

MISSOURI DEPARTMENT OF HIGHER EDUCATION

FORM NP: NEW PROGRAM PROPOSAL FORM

Sponsoring Institution(s): Washington University

Program Title: PhD in Statistics

Degree/Certificate: degree

Options: _____

Delivery Site(s): Washington University, Danforth Campus

CIP Classification: 27.0501

Implementation Date: September 26, 2013

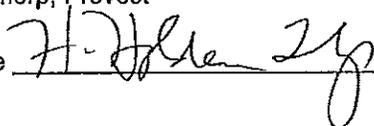
Cooperative Partners: _____

Expected Date of First Graduation: May 2016

AUTHORIZATION

Name/Title of Institutional Officer:

Holden Thorp, Provost

Signature  Date 10/30/13

Person to Contact for More Information:

Susan E. Hosack, University Registrar

Telephone: (314) 935-5567

MISSOURI DEPARTMENT OF HIGHER EDUCATION

Form SE: STUDENT ENROLLMENT PROJECTIONS

Year	1	2	3	4	5
Full Time	1-2	2-3	3-5	5-8	5-10
Part Time	0	0	0	0	0
Total	1-2	2-3	3-5	5-8	5-10

Form PS: PROGRAM STRUCTURE

A. Total credits required for graduation: 72

B. Residency requirements, if any: _____

C. General education: Total credits: _____ (SEE ATTACHED)

Courses (specific courses OR distribution area and credits):

_____ cr. _____ cr. _____ cr.

_____ cr. _____ cr. _____ cr.

D. Major requirements: Total credits: _____

_____ cr. _____ cr. _____ cr.

_____ cr. _____ cr. _____ cr.

E. Free elective credits: _____ (Sum of C, D, and E should equal A.)

F. Requirements for thesis, internship or other capstone experience: (SEE ATTACHED)

G. Any unique features such as interdepartmental cooperation:

MISSOURI DEPARTMENT OF HIGHER EDUCATION

Form PG: PROGRAM CHARACTERISTICS AND PERFORMANCE GOALS

Institution Name: Washington University

Program Name: PhD in Statistics

Date: September 26, 2013

(Although all of the following guidelines may not be applicable to the proposed program, please carefully consider the elements in each area and respond as completely as possible in the format below. Quantification of performance goals should be included wherever possible.)

Student Preparation (SEE ATTACHED)

- Any special admissions procedures or student qualifications required for this program which exceed regular university admissions, standards, e.g., ACT score, completion of core curriculum, portfolio, personal interview, etc. Please note if no special preparation will be required.
- Characteristics of a specific population to be served, if applicable.

Faculty Characteristics (SEE ATTACHED)

- Any special requirements (degree status, training, etc.) for assignment of teaching for this degree/certificate.
- Estimated percentage of credit hours that will be assigned to full time faculty. Please use the term "full time faculty" (and not FTE) in your descriptions here.
- Expectations for professional activities, special student contact, teaching/learning innovation.

Enrollment Projections (SEE ATTACHED)

- Student FTE majoring in program by the end of five years.
- Percent of full time and part time enrollment by the end of five years.

Student and Program Outcomes (SEE ATTACHED)

- Number of graduates per annum at three and five years after implementation.
- Special skills specific to the program.
- Proportion of students who will achieve licensing, certification, or registration.
- Performance on national and/or local assessments, e.g., percent of students scoring above the 50th percentile on normed tests; percent of students achieving minimal cut-scores on criterion-referenced tests. Include expected results on assessments of general education and on exit assessments in a particular discipline as well as the name of any nationally recognized assessments used.
- Placement rates in related fields, in other fields, unemployed.
- Transfer rates, continuous study.

Program Accreditation (SEE ATTACHED)

- Institutional plans for accreditation, if applicable, including accrediting agency and timeline. If there are no plans to seek specialized accreditation, please provide reasons.

Alumni and Employer Survey (SEE ATTACHED)

- Expected satisfaction rates for alumni, including timing and method of surveys
- Expected satisfaction rates for employers, including timing and method of surveys

Washington University, Department of Mathematics

Proposal For A Ph.D. Degree In Statistics

David Wright, Department of Mathematics wright@wustl.edu

Jeff Gill, Departments of Political Science, Biostatistics, and Surgery jgill@wustl.edu

I OVERVIEW

Describe Statement of Philosophy /Purpose

The Department of Mathematics proposes a new Ph.D. program in Statistics in order to take fuller advantage of faculty strengths and to satisfy the extraordinary demand for well-trained scholars in statistics throughout St. Louis, the United States, and the rest of the world. The Department of Mathematics houses statistics, and students in the department are allowed to specialize in Statistics, but the Ph.D. degree they currently receive is in Mathematics. There is currently no other means of studying statistics as the key component of the doctoral degree in the Graduate School of Arts & Sciences or any other units at Washington University.

The Department of Mathematics has substantial faculty strengths in Mathematical and Applied Statistics. There are currently four statisticians in the department, tenured or tenure-track. The importance of statistical analysis in the Twenty-First Century is obvious to anyone who thinks about data and information. One of the problems of modern life, academically, corporately, and personally, is that so much information is easily available that it is difficult to discern what important trends and features should be understood. The statistical analysis of data will continue to be an important skill in demand at universities, research centers, and corporate environments. No Ph.D. statistician lacks for career opportunities in modern society.

There are also substantial benefits for the university community as a whole. Statistics is the most *interdisciplinary* science imaginable. Nearly all of the social sciences require statistical analysis to perform research at the highest level. Many units in Arts & Sciences have graduate students who write theses and dissertations that require the analysis of data. The more institutionalized and the more overtly supported statistics is in the Department of Mathematics, the greater the benefit to the university as a whole since it will serve as a central hub for grant activities, a source of additional support, and a means of cross-fertilizing thesis committees. Statistics also plays a critical role in biomedical research, and therefore affects our efforts on the medical campus. Currently all of the statisticians in the department have research collaborations in the School of Medicine. In addition, Engineering and Applied Mathematics have long relied on statistical analysis for advances in electronics, construction, materials, and other areas. Finally, it is important to note that our peer institutions have strong statistics doctoral programs, including the University of Chicago, Duke University, Rice University, Vanderbilt University, Northwestern University, and others.

State How the Degree Program Will Serve the University's and the Unit's Academic Mission

Demand for training and demand for trained employees in statistics has never been higher in the university's history. As stated, many departments at Washington University depend upon the Department of Mathematics for courses in Statistics at the undergraduate and graduate level. For example, the department teaches Mathematics 2200 (*Elementary Probability and Statistics*, required by many majors), and Mathematics 3200 (*Elementary to Intermediate Statistics with Data Analysis*, required by quantitatively-oriented majors). Therefore the bulk of undergraduate statistical training falls to the Department of Mathematics. At the graduate level, departments currently across at least four schools rely on the department for advanced training that enables their graduate students to focus on data analysis in their dissertation work.

The proposed Ph.D. program in Statistics feeds these needs in several ways. It creates a set of highly trained doctoral graduates who can serve other units, most notably the School of Medicine where the demand for this expertise is extremely high and motivated by the pursuit of federal research grants. There are therefore direct grant revenue benefits. It also creates a body of experts in the form of Statistics graduate students who are available for consultation, and later, instruction. This process helps prepare them for academic, private sector, and government careers.

The proposed Ph.D. program in Statistics benefits the Department of Mathematics because it will draw graduate students in statistics to complement the current high quality mathematics graduate students. Secondly, we currently have four Statistics faculty (and possibly one vacant joint appointment). A Ph.D. program provides a stronger sense of intellectual community for these faculty as graduate students move through the system. Through directed teaching and mentorship, distinguished visitors, and internal seminars, the degree program strengthens the department's commitment to Statistics as one of the mathematical sciences.

II NEED FOR A NEW DEGREE PROGRAM

Specify What Needs, Opportunities Or Audiences Exist To Justify A New Degree Program

Statistics is a growing field of knowledge in which many job opportunities exist, in academics and in industry. Graduate Statistics students at Washington University have been graduating with a Ph.D. in Mathematics, and though they have found jobs (in some cases exceptionally good ones such as postdocs with leading scholars at Harvard University and the University of Florida), they would be better served if their Ph.D. were formally in Statistics.

In the six-year interval 2007-2012 we had seven graduating Ph.D. students whose concentration was in statistics. They are listed below with their year of graduation, their dissertation advisor, dissertation title, and where they found employment after graduation.

- Xiao Huang, 2011, (S. Sawyer), Using Dirichlet Process Priors for Bayesian Mixture Clustering, Seismic Imager, CGGVeritas (global provider of geophysical services and equipment), Houston, Texas

- Andrew Womack, 2011, (J. Gill), Predictive Alternatives in Bayesian Model Selection, Post Doctoral Researcher, Department of Statistics, University of Florida Gainesville, Florida.
- Qing Li, 2010, (N.Lin), On Bayesian Regression Regularization Methods, Biometrician, Merck & Co., Inc., White House Station, New Jersey.
- Ruibin Xi, Summer 2009, (N. Lin), Statistical aggregation: Theory and applications, Post Doctoral Researcher, Center for Biomedical Informatics, Harvard Medical School, Boston, Massachusetts.
- Haley Jane Abel, 2009, (S. Sawyer), The Role of Positive Selection in Molecular Evolution: Alternative Models for Within-Locus Selective Effects; Postdoctoral Researcher in the Division of Genetic Epidemiology, Department of Internal Medicine, University of Utah.
- Chunlin Fan, 2009, (W. Ploberger, Economics, S. Sawyer, Mathematics), Contributions to the Theory of Copula, Analyst, Midwest ISO, Carmel, Indiana.
- Amei, 2007, (S. Sawyer), A time-dependent Poisson random field model of polymorphism within and between two related species; Assist. Professor, Department of Mathematical Sciences, University of Nevada, Las Vegas.

There were 39 students who received the Ph.D. from our department in the years 2007-2012, so the above constitute almost one fifth of our graduating students. Our four in-house statisticians comprise one sixth of our 24 tenured and tenure track faculty, so they are more than carrying their weight as Ph.D. advisors. Note that four of these seven went into academic positions, which a little below the ratio of academic to non-academic jobs taken by our graduates overall (about two to one). (It is expected that a larger percentage of statisticians take positions in the private sector than that of pure mathematicians.)

State Clearly Differentiations Between This Proposed New Degree And Existing Programs

At Washington University there is *currently* no Ph.D. program in Statistics, Biostatistics, or related epidemiology. There are three related masters degrees programs: (1) a Masters of Arts in Statistics housed in the Department of Mathematics, (2) a Masters of Science in Statistics offered by University College and run by the Department of Mathematics that starts Fall of 2013, and (3) a two-year old Master of Science degree in Biostatistics offered by the Division of Biostatistics in the School of Medicine. All three of these programs serve different needs at different levels than the proposed doctoral program: (1) is a day-time terminal masters program where it has been rare to have students move on to a Ph.D. program, (2) is a new program offered in the evenings for professionals in the St. Louis area who have full time jobs and will not be going on to a Ph.D. program, (3) is a biostatistics masters program with tracks in Biostatistics and Statistical Genetics and is designed to produce mid-level biostatisticians for medical research environments (including the Washington University School of Medicine). No other university in the St. Louis area offers a Ph.D. in Statistics and the

closest are the University of Missouri (123 miles) and the University of Illinois (179 miles), neither of which are considered direct competing peer institutions.

Currently, doctoral students in the department who wish to emphasize Statistics take three qualifying examinations in pure mathematics from: Complex Analysis, Algebra, Geometry, and Real Analysis. They can then take the fourth qualifying examination in Statistics. This provides an imbalanced emphasis on pure Mathematics for these students. Under the proposed program, the department would add a second Statistics qualifying exam in linear models. Thus Statistics Ph.D. would take two of their examinations in their chosen field of emphasis (statistics), and two additional (pure mathematics). Therefore the department would retain our emphasis on the mathematical and theoretical side of the field of Statistics.

Describe the Distinctive Competence of the Unit and the University for Offering This Program

The Department of Mathematics is well-placed to expand the university's current commitment to teaching and research in Statistics. With four research-active faculty in the department (three housed in Couples I plus Jeff Gill who has offices on both campuses) and new coordination with other units there now exists a strong core of research statisticians in the department. In addition, the Department of Mathematics has received permission to recruit a tenure-track statistician in the Fall of 2013. The university hosts a relatively large number of theoretical and applied statisticians considering there is no traditional Statistics department. Many dissertations in the social, health, and engineering sciences contain extensive data analysis components and the faculty in these units are well-trained to direct this component. Existing relationships exist with the Brown School of Social Work, the Department of Political Science, Electrical and Systems Engineering, the Department of Computer Science, the Department of Psychology, the Olin Business School, and units in the School of Medicine. This is not an over-abundance, but instead reflects the centrality of the math department in teaching and research related to statistics.

The skills and experience of the department's statistical faculty are evidenced by their collaborative research with other units at the university. Dr. Jimin Ding is currently a co-PI with scholars in the Department of Neurology on an NIH R01 grant: Actigraphy in Sleep Medicine. In the past she worked on a United States Renal Data System project focused on creating a erythropoietin index and myocardial infarction registry. Dr. Jeff Gill has current projects in conjunction with the Division of Health Sciences (an NIH funded project on energetics and cancer), the Brown School of Social Work (access to health care), Internal Medicine (Warfarin dosage), the Department of Political Science (medium-term effects of childrens' exposure to war, expert elicitation), and in pure theoretical work. Dr. Nan Lin works with scholars in the Department of Anesthesiology on studying volatile anesthetic concentrations and another project on intraoperative awareness in a high-risk surgical population, and the Department of Pediatrics Emergency Medicine on RNA diagnostic for pediatric appendicitis. Finally, the two senior statisticians, Dr. Stanley Sawyer, and Dr. Ed Spitznagel, have had literally *hundreds* of collaborations with scholars in other departments at Washington University leading to a huge inventory of publications and grants over the last four decades. These interests and activities demonstrate

not only the importance of statistics at the university across academic disciplines, but also the necessarily collaborative nature of those working in this area. (We should note that Professor Sawyer has retired as of this year, but his tenure line remains and we expect to fill it soon with another statistician.)

Provide An Estimate of How Many Students are Expected To Participate in the Program In Its Early State and In Its Steady State. Describe What Efforts Have Been Made To Determine If There Is A Demand For Such A Program

We anticipate 1 or 2 of the incoming admitted statistics Ph.D. students in any given year at the steady state. The first and second year of the new program it might be as low as 0 or 1 students while we work to publicize the new degree. Current students in the Mathematics program who are specializing in Mathematical Statistics will be given the option to change to the Statistics program, provided they can meet its requirements. Since faculty in Statistics routinely obtain NSF and NIH grants, alone or with substantive researchers, we can begin writing in grant support to fund additional statistics Ph.D. students once the degree exists and attracts them to Washington University. This is expected to fund up to 2 students per year after the program is established. An eventual steady state size of 5 to 10 graduate students in Statistics is expected.

III STATEMENT OF DEGREE REQUIREMENTS

Outline the Proposed Curriculum For the Degree Program

Ph.D. students in the Department of Mathematics currently take a yearlong course in each of four subjects, capped by a final exam that serves as a "qualifier." As mentioned, these four tracks are now chosen from these course sequences: Algebra (Math 5031-5032), Measure Theory and Functional Analysis (Math 5051-5052), Complex Analysis (Math 5021-5022), Geometry (Math 5041-5042), and Mathematical Statistics (Math 5061-5062). If approved, the Statistics Ph.D. would require two of the four mathematical subjects (the first four just listed) and two statistical subjects – the last one plus Linear Statistical Models, now numbered 436 and 4392, which is an additional subject offered by the department.

The next step in the program is for the student to prepare both a "minor oral presentation" and a "major oral presentation" For Statistics Ph.D. students the major component would be in one of the two Statistics subjects and the minor component in one of the two pure Mathematics components. Topics for these orals are chosen in consultation with the advisor, and culminate in two public lectures. These should be completed by the end of the year following completion of the written qualifying exams.

This degree program will provide the opportunity for students to serve as teaching assistants to learn how to teach technical topics to students with a wide range of backgrounds, and is part of the professional development and degree requirement. Teaching experience is an increasingly important component of graduate education for students who seek employment in academics.

Summary of Degree Requirements

Prerequisites If Needed

- ▷ Linear Algebra, Mathematics 429 (0 credits towards the degree)
- ▷ Calculus III, Mathematics 233 (0 credits towards the degree)

Total of 72 graduate units required, as specified below

- 30 Units Required Courses
 - L24-5061 Theory of Statistics I (3 units)
 - L24-5062 Theory of Statistics II (3 units)
 - L24-439 Linear Statistical Models (3 units)
 - L24-4392 Advanced Linear Statistical Models (3 units)
 - L24-XXX Statistical Consulting Seminar (6 units)
 - Field 1 sequence* (6 units)
 - Field 2 sequence* (6 units)
 - 12 elective coursework units (see the list of options below).
 - Dissertation research, thesis preparation, and defense (30 units).

*Field sequence choices: L24-5021, L24-5022 or L24-5031, L24-5032 or L24-5041, L24-5042 or L24-5051, L24-5052

Other requirements

- 4 qualifying exams: 2 in statistics, 2 in mathematics.
- Graduate School Teaching Requirement for Ph.D. Students.
- Major and Minor oral presentation (see above).

Requirements By Semester

▷ Year 1, Fall Semester

- ▶ Math 5061 Theory of Statistics I
- ▶ Pure Math Exam Field 1 Course, one of Math 5021, 5031, 5041, 5051
- ▶ Elective (3 credits)

▷ Year 1, Spring Semester

- ▶ Math 5062 Theory of Statistics II

- ▶ Pure Math Exam Field 1 Course, the sequel Math 50X2 to the one selected above
- ▶ Elective (3 credits)
- ▷ Year 2, Fall Semester:
 - ▶ Math 439 Linear Statistical Models
 - ▶ Pure Math Exam Field 2 Course, another one of Math 5021, 5031, 5041, 5051
 - ▶ Elective (3 credits)
- ▷ Year 2, Spring Semester
 - ▶ Math 4392 Advanced Linear Models
 - ▶ Pure Math Exam Field 2 Course, the sequel Math 50X2 to the one selected above
 - ▶ Elective (3 credits)
- ▷ Year 3, Fall Semester:
 - ▶ Elective (3 credits)
- ▷ Year 3, Spring Semester
 - ▶ Elective (3 credits)

Statistics Elective Courses (3 units each)

- ▷ Mathematics 404, Numerical Methods
- ▷ Mathematics 408, Nonparametric Statistics
- ▷ Mathematics 420, Experimental Design
- ▷ Mathematics 425C, Multilevel Models in Quantitative Research
- ▷ Mathematics 434, Survival Analysis
- ▷ Mathematics 438, Sampling Techniques
- ▷ Mathematics 456, Financial Mathematics
- ▷ Mathematics 459, Bayesian Statistics
- ▷ Mathematics 475, Statistical Computation
- ▷ Mathematics 495, Stochastic Processes
- ▷ Mathematics 551, Advanced Probability I
- ▷ Mathematics 552, Advanced Probability II
- ▷ Mathematics 523C, Information Theory and Statistics (ESE 523)
- ▷ Electrical and Systems Engineering 405, Reliability and Quality Control
- ▷ Electrical and Systems Engineering 407, Analysis and Simulation of Discrete Event Systems
- ▷ Electrical and Systems Engineering 415, Optimization
- ▷ Electrical and Systems Engineering 425, Random Processes and Kalman Filtering

- ▷ Electrical and Systems Engineering 428, Probability
- ▷ Electrical and Systems Engineering 520, Probability and Stochastic Processes
- ▷ Electrical and Systems Engineering 521, Random Variables and Stochastic Processes I.
- ▷ Electrical and Systems Engineering 522, Random Variables and Stochastic Processes II.
- ▷ Electrical and Systems Engineering 523, Information Theory
- ▷ Computer Science & Engineering 511A, Introduction to Artificial Intelligence
- ▷ Computer Science & Engineering 514A, Data Mining
- ▷ Computer Science & Engineering 517A, Machine Learning
- ▷ Computer Science & Engineering 519T, Advanced Machine Learning
- ▷ Computer Science & Engineering 541T, Advanced Algorithms
- ▷ Biostatistics M19-550, Randomized Controlled Trials
- ▷ Biostatistics M21-623, Advanced Topics in Biostatistics
- ▷ Economics 5145, Advanced Theoretical Econometrics

Note that these electives allow students to develop their own tracks in: advanced statistical theory, applied engineering, and biostatistics. To be absolutely clear, these tracks are not designed to create engineering statisticians, financial statisticians, or biostatisticians; they are provided to accommodate mathematical-statistics students with applied data problems in their areas of interest. Students may also petition to take electives not on this list, and their request will be evaluated by their faculty advisor.

Provide Detail On Whether This Program Will Call For the Creation Of New Courses Or Rely On Existing Courses and Whether Any Program Components Are Off-Campus Or Include Online Education

The only course needed to launch the program will be the yet-to-be-numbered course Statistical Consulting Seminar, described below.

Course description for Statistical Consulting Seminar: Students will develop skills required of practicing statistical consultants, including exposure to statistical applications, and general problem-solving. Under faculty supervision, students address and solve consulting problems in the campus-wide walk-in consulting program housed in the Department of Mathematics. This includes follow-up if necessary with walk in clients and computational assistance with recommended modeling solution. Grades will be based upon assigned attendance hours in the walk-in center and selected followup with clients by faculty.

The rest of the curriculum is already intact.

Describe Time Line For Coursework and Other Requirements

Students are expected to finish their core coursework in the first two years, their qualifying examinations after the second year, their elective coursework by the end of the third year, and the dissertation in the next two

years. Thus the expected time for completing the degree is five years, which is standard for the Department of Mathematics.

IV SELECTION OF CANDIDATES AND ADMISSION CRITERIA

List Admission Requirements

Applicants to the Statistics Ph.D. Program must hold a minimum of a baccalaureate degree from an accredited college or university. Required course work in undergraduate or graduate courses are: Matrix Algebra, Calculus I II, III, as well as one introductory Statistics course (including Econometrics, Psychometrics, and Biostatistics). Applicants with degrees in Mathematics, Physics, or Engineering, are especially encouraged. All candidates must complete a Graduate School of Arts and Sciences application found at this location: <http://graduateschool.wustl.edu/>, and meet the requirements of the Graduate School and Program for admission. Nationally, students accepted into Ph.D. programs rarely have statistics as an undergraduate major. Typically they have received Mathematics, Economics, or Physics undergraduate degrees. Students coming from other backgrounds may need to take prerequisites as listed in Section III, as advised by the Director of Graduate Studies in the Department of Mathematics.

Identify Who Will Review Applications and Make Admissions Decisions

Upon receipt of the student's application for admission and all required materials, including transcripts and letters of recommendation, the application is reviewed by the Graduate Committee of the Department of Mathematics, under its Graduate Director, in consultation with the statistics faculty in the Department of Mathematics. The Statistics Committee consists of the five core faculty listed in Section V below. Suitable candidates are forwarded to the Dean of the Graduate School of Arts and Sciences for final approval for admission to the Program. The Department of Mathematics will notify accepted students by letter. These procedures are identical to current practice in the department.

V RESOURCES AND SUPPORT

State How This new Program Will Draw On Existing Faculty and Resources (including library resources) Or Will Provide New Resources

As stated before, no new resources are being requested, as the program will draw on existing faculty. Therefore no additional hiring is necessary, other than Professor Sawyer's replacement. The Statistics group in the mathematics department would then include that new hire together with Ed Spitznagel, Nan Lin, Jimin Ding, and Jeff Gill. If, as expected, the university's need for statistics continues to grow, we would hope to eventually increase the number of statisticians slightly, but this is not an immediate need. The department has seven staff members, and they would not be adversely affected since this program is run in parallel, and with the

same departmental procedures, as the regular Mathematics Ph.D. program. There will be no impact on library resources.

Consider Whether This New Degree Program Will Have An Effect On Other Units In the University

Several academic units at Washington University draw on the Department of Mathematics to provide Statistics training at the graduate level. The new masters degree in Biostatistics offered by the Division of Biostatistics in the Medical School (http://www.biostat.wustl.edu/msibs/index_files/page832.htm) draws heavily on mathematics-based courses. Students in the Social Sciences and in Engineering often take Statistics courses currently offered in the department. These units would benefit from reorganized and slightly extended Statistics offerings that would come from the new degree. This program will not affect the current M.A. and M.S. statistics programs in the Department of Mathematics, except that some courses will be taken by both masters and doctoral students.

List Core Faculty Who Will Oversee the Program. Include Rank and Department

Core Faculty:

- Jimin Ding, Assistant Professor, Department of Mathematics
- Jeff Gill, Professor of Statistics, Department of Political Science, Division of Biostatistics, Department of Surgery (Public Health Sciences), Courtesy appointment to the Department of Mathematics.
- Nan Lin, Associate Professor, Department of Mathematics
- The replacement for the retiring Stanley Sawyer, Professor of Mathematics (search has been approved for 2013-14)
- Edward Spitznagel, Professor, Department of Mathematics, Joint Appointment in the Division of Biostatistics.

Affiliated Faculty:

- Siddhartha Chib, Harry C. Hartkopf Professor of Econometrics and Statistics, Olin Business School
- Douglas A. Luke, Professor, Brown School of Social Work
- Andrew Martin, Charles Nagel Chair of Constitutional Law and Political Science Vice Dean and CERL Director, School of Law, College of Arts & Sciences
- John Patty, Associate Professor, Department of Political Science, College of Arts & Sciences
- Maggie Penn, Associate Professor, Department of Political Science, College of Arts & Sciences

- Jody O'Sullivan, Samuel C. Sachs Professor of Electrical Engineering, School of Engineering
- D.C. Rao, Professor of Biostatistics, Director of the Division of Biostatistics, School of Medicine
- Kilian Weinberger, Assistant Professor, Department of Computer Science & Engineering.

State Whether This New Program Will Require Additional Resources and Who Will Provide Them

Students taking admitted to this program will come from the Department's allotted students, except possibly students supported by a faculty member's grant. Therefore no new departmental funds would be needed for this program.

Consider Issues of Tuition and Financial Aid

Graduate student support through tuition and remission will be awarded exactly as done with the traditional mathematics Ph.D. students in the department.

VI PROGRAM ADMINISTRATION

State Which Department Or Program Will Administer the Program

The Ph.D. program in Statistics will be based in the Department of Mathematics. During the years of coursework, these students will be supported by Teaching and/or Research Assistantships in the Department. Management of graduate student issues will be through the departmental Director of Graduate Studies.

Identify the Program Director or Coordinator

This will be the Director of Graduate Studies in the Department of Mathematics, currently Professor Mohan Kumar.

Describe the Process for Evaluation of Student Performance

The qualifying exams described in Section III above serve as an evaluation of whether the student should continue toward the dissertation. Students have teaching duties and are supervised in this phase by Blake Thornton, Coordinator of Undergraduate Curriculum in Mathematics.

State Plans For Providing Adequate Advising, Mentoring and Support of Students In the Program

Students will be directed, evaluated, and mentored along with, and in the same manner as, current graduate students in Mathematics. Students are assigned faculty advisors who monitor their progress. Currently masters

students in statistics are assigned statistics faculty as advisors (Jimin Ding, Jeff Gill, Nan Lin, Ed Spitznagel), and this practice would continue with Ph.D. students in the future. The department has permission to do a statistics faculty search in the Fall of 2013, so the pool of advisors will increase.

VII EVALUATION OF PROGRAM

Describe How and How Often Program Evaluation Will Be Conducted

Informal evaluations of the program will necessarily occur as each student takes the four Comprehensive Examinations, where lack of success on the part of the student will be the occasion for reconsideration of why the student was insufficiently prepared. A similar evaluation will occur during each dissertation defense. These informal evaluations will be easy to manage because of the relatively small number of core faculty involved (up to six for the two Statistics examinations, four for the defense plus two outside members). No formal evaluation of Statistics alone, such as by an outside committee, will be held separate from general Departmental reviews, now occurring once every five to ten years.

VIII Policies on Courses Taken for the Masters Degrees

A Ph.D. student who leaves the program after completing two years of coursework may be granted the A.M. in statistics if the student meets the August 2013 updated A.M. requirements shown in the appendix to this proposal.

IX Appendix: The A.M. in Statistics

General requirements: 36 units of coursework and a thesis. Six units may be for thesis research. The minimum residence requirement is one full academic year of graduate study. A grade point average of "B" or better must be maintained in graduate course work.

Course Requirements

The student must take (or have taken) the following 5 required courses in mathematics or their equivalents: 493 and 494 (probability and mathematical statistics) or 5061 and 5062 (theory of statistics); 429 (linear algebra) or 4392 (advanced linear statistical models); 439 (linear statistical models); and 475 (statistical computation) or a suitable substitute elective approved by the department. In the case that an equivalent course has been taken and also proficiency in the course material has been demonstrated, other 400-level and above electives may be substituted in consultation with the advisor. Additional 400-level or higher electives will be chosen by the student in consultation with his or her advisor to make up the 36 units. Typically, at most two electives shall be chosen from outside the Mathematics Department. If not taken before, a course in C programming

is strongly recommended but cannot be included among the courses used to satisfy the 36 units requirement.

Possible electives include:

- ▷ MATH 449 Numerical Methods
- ▷ MATH 408 Nonparametric Statistics (SO)
- ▷ MATH 4111 Introduction to Analysis (F)
- ▷ Math 4121 Introduction to Lebesgue Integration
- ▷ Math 420 Experimental Design (SE)
- ▷ MATH 4301 Multilevel Modeling (POLI SCI 584C) (F)
- ▷ MATH 434 Survival Analysis (FO)
- ▷ MATH 4392 Advanced Linear Statistical Models (SO)
- ▷ MATH 459 Bayesian Statistics (S)
- ▷ MATH 495 Stochastic Processes (SO)
- ▷ MATH 5061-62 Theory of Statistics I / II (F)/(S)
- ▷ MATH 523C Information Theory and Statistics (ESE 523)
- ▷ MATH 551 - Advanced Probability I
- ▷ MATH 552 - Advanced Probability II
- ▷ MATH 5021 - Complex Analysis I
- ▷ MATH 5022 - Complex Analysis II
- ▷ MATH 5031 - Algebra I
- ▷ MATH 5032 - Algebra II
- ▷ MATH 5041 - Geometry I
- ▷ MATH 5042 - Geometry II
- ▷ MATH 5051 - Measure Theory and Functional Analysis I
- ▷ MATH 5052 - Measure Theory and Functional Analysis II
- ▷ BIO 4181 Population Genetics
- ▷ BIOL 5483 01 Human Linkage and Association Analysis
- ▷ BIOL 5495 01 Computational Molecular Biology
- ▷ CSE 514A Data Mining
- ▷ MEC 670 - Seminar in Econometrics
- ▷ ESE 522 - Random Variables and Stochastic Processes II

Please note: Not all courses are offered each year. Courses are listed in numerical order. The letters in parentheses after the name of a course mean:

- F = offered each fall

- FO = offered each fall in odd-numbered years
- FE = offered each fall in even-numbered years
- S = offered each spring
- SO = offered each spring in odd-numbered years
- SE = offered each spring in even-numbered years



Washington University in St. Louis

SCHOOL OF MEDICINE

**D.C. Rao, Professor and Director
Division of Biostatistics**

July 11, 2013

David Wright, PhD
Professor and Chair
Department of Mathematics
Campus Box 1146

Dear David:

It gives me great pleasure to enthusiastically support your proposal for a new PhD program in Statistics in the Department of Mathematics at Washington University. It has long been recognized by many that a premier institution like ours was not actively contributing to the training of statisticians. Your proposal represents an excellent effort to address this important academic need not only at this institution, but in the state of Missouri as well. The closest PhD program in Statistics is at the University of Missouri-Columbia with another at the University of Illinois. There is indeed great demand for well-trained statisticians in academia, government, and private industry.

For many years, students at Washington University have been able to pursue graduate studies in statistics, but only to receive a PhD in Mathematics; specialization in Statistics was not recognized until now. The new proposal will overcome that limitation and attract new students who may be currently lost to our competition. The Washington University Department of Mathematics has an excellent international reputation and will be able to build on that reputation with the new PhD program in Statistics. This program will provide recognition for the graduate student's contributions in mathematical statistics as well as include Washington University as a contender in the company of our peer institutions' doctoral training programs in Statistics.

The proposed PhD in Statistics will serve as an additional tier of training and will be differentiated from the current masters degree programs currently offered at WU: Master of Arts in Statistics (Department of Mathematics), Master of Science in Statistics (University College, run by the Department of Mathematics beginning the Fall of 2013), and a Master of Science degree in Biostatistics (Division of Biostatistics in the School of Medicine). As you know, the Division of Biostatistics is currently working toward developing a PhD Program in Biostatistics jointly with your Department. The focus of the PhD in Biostatistics is to promote statistics in biomedical and clinical research. It will provide research and training opportunities in clinical trials, epidemiology, biostatistics

David Wright, PhD
July 11, 2013
Page 2

and statistical genetics. Our joint proposal which is in the early planning stages will complement your current proposal for a PhD in Statistics.

I am especially pleased to see that your proposed program will capitalize on the academic strengths and spirit of cooperation among many departments, including the Division of Biostatistics. Students in your new program will be able to develop their own tracks in their area of interest such as statistical theory, applied engineering and biostatistics. This is an excellent example of a multidisciplinary endeavor that will enhance the University's existing curriculum and produce graduates with the high standards expected of Washington University.

It is obvious that you have spent a lot of time and effort developing this new program, and I wish you every success in getting this program launched at Washington University. The new PhD in Statistics program will be a tremendous asset to our overall academic portfolio of training programs here at Washington University and in the development of future well-trained statisticians. Thank you for your leadership.

Sincerely,



D. C. Rao, Ph.D.
Professor and Director
Program Director, MSIBS



SCHOOL OF ENGINEERING & APPLIED SCIENCE

Department of Computer Science and Engineering

June 24, 2013

Dr. David Wright
Professor and Chair
Department of Mathematics

Dear Dr. Wright,

The Department of Computer Science and Engineering has reviewed your proposal for a new Ph.D. program in Statistics, to be based in the Department of Mathematics. We gladly support the proposed program and consent to having your students take our courses, as specified in your proposal, as electives toward their degree. We look forward to teaching and interacting with students in the new program.

Sincerely,

A handwritten signature in black ink, appearing to read "Jeremy Buhler".

Jeremy Buhler
Professor and Interim Chair
Department of Computer Science and Engineering

 **Washington University in St. Louis**
ARTS & SCIENCES
Department of Economics

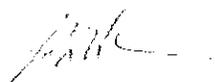
June 20, 2013

Professor David Wright
Department of Mathematics
Box 1146

Dear David,

This is to certify that the Department of Economics supports the proposal by the Department of Mathematics to start a Ph.D. program in statistics and happily consents to have students in that program take our courses, Econ 5145 in particular.

Best regards,



John Nachbar
Professor and Department Chair



Washington University in St. Louis

SCHOOL OF ENGINEERING & APPLIED SCIENCE

Preston M. Green Department of Electrical and Systems Engineering

June 24, 2013

Professor David Wright, Chair
Department of Mathematics
Campus Box 1146

Dear Professor Wright,

The Preston M. Green Department of Electrical and Systems Engineering supports the proposed Ph.D. program in Statistics and consents to having students in the program taking our courses.

Sincerely,

Arye Nehorai, Chair