MICHIGAN
ROSS SCHOOL OF BUSINESS

Technology and Operations Doctoral Program

Dear Prospective Student,

Thank you for your interest in the Technology and Operations Doctoral Program at the Ross School of Business, University of Michigan. Our program focuses on training leaders in thought and action in the field of "business technology and operations" broadly defined, including but not limited to specific areas such as supply chain management, information systems and technology, innovation, healthcare and public operations, and management science. Through a comprehensive education comprising coursework, research and teaching development, we prepare our students to be leading faculty members at top international business schools in the area. In the past few years, our graduates have accepted positions at or received offers from many highly reputable business schools, including Cornell University, Indiana University, University of Texas-Dallas, Johns Hopkins University, HEC Paris, McGill University, and the University of Arkansas, among others.

Our faculty and doctoral students motivate their research through close interactions with business leaders, thus identifying questions of immediate relevance and high impact at the highest levels of business. Resultantly, the research is not only academically rigorous and thorough, but is geared towards providing critical insights and policy recommendations that can be used to inform and support strategic business decisions. Students prepare themselves for conducting such research through a combination of rigorous coursework and close interaction with their faculty advisors. In addition, students prepare for the teaching aspect of a faculty career by teaching a full semester class, with appropriate guidance and preparation, where they have full responsibility for all activities including lectures, assignments, and student interactions. Our graduate students typically perform exceptionally well as teachers, often obtaining teaching evaluations that are at the top of the scale.

Please read on for a description of our doctoral program, including coursework and program milestones. Our webpage has more information including a list of our recent graduates and their initial placements, research seminars, current students, and application information. Please don't hesitate to contact the doctoral program co-ordinator if you have any questions. Warm regards,

T&O Doctoral Program Co-ordinator

Technology and Operations Department Doctoral Program.

The main elements of the doctoral program are:

(a) Courses (b) Research (c) Preliminary Examination and Candidacy

. **(a)** COURSES. Students are expected to take a sequence of doctoral-level courses over the first three years as a prelude to conducting their original dissertation research. These cover methodological foundations (e.g., real analysis, econometrics, and stochastic processes), theoretical foundations (e.g., microeconomics and dynamic programming), and advanced operations- specific seminars. Students select electives in areas relevant to their individual interests, in consultation with their faculty advisors.

. **(b)** RESEARCH. Doctoral students are encouraged to begin research as soon as they set foot on campus. A large-scale research paper, at a level suitable for eventual submission to a top journal, is completed by the student by end of their second year. This paper serves as the first paper in the student's dissertation, which is typically advised by one or two faculty mentors.

. **(c)** PRELIMINARY EXAMINATION AND CANDIDACY. A preliminary exam covering methodological and theoretical foundations is given between December and May of the second year. The exam ensures that students have mastered the material necessary to become an operations scholar, and students may waive exams if their mastery of the material is evidenced by their coursework grades. Students are then evaluated for advancement to candidacy after successfully writing and presenting their full- scale research paper to the department at the end of their second year.

It is expected that most students complete their degree requirements in five years. All admitted students receive full financial support, which includes tuition waiver and funding that covers living expenses for five years. More information about funding is available at https://michiganross.umich.edu/programs/phd/funding.

The T&O group at the Ross School of Business is dedicated to solving problems at the highest level of complexity and guiding decision-making processes dealt with by senior managers.

Detailed T&O Ph.D. Qualifier Exam and Core Course Requirements

[Updated Winter 2020.]

The student will take one exam between the end of their third semester and the end of their fourth semester (late December to early May). In this exam, students are expected to demonstrate competence in 5 subjects. There are 7 possible subject areas, of which the student must demonstrate competence in 5. The student can choose which 5, in consultation with the doctoral advisors.

Students can earn a waiver for each subject by meeting the following grade standard in core competency courses. The coursework requirements must be completed (via grades or exam) by May of the second summer in the program.

For the subject areas *Optimization, Probability, Dynamic Programming, Microeconomics, Analysis*, and the *Student-Advisor Initiated Option*:

> **[I]** In any subject area**, if a student receives B+ or below in a core course, the subject will be tested regardless of the grades in other courses in the same area.**
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> **[II] If a student takes multiple courses in one area, either (i) the average grade must be A or above or (ii) the student must receive A+ in at least one of course and no less than A- in all other courses to receive a waiver.**

For the subject area *Empirical Modeling*:

> **[I] If the student uses Econ 671 and/or Econ 672 to clear the area, the average grade in those courses must be an A-. If the student uses Econ 675 to clear the area, the grade in that course must be A or above. Both conditions must be true in order to receive a waiver.**

The core competency courses and waiver requirements for each area are as follows. All courses are 3 credits, unless otherwise specified.

a. **Optimization**: IOE510 (Linear programming), IOE511 (Nonlinear programming), IOE 610 (Linear programming, advanced), IOE 611 (Nonlinear programming, advanced).

Students need to take at least one 3-credit class in this area.

b. **Probability**: IOE 515 (Stochastic processes), IOE 516 (Stochastic process II), MATH 525 (Probability theory), STAT 620 (Applied probability and stochastic modeling).

Students need to take at least one 3-credit class in this area.

c. Dynamic Programming: IOE 512 (Dynamic programming), EECS 558 (Stochastic control), OMS 899 on Stochastic inventory or dynamic programming.

Students need to take one 3-credit class in this area.

ECON 610 (Stochastic dynamic optimization, half semester class): If a student receives A- in one of the above course, he/she can choose to take ECON 610. Students can obtain a waiver by receiving A+ in ECON 610.

d. Microeconomics: ECON 601, 602, 603, 604 (Microeconomic Theory I, II, III, IV, each 1.5 credits)

Students need to take at least 3 courses, totaling 4.5 credits, and receive average grade of A or above in three courses.

Alternatively, a student can receive a waiver by earning A or A+ in ECON 617 (Advanced game theory).

e. Analysis: There are two Math requirements: Basic and Advanced. Students need to fulfill both.

[Basic Requirement] If a student has majored in math or taken a senior-level/graduate level analysis, the basic requirement can be waived upon approval of the PhD committee. A student who has not taken a formal analysis class **must take ECON 600* (Mathematics for Economists) or MATH 451* in their first semester** to fulfill the basic requirement. A student receives a waiver for the basic requirement if they receive an A or A+ in one of those classes. If a student fails to receive an A or above, then the student must (1) take a qualifying exam on introductory analysis or (2) take a follow-up course (if such a course is offered in Winter) recommended by the PhD committee and get an A or above in the second semester.

*Note: Historically, ECON 600 starts in mid August and ends in early October. Students who want to take ECON 600 must arrive to Ann Arbor by early August.

[Advanced Requirement] All students need to do one of the following: (a) take one of the following courses in their first two years: MATH 597 (Real analysis II), STAT 520 (Mathematical methods in statistics), STAT 620 (Applied probability and stochastic modeling), STAT 621 (Theory of Probability II), or STAT 625 (Probability and Random Processes), or (b) have an alternative method of demonstrating advanced mathematical competence approved by the PhD Committee. If a student earns an A or A+ in their chosen course, they will fulfill the advanced mathematics requirement. If a student fails to receive an A or A+ in these courses, the PhD committee and advisor can ask a student to take a follow-up course to improve mathematical skills. Please note that the availability of follow-up courses varies every year. Thus, a student must try to register as early as possible.

f. Empirical modeling: ECON 671 (Econometric Analysis I), ECON 672 (Econometric Analysis II), ECON 675 (Empirical Econometrics).

Students need to take a total of 6 credit hours to meet this requirement.

g. Student-Advisor Initiated Option

A student, in consultation with their advisor, can propose a sequence of one or more courses to the doctoral program co-ordinator to fulfill this requirement. The track must have courses worth a minimum of 3 credits, and a maximum of 6 credits. This must be proposed by the student, with the advisors' approval, by the end of June in the first summer. The proposal must state how the track fits the student's research agenda. The advisor must also attest that the proposed track comprises courses that are substantively on par with our existing coursework requirements. Approval must be obtained before the student enrolls in any course in this track.

Examples: Machine Learning, Advanced Game Theory, Experimental methods, etc.

Departmental seminar:

The department offers a research seminar in every semester. All students in the first, second and third years are required to take this seminar for credit, unless the offered seminar has already been taken by the student.

Breadth requirements:

In addition to the above departmental core requirements, students must satisfy the MBA breadth requirement set by the business school. Students must take 2 MBA courses outside the TO department. It is expected that this is completed by the end of the fourth year or by the dissertation proposal defense, whichever is earlier. Students can take one executive education course to fulfill the requirement (the most popular of these are Finance and MO).

Exempting requirements based on prior graduate work.

a. Exempting core coursework: A student can petition to be exempted from the coursework requirements if they have taken equivalent graduate level courses as part of graduate education before entering our program. Specific rules on obtaining this exemption are as follows:

1. At most 2 of the areas can be exempted.
2. Only graduate courses, taken as part of a graduate degree, count towards exemptions.
3. The corresponding courses must have been taken no earlier than 2 years before starting our program.
4. Students must petition for exemptions before the end of the fall semester in the first year.
5. A petition for exemption must include the course syllabus, and an official transcript showing the grade. The doctoral co-ordinator may request other information as well.

b. Exempting breadth requirement: A student can petition to be exempted from the breadth requirements only if they have taken equivalent courses in an MBA program within the past 2 years. Even if the student was not studying for an MBA, taking a class that is part of the MBA program in the student's graduate school counts for this requirement. Additionally, the 5 rules listed above apply for these exemptions as well.

Other policies and incentives

Childbirth support: If you have a child while a PhD student, then, pending good academic standing and availability of funds, the T&O department will give you one term (4 months) of fully paid leave. All subsequent deadlines will also be extended by one term.

This will be contingent on academic standing and funding availability, as stated above. Student will apply to PhD co-ordinator, and a committee of at least 3 people (for example, student's faculty advisor(s), PhD co-ordinator, Department Chair) will review the application and decide.

Research incentives: If a research paper gets an R&R in the first round at an A journal, the student gets a $3000 cash award. If the paper gets an R&R at an A- journal, or a selective conference, or a selective paper competition, the student gets a $1000 cash award. A single paper can get at most one award for conference or competition, and at most one award for journal publication: that is, a total of at most

$4000. These will be awarded at the annual PhD celebration in August, after the annual reviews in the preceding summer.

Current T&O Expected Milestones:

[Effective Fall 2012, updated February 2015.]

Arrival: August of first year

After admission, students remain in contact with the doctoral program co-ordinator and doctoral office to plan their transition. Students typically arrive in early August, especially if they want to enroll in ECON 600 to meet the basic analysis requirement.

During this period, students meet frequently with the doctoral co-ordinator, who assesses their research inclinations. Advisor(s) are assigned by the doctoral co-ordinator by the end of September of the first year, based on student as well as faculty preferences. Students are informed that although they can change their advisors at any time, it is recommended that they stick with their assigned advisors at least until the end of the first summer. The students are also offered assistance in choosing and registering for courses for their fall term.

First summer research paper:

Students work with their doctoral advisors on a research topic during the course of their first summer. There is no paper requirement for the first summer's research. But, there is a presentation requirement, described next.

Milestone I: Coursework and progress review (February of second year)

In February of the second year, students deliver a presentation of approximately 25 minutes of their first summer research to all departmental faculty. Faculty then assess the student's research based on the presentation and advisor feedback, and also obtain an initial evaluation of the student's coursework (core, seminar, and breadth). Consolidated feedback is conveyed to the students by the end of February by the doctoral co-ordinator.

This milestone is particularly important given the fact that students are assigned advisors initially, rather than exercising their own choice. Thus, this evaluation also offers the opportunity for the student to change direction and work on a new topic, and/or with a new advisor, with enough time to do justice to their second summer research and advance to candidacy.

Milestone II: Exam (Between December and May of second year)

Written exam: If a student fails to satisfy any of the 5 course requirements determined by the Ph.D. committee, the student takes a written exam in each such area, administered by the departmental faculty. In addition to testing the areas in which the student has failed to obtain a waiver, the Ph.D. exam committee can assign additional subject(s) to be chosen by the Ph.D. committee and the student's advisor.

Milestone III: Candidacy Evaluation (First half of September of third year).

Students must submit a complete written summer paper to the doctoral co-ordinator by August 31 of their second year in the program. The paper is assigned to at least 2 departmental faculty to serve as readers. Students also make a research presentation of approximately 25 minutes, within the first two weeks of September.

After the presentation, faculty assess the student for advancement to early candidacy. Students are assessed on all dimensions of doctoral education: research, coursework (core, seminars and breadth), potential for teaching, etc. There are three possible outcomes at this assessment:

1. If overall progress is deemed satisfactory, student advances to early candidacy.
2. If faculty assessment indicates the student is unfit for the doctoral program, then the student will be terminated with a Masters at the end of the fall term of their third year.
3. If faculty assessment determines that the student appears to have potential but has not demonstrated competence yet, then the student can continue in the program under the following conditions:
    a. A clear plan on meeting the coursework and research requirements by February of the third year is formed.
    b. The student is informed that a research paper and presentation is required in February of the third year, at which point there are only two possible outcomes: advancement to candidacy, or termination with a Masters at the end of winter of the third year.

Consolidated feedback, including recommended next steps, are conveyed to the student by the doctoral program co-ordinator.

Teaching:

Students typically teach in the Winter of their third or fourth years. Students are encouraged to teach in their third year, but several factors are considered in scheduling the teaching: student preparedness, availability of teaching slots, student progress in the program, etc.

It is strongly recommended that students serve as a teaching assistant of the class they intend to teach in the year before their scheduled teaching.

Milestone IV: Proposal defense (Before the end of the 4th year)

The Ross Doctoral Studies Program requires that students form a dissertation committee and defend their proposal by August 31 of the 4th year.

Milestone V: Final defense (Before the end of the 5th year)

We expect students to finish their doctoral education and graduate within 5 years. Students are not guaranteed any funding after 5 years, and must pay their own tuition if they stay more than 6 years.