



**UNIVERSITY OF DELAWARE**

**DOCTOR OF PHILOSOPHY IN  
FINANCIAL SERVICES ANALYTICS**

**ACADEMIC PROGRAM  
APPLICATION**

**OCTOBER 29, 2013**

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**I. UNIVERSITY FACULTY SENATE FORM**

# Doctor of Philosophy in Financial Services Analytics

## Academic Program Approval

This form is a routing document for the approval of new and revised academic programs. Proposing department should complete this form. For more information, call the Faculty Senate Office at 831-2921.

**Submitted by:** Bintong Chen **phone number** 831-2756

**Department:** Business Administration **email address** bchen@udel.edu

**Action:** Request for New Doctoral Program in Financial Services Analytics

(Example: add major/minor/concentration, delete major/minor/concentration, revise major/minor/concentration, academic unit name change, request for permanent status, policy change, etc.)

**Effective term:** F14

(use format 04F, 05W)

**Current degree** N/A

(Example: BA, BACH, BACJ, HBA, EDD, MA, MBA, etc.)

**Proposed change leads to the degree of:** Ph.D.

(Example: BA, BACH, BACJ, HBA, EDD, MA, MBA, etc.)

**Proposed name:** Doctor of Philosophy in Financial Services Analytics

Proposed new name for revised or new major / minor / concentration / academic unit (if applicable)

Revising or Deleting:

Undergraduate major / Concentration: \_\_\_\_\_

(Example: Applied Music – Instrumental degree BMAS)

Undergraduate minor: \_\_\_\_\_

(Example: African Studies, Business Administration, English, Leadership, etc.)

Graduate Program Policy statement change: \_\_\_\_\_

(Must attach your Graduate Program Policy Statement)

Graduate Program of Study: \_\_\_\_\_

(Example: Animal Science: MS Animal Science: Ph.D. Economics: MA Economics: Ph.D.)

Graduate minor / concentration: \_\_\_\_\_

**Note: all graduate studies proposals must include an electronic copy of the Graduate Program Policy Document, highlighting the changes made to the original policy document.**

**List new courses required for the new or revised curriculum. How do they support the overall program objectives of the major/minor/concentrations)?**

(Be aware that approval of the curriculum is dependent upon these courses successfully passing through the Course Challenge list. If there are no new courses enter “None”)

### FSAN815/ELEG815 Analytics I Foundations of Statistical Learning\*

Introduction to the mathematics of data analysis: Review of probability and multivariate random variables; models and statistical inference, estimating the CDF; bootstrap; maximum likelihood estimation; hypothesis testing; Bayesian inference, decision theory; linear regression; Lasso methods; linear and kernel-based classification; unsupervised learning and clustering; dimensionality reduction: PCA and the SVD; directed graphs; high dimensional problems. Prerequisites: First course on probability and random variables. ELEG 310 or equivalent. (\*Primary designation ELEG; secondary designation FSAN. ELEG815 will be cross-listed as FSAN815.)

### FSAN820 Analytics II Foundations of Optimization

Concept of optimization, convex set, convex function, unconstrained optimization, convex optimization problems, including least-squares, linear, and quadratic optimization, duality theory, sensitivity analysis. Modeling of more advanced optimization techniques including integer programming, geometric and semi-definite programming, and convex relaxations. Prerequisites: First course on linear algebra and calculus.

### FSAN830 Business Process Management, Innovation, and Analysis

This course enables students to employ a data-driven approach to designing, managing, and improving the business processes that execute a firm's strategy. The course starts by exploring the linkage between strategy and business process design and quickly moves into identifying key process metrics which have greatest leverage on improving performance at both the process and firm-wide levels. Planning and controlling for variability in business processes is discussed with applications drawn from diverse settings. Students will become proficient in improving processes based on leveraging data and learning to deploy resources and information to achieve consistently good outcomes. Topics covered include Little's Law, process flow diagrams, throughput and flow time analysis, six-sigma capability, lean operations, service process performance, and inventory analysis. Selected research papers will be assigned for presentation and discussion.

### FINC841/FSAN841 Financial Services Firms and Markets

Focuses on the economic roles and interactions of the units in each sector of the financial services industry. The course will provide an overview of the current and changing layout of institutions, products, and practices. (Primary designation FINC; secondary designation FSAN. FINC841 will be cross-listed as FSAN841.)

### FINC842/FSAN842 Financial Services Risk Analytics

Develops the theoretical and practical foundations of resource allocation across time and risky assets, and of credit risk and systemic considerations. Major topics: (1) Allocation of resources across time (2) Allocation of resources across risks (3) Credit risk and systemic considerations. (Primary designation FINC; secondary designation FSAN. FINC842 will be cross-listed as FSAN842.)

### MISY831/FSAN831 Enterprise Information Systems

Enterprise information systems (EISs) provide a technology platform that enables organizations to integrate and coordinate their business processes and share information across all functional levels and management hierarchies. The proper implementation and management of EISs is a



critical factor in maintaining and increasing organizational performance. EISs include but not limited to Enterprise Resource Planning System (ERP), Supply Chain Management system, and Knowledge Management system. This course will explore the technology and strategic use of EISs. More specifically, the students will learn the critical role of EISs in business organizations, the interplay between business processes and EISs, how to use and configure an EIS (an ERP system), and the best practices in managing EISs. (Primary designation MISY; secondary designation FSAN. MISY831 will be cross-listed as FSAN831.)

#### FSAN816/ELEG816 Large Scale Machine Learning\*

Introduction to large scale machine learning. High-dimensional statistical learning for classification, regression, ranking, clustering, and supervised learning. L1 regression and sparse representations; dictionary learning; sparse PCA; sparse subspace clustering; randomized algorithms; low-rank matrix approximations; robust PCA; matrix completion and recommendation systems; approximate nearest neighbors; large scale kernel methods; dimensionality reduction; local linear embedding. Pre-requisites: FSAN 815 Analytics I and FSAN 820 Analytics II. (\*Primary designation ELEG; secondary designation FSAN. ELEG816 will be cross-listed as FSAN816.)

#### FINC843/FSAN843 Financial Services Regulation

Examines the regulatory environment of financial services industry, including policy choices, goals and costs/ benefits. We will consider how companies and individuals, using people, processes and technology, meet their ethics, compliance and control objectives in a global environment. (Primary designation FINC; secondary designation FSAN. FINC843 will be cross-listed as FSAN843.)

#### Seminar FSAN850 (up to 6 credits)

Concentrated study on selected areas in Financial Services Analytics. May include an appropriate 800 level course.

#### Current Research Topics FSAN860 (up to 9 credits)

Upper-level graduate research oriented toward the student's potential Doctoral Dissertation.

#### Doctoral Dissertation FSAN969

Independent dissertation research after completion of applicable coursework and examinations.

**Explain, when appropriate, how this new/revised curriculum supports the 10 goals of undergraduate education: <http://www.ugs.udel.edu/gened/>**

N/A

#### **Identify other units affected by the proposed changes:**

(Attach permission from the affected units. If no other unit is affected, enter "None")

Lerner College of Business and Economics:

Department of Accounting & MIS

Department of Business Administration

Department of Economics

Department of Finance

College of Engineering  
Department of Computer & Information Sciences  
Department of Electrical & Computer Engineering

College of Arts and Sciences  
Department of Mathematical Sciences

College of Agriculture and Natural Resources  
Department of Applied Economics and Statistics

**Describe the rationale for the proposed program change(s):**

(Explain your reasons for creating, revising, or deleting the curriculum or program.)

The financial services industry is one of the largest and most technologically innovative sectors in the global economy. The fundamental value of the financial services industry — enabling access to capital — has fueled mankind’s transition from an agrarian, subsistence society through the industrial revolution to the connected mobile commerce world of today. Along the way, the financial services industry has demonstrated its ability to develop and harness technological advancements, to adapt and re-create business models, and to invent products, delivery systems and platforms to meet societal needs.

Technology continues to shape our world, and impact the financial sector. A megatrend affecting all businesses, academia, and society is what has become known as “Big Data.” Big Data refers to the ability of businesses and governments to collect vast amounts of data and to use increasingly sophisticated analytical tools and science to analyze, predict, and draw conclusions from the data. Important to all industry sectors, the Big Data trend is particularly meaningful to the financial services industry, where mobile applications, on-line activity, and the ability of banks to deliver secure and confidential customer services in a wireless environment are transforming both the way people bank, and banks themselves. Financial Services Analytics is a developing multi-disciplinary field that studies information systems design, analysis, and techniques utilizing data produced and used in the financial services industry, with a primary focus on scientific inquiry, innovation in business functions, and ultimately improving the efficiency and effectiveness of the financial services industry for economic and societal benefit.

The focus of the program will be on how analytical data science is used and transforms financial services. A core objective will be to understand, and improve business efficiency, managerial decisions, and productivity using data-driven, quantitative and modeling-based technology and science.

The rationales for the proposed Ph.D. in Financial Services Analytics include:

- Big Data and analytics are a transformative trend in society and the financial services industry;
- Few other academic programs concentrate on, or offer a Ph.D. in Financial Services Analytics;

- The program will build upon the research strengths and infrastructure at the IFSA and in Departments across the College of Engineering and the Lerner College of Business and Economics;
- A multi-disciplinary Ph.D. program in Financial Services Analytics will enhance graduate student recruitment and help to attract and retain talented faculty in various areas, including computer science, engineering, accounting, finance, operations and information technology;
- A cross-college Ph.D. program at UD in Financial Services Analytics will provide opportunities for interactions among researchers from diverse disciplines;
- The program will provide a foundation for educational funding and training grant opportunities;
- The program will offer graduate education in a multi-disciplinary field essential for UD as a major research university, providing a critical component to the University’s strategic priorities in the intersection of business, science, technology, and data applications. Indeed the program aligns with the University strategic plan to:
- *“engage closely with the critical issues of our day, to increase the global impact of the University, and to raise its prominence in the world.”*  
(<http://www.udel.edu/prominence/>)

**Program Requirements:**

(Show the new or revised curriculum as it should appear in the Course Catalog. If this is a revision, be sure to indicate the changes being made to the current curriculum and **include a side-by-side comparison** of the credit distribution before and after the proposed change.)

**Table 4: FSA Ph.D. Program Degree Requirements Summary**

Degree Requirements (45-54 Credits)	
Core, Required, and Elective Courses (30 Credits)	
Financial Services Analytics Core	18 Credits
Required Class	3 Credits
Electives	9 Credits
Seminar and Research (15-24 Credits)	
Seminar	6 Credits
Research	(0-9) Credits
Doctoral Dissertation	9 Credits

**Table 5: FSA Ph.D. Program Curriculum**

Course Curriculum
Core (18)
(3) FSAN815/ELEG815 Analytics I – Foundations of Statistical Learning*
(3) FSAN820 Analytics II – Foundations of Optimization
(3) FSAN830 Business Process Management, Innovation, and Analysis
(3) CISC683 Introduction to Data Mining

Course Curriculum
(3) FINC841/FSAN841 Financial Services Firms and Markets*
(3) FINC842/FSAN842 Financial Services Risk Analytics*
Required Class (3)
(3) BUAD840 Ethical Issues in Domestic and Global Business Environments
Electives (9)
(3) FSAN816/ELEG816 Large Scale Machine Learning*
(3) MISY831/FSAN831 Enterprise Information Systems
(3) FINC843/FSAN843 Financial Services Regulation*
(3) ACCT804 Database Design, Networks and Implementation
(3) ACCT806 Systems Analysis, Design and Implementation
(3) ACCT817 Information Technologies Audit
(3) ACCT820 Financial Statement Analysis
(3) CISC686 Multi Agent Systems
(3) CISC684 Machine Learning
(3) CISC681 Artificial Intelligence
(3) ELEG630 Information Theory
(3) ELEG636 Statistical Signal Processing
(3) ELEG657 Search and Data Mining
(3) ELEG655 High-Performance Computing with Commodity Hardware
(3) ECON801 Microeconomics
(3) ECON803 Applied Econometrics I
(3) ECON810 Mathematics for Economists
(3) ECON861 Industrial Organization and Regulation
(3) FINC855 Financial Institutions and Markets
(3) FINC856 Risk Management and Financial Engineering
(3) FINC870 Theory of Financial Decision Making
(3) FINC871 Workshop in Finance: Seminar
(3) MATH612 Computational Methods for Equation Solving and Function Minimization
(3) MATH630 Probability Theory and Applications
(3) MATH631 Introduction to Stochastic Processes
(3) MATH672 Vector Spaces
(3) MATH829 Topics in Mathematics
(3) APEC801 Math Programming with Economic Applications
(3) APEC802 Operations Research Applications

<b>Course Curriculum</b>
(3) STAT601 Probability Theory for Operations Research and Statistics
(3) STAT602 Mathematical Statistics
(3) STAT611 Regression Analysis
(3) STAT615 Design and Analysis of Experiments
(3) STAT617 Multivariate Methods
(3) STAT620 Nonparametric Statistics
(3) STAT674 Applied Data Base Management
(3) STAT675 Logistic Regression
Seminar FSAN850 (6)
Research FSAN860 (0-9)
Doctoral Dissertation FSAN969 (9)

All courses with FSAN designation, FINC841, FINC842 and FINC843 are new courses submitted for permanent status

\* FSAN815/ELEG815 and FSAN816/ELEG816 are housed in and administered by the Department of Electrical and Computer Engineering. The courses will be cross-listed with FSAN as the secondary designation.

\* FINC841, FINC842, FINC843 are housed in and administered by the Department of Finance. FINC is the primary designation of FINC841, FINC842, and FINC843. The courses will be cross-listed with FSAN as the secondary designation.

**ROUTING AND AUTHORIZATION:** (Please do not remove supporting documentation.)

Dean of College (COE) \_\_\_\_\_ Date \_\_\_\_\_

Chairperson, College Curriculum Committee (COE) \_\_\_\_\_ Date \_\_\_\_\_

Dean of College (Lerner) \_\_\_\_\_ Date \_\_\_\_\_

Chairperson, College Curriculum Committee (Lerner) \_\_\_\_\_ Date \_\_\_\_\_

Chairperson, Senate Com. on UG or GR Studies \_\_\_\_\_ Date \_\_\_\_\_

Chairperson, Senate Coordinating Com. \_\_\_\_\_ Date \_\_\_\_\_

Secretary, Faculty Senate \_\_\_\_\_ Date \_\_\_\_\_

Date of Senate Resolution \_\_\_\_\_ Date to be Effective \_\_\_\_\_

Registrar \_\_\_\_\_ Program Code \_\_\_\_\_ Date \_\_\_\_\_

Vice Provost for Academic Affairs & International Programs \_\_\_\_\_ Date \_\_\_\_\_

Provost \_\_\_\_\_ Date \_\_\_\_\_

Board of Trustee Notification \_\_\_\_\_ Date \_\_\_\_\_

Revised 10/23/2007 /khs

## **II. RESOLUTION STATEMENT**

PROVISIONAL APPROVAL OF NEW PROGRAMS -- RESOLUTION

**DOCTOR OF PHILOSOPHY IN FINANCIAL SERVICES ANALYTICS**

WHEREAS, the proposed *Doctor of Philosophy in Financial Services Analytics* provides a new graduate course of study in an emerging discipline essential to 21<sup>st</sup> century business and engineering research and impacting the operations, efficiency, science, technology and management of the financial services and analytics fields, and

WHEREAS, the proposed program builds upon the research strength, education resources and infrastructure from Departments across the Colleges of Engineering, the Lerner College of Business and Economics and the College of Arts & Sciences, as well as from the Institute for Financial Services Analytics, and

WHEREAS, the proposed program contributes to the scholarly and educational missions of the University—to disseminate scientific, humanistic, and social knowledge for the benefit of the larger society and to produce graduates who are prepared to contribute to a global society, addressing the critical needs of the state, nation and global community, and

WHEREAS, the proposed program fosters multi- and interdisciplinary research and educational collaboration across campus, providing a critical component to University's strategic priorities in energy, environment, and life and health sciences, and serving as a pillar of UD's *Path to Prominence*, be it therefore

RESOLVED, that the Faculty Senate recommends provisionally, for five years, the establishment of a new program leading to the *Doctor of Philosophy in Financial Services Analytics*, effective June 1, 2014.



### **III. GRADUATE CATALOG LISTING**

Financial Services Analytics

Telephone: (302) 831-2756

## **A. Program Overview**

*Financial Services Analytics* is an emerging multi-disciplinary field that studies information systems design, analysis, and techniques utilizing data produced and used in the financial services industry, with a primary focus on scientific inquiry, innovation in business functions, and ultimately improving the efficiency and effectiveness of the financial services industry for economic and societal benefit. It is a rapidly expanding field where business, engineering, technology, management science, finance and economics disciplines converge.

The financial services industry supports society's processes and institutions, including financial markets, by creating, distributing and intermediating financial products and services globally. The industry includes banks and similar institutions that take deposits and make loans, investment banks, investment companies, hedge funds, private equity and venture capital, brokerages, trading firms, securities, commodities and derivatives exchanges and over-the-counter markets, government sponsored entities, insurance companies, consumer finance and other similar producers or intermediaries of financial products.

The financial services industry is fast moving and innovative, an industry where new products are developed, brought to market, and commoditized perhaps more quickly than in any other industry. Technology has always been essential to the financial services industry.

The Ph.D. in Financial Services Analytics is offered as a university-wide multi-disciplinary graduate program with scientific curriculum that builds upon the research and educational strengths of departments across the College of Engineering, and the Lerner College of Business and Economics. Graduates of the Ph.D. in Financial Services Analytics Program are researchers and professionals, who play key roles in multi- and interdisciplinary teams, bridging the financial services industry and data and operational sciences. The Program provides students with the knowledge, skills, tools and tactics to turn data into value.

## **B. Requirements For Admission**

Applicants to the Ph.D. program in Financial Services Analytics may have undergraduate degrees from business or engineering, computational science, or other disciplines. Candidates for admission need not have majored in any specific field, but well-qualified students will have:

- Strong written and oral communication skills;
- Substantial quantitative coursework and/or hands-on experience with software development.

Admission to graduate programs at the University of Delaware is selective and competitive based on the number of well-qualified applicants and the limits of available faculty and facilities. Those who meet stated minimum academic requirements are not guaranteed admission, nor are those who fail to meet those requirements necessarily precluded from admission if they offer other appropriate strengths. Students deficient in any of the admission requirements may be admitted on conditional status and required to complete prerequisite non-degree coursework.

The following should be considered the minimum requirements for consideration for admission:

- Comply with all of the requirements in the [Graduate Admissions](#) section of this catalog;

- Hold the equivalent of a 4-year U.S. Bachelor's degree from an accredited college or university and a minimum overall GPA of 3.0 (out of 4.0);
- The following GRE scores are competitive: Quantitative: 650, Verbal + Quantitative: 1200 if taken prior to August 1, 2011 or Quantitative: 151, Verbal + Quantitative: 307 if taken after August 1, 2011. [No GRE subject test is required];
- International student applicants must demonstrate a satisfactory level of proficiency in the English language if English is not the first language. International applicants must have an official TOEFL score of at least 232 on computer-based or 90 on Internet-based tests. TOEFL scores more than two years old cannot be considered official. Alternatively, IELTS can be accepted in place of the TOEFL. The minimum IELTS score is 6.5 overall with no individual sub-score below 6.0;
- A completed University of Delaware Graduate Studies application including;
- Official transcripts of all previous academic work;
- Three (3) letters of recommendation. At least one letter must be from a professor, other letters can be from employers or others who have had a supervisory relationship with the applicant and are able to assess the applicant's potential for success in graduate studies;
  - A resume outlining work and academic experience;
  - An application essay consisting of the answers to the following questions:
    1. What educational background and scientific research or employment experience prepare you for this degree program?
    2. What are your long-term professional objectives?
    3. What specific attributes of the program make you feel that this degree is appropriate to help you achieve your professional objectives?

See Graduate Admissions for additional information, particularly for application procedures and deadlines.

### **C. Program Requirements:**

Students must complete a minimum of 30 hours of coursework, plus 6 credit hours of seminar, and 9 credit hours of doctoral dissertation. Students must maintain a 3.0 cumulative GPA. Minimum residency requirement is one year.

**Table 6: FSA Ph.D. Program Curriculum**

Degree Requirements (45-54 Credits)	
Core, Required, and Elective Courses (30 Credits)	
Financial Services Analytics Core	18 Credits
Required Class	3 Credits
Electives	9 Credits
Seminar and Research (15-24 Credits)	
Seminar	6 Credits
Research	(0-9) Credits
Doctoral Dissertation	9 Credits

**Total number of required credits: 45-54**

Course Curriculum
Core (18)
(3) FSAN815/ELEG815 Analytics I – Foundations of Statistical Learning*
(3) FSAN820 Analytics II – Foundations of Optimization
(3) FSAN830 Business Process Management, Innovation, and Analysis
(3) CISC683 Introduction to Data Mining
(3) FINC841/FSAN841 Financial Services Firms and Markets*
(3) FINC842/FSAN842 Financial Services Risk Analytics*
Required Class (3)
(3) BUAD840 Ethical Issues in Domestic and Global Business Environments
Electives (9)
(3) FSAN816/ELEG816 Large Scale Machine Learning*
(3) MISY831/FSAN831 Enterprise Information Systems
(3) FINC843/FSAN843 Financial Services Regulation*
(3) ACCT804 Database Design, Networks and Implementation
(3) ACCT806 Systems Analysis, Design and Implementation
(3) ACCT817 Information Technologies Audit
(3) ACCT820 Financial Statement Analysis
(3) CISC686 Multi Agent Systems
(3) CISC684 Machine Learning
(3) CISC681 Artificial Intelligence
(3) ELEG630 Information Theory
(3) ELEG636 Statistical Signal Processing
(3) ELEG657 Search and Data Mining
(3) ELEG655 High-Performance Computing with Commodity Hardware

Course Curriculum
(3) ECON801 Microeconomics
(3) ECON803 Applied Econometrics I
(3) ECON810 Mathematics for Economists
(3) ECON861 Industrial Organization and Regulation
(3) FINC855 Financial Institutions and Markets
(3) FINC856 Risk Management and Financial Engineering
(3) FINC870 Theory of Financial Decision Making
(3) FINC871 Workshop in Finance: Seminar
(3) MATH612 Computational Methods for Equation Solving and Function Minimization
(3) MATH630 Probability Theory and Applications
(3) MATH631 Introduction to Stochastic Processes
(3) MATH672 Vector Spaces
(3) MATH829 Topics in Mathematics
(3) APEC801 Math Programming with Economic Applications
(3) APEC802 Operations Research Applications
(3) STAT601 Probability Theory for Operations Research and Statistics
(3) STAT602 Mathematical Statistics
(3) STAT611 Regression Analysis
(3) STAT615 Design and Analysis of Experiments
(3) STAT617 Multivariate Methods
(3) STAT620 Nonparametric Statistics
(3) STAT674 Applied Data Base Management
(3) STAT675 Logistic Regression
Seminar FSAN850 (6)
Research FSAN860 (0-9)
Doctoral Dissertation FSAN969 (9)

All courses with FSAN designation, FINC841, FINC842 and FINC843 are new courses submitted for permanent status

\* FSAN815/ELEG815 and FSAN816/ELEG816 are housed in and administered by the Department of Electrical and Computer Engineering. The courses will be cross-listed with FSAN as the secondary designation.

\* FINC841, FINC842, FINC843 are housed in and administered by the Department of Finance. FINC is the primary designation of FINC841, FINC842, and FINC843. The courses will be cross-listed with FSAN as the secondary designation.

## **IV. Proposal**

## I. Description

### A. Background

The financial services industry is constantly evolving, global field that facilitates innovation, economic growth, business development, wealth creation, distribution and preservation. The access to investment capital provided by the financial services industry, and the global trading and distribution markets that have developed have been a major driver in the development and advancement of society from the agrarian age, to the industrial revolution and to the internet and technology advances of today. Banks and investment vehicles have provided access to capital to virtually all human endeavors, including biology, science, business, technology, medicine and the arts.

The financial services industry is well suited to capitalize on technological advances, and the industry has been among first adopters of information technology to support operations (e.g., FedWire in 1918), and create new products and services. At the core of the industry, and the new paradigm technology has enabled, is an enormous volume of data being produced, captured, and stored. Advancements in modeling techniques, computational power, and data manipulation, when combined with the vast troves of data available to the industry, have ushered in a new era or trend, often referred to as “Big Data”. Big Data broadly refers to industry’s need and ability to create or find business value in the data available to it; as a result, the financial services industry is becoming an increasingly quantitative field. Computational approaches, in combination with experimental methods, have become essential for generating novel hypotheses, deriving new scientific knowledge, and driving discovery and innovation.

*Financial Services Analytics* is an emerging and rapidly expanding field where business, engineering, technology, management science, finance and economics disciplines converge. It is a developing multi-disciplinary field that studies information systems design, analysis, and techniques utilizing data produced and used in the financial services industry, with a primary focus on scientific inquiry, innovation in business functions, and ultimately improving the efficiency and effectiveness of the financial services industry for economic and societal benefit.

Due to the multi-disciplinary nature of financial services analytics, experts in these fields within the University of Delaware are housed in several Colleges and Departments on campus and may be in one of several engineering, business or economics disciplines. Therefore, the Ph.D. in Financial Services Analytics will be offered as a university-wide multi-disciplinary graduate program that will attract students to UD and draw them into academic interaction with faculty researchers in LCBE and COE. The program will be administrated by the FSA Ph.D. Program Faculty Director, FSA Ph.D. Program and the FSA Ph.D. Program Faculty Committee, with students being supervised and taught by faculty members from LCBE or COE as appropriate.

In addition, this new Ph.D. program will be synergistic to the existing degree programs, providing a critical component to University’s strategic priorities in business and engineering, and serving as a pillar of UD's *Path to Prominence*.

## **B. Role of JP Morgan Chase**

In 2009, recognizing and anticipating the future importance of this trend, the University of Delaware embarked on an innovative Collaboration with JPMC. The JPMC-UD Collaboration is a multi-disciplinary venture with the College of Engineering (COE) and the Alfred Lerner College of Business and Economics (LCBE). The Collaboration has the following elements: the creation of the Institute for Financial Services Analytics (IFSA); sponsored faculty research; and the creation of an undergraduate minor in the LCBE Department of Accounting & MIS called “GET” or Global Enterprise Technology. LCBE and COE received approval on August 12, 2013 from the University Provost recognizing the IFSA formally as a University institute. Prof. Bintong Chen was appointed the founding director of IFSA. In addition, the Collaboration serves as a conduit for recruiting UD students to JPMC (at both the intern and full-time levels). To facilitate the Collaboration, JPMC and UD have established the JPMC Innovation Center, a JPMC office located on the first floor of Purnell Hall. The JPMC Innovation Center is unique to UD in that it is a fully staffed and functional JPMC office where UD student interns can work on campus.

Regarding sponsored faculty research under the Collaboration, JPMC agreed in 2011 to provide at \$1 million per year for applied research and curriculum development for a total of five years. This component of the Collaboration is on-going, and will remain in effect (pursuant to its terms) together with the proposed Ph.D. Program. Faculty who are not directly involved with the proposed program would continue to have the opportunity to apply for sponsorship for applied research or curriculum development under the terms of this program.

Since its inception, the Collaboration has been successful. In 2012, JPMC and the University began to work together to expand the Collaboration and the relationship with a goal of creating a lasting, and unique environment in which an academic-industry collaboration could truly flourish and be self-sustaining by adding continuing value to the missions and programs of both collaborators. The proposed Ph.D. is the centerpiece of these efforts, driven in part by a commitment by JPMC to provide funding of \$14.1 million over the next ten years (together with an additional \$2.5 million for renovations to Purnell Hall). Taken together, the combined funding will represent the largest single program corporate gift in UD’s history. Importantly, the University, LCBE, and COE are contributing financially to this effort in a true industry-academic collaboration. Other aspects of the JPMC gift will include the creation of JPMC faculty fellows who will work with the Ph.D. candidates and JPMC in furthering the mission of the Collaboration, IFSA, and the advancement of academic research in the field.

It should be noted that while JPMC is a sponsoring organization of the FSA Ph.D. Program and the IFSA:

- The FSA Ph.D. Program is wholly governed by the faculty.
- The FSA Ph.D. Program Faculty Committee is the sole supervising body of the Program.
- All members of the Faculty Committee are tenured or tenure-track faculty at the University.
- The Faculty Committee is responsible for admission standards and processes, advising and evaluation of students and curriculum revisions including preparing proposals and managing the department, college and faculty senate approval processes.



- Any sponsoring organization, including JPMC can only offer input to the Faculty Director and the Faculty Committee in an advisory capacity.
- No sponsoring organization, including JPMC is entitled to membership on any committee related to the Program, including dissertation committees.
- The Program will comply with all University's policies and procedures with respect to research, grants, publishing and other items of academic concern apply to the proposed program.
- All members of dissertation committees, both from the University and outside members will be recognized scholars in the area of research in the dissertation.

### **C. FSA Ph.D. Program Organization**

The development, administration and progress assessment of the overall Ph.D. Program in Financial Services Analytics will be guided by the FSA Ph.D. Program Faculty Director and the FSA Ph.D. Program Faculty Committee, as outlined below.

#### **C.1 Appointment of FSA Ph.D. Program Faculty Director**

The FSA Ph.D. Program Faculty Director will be appointed by the Dean, COE, and the Dean, LCBE. The Faculty Director will serve a three-year term, which is renewable.

#### **C.2 FSA Ph.D. Program Faculty Committee**

The FSA Ph.D. Program Faculty Committee will consist of seven members initially, one from each of the six participating departments – Accounting & MIS, Business Administration, Computer Science, Economics, Electrical and Computer Engineering and Finance – and the Faculty Director (ex officio). The term for members of the Faculty Committee is one-year and can be renewed. After the initial term, the committee will have three members from each college and the Faculty Director (ex officio). Only tenured faculty or those holding tenure track appointments can serve on the Faculty Committee. The Faculty Committee members from the LCBE will consist of one member each from the departments of Finance and Accounting & MIS and one at-large member from the Business Administration Department or the Economics Department. The members of the Committee are chosen in a manner to be determined by their respective departments with Lerner committee memberships proposed through the Lerner Committee on Organization, and membership approvals by vote of the Lerner faculty. The Faculty Director is a non-voting member, who votes only to break a tie.

For the first academic year after approval of the program, the Faculty Committee will consist of the members of the Curriculum Committee. The next year, the Faculty Committee members will be determined in the manner described above.

The Faculty Committee elects its own chair. The term of Chair of the FSA Ph.D. Program Committee is one-year (renewable).

The Faculty Committee is responsible for admission standards and processes, advising and evaluation of students and curriculum revisions including preparing proposals and managing the

department, college and faculty senate approval processes. The Faculty Committee is expected to work closely with the students' Advisors and Dissertation Committee Chairs.

The activities related to the FSA Ph.D. program that are to be governed, and the anticipated roles and responsibilities of each party are shown in the table below.

**Table 4: Roles and Responsibilities**

<b>Activities</b>	<b>Primary Responsibility</b>	<b>Oversight*</b>
Compliance with UD graduate degree program policies	FSA Ph.D. Program Faculty Director (Faculty Director)	Dean of the College in which the Faculty Director has his/her primary appointment
Evaluation of Faculty Director	Deans of LCBE & COE	Provost
Call for nominations and selections of JPMC Faculty Fellows and Launch Leaders	Deans of LCBE & COE, in consultation with Faculty Director and recommendation of the relevant Department Chair	Provost
Ph.D. program's daily operations and budget control	Faculty Director	Deans of LCBE & COE
Curriculum proposals and revisions	FSA Ph.D. Program Faculty Committee (Faculty Committee)	COE Educational Activities Committee, and Lerner Graduate Program Committee
FSA program course scheduling	Faculty Director and Department Chairs	Deans of LCBE & COE
Student admissions, Ph.D. candidacy approval, dissertation committee approval	Faculty Director and Faculty Committee	Vice Provost for Graduate and Professional Education
Annual evaluation of Faculty Fellows, Launch Leaders, and participating FSA Ph.D. Program faculty	Department Chairs, with input from Faculty Director	Deans of LCBE & COE

\*Secondary responsibility to review and ensure it is done

#### **D. Rationale and Demand**

The rationales for the proposed Ph.D. in Financial Services Analytics include:

- Big Data and analytics are a transformative trend in society and the financial services industry;
- Few other academic programs concentrate on or offer a Ph.D. in Financial Services Analytics;
- The program will build upon the research strength and infrastructure at the IFSA and from Departments across the College of Engineering and the Lerner College of Business and Economics;
- An multi-disciplinary Ph.D. program in Financial Services Analytics will enhance graduate student recruitment and help to attract and retain talented faculty in various areas, including computer science, engineering, accounting and information technology;
- A cross-college Ph.D. program in Financial Services Analytics will provide opportunities for interactions among researchers from diverse disciplines;

- The program will provide a foundation for educational funding and training grant opportunities;
- The program will offer graduate education in a discipline essential for UD as a major research university, providing a critical component to University’s strategic priorities in the intersection of business, science, technology, and data applications. Indeed the program aligns with the University strategic plan to “*engage closely with the critical issues of our day, to increase the global impact of the University, and to raise its prominence in the world.*”

## **E. Institutional Factors**

### **E.1 Compatibility with University Academic Priorities**

A strong educational program in financial services analytics will contribute to the scholarly and educational missions of the University—to *disseminate scientific, humanistic, and social knowledge for the benefit of the larger society* and to produce graduates who *are prepared to contribute to a global society, addressing the critical needs of the state, nation and global community.*

### **E.2 Planning Process**

The planning process began in 2011 with the establishment of the Institute for Financial Services Analytics, which was created and initially funded by JPMC as part of the larger JPMC-UD Collaboration. The IFSA serves as the University’s focal point for education, research, and industry and policy engagement in the financial services analytics field. IFSA received formal approval as a UD institute in August 2013, and Professor Dr. Bintong Chen was named the Director of IFSA. Commencing in the summer of 2012, planning meetings and discussions around the need for and the funding of the proposed Ph.D. program began. These meetings involved UD President Harker, LCBE Dean Bruce Weber, COE Dean Babatunde Ogunnaike, COE Deputy Dean Kristi Kiick, Dr. Bintong Chen, University Development Senior Director Robb Rudd, LCBE Associate Director of Corporate Outreach Roger Coffin, JPMC officials and others. These meetings culminated in the commitment by JPMC to fund the program with a grant of \$14.1 million over 10 years, together with an additional \$2.5 million for space renovations and construction to Purnell Hall to house the program. The combined JPMC gift will constitute the single largest corporate donation to one program in UD history.

A Curriculum Committee was established in February 2013 to guide the development of the Ph.D. program in Financial Services Analytics. The members were recommended by their Department Chairs, and are faculty members from six Departments across LCBE and COE, with broad expertise in business and engineering (Table 5).

**Table 5: FSA Ph.D. Curriculum Committee**

Member	College	Department	Expertise
Chen, Bintong(Chair)	LCBE	Business Administration	Analytics, Optimization, and Operations Management
Arce, Gonzalo	COE	Electrical and Computer Engineering	Statistical learning, Low-dimensional models in signal processing, Sparsity in inverse problems, Computational imaging.
Beck, Stacie	LCBE	Economics	International Macroeconomics, Financial Economics
Fleischhacker, Adam	LCBE	Business Administration	Uncertainty Management in Business Processes and Supply Chains
Laux, Paul	LCBE	Finance	Corporate finance, Market microstructure, Financial markets, Law and finance
Lloyd, Errol	COE	Computer & Information Sciences	Algorithms, Optimization and Approximation
Wang, Harry	LCBE	Accounting & MIS	Business process management, Business Intelligence and Analytics, Enterprise Information Systems

### **E.3 FSA Ph.D. Program Organization**

The FSA Faculty Director will be appointed by the Dean, COE, and the Dean, LCBE. The FSA Ph.D. Program Faculty Committee will consist of seven members initially, one from each of the six participating departments – Accounting & MIS, Business Administration, Computer Science, Economics, Electrical and Computer Engineering and Finance – and the Faculty Director (ex officio). The term for members of the Faculty Committee is one-year and can be renewed. After the initial term, the committee will have three members from each college and the Faculty Director (ex officio). Only tenured faculty or those holding tenure track appointments can serve on the Faculty Committee. The Faculty Committee members from the LCBE will consist of one member each from the departments of Finance and Accounting & MIS and one at-large member from the Business Administration Department or the Economics Department. The members of the Committee are chosen in a manner to be determined by their respective departments with Lerner committee memberships proposed through the Lerner Committee on Organization, and membership approvals by vote of the Lerner faculty. The Faculty Director is a non-voting member, who votes only to break a tie.

For the first academic year after approval of the program, the Faculty Committee will consist of the members of the Curriculum Committee. The next year, the Faculty Committee members will be determined in the manner described above.

The Faculty Committee elects its own chair. The term of Chair of the FSA Ph.D. Program Committee is one-year (renewable).

The Faculty Committee is responsible for admission standards and processes, advising and evaluation of students and curriculum revisions including preparing proposals and managing the

department, college and faculty senate approval processes. The Faculty Committee is expected to work closely with the students' Advisors and Dissertation Committee Chairs.

#### **E.4 Significant Impact on Other University Programs**

The positive impact of the proposed Ph.D. program in Financial Services Analytics on University research and educational programs is multi-fold:

- It will offer graduate education in a new multi-disciplinary field establishing the University of Delaware as a leader in the field, and an innovator among major research universities;
- Courses that are offered as part of the Ph.D. program may be used as electives in current graduate programs, and may be used for the development of new minors, concentrations, or degree programs, thus, complementing, not competing with already existing degree programs;
- It will create a context for faculty from the various participating disciplines across-campus to articulate the interface of their research and foster research collaborations;
- It will produce graduate students with knowledge and professional expertise in financial services analytics, who can play a key role in multi- and interdisciplinary teams;
- The educational program, coupling with collaborative multi-disciplinary research, and the activities of the Institute for Financial Services Analytics will provide a solid foundation for the University of Delaware to become internationally and nationally recognized in a developing, but major field transforming industry and society.

#### **E.5 Utilization of Existing Resources**

With strong business and computer related engineering programs, as well as state-of-the-art facilities in COE and LCBE, including the planned opening in Fall 2014 of a construction of over 6,000 new square feet of state of the art space to house the Program, JPMC Faculty Fellows, and Ph.D. students, the University of Delaware provides a rich environment for educational programs in financial services analytics. The proposed Ph.D. program will build upon the strength of existing resources, and add to our strengths, creating something new and greater than the sum of its parts.

There are many experts in the field of financial services analytics at the University of Delaware, dispersed throughout LCBE and COE. An important element of the JPMC funding of the proposed program will be the appointment of five JPMC Faculty Fellows. JPMC Fellows will be chosen from UD faculty, and will contribute to the growth and management of the IFSA and the Ph.D. Program by, among other things, pursuing theoretical or practical research related to financial services analytics, developing and teaching Ph.D. classes, and supervising Ph.D. students.

The Ph.D. program in Financial Services Analytics has the support from the Chairs of the contributing Departments the relevant Colleges—encouraging faculty participation as Program Faculty, primary faculty advisors, dissertation committee members, and/or members of the FSA Ph.D. Program Faculty Committee, as well as offering core courses, required courses, and/or

elective courses in the curriculum. The letters of support from the Chair of the contributing Department are attached in Appendix I.

## **F. Student Demand**

### **F.1 Enrollment Projections**

The proposed program will operate on a cohort model with the expectation that the first cohort of 8 fully funded by JPMC graduate students entering the Ph.D. program in Fall of 2014. Two years after the original cohort, a second cohort of 8 graduate students will enter the program (six of which will be fully funded by JPMC) for a total of 16. Two years after that, a third cohort of 8 students, 4 of which will be fully funded by JPMC will enter. This will consist of the steady state going forward. For the JPMC funded graduate students, full tuition and a stipend in excess of University minimums will be provided by JPMC.

### **F.2 Needs of Student Clienteles**

The Ph.D. program in Financial Services Analytics will support students from different educational backgrounds and with different career aspirations. The students may come from business and computational sciences, and engineering. The program offers both academic rigor, as well as flexibility, to meet the needs and interests of students and their primary faculty advisors. Upon completion of the graduate program, students will have a firm grasp of both the business and engineering –the financial services and the analytical--aspects of the program.

## **G. Transferability**

Previous graduate level courses with applicability to FSA Program requirements (a maximum of 9 credit hours) may be considered towards the completion of the Ph.D. requirements, upon request of the applicant and are subject to written approval by the Graduate Program Committee. Transfer credits will be accepted provided that such credits: (i) were earned with a grade of no less than B, (ii) are approved by the Graduate Program Committee, (iii) are in accord with the Program Policy Statement of the Ph.D. program in Financial Services Analytics, (iv) are not older than five years, (v) are graduate level courses, and (vi) were completed at an accredited college or university. Graduate courses counted toward a degree received elsewhere may not be transferred into a degree at UD. Credits from institutions outside of the United States are generally not transferable to UD.

Students who complete graduate credits with the classification of CEND (Continuing Education Non-degree) at the University of Delaware may use a maximum of 9 graduate credits earned with this classification toward their graduate degree.

## **H. Access to Graduate and Professional Programs**

The graduates of the Ph.D. program in Financial Services Analytics will have different career paths and students will complete the program prepared to pursue careers for research, education, or development in academia, business, industry, government agencies, or non-profit organizations.

## **I. Demand and Employment Factors**

We anticipate high industry demand for program graduates. According to many industry reviews, the financial services industry has rebounded from the 2008 financial crisis, and despite its reputation as a cyclical industry, financial services continues to be a vibrant, and growing component of both the US and global economy. The modern financial services industry is becoming increasingly dependent on quantitative sciences and this fundamental shift is requiring a new workforce of adequately trained business leaders with analytical skills, data scientists, programmers, and management able to see and extract value from the troves of data stored by the industry.

We anticipate a similar high demand in academia. Students with a Ph.D. in Financial Services Analytics will be valuable resources and able to perform research and teach in a variety of diverse subjects and departments, including analytics programs, operations, management information systems, computer science and related engineering areas. In addition, we believe the field of financial services analytics more generally is and will develop into its own unique area of study. Other programs modeled after the proposed program may develop, with supporting departments or academic centers or institutes evincing a demand for graduates of our program. Between the high demand in industry, and within the financial services sector in particular, and the anticipated demand in academia, we believe strongly that program graduates will be well positioned in the marketplace.

## **J. Regional, State and National Factors**

In our searches, we found no existing Ph.D. program in Financial Services Analytics at an accredited U.S. university. Many universities offer Masters Programs in Finance and in Analytics. Some, including Drexel for Example, offer a M.S. in Business Analytics. Moreover, Ph.D. Programs in Finance, and in Analytical Sciences including Computer Engineering and Programming, are offered by many universities, including top tiered research universities, such as Harvard University, Stanford, and The Wharton School. Other institutions, including Princeton University and New York University, offer Ph.D. programs in financial engineering, a related, but different, area of study than financial services analytics. None of these programs is directly on point with the proposed program. Therefore, the University of Delaware is positioned to become a pioneer in this developing field by becoming leading the way in defining and developing the new field of financial services analytics.

### **J.1 Comparable Courses of Study in the Region or State**

No other academic institution in the State of Delaware offers a Ph.D. program in Financial Services Analytics, nor any related field. The Ph.D. program in Financial Services Analytics will emerge as a highly competitive educational opportunity based on: (i) a strong interdisciplinary curriculum (ii) proximity to major banking centers and industry (including Delaware itself, but also New York, Washington DC and Philadelphia), and (iii) rich opportunities for dissertation research projects.

### **J.2 External Requirements**

There are no formal guidelines for a Ph.D. program in Financial Services Analytics, nor are there accreditation standards. The program should, however, be helpful for Lerner College to maintain its AACSB accreditation. The proposed FSA Ph.D. curriculum was designed based on a careful study of our current curricula and the masters and doctoral programs offered by other institutions, along with input from industry practitioners. We have examined related programs offered at selected, prominent research universities, and recognize the needs from both the student and employer perspectives. The proposed curriculum is based on the information gathered from these resources, and provides a carefully tailored program building on existing offerings and trends.

## **K. Other Strengths**

### **K.1 Special Features**

A special feature of the proposed program is the close collaboration among participating Departments across Colleges. These Departments have been successfully working together under the JPMC-UD Collaboration, and it has been the success of these efforts that is directly attributable to JPMC's commitment to help fund the proposed Ph.D. Program. In addition, faculty members from the various Departments are members of the FSA Curriculum Committee and the Graduate Program Committee. The financial services industry has been a strong supporter of the University in general, and LCBE in particular owes its name to Alfred Lerner, former chairman of MBNA, a leading financial institution in Delaware that was bought by Bank of America in 2006. Our proximity to major banking centers, our relationships with corporate sponsors and banks, and the opportunities for experiential learning (including the Horn Program in Entrepreneurship, the Lerner College Trading Lab and the Blue Hen Investment Club) demonstrate our commitment to financial services at LCBE and COE. Therefore, the University is in a strong position to offer a robust program in Financial Services Analytics.

### **K.2 Collaborative Arrangements**

No new collaborative arrangements are required for the proposed Ph.D. program to operate. However, the Program would welcome other collaborators as appropriate to work with the proposed Ph.D. program.

## **II. Enrollment Admissions and Financial Aid**

### **A. Enrollment**

Enrollment is estimated at a cohort of 8-10 students in the Fall of 2014, with a similar size cohort every other year in the steady state.

### **B. Admission Requirements**

#### **B.1 Application Process and Requirements**



Applicants to the Ph.D. program in Financial Services Analytics may have undergraduate degrees from business or engineering, computational science, or other disciplines. Candidates for admission need not have majored in any specific field, but well-qualified students will have:

- Strong written and oral communication skills;
- Substantial quantitative coursework and/or hands-on experience with software development.

Admission to graduate programs at the University of Delaware is selective and competitive based on the number of well-qualified applicants and the limits of available faculty and facilities. Those who meet stated minimum academic requirements are not guaranteed admission, nor are those who fail to meet those requirements necessarily precluded from admission if they offer other appropriate strengths. Students deficient in any of the admission requirements may be admitted on conditional status and required to complete prerequisite non-degree coursework.

The following should be considered the minimum requirements for consideration for admission:

- Comply with all of the requirements in the [Graduate Admissions](#) section of this catalog;
- Hold the equivalent of a 4-year U.S. Bachelor's degree from an accredited college or university and a minimum overall GPA of 3.0 (out of 4.0);
- The following GRE scores are competitive: Quantitative: 650, Verbal + Quantitative: 1200 if taken prior to August 1, 2011 or Quantitative: 151, Verbal + Quantitative: 307 if taken after August 1, 2011. [No GRE subject test is required];
- International student applicants must demonstrate a satisfactory level of proficiency in the English language if English is not the first language. International applicants must have an official TOEFL score of at least 232 on computer-based or 90 on Internet-based tests. TOEFL scores more than two years old cannot be considered official. Alternatively, IELTS can be accepted in place of the TOEFL. The minimum IELTS score is 6.5 overall with no individual sub-score below 6.0;
- A completed University of Delaware Graduate Studies application including;
- Official transcripts of all previous academic work; Three (3) letters of recommendation. At least one letter must be from a professor, other letters can be from employers or others who have had a supervisory relationship with the applicant and are able to assess the applicant's potential for success in graduate studies;
  - A resume outlining work and academic experience;
  - An application essay consisting of the answers to the following questions:
    1. What educational background and scientific research or employment experience prepare you for this degree program?
    2. What are your long-term professional objectives?
    3. What specific attributes of the program make you feel that this degree is appropriate to help you achieve your professional objectives?

See Graduate Admissions for additional information, particularly for application procedures and deadlines.

## **B.2 Change of Classification**

Students currently matriculating in other graduate degree programs should complete a “Change of Classification Form” to seek approval to enter the Ph.D. program in Financial Services Analytics. The Program Committee will evaluate each “Change of Classification” request on a case-by-case basis and determine whether the student is required to submit a completed admission application form to the Office of Graduate and Professional Education and follow the same procedures for admission as other applicants.

## **B.3 Application Deadlines**

Admission decisions are made on a rolling basis as and when applications are complete. Complete applications received by February 15th for Fall admission will have the best opportunity for admission. While most students are expected to join the program every other year, under special circumstances students can be admitted in odd years. These students would advance their studies taking elective and FSA courses available during their first year. They will then cycle into the core course offerings in their second year. As such, they are required to complete the Ph.D. qualifier after the second year of study.

## **C. Student Expenses and Financial Aid**

### **C.1 Student Expenses**

The Ph.D. in Financial Services Analytics does not require student expenses beyond the traditional fees, except perhaps for the availability of a personal computer or laptop.

### **C.2 Financial Aid**

Financial assistance is awarded on a competitive basis from the pool of admitted applicants. The University of Delaware's policies apply to all forms of financial aid. Please refer to the University Policies for Graduate Student Assistantships and Fellowships.

## **III. Curriculum Specifics**

### **A. Institutional Factors**

Students who successfully complete the Ph.D. program in Financial Services Analytics will be awarded the degree by the home College of the student's primary faculty advisor.

### **B. Curriculum Description**

#### **B.1 Degree Requirements**

Each student is expected to establish a Dissertation Committee as soon as he/she passes the qualifying exam but no later than the end of the second year of study. The Committee should

consist of at least four faculty members, including a primary faculty advisor, and at least one faculty member from COE and LCBE.

The development of a program of study will be the joint responsibility of the student in consultation with the Dissertation Committee. Failure to obtain a primary faculty advisor within an appropriate time frame will generally be considered as unsatisfactory progress by the student toward reaching the program degree.

Students must maintain a 3.0 cumulative GPA.

Degree Requirements (45-54 Credits)	
Core, Required, and Elective Courses (30 Credits)	
Financial Services Analytics Core	18 Credits
Required Class	3 Credits
Electives	9 Credits
Seminar and Research (15-24 Credits)	
Seminar	6 Credits
Research	(0-9) Credits
Doctoral Dissertation	9 Credits

The qualifying examination will be taken at the end of the first year of study and will consist of a written exam in subjects based on the program core. Students will be graded on a scale of Pass, Re-Take, or Fail for the qualifying examination. Students will be tested on the six core curriculum courses. In order to advance in the program, they must successfully complete five of the six core requirements. Students who receive more than one grade of C or below in the core curriculum are not eligible to sit for the qualifying examination. If a student receives a grade of a C or lower on any of the six core curriculum courses, that student must take, and pass the qualifying examination for all six courses. If a student receives a Fail or Re-take grade in a particular subject, they may retake an examination in the subject(s) that he or she received less than a passing grade (up to, but no more than, two subjects). Qualifying examinations will be offered in the summer, with the re-take exam to be scheduled in January. If a student is unable to pass the required five elements of the qualifying examination, the Graduate Program Committee may recommend dismissal from the program.

The candidacy examination must be completed by the end of the third year. It requires a formal, detailed proposal be submitted to the Dissertation Committee and an oral defense of the student's proposed research project. Upon the recommendation of the Dissertation Committee, the student may be admitted to candidacy for the Ph.D. degree. The stipulations for admission to doctoral candidacy are that the student has (i) completed one academic years of full-time graduate study in residence at the University of Delaware, (ii) passed the preliminary exams, (iii) demonstrated the ability to perform research, and (iv) had a research project accepted by the Dissertation Committee.

The dissertation examination of the Ph.D. program will involve the approval of the written dissertation and an oral defense of the candidate's dissertation. It is expected that a student's Dissertation have application and interest to cutting edge practices in Financial Services Analytics and be published. The written dissertation will be submitted to the Dissertation Committee at least three weeks in advance of the oral defense date. The oral defense date will be publicly announced at least two weeks prior to the scheduled date. The oral presentation will be

open to the public and all members of the Financial Services Analytics program. The Dissertation Committee will approve the candidate’s dissertation. The student and the primary faculty advisor will be responsible for making all corrections to the dissertation document and for meeting all Graduate School deadlines. A copy (electronic and printed hard copy) of the final completed dissertation should be provided to the degree-granting College.

Students in the program are required to complete their degrees and all requirements within a period of five years (in the case of students with previous graduate or masters degrees) or seven years (in the case of students with bachelor degrees).

## B.2 Curriculum

The table below lists the course curriculum for the Ph.D. in Financial Services Analytics. New or revised courses required for the curriculum are marked. All of these courses have been submitted to the Course Challenge list and will be effective for the Fall 2014 term.

Degree Requirements (45-54 Credits)	
Core, Required, and Elective Courses (30 Credits)	
Financial Services Analytics Core	18 Credits
Required Class	3 Credits
Electives	9 Credits
Seminar and Research (15-24 Credits)	
Seminar	6 Credits
Research	(0-9) Credits
Doctoral Dissertation	9 Credits

Course Curriculum
Core (18)
(3) FSAN815/ELEG815 Analytics I – Foundations of Statistical Learning*
(3) FSAN820 Analytics II – Foundations of Optimization
(3) FSAN830 Business Process Management, Innovation, and Analysis
(3) CISC683 Introduction to Data Mining
(3) FINC841/FSAN841 Financial Services Firms and Markets*
(3) FINC842/FSAN842 Financial Services Risk Analytics*
Required Class (3)
(3) BUAD840 Ethical Issues in Domestic and Global Business Environments
Electives (9)
(3) FSAN816/ELEG816 Large Scale Machine Learning*
(3) MISY831/FSAN831 Enterprise Information Systems
(3) FINC843/FSAN843 Financial Services Regulation*
(3) ACCT804 Database Design, Networks and Implementation

Course Curriculum
(3) ACCT806 Systems Analysis, Design and Implementation
(3) ACCT817 Information Technologies Audit
(3) ACCT820 Financial Statement Analysis
(3) CISC686 Multi Agent Systems
(3) CISC684 Machine Learning
(3) CISC681 Artificial Intelligence
(3) ELEG630 Information Theory
(3) ELEG636 Statistical Signal Processing
(3) ELEG657 Search and Data Mining
(3) ELEG655 High-Performance Computing with Commodity Hardware
(3) ECON801 Microeconomics
(3) ECON803 Applied Econometrics I
(3) ECON810 Mathematics for Economists
(3) ECON861 Industrial Organization and Regulation
(3) FINC855 Financial Institutions and Markets
(3) FINC856 Risk Management and Financial Engineering
(3) FINC870 Theory of Financial Decision Making
(3) FINC871 Workshop in Finance: Seminar
(3) MATH612 Computational Methods for Equation Solving and Function Minimization
(3) MATH630 Probability Theory and Applications
(3) MATH631 Introduction to Stochastic Processes
(3) MATH672 Vector Spaces
(3) MATH829 Topics in Mathematics
(3) APEC801 Math Programming with Economic Applications
(3) APEC802 Operations Research Applications
(3) STAT601 Probability Theory for Operations Research and Statistics
(3) STAT602 Mathematical Statistics
(3) STAT611 Regression Analysis
(3) STAT615 Design and Analysis of Experiments
(3) STAT617 Multivariate Methods
(3) STAT620 Nonparametric Statistics
(3) STAT674 Applied Data Base Management
(3) STAT675 Logistic Regression
Seminar FSAN850 (6)
Research FSAN860 (0-9)
Doctoral Dissertation FSAN969 (9)

All courses with FSAN designation, FINC841, FINC842 and FINC843 are new courses submitted for permanent status

\* FSAN815/ELEG815 and FSAN816/ELEG816 are housed in and administered by the Department of Electrical and Computer Engineering. The courses will be cross-listed with FSAN as the secondary designation.

\* FINC841, FINC842, FINC843 are housed in and administered by the Department of Finance. FINC is the primary designation of FINC841, FINC842, and FINC843. The courses will be cross-listed with FSAN as the secondary designation.

## **IV. Resources Available**

### **A. Learning Resources**

We do not anticipate requiring any special Learning Resources to support this degree program. If new resources are required in the future, the program will endeavor to make them available to students. No new library or non-standard technology resources will be required for this Ph.D. program in Financial Services Analytics, as it will extend from the previous courses in the participating Departments and build upon the infrastructure from the JPMC-UD Collaboration and the IFSA. The library's current holdings and subscriptions have covered financial and analytics journals (many are open-access) and are anticipated to be sufficient as instructional and research support materials.

### **B. Faculty/Administrative Resources**

Faculty resources will be available to the Ph.D. program in Financial Services Analytics for course offerings from the participating Departments (see letters of approval attached in Appendix D). JPMC Fellows will supervise students, teach program courses, and will be the primary contacts for students as they develop their courses of study.

JPMC Faculty Fellows are appointed for a term of three years (renewable). In the final academic year of a Fellow's term, the FSA Ph.D. Program Faculty Director will put out a call for nominations for Fellows to serve in the following academic year by October 1. Nominees should submit a statement, accompanied by a CV to their respective Department Chair by November 1. Nominations with the recommendation of the respective Department Chair are due to the FSA Ph.D. Program Faculty Committee by February 1. The Dean of COE and the Dean of Lerner College in conjunction with the FSA Ph.D. Program Director will select the Faculty Fellows for the following term by March 1. Fellows can be nominated by the Faculty Director of the Program, Current Fellows, Department Chairs or self-nominate.

### **C. External Funding**

The Ph.D. Program in Financial Services Analytics is being partly funded by combined grants from JPMC of approximately \$17 million over 10 years which will cover student tuition and stipends. This grant comprises \$14.1 million for the program itself, and \$2.5 million to partially fund the construction and renovations to Purnell Hall to house the program, faculty offices, conference rooms, and technology support and student cubicles. In addition, funding from the LCBE, the COE and UD Administration is being provided. The funding levels are adequate to start the program and maintain it at a high level for the foreseeable future.

The legal framework for the Collaboration and the proposed Ph.D. program, among other things, is contained in a 2009 Master Collaboration Agreement between the University and JPMC, and several subsequent Exhibits thereto. These contracts are on file with the Office of the University General Counsel and the Office of the Dean of LCBE.

The following table shows a detailed breakdown by year of faculty participation, student enrollment and pre-committed funding.

**Table 6: Faculty Participation, Student Enrollment and Pre-Committed Funding through 2024**

Year	Faculty Fellows	Launch Leaders	S-contracts Generated	Classes Offered	Expected Admissions	Students In Program (minimum)	JPMC Funded Students
1	3	3					
2	3	3	6	5	8	8	8
3	5		5-10*	5		8	8
4	5		5-10	5	8	16	14
5	5		5-10	5		16	14
6	5		5-10	5	8	16	10
7	5		5-10	5		16	10
8	5		5-10	5	8	16	8
9	5		5-10	5		16	8
10	5		5-10	5	8	16	8

\* Based on the grant funding, each Faculty Fellow will receive a course reduction, for which their home department will receive an S-contract to cover the course they would have otherwise taught. In a given year, a Faculty Fellow may teach a course in the FSAN program, for which their home department will receive an S-contract to cover the course.

For each JPMC Faculty Fellow and Launch Leader teaching one course in the program or receiving a course buy-out, the host Department will receive an S contract for each course and/or extra funding. (The title, JPMC Faculty Fellow, was chosen to be consistent with the University’s development guidelines and to offer appropriate donor recognition) Each funded graduate student will receive full graduate tuition as well as a stipend above the UD minimum (or in certain cases, upon the student’s interest and application, a paid internship, also above the UD minimum).

Ph.D. programs are funded primarily through external grants and by the host University. The benefits of the proposed FSA Ph.D. program are manifold, and include a stronger external reputation, greater faculty research opportunities, and exposure to more advanced courses and educational opportunities for existing and future UD students. Through the funding support of JPMC, it is feasible to offer this program without adverse resource impacts on existing programs. As detailed in Section VII.C.1, the two deans of the COE and LCBE will exercise oversight of the Ph.D. program budget on an ongoing basis. In the final year of the current external funding commitment, 2023-24, the FSA Ph.D. Program will be reviewed and its ongoing financial requirements assessed in order to determine the viability of the program.

As already noted, the FSA Ph.D. program has secured external funding from industry. The initial funding provided by JPMC is sufficient to cover a substantial portion of the FSA Ph.D. program expenses through 2024. The remaining support will be provided by the LCBE and COE. After 2016, students without support from the JPMC funding and who are not otherwise funded, will be expected to provide teaching assistance or student instruction for COE or LCBE. The major budget items for the FSA Ph.D. are:

Program and student support:

- Salary and benefits for the FSA Ph.D. Program Faculty Director and support staff
- Graduate assistantships for admitted students for at least two years
- Graduate student tuition for admitted students that will receive support

Department Support:

- S-contracts for each course release given for teaching or service to the FSA Ph.D. program (5-10 per year total)
- Overhead support for each Faculty Fellow

Faculty Fellows/Launch Leaders:

- A support budget sufficient to cover all research expenses not already provided by their department
- One month of summer research support

## **V. Resources Required**

### **A. Learning Resources**

We do not anticipate requiring any special Learning Resources to support this degree program. If new resources are required in the future, the program will endeavor to make them available to students. No new library or non-standard technology resources will be required for this Ph.D.

### **B. Personnel Resources**

No additional personnel resources will be requested beyond the faculty and administrative resources described in Section V.

### **C. Budgetary Needs**

#### **C.1 Projected Expenses**

The projected expenses for the Ph.D. program in Financial Services Analytics, including personnel costs for program administration, annual costs for student recruitment and marketing, materials and supplies, faculty support, and educational program activities will be borne by COE, LCBE and IFSA as part of their respective operating budgets. The COE, LCBE, and IFSA have received funding support from JPMC. The costs for course instruction by tenure-track faculty



represent redirections of effort, as their salaries are already being paid by the respective Departments/Colleges.

## **C.2 Budget Plan**

A budget plan is in place and agreed upon among the Deans of the COE, the LCBE and the Faculty Director to cover the costs of launching the program initially, to incentivize faculty members to participate and contribute to this educational program, and to compensate the departments of the faculty members involved, and to attract outstanding students to the program.

# **VI. Implementation and Evaluation**

## **A. Implementation Plan**

The Ph.D. program in Financial Services Analytics is planned for an official start in the Fall semester of 2014. The Program Committee will establish policies of their operation and for the program, and coordinate with participating departments about course offerings.

Simultaneously with this proposal, Faculty Senate approval will be sought for new or revised courses required for the curriculum, as submitted to the Course Challenge list.

## **B. Assessment Plan**

### **B.1 Program Objective**

The Ph.D. program in Financial Services Analytics aims to train the next-generation of researchers and professionals who will play a key role in multi- and interdisciplinary teams, bridging financial services and data science and analytics.

### **B.2 Curricular Map and Learning Outcomes**

The Ph.D. program has five major curriculum components:

1. Core in Financial Services Analytics
2. Electives in Financial Services Analytics
3. Seminar
4. Research Methods
5. Dissertation

The curricular map indicates the following learning outcomes addressed in the curriculum:

1. Core competency in Financial Services Analytics
2. Advanced knowledge of the area and related disciplines
3. Ability to carry out independent, original research
4. Ability to use experimental, statistical and computational methods

5. Competence in written and oral scientific communication
6. Experience working with multi-disciplinary teams, and
7. Ability to contribute effectively as an individual and as a team member in academia, industry and government

**Table 7: Learning Outcomes**

	Curriculum	Core	Electives	Seminar	Research	Dissertation
Learning Outcomes	Core competency in Financial Services Analytics	x				
	Advanced knowledge of program & related disciplines		x	x	x	x
	Independent research experience				x	x
	Ability to use experimental, statistical and computational methods	x	x	x	x	
	Competence in written and oral scientific communication			x	x	x
	Experience working with multi-disciplinary teams	x	x	x	x	x
	Professional knowledge and skills			x	x	x

The following skill matrix demonstrates core skillsets, and how they will be met via curriculum and assessed in the program:

**Table 8: Skill Matrix**

Skill	Pre-Knowledge	Core	Illustrative Electives (see curriculum for more detailed list)	Potential Ph.D. Research Topics	Qualifying Exam
<b>Skill 1: Computer Programming</b>	Undergraduate education in relevant or industry experience	CISC683: Data Mining	MISY831/FSAN831: Enterprise Information Systems CISC681: Artificial Intelligence ELEG655: High Performance Computing	Yes	Yes
<b>Skill 2: Financial Services/Markets</b>	Undergraduate education in relevant or industry experience	FINC841/FSAN841: Financial Services Firms and Markets FINC842/FSAN842: Financial Services Risk Analytics	FINC856: Financial Engineering and Risk Management ACCT820: Financial Statement Analysis	Yes	Yes
<b>Skill 3: Data Analysis</b>	Undergraduate education in relevant or industry experience	FSAN815/ELEG815: Analytics I FSAN820: Analytics II	MATH672: Vector Spaces FSAN816/ELEG816: Large Scale Machine Learning	Yes	Yes

### B.3 Assessment plan

Program improvement will be an ongoing process. The results of the assessment measures will be shared with the FSA Ph.D. Program Faculty Committee. The curriculum will be modified as necessary to achieve the goal of producing graduates who apply the knowledge, skills and abilities gained from the Ph.D. program in Financial Services Analytics to their career.

**Table 9: Assessment Plan**

Objectives	Strategic Activities	Measures	Short-term Outcomes	Long-term Impact
Train students in the science disciplines pertinent to financial services analytics	Recruit high quality graduate students through faculty networks and leading researchers in the field.	Numbers, credentials and demographic data of student applicants and matriculated students	Retention and time to degree statistics	Students gain employment in FSA related fields
	Course work covering the disciplines related to the program core and electives	Faculty evaluation of student progress in course work; student's progress on schedule Survey of students in the program and post-graduation	Course work helped students secure initial employment; Students and graduates report applying knowledge from courses to work settings	Graduates enjoy long term success in academic or professional careers
Provide experiential training in research to prepare student as researchers and professionals in academia and industry	Conduct cutting-edge research through mentored dissertation projects  Lectures and discussions on specialized topics and cutting-edge developments (Seminar)	Survey of students focusing on their experiences; Survey of graduates to determine the utility of their experiential training to their career; Primary faculty advisor evaluation of both the project and the written reports and presentation; Interviews and surveys of faculty advisors and internship mentors	Experiential training prepares students for the workplace and helps them secure their first post-graduation position	Graduates enjoy long term success in academic or professional careers

## **VII. Program Policy Statement**

### **A. Program History**

#### **1. Statement of purpose and expectation of graduate study in the program.**

The Ph.D. in Financial Services Analytics is offered as a university-wide multi-disciplinary graduate program with scientific curriculum that builds upon the research and educational strengths of departments across the College of Engineering, and the Lerner College of Business and Economics. Graduates of the Ph.D. in Financial Services Analytics Program are researchers and professionals, who play key roles in multi- and interdisciplinary teams, bridging the financial services industry and data and operational sciences. The Program provides students with the knowledge, skills, tools and tactics to turn data into value.

#### **2. Date of Permanent Status (or current status).**

Date Approved by the Faculty of the College of Engineering

Date: Approved by the Lerner College of Business and Economics Graduate Program Committee

Date: Approved by the Faculty of the Lerner College of Business and Economics

Date: Submitted to the University Faculty Senate for approval

#### **3. Degrees offered (include brief description of concentrations, fields, etc.).**

Ph.D. in Financial Services Analytics

### **B. Admission Requirements**

#### **1. Application Process and Requirements**

Applicants to the Ph.D. program in Financial Services Analytics may have undergraduate degrees from business or engineering, computational science, or other disciplines. Candidates for admission need not have majored in any specific field, but well-qualified students will have:

- Strong written and oral communication skills;
- Substantial quantitative coursework and/or hands-on experience with software development.

Admission to graduate programs at the University of Delaware is selective and competitive based on the number of well-qualified applicants and the limits of available faculty and facilities. Those who meet stated minimum academic requirements are not guaranteed admission, nor are those who fail to meet those requirements necessarily precluded from admission if they offer other appropriate strengths. Students deficient in any of the admission requirements may be admitted on conditional status and required to complete prerequisite non-degree coursework.

The following should be considered the minimum requirements for consideration for admission:

- Comply with all of the requirements in the [Graduate Admissions](#) section of this catalog;
- Hold the equivalent of a 4-year U.S. Bachelor's degree from an accredited college or university and a minimum overall GPA of 3.0 (out of 4.0);
- The following GRE scores are competitive: Quantitative: 650, Verbal + Quantitative: 1200 if taken prior to August 1, 2011 or Quantitative: 151, Verbal + Quantitative: 307 if taken after August 1, 2011. [No GRE subject test is required];
- International student applicants must demonstrate a satisfactory level of proficiency in the English language if English is not the first language. International applicants must have an official TOEFL score of at least 232 on computer-based or 90 on Internet-based tests. TOEFL scores more than two years old cannot be considered official. Alternatively, IELTS can be accepted in place of the TOEFL. The minimum IELTS score is 6.5 overall with no individual sub-score below 6.0;
- A completed University of Delaware Graduate Studies application including;
- Official transcripts of all previous academic work; Three (3) letters of recommendation. At least one letter must be from a professor, other letters can be from employers or others who have had a supervisory relationship with the applicant and are able to assess the applicant's potential for success in graduate studies;
  - A resume outlining work and academic experience;
  - An application essay consisting of the answers to the following questions:
    1. What educational background and scientific research or employment experience prepare you for this degree program?
    2. What are your long-term professional objectives?
    3. What specific attributes of the program make you feel that this degree is appropriate to help you achieve your professional objectives?

See Graduate Admissions for additional information, particularly for application procedures and deadlines.

## **2. Change of Classification**

Students currently matriculating in other graduate degree programs should complete a "Change of Classification Form" to seek approval to enter the Ph.D. program in Financial Services Analytics. The Program Committee will evaluate each "Change of Classification" request on a case-by-case basis and determine whether the student is required to submit a completed admission application form to the Office of Graduate and Professional Education and follow the same procedures for admission as other applicants.

## **3. Application Deadlines**

Admission decisions are made on a rolling basis as and when applications are complete. Complete applications received by February 15th for Fall admission will have the best opportunity for admission. While most students are expected to join the program every other year, under special circumstances students can be admitted in odd years. These students would advance their studies taking elective and FSA courses available during their first year. They will

then cycle into the core course offerings in their second year. As such, they are required to complete the Ph.D. qualifier after the second year of study.

### C. Degree Requirements

The table below lists the course curriculum for the Ph.D. in Financial Services Analytics. New or revised courses required for the curriculum are marked. All of these courses have been submitted to the Course Challenge list and will be effective for the Fall 2014 term.

Degree Requirements (45-54 Credits)	
Core, Required, and Elective Courses (30 Credits)	
Financial Services Analytics Core	18 Credits
Required Class	3 Credits
Electives	9 Credits
Seminar and Research (15-24 Credits)	
Seminar	6 Credits
Research	(0-9) Credits
Doctoral Dissertation	9 Credits

Course Curriculum	
Core (18)	
(3) FSAN815/ELEG815 Analytics I – Foundations of Statistical Learning*	
(3) FSAN820 Analytics II – Foundations of Optimization	
(3) FSAN830 Business Process Management, Innovation, and Analysis	
(3) CISC683 Introduction to Data Mining	
(3) FINC841/FSAN841 Financial Services Firms and Markets*	
(3) FINC842/FSAN842 Financial Services Risk Analytics*	
Required Class (3)	
(3) BUAD840 Ethical Issues in Domestic and Global Business Environments	
Electives (9)	
(3) FSAN816/ELEG816 Large Scale Machine Learning*	
(3) MISY831/FSAN831 Enterprise Information Systems	
(3) FINC843/FSAN843 Financial Services Regulation*	
(3) ACCT804 Database Design, Networks and Implementation	
(3) ACCT806 Systems Analysis, Design and Implementation	
(3) ACCT817 Information Technologies Audit	
(3) ACCT820 Financial Statement Analysis	
(3) CISC686 Multi Agent Systems	
(3) CISC684 Machine Learning	
(3) CISC681 Artificial Intelligence	

Course Curriculum
(3) ELEG630 Information Theory
(3) ELEG636 Statistical Signal Processing
(3) ELEG657 Search and Data Mining
(3) ELEG655 High-Performance Computing with Commodity Hardware
(3) ECON801 Microeconomics
(3) ECON803 Applied Econometrics I
(3) ECON810 Mathematics for Economists
(3) ECON861 Industrial Organization and Regulation
(3) FINC855 Financial Institutions and Markets
(3) FINC856 Risk Management and Financial Engineering
(3) FINC870 Theory of Financial Decision Making
(3) FINC871 Workshop in Finance: Seminar
(3) MATH612 Computational Methods for Equation Solving and Function Minimization
(3) MATH630 Probability Theory and Applications
(3) MATH631 Introduction to Stochastic Processes
(3) MATH672 Vector Spaces
(3) MATH829 Topics in Mathematics
(3) APEC801 Math Programming with Economic Applications
(3) APEC802 Operations Research Applications
(3) STAT601 Probability Theory for Operations Research and Statistics
(3) STAT602 Mathematical Statistics
(3) STAT611 Regression Analysis
(3) STAT615 Design and Analysis of Experiments
(3) STAT617 Multivariate Methods
(3) STAT620 Nonparametric Statistics
(3) STAT674 Applied Data Base Management
(3) STAT675 Logistic Regression
Seminar FSN850 (6)
Research FSN860 (0-9)
Doctoral Dissertation FSN969 (9)

All courses with FSN designation, FINC841, FINC842 and FINC843 are new courses submitted for permanent status

\* FSN815/ELEG815 and FSN816/ELEG816 are housed in and administered by the Department of Electrical and Computer Engineering. The courses will be cross-listed with FSN as the secondary designation.

\* FINC841, FINC842, FINC843 are housed in and administered by the Department of Finance. FINC is the primary designation of FINC841, FINC842, and FINC843. The courses will be cross-listed with FSN as the secondary designation.



## **D. Satisfactory Progress**

### **4. Faculty Advisor**

A student entering the program will be assigned an Initial Advisor who will be a JPMC Faculty Fellow or a Launch Leader. After he/she passes the qualifying exam but no later than the end of the second year of study, the student is expected to find a Primary Faculty Advisor, and establish a Dissertation Committee. Failure to obtain a Primary Faculty Advisor within an appropriate time frame will generally be considered as unsatisfactory progress by the student toward reaching the program degree.

The Faculty Advisor (initial or primary) will be the primary contact of the student for questions and advice. The student will develop a cohesive plan of study for the program with the Faculty Advisor as appropriate.

The Faculty Advisor will prepare and discuss with the FSA Ph.D. Program Faculty Director and with the student an annual report documenting the student's progress in the program.

The Faculty Director will verify that the student has completed the requirements for the program and will approve the application for the degree upon successful completion of the requirements.

### **5. Academic Load**

Students in the Ph.D. program will typically complete the program in four years.

Students enrolled in at least 9 credit hours or in sustaining credit are considered full-time students. Those enrolled for fewer than 9 credit hours are considered part-time students, although students holding assistantships are considered full-time with six credits. Generally, a maximum load is 12 graduate credit hours; however, additional credit hours may be taken with the approval of the student's primary faculty advisor and the Office of Graduate and Professional Education. A maximum course load in either summer or winter session is 7 credit hours. Permission must be obtained from the Office of Graduate and Professional Education to carry an overload in any session.

### **6. Transferability**

Previous graduate level courses (a maximum of 9 credit hours) will be considered towards the completion of the Ph.D. requirements, subject to approval by the FSA Graduate Program Committee. Transfer credits will be accepted provided that such credits: (i) were earned with a grade of no less than B, (ii) are approved by the FSA Graduate Program Committee, (iii) are in accord with the Program Policy Statement of the Ph.D. program, (iv) are not older than five years, (v) are graduate level courses, and (vi) were completed at an accredited college or university. Graduate courses counted toward a degree received elsewhere may not be transferred into a degree at UD. Credits from institutions outside of the United States are generally not transferable to UD.

Students who complete graduate credits with the classification of CEND (Continuing Education Non-degree) at the University of Delaware may use a maximum of 9 graduate credits earned with this classification toward their graduate degree.

### **7. Dissertation**

The qualifying examination will be taken at the end of the first year of study and will consist of a written exam in subjects based on the program core. Students will be graded on a scale of Pass, Re-Take, or Fail. Students will be tested on the six core curriculum courses. In order to advance in the program, must successfully complete five of the six core requirements. If a student receives a Fail or Re-take grade in a particular subject, they may retake an examination in the subject(s) that he or she received less than a passing grade. If a student is unable to pass the required five elements of the qualifying examination, the FSA Graduate Program Committee may recommend dismissal from the program.

Each student is expected to establish a Dissertation Committee as soon as he/she passes the qualifying exam but no later than the end of the second year of study. The Committee should consist of at least four faculty members, including a primary faculty advisor, and at least one faculty member from COE and LCBE.

The candidacy examination must be completed by the end of the third year. It requires a formal, detailed proposal be submitted to the Dissertation Committee and an oral defense of the student's proposed research project. Upon the recommendation of the Dissertation Committee, the student may be admitted to candidacy for the Ph.D. degree. The stipulations for admission to doctoral candidacy are that the student has (i) completed one academic years of full-time graduate study in residence at the University of Delaware, (ii) passed the preliminary exams, (iii) demonstrated the ability to perform research, and (iv) had a research project accepted by the Dissertation Committee.

Students who need to complete prerequisite courses may request a deadline extension for the preliminary and subsequently the candidacy examination. Requests must be submitted to the Graduate Program Committee prior to the start of the third semester.

The dissertation examination of the Ph.D. program will involve the approval of the written dissertation and an oral defense of the candidate's dissertation. The written dissertation will be submitted to the Dissertation Committee at least three weeks in advance of the oral defense date. The oral defense date will be publicly announced at least two weeks prior to the scheduled date. The oral presentation will be open to the public and all members of the Financial Services Analytics program. The Dissertation Committee will approve the candidate's dissertation. The student and the primary faculty advisor will be responsible for making all corrections to the dissertation document and for meeting all Graduate School deadlines. A copy (electronic and printed hard copy) of the final completed dissertation should be provided to the degree-granting College.

## **8. Grade Requirements**

Students should maintain a cumulative 3.0 GPA to graduate from the Ph.D. program. Students may file an appeal to the Graduate Program Committee for approval to retake the course and remain in the program if the appeal is approved.

## **9. Consequences of Unsatisfactory Academic Progress**

The FSA Ph.D. Program Faculty Committee will meet once each year to evaluate each student's progress based on the annual report of the Primary Faculty Advisor. If a student is failing to make satisfactory progress towards a degree, the committee will recommend suitable action to the Faculty Director. Possible actions include (but are not limited to): (i) requirement for

additional courses, (ii) suspension of financial support, and/or (iii) recommendation for dismissal. To the extent applicable, students may apply to other University programs and transfer credits towards other degrees, if such credits or courses apply to such programs under relevant requirements.

## **10. Standards of Student Conduct**

All graduate students are subject to University of Delaware regulations regarding academic honesty. Violations of the UD regulations regarding academic honesty or other forms of misconduct may result in immediate dismissal from the Program in accordance with UD regulations and policy.

## **11. Dismissal**

The procedures for dismissal as detailed in the University Catalog will be followed. Briefly, the FSA Ph.D. Program Faculty Committee will report its recommendation and reason for dismissal to the Faculty Director. The Director will make a recommendation to the Office of Graduate Studies, who will decide whether to dismiss the student. The student may appeal this decision to the Office of Graduate Studies, following the procedure given in the University Catalog.

## **12. Graduate Student Grievance Procedures**

Students who feel that they have been graded inappropriately or receive what they perceive as an unfair evaluation by a faculty member may file grievances in accordance with University of Delaware policies. Students are encouraged to contact the Faculty Director prior to filing a formal grievance in an effort to resolve the situation informally.

### **Attendance at Conferences and Professional Meetings**

The Financial Services Analytics Ph.D. program encourages students to attend conferences and professional meetings. They provide opportunities to meet future employers and colleagues, and can offer specialized training beyond course work.

## **E. Financial Aid**

### **1. Financial Awards**

Admission to the Ph.D. program does not automatically entitle an applicant to financial aid. Students may seek financial aid opportunities, such as fellowships or scholarships from sources within the University and from private and federal agencies. Interested students should check the Office of Graduate Studies for the most current opportunities.

Financial aid is awarded on a competitive basis from the pool of admitted applicants. The University of Delaware's policies apply to all forms of financial aid. Please refer to the University Policies for Graduate Student Assistantships and Fellowships.

While we anticipate the FSA Ph.D. Program will support students in the program financially, students otherwise may apply for other sources of Graduate Assistantships:

- **Research Assistantships (RAs)** are generally funded by research grants and contracts provided by external funding agencies. Students may be supported as an RA through a faculty member's research funds after their first year. A research assistantship provides full tuition and a stipend. The RA's primary faculty advisor is responsible for defining

the student's responsibilities and for evaluating the student's performance. The amount of service or research may vary from week to week but the average is usually expected to be 20 hours per week.

- **Teaching Assistantships** (TAs) are offered for graduate students to perform teaching and other instructional activities. The amount of service may vary from week to week but the average is usually expected to be 20 hours per week. A teaching assistantship provides full tuition and a stipend. In accordance with University of Delaware regulations, foreign students must achieve a TOEFL score of at least 250 (computer-based) or 100 (Internet-based) in order to qualify for teaching assistantships.

## **2. Continuation of Financial Aid**

Students who are awarded financial aid must maintain satisfactory academic progress with satisfactory performance of assistantship duties (when applicable). Satisfactory academic progress includes registering for a minimum of 6 graduate-level credits each Fall and Spring semester, and maintaining a minimum 3.0 GPA.

The RA's responsibilities and performance standards will be established by the Primary Faculty Advisor. In the event of an unsatisfactory performance by an RA, the primary advisor will notify the student and the Graduate Program Committee at least four weeks prior to terminating the assistantship.

The TA's responsibilities and performance standards will be established by the Director of the course in which the student teaches. In the event of an unsatisfactory performance by a TA, the Course Director will notify the student and the Graduate Program Committee of the academic department offering the course. The Committee may recommend termination of the assistantship to the Department Chair.

## **F. Assessment Plan**

Program improvement will be an ongoing process. The results of the assessment measures will be shared with the Graduate Program Committee. The curriculum will be modified as necessary to achieve the goal of producing graduates who apply the knowledge, skills and abilities gained from the Ph.D. program in Financial Services Analytics to their career.

Objectives	Strategic Activities	Measures	Short-term Outcomes	Long-term Impact
Train students in the science disciplines pertinent to financial services analytics	Recruit high quality graduate students through faculty networks and leading researchers in the field.	Numbers, credentials and demographic data of student applicants and matriculated students	Retention and time to degree statistics	Students gain employment in FSA related fields
	Course work covering the disciplines related to the program core and electives	Faculty evaluation of student progress in course work; student's progress on schedule Survey of students in the program and post-graduation	Course work helped students secure initial employment; Students and graduates report applying knowledge from courses to work settings	Graduates enjoy long term success in academic or professional careers
Provide experiential training in research to prepare student as researchers and professionals in academia and industry	Conduct cutting-edge research through mentored dissertation projects  Lectures and discussions on specialized topics and cutting-edge developments (Seminar)	Survey of students focusing on their experiences;  Survey of graduates to determine the utility of their experiential training to their career;  Primary faculty advisor evaluation of both the project and the written reports and presentation;  Interviews and surveys of faculty advisors and internship mentors	Experiential training prepares students for the workplace and helps them secure their first post-graduation position	Graduates enjoy long term success in academic or professional careers

## **G. FSA Ph.D. Program Organization**

The development, administration and progress assessment of the overall Ph.D. Program in Financial Services Analytics will be guided by the FSA Ph.D. Program Faculty Director and the FSA Ph.D. Program Faculty Committee, as outlined below.

### **G.1 Appointment of FSA Ph.D. Program Faculty Director**

The FSA Ph.D. Program Faculty Director will be appointed by the Dean, COE, and the Dean, LCBE. The Faculty Director will serve a three-year term, which is renewable.

### **G.2 FSA Ph.D. Program Faculty Committee**

The FSA Ph.D. Program Faculty Committee will consist of seven members initially, one from each of the six participating departments – Accounting & MIS, Business Administration, Computer Science, Economics, Electrical and Computer Engineering and Finance – and the Faculty Director (ex officio). The term for members of the Faculty Committee is one-year and can be renewed. After the initial term, the committee will have three members from each college and the Faculty Director (ex officio). Only tenured faculty or those holding tenure track appointments can serve on the Faculty Committee. The Faculty Committee members from the LCBE will consist of one member each from the departments of Finance and Accounting & MIS and one at-large member from the Business Administration Department or the Economics Department. The members of the Committee are chosen in a manner to be determined by their respective departments with Lerner committee memberships proposed through the Lerner Committee on Organization, and membership approvals by vote of the Lerner faculty. The Faculty Director is a non-voting member, who votes only to break a tie.

For the first academic year after approval of the program, the Faculty Committee will consist of the members of the Curriculum Committee. The next year, the Faculty Committee members will be determined in the manner described above.

The Faculty Committee elects its own chair. The term of Chair of the FSA Ph.D. Program Committee is one-year (renewable).

The Faculty Committee is responsible for admission standards and processes, advising and evaluation of students and curriculum revisions including preparing proposals and managing the department, college and faculty senate approval processes. The Faculty Committee is expected to work closely with the students' Advisors and Dissertation Committee Chairs.

The activities related to the FSA Ph.D. program that are to be governed, and the anticipated roles and responsibilities of each party are shown in the table below.

<b>Activities</b>	<b>Primary Responsibility</b>	<b>Oversight*</b>
Compliance with UD graduate degree program policies	FSA Ph.D. Program Faculty Director (Faculty Director)	Dean of the College in which the Faculty Director has his/her primary appointment
Evaluation of Faculty Director	Deans of LCBE & COE	Provost

Call for nominations and selections of JPMC Faculty Fellows and Launch Leaders	Deans of LCBE & COE, in consultation with Faculty Director and recommendation of the relevant Department Chair	Provost
Ph.D. program's daily operations and budget control	Faculty Director	Deans of LCBE & COE
Curriculum proposals and revisions	FSA Ph.D. Program Faculty Committee (Faculty Committee)	COE Educational Activities Committee, and Lerner Graduate Program Committee
FSA program course scheduling	Faculty Director and Department Chairs	Deans of LCBE & COE
Student admissions, Ph.D. candidacy approval, dissertation committee approval	Faculty Director and Faculty Committee	Vice Provost for Graduate and Professional Education
Annual evaluation of Faculty Fellows, Launch Leaders, and participating FSA Ph.D. Program faculty	Department Chairs, with input from Faculty Director	Deans of LCBE & COE

\*Secondary responsibility to review and ensure it is done

## **VIII. Appendix**

### **A. Appendix I: Letters of Approval from Contributing Departments/Units**

#### College of Engineering

1. Dr. Errol Lloyd, Chair, Department of Computer & Information Sciences
2. Dr. Kenneth Barner, Chair, Department of Electrical & Computer Engineering

#### Lerner College of Business and Economics

3. Dr. Scott Jones, Chair, Department of Accounting and MIS
4. Dr. Stewart Shapiro, Chair, Department of Business Administration
5. Dr. James Butkiewicz, Chair, Department of Economics
6. Dr. Helen Bowers, Chair, Department of Finance

#### College of Arts and Sciences

7. Dr. John Pelesko, Chair, Department of Mathematical Sciences

#### College of Agriculture and Natural Resources

8. Dr. Titus Awokuse, Chair, Department of Applied Economics & Statistics



**B. Appendix II: Letters of Support from Deans of Participating Colleges:**

1. Dr. Babatunde A. Ogunnaike, Dean, College of Engineering
2. Dr. Bruce Weber, Dean, Lerner College of Business and Economics

### **C. Appendix III: Course Descriptions**

#### **FSAN815/ELEG815 Analytics I Foundations of Statistical Learning\***

Introduction to the mathematics of data analysis: Review of probability and multivariate random variables; models and statistical inference, estimating the CDF; bootstrap; maximum likelihood estimation; hypothesis testing; Bayesian inference, decision theory; linear regression; Lasso methods; linear and kernel-based classification; unsupervised learning and clustering; dimensionality reduction: PCA and the SVD; directed graphs; high dimensional problems. Prerequisites: First course on probability and random variables. ELEG 310 or equivalent. (\*Primary designation ELEG; secondary designation FSAN. ELEG815 will be cross-listed as FSAN815.)

#### **FSAN820 Analytics II Foundations of Optimization**

Concept of optimization, convex set, convex function, unconstrained optimization, convex optimization problems, including least-squares, linear, and quadratic optimization, duality theory, sensitivity analysis. Modeling of more advanced optimization techniques including integer programming, geometric and semi-definite programming, and convex relaxations. Prerequisites: First course on linear algebra and calculus.

#### **FSAN830 Business Process Management, Innovation, and Analysis**

This course enables students to employ a data-driven approach to designing, managing, and improving the business processes that execute a firm's strategy. The course starts by exploring the linkage between strategy and business process design and quickly moves into identifying key process metrics which have greatest leverage on improving performance at both the process and firm-wide levels. Planning and controlling for variability in business processes is discussed with applications drawn from diverse settings. Students will become proficient in improving processes based on leveraging data and learning to deploy resources and information to achieve consistently good outcomes. Topics covered include Little's Law, process flow diagrams, throughput and flow time analysis, six-sigma capability, lean operations, service process performance, and inventory analysis. Selected research papers will be assigned for presentation and discussion.

#### **FINC841/FSAN841 Financial Services Firms and Markets**

Focuses on the economic roles and interactions of the units in each sector of the financial services industry. The course will provide an overview of the current and changing layout of institutions, products, and practices. (Primary designation FINC; secondary designation FSAN. FINC841 will be cross-listed as FSAN841.)

#### **FINC842/FSAN842 Financial Services Risk Analytics**

Develops the theoretical and practical foundations of resource allocation across time and risky assets, and of credit risk and systemic considerations. Major topics: (1) Allocation of resources across time (2) Allocation of resources across risks (3) Credit risk and systemic considerations. (Primary designation FINC; secondary designation FSAN. FINC842 will be cross-listed as FSAN842.)

#### **MISY831/FSAN831 Enterprise Information Systems**

Enterprise information systems (EISs) provide a technology platform that enables organizations to integrate and coordinate their business processes and share information across all functional levels and management hierarchies. The proper implementation and management of EISs is a critical factor in maintaining and increasing organizational performance. EISs include but not limited to Enterprise Resource Planning System (ERP), Supply Chain Management system, and Knowledge Management system. This course will explore the technology and strategic use of EISs. More specifically, the students will learn the critical role of EISs in business organizations, the interplay between business processes and EISs, how to use and configure an EIS (an ERP system), and the best practices in managing EISs. (Primary designation MISY; secondary designation FSAN. MISY831 will be cross-listed as FSAN831.)

#### FSAN816/ELEG816 Large Scale Machine Learning\*

Introduction to large scale machine learning. High-dimensional statistical learning for classification, regression, ranking, clustering, and supervised learning. L1 regression and sparse representations; dictionary learning; sparse PCA; sparse subspace clustering; randomized algorithms; low-rank matrix approximations; robust PCA; matrix completion and recommendation systems; approximate nearest neighbors; large scale kernel methods; dimensionality reduction; local linear embedding. Pre-requisites: FSAN 815 Analytics I and FSAN 820 Analytics II. (\*Primary designation ELEG; secondary designation FSAN. ELEG816 will be cross-listed as FSAN816.)

#### FINC843 Financial Services Regulation

Examines the regulatory environment of financial services industry, including policy choices, goals and costs/ benefits. We will consider how companies and individuals, using people, processes and technology, meet their ethics, compliance and control objectives in a global environment. (Primary designation FINC; secondary designation FSAN. FINC843 will be cross-listed as FSAN843.)

#### ACCT804 Database Design, Networks and Implementation

Covers the design and implementation of enterprise databases in a business environment. Special consideration will be placed on issues related to systems in a networked setting, including current topics related to the management and implementation of databases in such systems.

#### ACCT806 Systems Analysis, Design and Implementation

Explores the management, organizational and technical challenges of developing systems. Analyzes business processes within a data-driven development methodology. Students will elicit requirements, weigh alternatives and design and implement solutions. Data, process and object modeling will be covered. Prerequisites: ACCT804

#### ACCT817 Information Technologies Audit

Analysis of current and prospective developments in professional auditing. Topics include auditing computerized systems and the use of statistical sampling by the auditor. Prerequisites: ACCT417

#### ACCT820 Financial Statement Analysis

Examines contemporary aspects of financial statement analysis such as the supply and demand for accounting information, statistical properties of accounting numbers and the impact of information on securities prices. Prerequisites: ACCT800

#### BUAD840 Ethical Issues in Domestic and Global Business

Topics include ethics in organizations, and problems and challenges dealing with external environment demands including global issues.

#### CISC686 Multiagent Systems:

Introduces the notion of an agent, leading to an understanding of what an agent is, how they can be constructed, how agents can be made to cooperate effectively with one another to solve problems, and approaches to decision making in multiagent contexts. Prerequisites: CISC220 (Data Structures) or equivalent.

#### CISC681 Artificial Intelligence:

Programming techniques for problems not amenable to algorithmic solutions. Problem formulation, search strategies, state spaces, applications of logic, knowledge representation, planning and application areas. Prerequisites: CISC220 (Data Structures) or equivalent.

#### CISC684 Machine Learning:

The development of methods to learn to solve a task using examples. Several machine learning algorithms/techniques are covered and their strengths and weaknesses discussed. Prerequisites: Programming experience

#### ELEG 636 Statistical Signal Processing

Introduction to random vectors and random processes and second-order moment and spectral characterizations. Linear transformations of stationary processes. Parameter estimation. Orthogonality principle and optimal linear filtering. Levinson recursion and lattice prediction filters. AR and ARMA models and their Yule-Walker characterizations. Classical and modern spectrum estimation. Kalman filters. Prerequisites: First course on probability and random variables. ELEG 310 or equivalent.

#### CPEG/ELEG 457/657 Search and Data Mining

Introduction to search and data mining. Theory and practice of information systems powering Google, Twitter, Facebook graph search, Watson and Amazon recommendation systems. Topics include indexing, search models, result organization, recommendation, information filtering, text classification, text clustering, social network analysis, etc. Prerequisite: Programming skills.

#### ELEG655 High-Performance Computing with Commodity Hardware

New commodity computing devices, e.g., GPUs, bring the originally elite high performance computing into the reach of general public. Principles of program optimization, GPU and IBM Cell architecture, along with concepts and techniques for optimizing general purpose computing on the new hardware.

#### ECON801 Microeconomics

Analyzes consumer behavior and market demand, production, costs and the theory of the firm; market structures and competition in open and closed markets; general equilibrium theory and

welfare economics. NOTE: Intended for MA (Economics) and students enrolled in other graduate programs. Cannot be taken for credit toward MS or Ph.D. degree in Economics.

#### ECON803 Applied Econometrics I

Applies and modifies statistical techniques to economic data; presents the essentials of econometric theory. PREQS: MATH202 or STAT371 or equivalent. NOTE: Intended for MA (Economics) and students enrolled in other graduate programs. Cannot be taken for credit toward MS or Ph.D. degree in Economics.

#### ECON810 Mathematics for Economists

Introduces fundamental mathematical tools utilized in theoretical economic analysis. Typical topics include basic set theory and real analysis optimization in both static and dynamic environments, linear algebra, difference and differential equations, and probability theory. The use of these tools in constructing and analyzing economic models is heavily emphasized. Prerequisites: a course in multivariate calculus.

#### ECON861 Industrial Organization and Regulation

Uses microeconomic theory and game theory to analyze the strategic interaction among firms. Topics include vertical and horizontal integration, vertical restrictions, cartels and collusion, pricing practices, entry deterrence, diffusion of technology, product differentiation, and government regulation of industry. Prerequisites: ECON801 or ECON811 and ECON803 or ECON822.

#### MATH612 Computational Methods for Equation Solving and Function Minimization

LU and QR factorizations, singular value and eigenvalue decompositions, matrix conditioning, solution of linear systems and linear least-squares problems, iterative methods in linear algebra, descent and quasi-Newton methods of optimization, globalizing convergence, constrained optimization, applications.

#### MATH630 Probability Theory and Applications

Introduction to probability theory as background for further work in statistics or stochastic processes. Sample spaces and axioms of probability; discrete sample spaces having equally likely events; conditional probability and independence; random variables and describing their distributions; classical discrete and continuous random variables; mathematical expectation and moments of a distribution; the distribution of a function of a random variable; Chebyshev's inequality; the law of large numbers; central limit theorem.

#### MATH631 Introduction to Stochastic Processes

Classical stochastic processes with emphasis on their properties which do not involve measure theory. Markov chains in discrete and in continuous time with examples from random walk, birth and death processes, branching processes and queuing theory. Renewal and Markov renewal processes. Basic notions of Brownian motion and second-order processes.

#### MATH672 Vector Spaces

Vector spaces, linear transformations, decomposition theorems and bilinear forms. Prerequisites: MATH349

### MATH829 Topics in Mathematics

Topics vary and are chosen from a variety of areas in pure and applied mathematics.

### APEC801 Math Programming with Economic Applications

The development application of optimization models and methods such as linear, integer, nonlinear, and goal programming. Applications to both firm and sector-level economic issues with emphasis on agricultural, environmental and resource economics applications.

Prerequisites: ORES 601 or permission of Instructor.

### APEC802 Operations Research Applications

Applications of models and principles of basic interest to the theory and practice of operations research. Classic models of inventory and queuing theories, maintenance and replacement of equipment and government planning. Contemporary models from research literature of energy management, urban planning, artificial intelligence and flexible manufacturing systems.

Prerequisites: MATH529, STAT601 or MATH630

### STAT601 Probability Theory for Operations Research and Statistics

Provides the basic background in probability theory for further work in statistics and operations research. Basic topics: sample spaces and axioms of probability; conditional probability and independence; Bayes theorem; random variables; moments and moment generating functions; transformations of random variables; common families of distributions; multivariate distributions, covariance and correlation; probability inequalities and limit theorems.

Prerequisites: MATH243

### STAT611 Regression Analysis

Simple linear and nonlinear regression. Subset regression; principal component and ridge regression. Introduction to experimental design and design models. Prerequisites: MATH202 or STAT371

### STAT615 Design and Analysis of Experiments

Fundamental principles of design, randomized designs, Latin squares, sources of error, components of error. Factorial designs, response surfaces, models for design. Prerequisites: STAT371

### STAT617 Multivariate Methods

Multivariate analysis of variance and covariance; classification and discrimination; canonical correlation; principal components; factor analysis. Prerequisites: STAT602 and permission of instructor.

### STAT620 Nonparametric Statistics

Statistical procedures valid under unrestrictive assumptions; scales of measurement; efficiency comparisons; signed rank procedures; two-sample rank tests; zeros, ties, and other problems of discrete data; order statistics; k-sample procedures; nonparametric measures of correlation.

Prerequisites: STAT371, STAT601

### STAT674 Applied Data Base Management

Provides an in-depth understanding of using computers to manage data using programs such as SAS and Microsoft/Access.

**STAT675 Logistic Regression**

Practical and computational introduction to logistic regression and related topics. Applications include financial, marketing and biomedical research. The use of SAS and other statistical packages will be emphasized.

**Seminar FSAN850**

Concentrated study on selected areas in Financial Services Analytics. May include an appropriate 800 level course.

**Research FSAN860**

Upper-level graduate research oriented toward the student's potential Doctoral Dissertation.

**Doctoral Dissertation FSAN969**

Independent dissertation research after completion of applicable coursework and examinations.