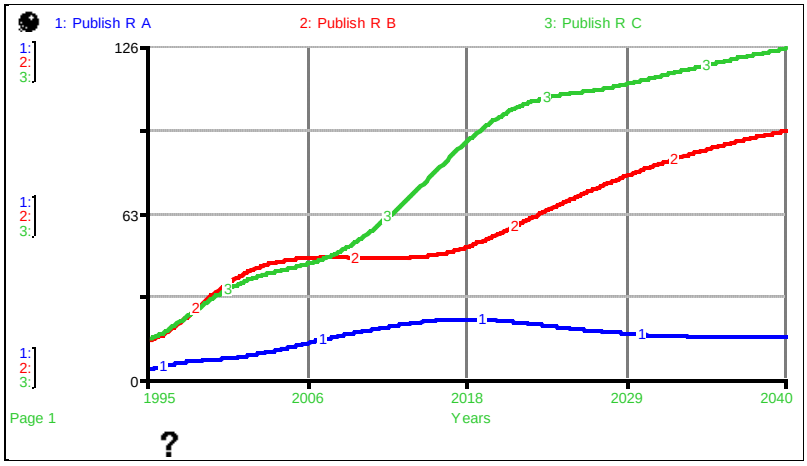

Figure 28: Publish Rates under Policy 3.

Policy 4: Emphasizing research for Quality

This policy says that, normally researchers are supposed to do *A type research* because the most important thing is quality. In the model, the normal level of *fract of res t for A* is

increased to 0.6 and the normal level of *fract of Res t for C* is decreased to 0.1 gradually between 2006-2040.

Fract of res t for A reaches its highest value compared to its values under the other policies applied. Publication pressure increases *B type research* rather than *C type research* (Figure 29).

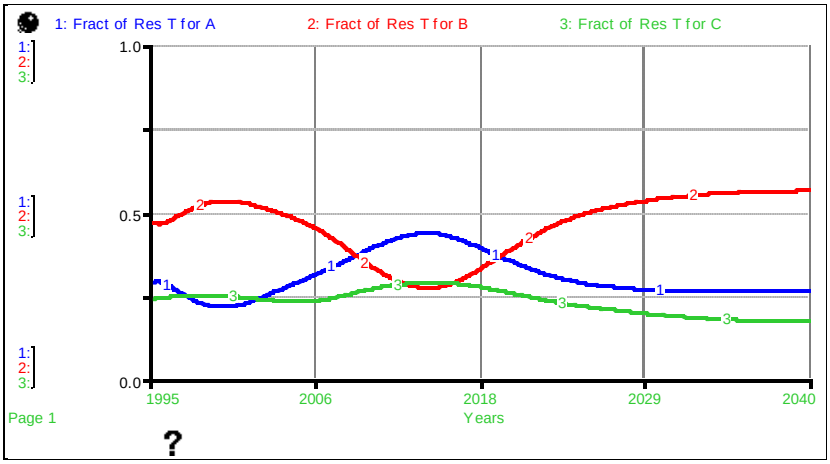

Figure 29: Research time allocation under Policy 4.

Although *avg pub/f/y* is low, if citation performance is more important than other measures, this policy is good enough to be adopted bringing high *average citation/publication* values (Figure 30).

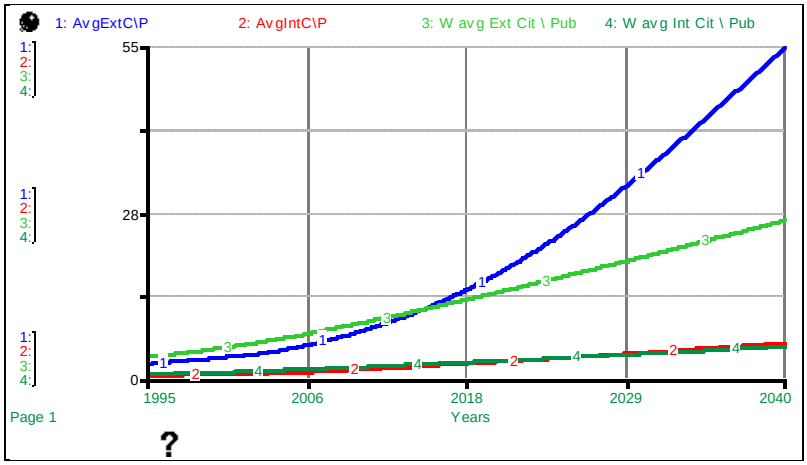

Figure 30: *Citation per publication* values under Policy 4.

Table 4: The final values of selected variables in the base run and in policy experiments.

	Base	Policy 1	Policy 2	Policy 3	Policy 4
Fraction of Research Time (A-B-C)	0.15 0.46 0.39	0.13 0.40 0.46	0.10 0.41 0.49	0.17 0.50 0.33	0.26 0.57 0.17
Research Time	0.43	0.53	0.43	0.54	0.45
Avg Pub / F / y	1.18	1.44	1.19	1.4	1.13
Avg Cit / Pub	43	37	36	45	61
Publish Rate (A+B+C =Total Pub R)	11+70+116 =197	11+71+160 =240	7+57+134 =198	16+94+126 =236	24+102+62 =188
Acceptance Fraction	0.54	0.50	0.50	0.54	0.62
Reputation	63	56	55	63	86

CONCLUSION

Number of publications and citation impact are two most basic components of research performance measure. This study focuses on these two performance measures and investigates the following question: in what directions will the dynamics of publications and citations of faculty evolve in the long term, under different scenarios and policies?

A simulation model is constructed by employing the system dynamics methodology. Reputation of the faculty, skill level, total time devoted to research activities, fraction of the papers accepted by the journals, publication and citation pressure on researchers are the basic variables in the model. Real data from Boğaziçi University Engineering Faculty and estimations based on the real behaviors observed are used for initializing the model. The model is tested and validated with extensive structural and behavior tests.

With the first scenario, we analyzed the effects of increasing skill level of the faculty members. Both the citation and publication performances become better with higher skill level. On the contrary, the second scenario showed that, if skill level decreases in time, both the citation and publication performances become worse.

In the model, publication pressure is exerted on researchers by dictating a benchmark value for the yearly publishing rate. Under the first policy, the benchmark value for yearly publishing rate is increased in time. This made the publication pressure on researchers more persistently perceivable. Researchers tend to increase total time devoted to research activities to catch the dictated benchmark value. This results in an increase in only C type, low quality publications. Through increasing research time, A and B type publications are continued to be published. However, there is no improvement in citation performance, in fact, number of average citations per publication decreases.

With the second policy, the benchmark for yearly publishing rate is not changed, but faculty members are forced to reach the benchmark value in the expense of a decreased citation performance. This makes researchers produce mostly low quality publications, which are written in shorter time. Citation performance decreases dramatically, but there is no improvement in yearly publishing rates either. This policy does not achieve what it is intended to do.

The third policy examines the situation where the management allows researchers to devote more time on research activities by easing their administrative or educational loads. Under such a policy, researchers become better publication producers. Moreover, number of high quality publications increases remarkably, resulting in increased citations.

Finally, a policy stating 'publish for quality' is examined. The sheer number of publications becomes less important in time. This eventually results in the highest 'citation per publication' value in all experiments. That is to say, if researchers are expected to make high quality research, then if the pressure regarding number of publications is lowered, they act in the expected direction and do high quality research.

The policies are not imaginary, from the literature it is known that they are being applied in various forms in real life. This study provides a platform for analyzing long term behaviors of researchers under different policies regarding citations and publications.

As future research, new factors can be included in the model. A good extension of the model can be representing the skill level –currently an exogenous variable- as an endogenous variable, affected by the internal structure of the model. Number of journals covered by ISI has been increasing significantly in recent years. Investigating the reasons underlying this increase in the number of journals, together with journal impact factor and modeling their dynamic effects may constitute a good further research. An interactive simulation game can be constructed based on this model and decisions of players can be analyzed under publication and citation pressures. Finally, an agent-based model can be constructed in order to analyze the aggregation from the micro dynamics.

References

Barker, K. 2007. "The UK Research Assessment Exercise: the evolution of a national research evaluation system." *Research Evaluation* 3(12).

Barlas, Y. 1996. "Formal aspects of model validity and validation in system dynamics." *System Dynamics Review* 12(3):183-210.

Besancenot, D. and Vranceanu, R. 2007. "Can incentives for research harm research? A business school's tale." *The Journal of Socio-Economics* 37(3):1248-1265.

Butler, L. 2002. "A list of published papers is no measure of value." *Nature* 419(6910):877.

Butler, L. 2004. “The use of publication and patent statistics in studies of S&T systems.” In *Handbook of quantitative science and technology research*, edited by H. F. Moed and W. Glanzel, 389-406. London:Kluwer Academic Publishers.

Coccia, M. 2008. “Measuring scientific performance of public research units for strategic change.” *Journal of Informetrics* 2(3):183-194.

Frolic, N. 2006. “Funding systems and their effects on higher education systems.” *Norway: OECD National study*.

Garfield, E. 1970. "Citation Indexing for Studying Science." *Nature* 669(1):669-671.

Glanzel, W.,Thijs, B. and Schlemmer, B. 2004. “A bibliometric approach to the role of author self-citations in scientific communication.” *Scientometrics* 59(1):63-77.

Hamilton , D. P. 1990. “Publishing by and for the numbers.” *Science* 250.

Küçük, B., Tamçakır, A. S. and Güler, N. 2007. “Measurement Analysis and Evaluation of Academic Publications and Citations.” BS Senior Thesis., Bogazici University.

Lariviere, V., Archambault E. and Gingras, Y. 2008. “Long-term variations in the aging of scientific literature: From exponential growth to steady-state science (1900-2004).” *Journal Of The American Society For Information Science And Technology* 59(2):288-296.

Moed, Henk F. 2005. *Citation Analysis in Research Evaluation*. The Netherlands: Springer.

Moed, Henk F. 2008. “UK Research Assessment Exercises: Informed judgments on research quality or quantitiy.” *Scientometrics* 74(1):153-161.

Onsel, Nisa. 2011. “Modeling the dynamics of academic publications and citations.” MS Thesis, Bogazici University.

Price, D. J. 1964. "Ethics of Scientific Publication." *Science* 144(1):655-657.

Taubes, G. 1993. “Measure for measure in science.” *Science* 260(5110):884-886.