University of Washington

SELF-STUDY DOCUMENT FOR INTERDISCIPLINARY COMPUTATIONAL FINANCE GRADUATE CERTIFICATE PROGRAM

Five-Year Program Review

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PART A BACKGROUND INFORMATION

1) OVERVIEW

Motivation and Mission

The needs of the modern finance, risk, and insurance industries demand a broad interdisciplinary and computationally oriented approach to educating the next generation of financial researchers, analysts, risk managers, and financial information technology professionals. These needs were quite clear at time of launching the University of Washington Computational Finance Graduate Certificate (CFGC) Program in 2004, as reflected for example in the rapid growth in new "quantitative finance" Master of Science (MS) programs from only a handful in 2000 to approximately 20 in the United States and approximately 35 internationally in 2004.[1] These numbers have more than doubled as of January 2010 as is documented in the sub-section below on the current status of such programs.

The important needs cited above remain all the more so in the wake of the financial markets collapse of 2008-9 when the markets and country experienced the nearly disastrous consequences of systemic risk and cross-market correlations never before imagined by practitioners. Going forward there is the need for a deeper and broader understanding of the beneficial use as well as the limitations of quantitative methods in designing investments and managing their risk.

The CFGC mission is to meet the above needs by leveraging faculty expertise in several departments to integrate education and research across the following key areas: (a) basic finance and financial econometric concepts and theory; (b) mathematics, statistics and econometric modeling and analysis methods needed to construct and manage the risk of investment portfolios across a broad range of investor groups that include endowments, pensions, family offices, individuals and finance industry asset management companies such as hedge funds and funds-of-hedge funds; and (c) computer science and information systems tools needed to implement modeling and analysis methods in finance industry organizations.

The CFGC specific goals with respect to students are to deliver a high-quality program that enables them to:

- Pursue a finance industry career upon graduation (the majority of the students)
- Pursue an interdisciplinary academic career (a small fraction of the students)
- Carry out interdisciplinary dissertation research at the interface between finance, economics, statistics, applied mathematics and computing if they wish to do so.

[1] Such programs invariably have one of the following three names: Computational Finance, Financial Engineering or Mathematical Finance. Whenever we use the term "quantitative finance program" we are referring to any one of these three types of programs, which have different emphases.

The Computational Finance Graduate Certificate

The CFGC program is currently intended for Ph.D. students in highly quantitative departments in Engineering and Science, and the certificate is awarded upon completion of six courses plus a capstone event as described in Section 3. As such the program constitutes a minor area of study for Ph.D. students. The departments that participate in the program are Economics, Finance, Mathematics and Statistics, with Economics and Statistics as lead departments.

Since the program's inception 12 students from four departments (Economics, Statistics, Computer Science and Physics) have completed the CFGC requirements between 2006 and 2009. These students have obtained excellent job placements upon graduation, 9 in the finance industry and 3 in academia. Further details on student placements are provided in Section 4. . We forecast that 3-4 students will complete the certificate in 2010.

Quantitative Finance MS Programs

It is important to be aware of the number, growth rate and lead academic units of quantitative finance MS programs in the United States as context for the viability of our CFGC program (see Section 6 below and the answer to Question 4 in Sections B2 of Part B). Whereas there were only about 20 such programs as of 2004, a 2010 survey reveals that there are now 43 such programs.[2] We break these 43 programs down according to the lead academic unit as follows.

LEAD UNIT	BUSINESS	MATH/AMATH	ENG'G	ECON	STAT	TOTAL
Number of Programs	18	16	7	1	1	43

Of the 18 programs with a business school as the lead unit, only about three have significant involvements by departments outside the business school. At the same time relatively few of the programs led by units outside a business school have significant involvements by the business school. We believe this reflects an aversion on the part of business schools to participate in interdisciplinary programs that cross business school boundary lines, perhaps based on high cost structures of business schools and turf considerations, The large number of Mathematics and Applied Mathematics departments that are leads of Mathematical Finance MS programs reflects their affinity to quantitative finance instruction and research, and this is also the case for Schools of Engineering and departments of Industrial Engineering and Operations Research in particular.

The fact that only one Economics Department is a lead and only one Statistics Departments is a lead for quantitative finance MS programs is quite striking. that the reason we say this is that very significant aspects of portfolio construction, investment decision making and risk management involve econometric and statistical modeling, as well as analysis and management of large complex data sets.

Appendix E provides further information on quantitative finance programs in the U.S. and abroad, namely: (a) a ranking of the top 23 domestic quantitative finance MS

[2] The 2004 survey was by PRIMIA and dated March 2004. The 2010 survey was by Global Derivatives, Inc. and dated January 2010. The latter survey did not include the new UCLA Financial Engineering MS degree that was launched in 2008-9, bringing the total number of domestic programs to 44.

programs with their tuitions and duration (1, 1.5 and 2 year programs)[3], (b) data on the number of quantitative finance MS programs abroad by region (a total of 99 programs in 71 universities, up from 35 programs in 2004), and (c) information on quantitative finance Ph.D. programs in the U.S. (there are only six of these).

Lack of Quantitative Finance Programs in the Northwestern United States

There are currently no quantitative MS programs or other program similar to our CFGC in the Northwestern United States. On the other hand there are five quantitative finance MS programs in California at Berkeley, Stanford, USC, Claremont and UCLA (the latter was just launched in 2008-9). From 1997 to 2002 there was a Computational Finance MS Program at the Oregon Graduate Institute (OGI) that was self-sustaining by 2000 and generated approximate $180K profit by 2002 with approximately 25 students (see the revenue and profit and loss history of the OGI program at the end of Appendix E). This program was discontinued when OGI was subsumed by the Oregon Health Sciences University, which had little interesting in the Computational Finance MS degree, and the MS program director John Moody left.

Development Plans

Our CFGC program could continue as the very small program that it has been during the past five years and be successful on a modest scale. However, with appropriate development discussed in Section 6 and in further detail in Section B2 of Part B, we believe it could become a top ten program nationally.

2) ORGANIZATION AND RESOURCES

Program Management and Staffing

Professor Douglas Martin in Statistics is the Director of the CFGC program and Professor Eric Zivot in Economics is Co-Director of the program. Ellen Chan Reynolds, Senior Academic Counselor in Statistics provides support for the program in a number of ways including answering questions and processing student applications to the program, and maintaining records of student completions of certificate course and capstone requirements.

At the inception of the program a Steering Committee was formed consisting of Martin, Zivot along with Professor Avraham Kamara in the Finance Department and James Burke in the Mathematics Department. One function of the Steering Committee was to serve as the Admissions Committee. Given the small size of the program, however, it was not found necessary to make use of this committee and admissions decisions were taken by Martin and Zivot.

Program Budget

One year prior to the program launch in fall of 2004 we were awarded a two-year budget of $110K from the University of Washington Tools for Transformation program to support curriculum development and seminar speakers, as follows.

[3] Due to QuantNetwork, see www.quantinvest.com .

	2003-4	2004-5
Director Support (Doug Martin)		
Partial Salary with Benefits	**$28,000.00**	**$14,000.00**
Teaching Assistants		
Two T.A.s (primarily software development)	**$26,000.00**	**$26,000.00**
Seminar Speakers		
Travel/Honoraria	**$4,000.00**	**$12,000.00**
	$58,000.00	$52,000.00
Total Two-Year Cost		**$110,000.00**

The teaching assistants were shared primarily between Professors Martin and Zivot and used mainly for development of S-PLUS software to support three of the core courses (ECON 424, STAT 547 and STAT 549) described in Section 3 below, plus access and organization of financial data needed in support of these courses. A small portion of the budget was allocated to Professor Burdzy in the Mathematics Department for conversion of MATH/STAT 492 from a general stochastic processes course to the current Stochastic Calculus for Options version of the course.

From spring quarter 2004 through spring quarter 2005 part of the above funding supported a well-attended seminar series of notable outside speakers from NYC and Chicago as well as locally. The funds also supported a five week short course on "Stochastic Optimization and Asset Liability Management" by Professor Bill Ziemba from the University of British Columbia.

Since the end of 2005 there has been no other special dedicated budget for the CFGC program. The program has continued because Martin and Zivot, and the other participating faculty members described in the next section, taught the needed courses as part of their regular departmental teaching assignments.

University of Washington Endowment Fund Support

We have been fortunate to have the ongoing support of the University of Washington Endowment fund through graduate student assistant (GSA) funding of several students, starting with the first Statistics student to earn the CFGC (H. Bailer in 2006). This is an excellent environment for our students to learn how a large endowment fund invests their money and manages risk, At the same time the students have been able to contribute to the management of the fund by implementing modern statistical methods that deal with problems in manager-of-managers/fund-of-fund such as unequal returns histories, non-normal returns distributions, outliers, and non-linear correlations (that increase when markets go down and decrease in up markets). The most recent GSA funded by the UW Endowment Fund, Yindeng Jiang, was hired full-time as the first highly quantitative Investment Research Analyst upon completing his Ph.D. in August 2010. Special thanks are due to Deputy CIO Garth Reistad for his ongoing interest in the CFGC program and for facilitating the GSA support.

3) CURRICULUM AND FACULTY

The curriculum described below was designed for matriculated Ph.D. students. We note however that from time to time one or more qualified non-matriculated students were allowed to enroll in a course.

Students from departments other than Finance must currently take one of two tracks shown in Table 1 below, depending upon whether they pursue academic or industry careers.

Table1: CFGC Core Curriculum

Course Title	Course Number
Fall	
Computational Finance and Financial Econometrics (Track I)	ECON 424
Derivatives: Theory, Statistics, and Computation (Track I)	STAT 547
Winter	
Statistical Computing III (Track I)	STAT 538
Stochastic Calculus for Option Pricing (Track II)	MATH/STAT 492
Doctoral Seminar in Capital Market Theory (Track II)	FIN 590
Spring	
Statistical Methods of Portfolios (Track I)	STAT 549
Doctoral Seminar in Financial Research[1] (Track II)	FIN 592
Management of Financial Risk (Track I)	FIN 562

[1]Topics vary depending on instructor.

Industry Track I one consists of four of the five Track 1 courses plus two additional elective courses. Academic Track II consists of all Track II courses plus one fall Track I course, one spring Track I course, and one elective. Elective courses may be one of the other courses listed in the Table 1above, or in the electives Table 2 below. Course substitutions must be approved by the Program Director. No Finance Department students have completed the CFGC program to date.

Table 2: CFGC Elective Courses

Course Group and Title	Course Number
Computing	
Statistical Computing I	STAT 534
Statistical Computing II	STAT 535
Statistical Computing III	STAT 538
Finance	
Financial Markets	B ECON 520
Financial Economics Seminar	FIN 580
Corporate Finance Seminar	FIN 591

Financial Econometrics	
Topics in Financial Econometrics	ECON 512
Econometric Theory II - Time Series	ECON 584
Advanced Applied Time Series Analysis	ECON 586
Mathematical Finance	
Nonlinear Optimization	MATH 408

The core courses ECON 424, ECON 512, STAT 547, and STAT 549 were developed using the start-up funding described in Section 2 and resulted in a new textbook for ECON 424 by Zivot and a new textbook for STAT 549 by Martin (both are described in Section 6). These courses have been designed to be responsive to evolving methodology demands of the finance industry and to the results of relatively recent quantitative finance research. For example: ECON 424 surveys the statistical analysis of asset returns, risk measures and classical mean-variance portfolio theory; ECON 512 covers univariate and multivariate volatility modeling and the statistical analysis of high frequency financial time series; STAT 547 covers both standard graduate level option and derivatives pricing along with modern advanced methods such as option pricing with fat-tailed skewed distributions and volatility clustering; STAT 549 focuses considerable attention to post-modern portfolio optimization methods based on downside risk measures, fat-tailed skewed distributions and nonlinear correlations, and on related tail risk budgeting methods to guide asset allocation.

Faculty

The distribution of the eight core courses across the participating departments' faculty is as follows: 3.5 courses from Statistics faculty, 3 from Finance faculty, 1 from Economics faculty and .5 from Mathematics faculty. The fractional count for Statistics and Mathematics is because the two departments alternate the teaching of MATH/STAT 492 from year to year. The department and faculty contributors and the number of courses offered over the past five years are as follows:

- Statistics: D. Martin (2), W. Stuetzle or M. Meila (1), T. Gneiting (.5) (he has since left UW)
- Economics: E. Zivot (1)
- Finance: Various faculty members (3). For the advanced FIN 590 and 592 it was J. Hahn and J. Duarte in the earlier years (both have since left UW) and most recently T. Gilbert and P. Malatesta. Duarte had also taught introductory Risk Management FIN 562, and this year it will be taught by two professionals from BlackRock, Inc. in Seattle.
- Mathematics: C. Burdzy and S. Pal (.5) for MATH/STAT 492. Pal is a new Assistant Professor who we hope will continue teaching MATH/STAT 492 along with Burdzy.

The following points should be noted to obtain a clear understanding of the department and faculty contributions to the program:

- E. Zivot's ECON 424 is an entry CFGC course given every year with very high enrollments that have been capped at 45 students in recent years. In addition many CFGC students take either Zivot's ECON 512 elective course, or else Economics electives ECON 584 or ECON 586 taught by Professor C. Kim.
- Martin's has STAT 547 and STAT 549 courses are taken by virtually all CFGC students.
- STAT 538 appears to be taken by a fair number of CFGC students, but we have not yet collected the data on this.
- MATH/STAT 492 appears to be taken by many CFGC students, but we have not yet collected the data on this.
- FIN 590 and 592 typically have single digit enrollments and are taken by relatively few CFGC students (though strong CFGC students are encouraged to take them). However, Economics students who take their field exams in Finance and/or who are pursuing the CFGC typically take these courses

- FIN 562 is an important course for CFGC students to take. Unlike FIN 590 and 592, FIN 562 is an MBA course in the Business School and students outside the Business School can only enroll in the course if it is not filled by MBA students. The good news is that to date this has not limited enrollment by CFGC students, and the course is being taught this spring for the first time by two risk management professionals from Blackrock's Seattle office.

Teaching Evaluation

Teaching evaluation is carried out using the standard University of Washington student course evaluation process. This has been carried out fairly uniformly in the case of the Statistics and Economics course offerings, and the results are given in Appendix F.

Research Advising

All the students who have completed the CFGC certificate requirements and graduated as of the end of 2009 were Ph.D. students except one who was a M.S. student. Martin was thesis advisor of three of these and Zivot was thesis advisor of four students. Both Martin and Zivot continue to be the thesis advisor to a number of CFGC Ph.D. students, with Martin currently advising four and Zivot currently advising two. We have also been involved with Ph.D. students in the CFGC program in other ways. For example, Martin joined Professor Jim Burke in Mathematics to administer a reading course in modern regression methods for two Applied Mathematics Ph.D. students during fall quarter 2009. Zivot provided NSF funding (in conjunction with Insightful Corporation) for one CFGC student to help develop statistical software for simulation-based estimation and inference.

4) STUDENTS

Student Recruitment, Composition, Quantity and Quality

CFGC students are recruited primarily by distributing program information and an application invitation to matriculated graduate students in engineering and science departments via email. Awareness of the program developed this way has resulted in two graduate students transferring from another department to the Statistics Department (one from Industrial Engineering and one from Applied Mathematics, and in the first case the student obtained the highest score in both the M.S. and Ph.D. Statistics Theory exams).

Some students are attracted to apply for admittance to the Ph.D. programs in Statistics and Economics by browsing the web site for the CFGC program at www.stat.washington.edu/compfin. Professor Michael Perlman reports that on the order of 3-4 strong students have applied to the Statistics Department in the last few years because of their interest in the CFGC program. However these students were not admitted, at least in part because of lack of financial support for these applicants. Economics typically has 2-3 PhD students per year who have chosen UW because of the CFGC and the possibility to concentrate in computational finance or financial econometrics.

While to date the majority of the students in the program have been from the Economics and Statistics Departments, the home department composition of the other students in the program is quite broad and includes Applied Mathematics, Computer Science, Industrial Engineering and Physics. Going forward we expect

the majority of the students to come from departments other than Economics and Statistics, as is indicated by the data in Appendix G.

In the original proposal to the Graduate School in 2004 we set a target of having 15 students enrolled in the program within two to three years. In fact by the fall of 2005 we had 22 students enrolled (as was reported in the 2003-5 Status Report made available to the Review Committee). There are currently 18 Ph.D. students enrolled in the program from six different departments as shown below.

Name	Department	Name	Department
Cahan Ercument	Economics	Lei Xu	Statistics
Brian Donhauser	Economics	Nicholas Basch	Statistics
Yuwen Dai	Economics	Sasha Arukin	Mathematics
Abraham Robison	Economics	Peizhe Shi	Applied Math
Dong Lee	Economics	Yun Zhang	Applied Math
Qiong (Linda) Li	Finance	Chen Xi	Industrial Eng'g.
Dustin Lennon	Statistics	Wei Wang	Industrial Eng'g.
Tatiana Maravina	Statistics	Todd Schiller	Computer Science
Minfeng Zhu	Statistics	Peng Dai	Computer Science

The CFGC program tends to attract high quality students. For example as of the end of the 2006-7 academic year there were 8 Statistics Ph.D. students in the program and 6 of these 8 had GPA's above the upper quartile of 3.8 for all 47 Statistics graduate students at the time, and while the other two GPA's only slightly lower at 3.73.

Shortly we will solicit new CFGC program applications and report updated results on the number of students enrolled prior to the Review Committee site visit on May 7.

We believe that by expanding the CFGC program in the direction envisioned in Section 6, and correspondingly building more program awareness on campus, we will attract increased numbers of Ph.D. students to the program from quantitative departments on the UW campus other than Economics and Statistics.

Internship and Work-Study Placements

We have been able to find internship and work-study placements for CFGC students who are well advanced in their academic program, as shown in the table below.

INTERNSHIP AND WORK/STUDY PLACEMENT

Name	Department	Company
Ercument Cahan	Economics	Pengrove Capital Mgt.
Brian Donhauser	Economics	Nicholas Applegate
Ying Gu	Economics	Insightful Corp.
Peter Fuleky	Economics	Insightful Corp.
Jun Ma	Economics	Frank Russell
Heiko Bailer	Statistics	UW Endowment
Yindeng Jiang	Statistics	Quellos/Blackrock

Shengyu Zhang	Statistics	Washington Mutual*
Lei Xu	Statistics	Washington Mutual*
Dustin Lennon	Statistics	Numerix, Inc.
Tatiana Maravina	Statistics	McKinley Capital
Chris Green	Statistics	Wash. State Invest. Board**

* Subsequently took job at Freddie Mac in Washington, DC

** State of Washington Pension Plan

To date these placements have been mostly in the Puget Sound area to date, but we anticipate broader geographic placements going forward.

Job Placement Success

The CFGC program has resulted in 9 finance industry job placements and 3 academic job placements since 2006 as shown below. Of these students all but 3 have graduated from the relevant department's Ph.D. program.

Student Name	**Department**	**Job Placement**
Will Portnoy	Computer Science	Morgan Stanley (NYC, 2006)
Heiko Bailer	Statistics	ABN Amro (London, 2006)
Ying Gu	Economics	Bear Stearns (NYC, 2007)
Tao Ling	Physics	Washington Mutual (2007)
Jun Ma	Economics	Univ. of Alabama (2007)
Drew Creal	Economics	Univ. of Chicago School of Business (2008)
Kapil Phadnis*	Statistics	Citadel (NYC, 2008)
Lei Xu**	Statistics	Freddie Mac (Washington, DC, 2009)
Shengyu Zhang	Statistics	Freddie Mac (Washington, DC, 2009)
Chris Green**	Statistics	Washington State Investment Board (2009)
Yindeng Jiang	Statistics	University of Washington Endowment (2009)
Peter Fuleky	Economics	Univ. of Hawaii Business School (2009)

* M.S. level student

** Ph.D. dissertation remains to be completed

5) SCHOLARLY IMPACT

Results of research by Doug Martin associated with the CFGC program

Book for STAT 549: *Modern Portfolio Optimization with NuOPT, S-PLUS and S+Bayes* (2005), with Bernd Scherer, Springer.

Papers: 3 reviewed papers on applications of robust statistics to portfolio management. Two papers on risk management methods and one paper on robust alpha estimation in preparation for submission.

Finance Industry Short Courses: 2 two-day short courses on Modern Portfolio construction in NYC and multiple two-hour segments of three two-day Risk Management short courses in NYC and London.

Finance Industry Conference Presentations: 5 conference presentations spread across Boston, NYC and Seattle

Results of research Eric Zivot associated with the CFGC program

Book for ECON 424: *Modeling Financial Time Series with S-PLUS* (2003), with Jiahui Wang, Springer (*Second Edition*, 2006). *Introduction to Computational Finance and Financial Econometrics* (manuscript in preparation). *Modeling Financial Time Series with R* (manuscript in preparation).

Papers: Published 5 reviewed papers in the area of empirical finance/financial econometrics.

Short Courses: One day short course on volatility modeling and the statistical analysis of high frequency data using S-PLUS in Atlantic City, New Jersey. One week summer school on financial econometrics at American University. Two day short course on the analysis of high frequency data at the University of Sao Paulo. Four day short course on simulation-based methods for estimation and inference at ETH, Switzerland.

Conference Presentations: 10 conference presentations related to research on empirical finance and financial econometrics.

Ph.D. Dissertations

Doug Martin was the Ph.D. Advisor of three CFGC students who have graduated (Bailer, Zhang and Jiang) and is currently advising three long-time CFGC Ph.D. students (Green, Maravina and Zhu) and one new CFGC student (Basch).

Eric Zivot was the PhD Advisor of three CFGC students who have graduated (Creal, Fuleky and Gu), and is the Advisor of two current CFGC students (Cahan and Donhauser).

6) FUTURE DIRECTIONS

The CFGC program is located administratively as an interdisciplinary unit in the Graduate School, and is primarily supported by the Economics and Statistics departments through the teaching, research and management contributions of Martin and Zivot. However, neither of these two departments has embraced the program as an important component of their overall academic offerings. This is consistent with the data on leadership of quantitative finance MS programs presented in Section 1 in that Economics and Statistics departments are almost never the lead units. In order to maximize the future potential of the program it needs: (a) a sustainable financial model, and (b) a home academic department that sees real benefit from embracing and nurturing an enlarged and energized Computational Finance program (possibly rebranded as a Financial Engineering and Risk Management program). It will be appropriate that Martin's position and at least part of Zivot's position is transferred to such a department.

With the above considerations in mind, our goals for enhancing and financing the program are as follows (our answers to Question 4 of Part B2 provide further detail).

- Create an online MS program that will finance a large fraction of the operating costs of enhancing the program through an expanded curriculum, additional full-time and part-time faculty, seminar series speaker expenses, and graduate student support. We will provide a draft financial operating budget to the Review Committee by the end of April.
- Determine the overall academic and financial viability of expanding the online MS program into a Professional MS program for resident students
- Expand the current curriculum by developing four new core courses. When combined with the current core courses and electives this will provide a strong curriculum for the MS degree as well as add breadth and depth to the certificate program for Ph.D. students
- Secure start-up funding for 2010-2011 and 2011-2012 from a combination of internal and external industry and foundation sources to carry the program until the online (and possibly resident student) MS program is fully operational. Amounts of start-up funding required will be included in the draft financial operating budget delivered by the end of April
- Appoint selected Northwest finance industry professionals as Affiliate faculty to teach courses for which they have special expertise, including possibly one or more of the four new courses. Such involvement of local industry professionals will enrich the program and help build ties between the program and the local finance industry
- Re-introduce a regular seminar series that was discontinued in 2006, using both local and nationally prominent outside speakers with many speakers being industry professionals
- Engage finance organizations in the Puget Sound area and elsewhere for creation of internship and work-study programs to support graduate students, job placement for graduates, targeted research grants, and program donations
- Add one new interdisciplinary UW FTE faculty position in 2011-2012 to support the program and become the next Director of the Program. Vigorously seek a source for endowing a Chair for the program by 2012-2013.
- Explore with finance industry representatives and the National Science Foundation (and other foundations) whether a Center structure is a fundable vehicle to enhance program success
- In the process of evolving the program over the next academic year we will determine whether or not an interdisciplinary Ph.D. program is viable
- Based on achieving a number of the above goals we forecast having about 25-30 PhD students in the CFGC program and about 20-30 students in the MS online program by 2012.

NOTE: Martin was on leave of absence from the University of Washington during academic years 2006-7 and 2007-8, during which time he was located in NYC serving as the CEO of a portfolio optimization and risk management company that he founded (www.finanalytica.com). He returned to the University in fall quarter 2008 primarily to re-energize the Computational Finance program, and based on the above opportunities intends to focus on this for another five years at which time he plans to retire. The sustainability of the program at its current minimal level beyond that time scale is an open question addressed further in Section B3.

Local and National Benefit

Though the CFGC program is small it has provided some local and national benefit through placement of its students in the important finance industry jobs as discussed in Section 4. We recall that: one graduate (Y. Jiang) is the first dedicated quantitative finance staff member at the University of Washington Endowment fund; another CFGC student (C. Green) is the first dedicated quantitative finance staff member at the Washington State Pension Plan (the Washington State Investment Board); two CFGC students (L. Xu and S. Zhang) worked on risk management validation at Washington Mutual (WAMU) until the business failed and they now do similar work at Freddie Mac in Washington, D.C. Other CFGC students have taken significant finance industry jobs in NYC and London, and one of the students (D. Creal) obtained a faculty position at the University of Chicago Business School.

PART B UNIT-DEFINED QUESTIONS

Some of the questions in the sections below have been at least partially answered in Part A. In order to make this Part B self-contained we repeat some of those answers in brief form and provide more detailed discussion where needed.

B1. HOW SUCCESSFUL HAS THE PROGRAM BEEN?

Q1: What has been the level of student interest and enrollment?

The original CFGC proposal had a target of 15 students enrolled within 2-3 years and by fall of 2005 we had 22 students enrolled, which reflected considerable interest in the program. We currently have 18 students enrolled and believe that interest will increase with more effective on-campus marketing of the existing form of the program. The enrolment will increase substantially if we further develop and energize the program as described in Section 6 of Part A and in Section B2 below.

Q2: What has been the student internship and job placement success?

We believe that we have been reasonably successful in placing students in internships in finance industry companies in the Puget Sound area, but can improve upon this. We believe we have been quite successful in placing students in excellent finance industry positions, including places such as the University of Washington Endowment, the Washington State Pension Fund (WSIB), Washington Mutual and Freddie Mac, as well as at three universities, e.g., the University of Chicago Business School. See Section 4 of Part A for details.

Q3: Which departments and faculty members support the program?

In terms of new core courses that were specifically developed for the CFGC program and are offered on an ongoing basis, Economics has developed one course (ECON424 by Zivot), Mathematics has developed one course (MATH/STAT492, taught in alternate years by Mathematics and Statistics) and Statistics has developed two course (STAT547 and STAT549 taught by Martin). Zivot has also developed an elective course (ECON512) that fits program needs well.

The Finance Department makes available three elective courses (FIN562, FIN590 and FIN592), and CFGC students have on occasion taken some other Finance Department courses. Students have also taken Mathematics Department graduate and undergraduate level optimization courses from time to time.

The Finance Department has also made available important financial data sets such as CRSP, and has appointed Martin and Zivot as Adjunct Professors of Finance.

Q4: What goals have been missed?

The main goal missed was the creation of a virtual Computational Finance Laboratory (CFL) as described in Section 2.4 of the original CFGC proposal dated January 21, 2004. This goal was missed in part because Doug Martin was on leave of absence for academic years 2006-7 and 2007-8 and was not able to devote energy to it during those times. Also, the CFL was intended to leverage a Simulated Trading Room in the Business School that was funded by a $250K NASDAQ

donation plus Business School matching funds, but the facility had to be closed in August 2008 due to lack of ongoing support funds. None-the-less considerable amount of code development in S-PLUS and R to support ECON 424, STAT547 and STAT549 was accomplished by E. Zivot and D. Martin and Research Assistants using part of the initial $110K program start-up funding (see the Computational Finance Software Development Section of the CFGC Status Report dated 1/18/06 for details).

B2. HOW SUCCESSFUL CAN THE PROGRAM BE GOING FORWARD?

We provide a composite answer to the above broad question by first answering the following specific questions and then providing a summary statement, keeping mind that the discussion of the following section on sustainability of the program will have a large impact on the overall answer.

Q1: What is the ongoing need for the program?

The ongoing need for the program has not diminished since its inception in 2004, which is reflected by: (a) the growth in the U.S. of quantitative finance MS programs described in Section 1 of Part A (43 such programs today versus 21 in 2004), (b) continuing student interest in the program at the University of Washington, and (c) the lack of any comparable program in the Northwestern region of the United States. Furthermore, the financial melt-down of 2008-9 has revealed the need for a deeper understanding of current and future quantitative methods in finance, as well as their limitations, and the need for a deeper understanding of systemic risk and higher interdependent components of the overall financial markets. Among other things these needs suggest the potential use of modern statistical methodologies that have not seen much broad use in quantitative finance, such as graphical models, statistical/machine learning methods, fat-tailed distribution models, and survival analysis.

Q2: What is the projected level of student interest and job placement opportunities?

There are currently 18 students enrolled in the CFGC program. We believe that by effectively marketing the CFGC program in its current form to UW graduate students in quantitative fields during spring and summer quarters 2010 and allowing for some attrition, we will have about 20 PhD students enrolled from a wide variety of departments by fall quarter 2010.
We were initially concerned that the financial markets melt-down in 2008-9 would result in an inability to place graduating students in good finance industry jobs. Our experience to date proves otherwise, as the placement results in Section 4 of Part A show. For example when two of our students lost jobs at Washington Mutual they were able to obtain employment at Freddie Mac in Washington, D.C. Of course we currently graduate only 2-3 Ph.D.'s in the CFGC program per year, and even if we graduate 4-5 per year, it will be quite possible to find good finance job placements for such small numbers of high quality students.

It is also relevant to be aware that large quantitative finance MS programs have been able to place most of their students in 2008-9, though often with substantially increased effort by key program faculty members. This was the case for the Carnegie Mellon program that graduates on the order of 80 students per year between the Pittsburgh and NYC campuses, as communicated to D. Martin by John Lehoczky. As another reference point, the sixth cohort in the Masters in Financial Engineering program at Baruch College (City College of New York) graduated in December 2008, 15 of the 17 students seeking finance industry employment were

employed by April 2009 with an average salary of $92K. See www.baruch.cuny.edu/math/master.html for this information and a wealth of performance data on their highly ranked program.

Q3: What is a minimal version of CFGC program going forward?

A minimal version of the CFGC program would be to continue it at the same number of current core course offerings and at the same level of student enrollment described in Part A. In that case, since Zivot's ECON 424 course would be offered even if the CFGC program were discontinued, the faculty level of effort for core courses that would not otherwise be offered would be .65 (two courses plus Director role for Martin) and .25 (one course shared by Mathematics and Statistics) for a total of .9 FTE. We believe that a considerable amount of value is delivered for this level of faculty effort committed to the program.

Q4: What is an optimal version of CFGC program going forward?

An optimal version of the program, one with the potential to grow the program in breadth and depth and move it to a top-ten ranked program nationally, is as follows:

- In addition to the current core courses shown in Section 3 of Part A, we would have:
    - An entry level quantitative investments course for master's level students in any quantitative field based on the ideal textbook Investment Science by D. G. Luenberger (1998). This course could eventually serve on the order of 100+ students in either the College of Engineering or in the Sciences Departments in the College of Arts and Sciences.
    - A simulation for finance course similar to the P. Glasserman (2004) book. Such a course given by John Lehoczky at CMU has had enrollments of about 100 students.
    - A risk management course sequence that builds on the existing FIN 562
    - An optimization course focused on single-period portfolio construction and on multi-period asset liability management (ALM).
    - A course on option pricing via numerical solutions to partial differential equations
    - A regular seminar series

- Substantial leveraging of the rapidly developing capabilities of the open source R system for finance (e.g., R-metrics and other packages), and of financial data donations to complement data available through the Business School (such as the widely used CRSP data). Zivot has already retooled his courses to utilize R instead of S-PLUS and is in the process of updating his book *Modeling Financial Time Series with S-PLUS* to use R. Martin has recently obtained for the CFGC program free access to the Hedgefund.net large hedge fund database, as well as mutual funds and ETF's data from Reuters, and hopes to obtain the Russell indices and their constituents from the Russell company in Tacoma.
- An online MS program that also serves working professionals who do not wish to obtain an MS but want to develop new skills in computational finance and risk management. This online program is expected to provide substantial CFGC program funding.
- Substantial involvement and support of the finance industry in the Northwest, including support of student internships, student work-study programs, affiliate faculty positions and teaching of courses for which finance industry professionals have special expertise that UW faculty members do not have. If at all possible obtain finance industry donations to the overall Computational Finance program and possible annual subscriptions to a Center of

Computational Finance or Financial Engineering and Risk Management could mutually benefit both the companies and the UW program.

- Substantive participation in the program by multiple departments having expertise that uniquely contributes to the program.
- The above optimal program would require at least 2 new dedicated faculty members by 2011-2012. This would initially be achieved by 1 new dedicated state funded faculty position plus part-time new Affiliate faculty members from the pool of finance professionals in the Puget Sound area. For example a portfolio optimization course as described above and a credit risk course in the extended risk management sequence might be very effectively taught by a new Affiliate faculty members with expertise in these areas.
- The capstone event for PhD students whose dissertation happens to be in quantitative finance can remain their General Exam. For other Ph.D. students we may move to a capstone event consisting of an extended project that approaches the level of an MS thesis.

Q5: What UW departments are potential contributing partners in the program?

In addition to Economics and Statistics as the primary contributing departments to date, the following departments are by nature potential contributors in the sense of providing currently existing core or elective course, and ideally one or more new courses needed for the optimal program described above: Applied Mathematics, Finance, Industrial Engineering, Information Systems and Operations Management, Mathematics. Unfortunately it does not seem likely under current budget constraints that any department other than a home department for the program would contribute a new course. In addition, the computing requirement of the program might be strengthened with a current course offering by the Computer Science department.

Q6: What is the potential for finance industry program support in the Northwest?

We are uncertain but hopeful of the potential for the local finance industry (including major players like Russell, Microsoft Treasury, Weyerhauser, Boeing Corporate Finance, and hedge funds and funds-of-hedge funds) to support the CFGC program in multiple ways going forward. We will be exploring this possibility in depth during spring and summer quarters 2010, and have developed a draft version of a pitch book for promoting involvement by the local finance industry. Our efforts here could be considerably helped by one or more local finance industry professionals taking a lead in helping us.

Q7: Will creating a “Center” structure facilitate support from industry and funding agencies?

The CFGC educational program is reflects the quantitative and computational needs of the finance industry in an ongoing evolutionary manner. Thus a Center organizational structure that provides deliverables to industry and has the potential to obtain funding from the National Science Foundation and other funding agencies may be a useful structure. This remains to be investigated in detail. In doing so we will learn as much as possible from the highly successful UW Center for Process Analytic Chemistry (CPAC) that has had strong connections with industry for many years

Q8: Can we create an on-line Master’s program that will make CFGC self-sustaining?

We feel confident of creating a number of on-line courses that can generate substantial enrollments and corresponding revenue with an effective marketing program. ECON424 and STAT549 are prime candidates in this regard, as are some

of the new courses proposed above, in particular the Investment Science course and the Optimization course with a portfolio optimization focus. Enrollment by individuals working full-time and by individuals in the Far East seems particularly promising. We will fully evaluate such a possibility during spring and summer quarters 2010, with guidance from Educational Outreach and the Applied Mathematics Department's Online MS program success to date.

Q9: What is the future of UW support for interdisciplinary programs such as CFGC?

This is a crucial question in view of the proposed ABB method of crediting departments for course offerings. It is our understanding that the current proposal for graduate courses is to give the majority of credit to the student's home department and 0% credit to the department offering the course. This makes no sense what-so-ever to us, and will be a real killer of interdisciplinary education and research at the graduate level. We hope the Graduate School will strongly oppose this proposed crediting method for graduate courses, and reverse it to 100% credit to the department that offers the course.

B3. WHAT IS NEEDED TO SUSTAIN THE PROGRAM?

Eric Zivot's ECON 424 core course is expected to be offered by the Economics Department whether or not the CFGC program continues, and all other courses in the program except for STAT 547, STAT 549 and MATH/STAT 492 are regularly offered by their respective departments independently of the existence of the CFGC program. Thus sustainment of the program in its current minimal form requires only the continued contribution of .65 FTE of Martin and the .25 FTE shared by Mathematics and Statistics, for a total of .775 FTE from Statistics and .125 FTE from Mathematics.

It is important to note that Doug Martin plans to continue as a faculty member for another five years and then retire. Thus the main sustainability question for a minimal CFGC program of the current form beyond five years is whether or not the Statistics Department considers its involvement in the CFGC program a high enough priority to commit in principle to replacing Martin upon his retirement with a faculty member who is totally devoted to the CFGC program. Failing that, the program would need to be discontinued a year or two prior to Martin's retirement. There is also the risk that Zivot would leave the University of Washington, and in that event there is the question of whether or not the Economics Department would replace him with someone dedicated to the CFGC program.

Given the above facts it seems clear that to insure long-term sustainability with a growth trajectory toward the optimal program described Question 4 of B3 above, the program needs a department home that embraces the program as an important academic component opportunity of the department's future (to date the Economics and Statistics Departments have not shown strong interest in fulfilling this need). In the event that such a department home becomes available it will be appropriate for Martin to have his faculty position transferred to that department, and for Zivot have to at least half of his position transferred to that department. In that event both Martin and Zivot would put considerable energy into developing a top ranking program as envisioned in the answer to Question 4 in Part B2 above.

PART C APPENDICES

Appendix A: Organization List

Program Director: Douglas Martin, Dept. of Statistics
Program Co-Director: Eric Zivot, Dept. of Economics
Staff Support: Ellen Reynolds, Dept. of Statistics.

Appendix B: Budget Summary

The only University budget allocation to the program is as follows:

Economics: .25 FTE annually for Eric Zivot (see, however the Note below)

Statistics: .65 FTE for Doug Martin, .125 FTE on average for MATH/STAT 492, and approximately .05 FTE of staff support by Ellen Reynolds.

Mathematics: .125 FTE on average for MATH/STAT 492

Total Faculty plus Staff Allocation: .9 FTE + .05 FTE (not counting Zivot above)

Note: Zivot's highly successful ECON 424 core course for the CFGC would be offered regularly even if the CFGC program were terminated. With that in mind, the effective faculty allocation for continuing the program as-is would be .9 FTE.

Appendix C: Information about Faculty

The following faculty taught CFGC core and elective courses in 2008-9.

Faculty Name	Rank	Affiliation	Core Courses Taught
Gilbert, T.	Assistant Professor	Dept. of Finance	FIN 590
Gneiting, T.	Professor	Dept. of Statistics	MATH/STAT 492
Henniger, J.	Acting Assist. Prof.	Washington Mutual	STAT 547
Malatesta, P.	Professor	Dept. of Finance	FIN 592
Martin, R. D.	Professor	Dept. of Statistics	STAT 591
Martin, R.D.	Professor	Dept. of Statistics	STAT 549
Richardson, T.	Professor	Dept. of Statistics	STAT/BIOST 538
Zivot, E.	Professor	Dept. of Economics	ECON 424

Of the above courses only MATH/STAT 492, STAT 547 and STAT 549 exist because of the CFGC program.

Appendix D: Existing Program Review HEC Board Summary

Lead Units: Departments of Economics and Statistics
College: Arts and Sciences
Degree: Computational Finance Graduate Certificate
Last Review: No prior review
Date: April 1, 2010

1. BACKGROUND AND CONTINUING NEED

Program Background Information

The Computational Finance Graduate Certificate (CFGC) program is a highly interdisciplinary program that exists under the authority of the Graduate School at the University of Washington. The program was approved by the Board of Regents in spring quarter of 2004 and launched in fall quarter 2004. Completion of CFGC requirements results in the award of an Interdisciplinary Graduate Certificate in Computational Finance that is recorded on an awardees' transcript. The requirements consist of 6 courses in one of two tracks, an "Industry Track" and an "Academic Track", depending on a student's professional goal upon graduation, and a capstone event. Details concerning the program may be found at the program's website: www.stat.washington.edu/compfin.

Doug Martin in the Department of Statistics and Eric Zivot in the Department of Economics are the faculty leads of the CFGC program and serve as program Director and Co-Director respectively. Martin and Zivot have been Ph.D. thesis advisors to many graduate students in the program who do their dissertation research at the interface between Economics, Finance, Statistics and Computing. The other two departments that currently contribute to the CFGC program curriculum are the Mathematics Department in the College of Arts and Sciences and the Finance Department in the Foster Business School.

Initial funding in the amount $110K was provided during academic years 2003-4 and 2004-5 from the (now defunct) University of Washington Tools for Transformation Program. The majority of the funding was used to develop four new core courses for the curriculum, including substantial software development.

The Field of "Quantitative Finance" and the Ongoing Need for the CFGC Program

The term "Computational Finance" along with "Mathematical Finance" and "Financial Engineering" comprise three terms that we refer to by the over-arching term "Quantitative Finance". The use of quantitative and computational finance methods in the finance industry has exploded over the last decade, as any perusal of what is going on in the finance industry reveals. Quantitative finance is not just about derivatives, which have become infamous as a scapegoat for the financial markets collapse of 2008-9.[4] Rather it is a broad collection of classical and modern methods statistical and econometric modeling, mathematical analysis and computing in support of better methods of portfolio construction, investment decision making and

[4] In spite of pejoratives such as Warren Buffet's "Beware geeks bearing formulas", the failure has not been due to the creation of fancy derivatives such as credit default swaps, but in the failure to adequately regulate a number of aspects of the finance industry including enforcing that credit default swaps be exchange traded rather than traded over-the-counter (OTC).

risk management. These methods are increasingly critical to the management of close to home investment management organizations such as the University of Washington Endowment Fund and the Washington State Investment Board (the State of Washington pension plan), as well as to endowments and pensions generally, and of course to other types of organizations such as hedge funds, funds-of-hedge funds, family offices and quantitative asset management companies that primarily serve institutional investors.

A clear reflection of the need and opportunity nationally for advanced quantitative finance education and research is the explosion in quantitative finance MS degree programs, both domestically and internationally. In the U.S. we estimate that the number of such programs in 2000 was less than about 10, while in 2004 there were approximately 20 and this number has grown to 43 as of January 2010.[5] Internationally there were 35 such programs in 2004 and now in 2010 there are 99 programs in 77 universities.

We note that at present there are only a handful of quantitative finance Ph.D. programs in the U.S. Thus our current CFGC program emphasis on Ph.D. students takes advantage of an open space opportunity in the overall market for quantitative finance programs.

Furthermore there are no competitive quantitative finance programs at either the MS or PhD level in the Northwestern United States, whereas there are five quantitative finance programs in California, namely at Berkeley, Stanford, USC, Claremont, and UCLA (the latter was just launched in 2008-9). Thus the CFGC fulfills a need created by a total vacuum for quantitative finance programs in the Northwest. Finally, the level of student interest in the program remains high as discussed in the next section.

2. Student Interest and Outcomes

Student interest in the University of Washington CFGC program is reflected by the following. The original CFGC proposal had a goal of enrolling 15 students within two to three years of the fall 2004 launch, and by fall 2005 there were 22 students enrolled. There are currently about 18 students enrolled and we expect this number to grow substantially by fall 2008.

Furthermore, each year approximately 3-4 high quality graduate students apply for admission to the Statistics Department's Ph.D. program because of their interest in the CFGC program. Economics typically has 2-3 PhD students per year who have chosen UW because of the CFGC and the possibility to concentrate in computational finance or financial econometrics.

A total of 12 CFGC students have been placed in jobs since 2006 (2 in 2006, 3 in 2007, 2 in 2008 and 4 in 2009), 3 in academia and 9 in large finance industry organizations including Morgan Stanley, ABN Amro, Citadel, Freddie Mac, etc.. Of these students, 9 completed Ph.D.'s in their respective departments (Computer Science, Economics, Physics and Statistics), 2 are currently completing their Ph.D. dissertations part-time, and one finished with a Statistics MS degree. Specific placement successes include the following: one graduate is now the first full-time quantitative finance employee at the UW Endowment Fund (with the title Investment Research Analyst reporting to the Deputy CIO); another student is now the first full-time quantitative finance employee at the Washington State Investment Board (the

[5] PRIMIA survey in 2004 and Global Derivatives, Inc. survey in January 2010.

Washington State Pension Plan); and one graduate is now a faculty member at the University of Chicago Business School.

3. Program Sustainability and Enhancement

Currently all of the courses in the CFGC curriculum, except for three courses, are offered on a regular basis by the Economics, Finance, Mathematics and Statistics departments collectively irrespective of the existence of the CFGC program. The total ongoing faculty cost in FTE of delivering these three courses, plus partial support of the Director, is .25 x 3 + .15 = .9 FTE faculty.

Given the above modest faculty and cost requirements for the CFGC program, it can continue and be successful in its current form so long as Martin and Zivot remain in their faculty positions at the University of Washington and continue to teach their CFGC core courses. Martin plans to continue in his faculty for another five years, and then retire. In the meanwhile Martin and Zivot are motivated to devote considerable energy to create an enhanced CFGC program along lines described below.

At the moment it is an open question whether or not the Economics and Statistics Departments have the CFGC program as a sufficiently high priority to commit to sustaining it for the long-term beyond Martin's retirement in five years, particularly in view of the budgetary problems that the university and departments face. In fact the table below, that displays the current distribution of home/lead units for quantitative finance MS programs in the U.S., reveals that a priori Economics Departments and Statistics Departments are unlikely lead candidates. This is in spite of the fact that a large part of portfolio construction, investment decision making and risk management involve statistical and econometric modeling and analysis.

LEAD UNIT	BUSINESS	MATH/AMATH	ENG'G	ECON	STAT	TOTAL
Number of Programs	18	16	7	1	1	43

<u>Program Enhancements</u>

Whatever the academic department home of a sustainable CFGC program going forward, we envision an enhanced and exciting program obtained by executing on as much as possible of the following improvements incrementally over the next two years. To date the CFGC program has been located administratively as an interdisciplinary unit in the Graduate School and is primarily supported by the Economics and Statistics departments through the teaching, research and management contributions of Martin and Zivot. However, neither of these two departments has embraced the program as an important component of their overall academic offerings. This is consistent with the data on leadership of quantitative finance MS programs presented in Section 1 in that Economics and Statistics departments are almost never the lead units. In order to maximize the future potential of the program it needs: (a) a sustainable financial model, and (b) a home academic department that sees real benefit from embracing and nurturing an enlarged and energized Computational Finance program (possibly rebranded as a Financial Engineering and Risk Management program). It will be appropriate that Martin's position and at least part of Zivot's position is transferred to such a department.

With the above considerations in mind, our goals for enhancing and financing the program are as follows.

- Create an online MS program that will finance a large fraction of the operating costs of enhancing the program through an expanded curriculum, additional full-time and part-time faculty, seminar series speaker expenses, and graduate student support. Provide a draft financial operating budget to the Review Committee by the end of April.
- Determine the overall academic and financial viability of expanding the online MS program into a Professional MS program for resident students
- Expand the current curriculum by developing four new core courses. When combined with the current core courses and electives this will provide a strong curriculum for the MS degree as well as add breadth and depth to the certificate program for Ph.D. students
- Secure start-up funding for 2010-2011 and 2011-2012 from a combination of internal and external industry and foundation sources to carry the program until the online (and possibly resident student) MS program is fully operational. Amounts of start-up funding required will be included in the draft financial operating budget delivered by the end of April
- Appoint selected Northwest finance industry professionals as Affiliate faculty to teach courses for which they have special expertise, including possibly one or more of the four new courses. Such involvement of local industry professionals will enrich the program and help build ties between the program and the local finance industry
- Re-introduce a regular seminar series that was discontinued in 2006, using both local and nationally prominent outside speakers with many speakers being industry professionals
- Engage finance organizations in the Puget Sound area and elsewhere for creation of internship and work-study programs to support graduate students, job placement for graduates, targeted research grants, and program donations
- Add one new interdisciplinary UW FTE faculty position in 2011-2012 to support the program and become the next Director of the Program. Vigorously seek a source for endowing a Chair for the program by 2012-2013.
- Explore with finance industry representatives and the National Science Foundation (and other foundations) whether a Center structure is a fundable vehicle to enhance program success
- In the process of evolving the program over the next academic year we will determine whether or not an interdisciplinary Ph.D. program is viable
- Based on achieving a number of the above goals we forecast having about 25-30 PhD students in the CFGC program and about 20-30 students in the MS online program by 2012.

NOTE: Martin was on leave of absence from the University of Washington during academic years 2006-7 and 2007-8, during which time he was located in NYC serving as the CEO of a portfolio optimization and risk management company that he founded (www.finanalytica.com). He returned to the University in fall quarter 2008 primarily to re-energize the Computational Finance program. Based on the above opportunities Martin intends to focus on this for another five years at which time he plans to retire.

4. Summary

We believe that the CFGC Program has delivered considerable value for a modest initial investment cost and relatively little ongoing incremental faculty cost over and above the courses that are being taught independent of the existence of the CFGC program. We also believe that now is the time to determine the extent to which Economics and Statistics are the right home for the program, and if they are not the right home then find an alternative home. In the latter case it will be appropriate for Martin's position to be transferred to the new home and likewise for at least half of Zivot's position. Since it is likely to take time to sort this out, we propose that the CFGC program be continued at least through academic year 2010-2011, and have a brief program review in May of 2011 to determine whether the program should be terminated or continued.

5. Faculty and Students Statistics

In the following table Type 1 Instructional Faculty are those that are dedicated to teaching CFGC courses, and Type 2 Instructional Faculty are those teaching courses that would be offered even if the CFGC program did not exist.

	2006-2007	2007-2008	2008-2009	2009-2010	TOTAL
FTE Instructional Faculty Type 1	0.5*	0.5*	0.9	0.9	1.8
FTE Instructional Faculty Type 2	1	1	1	1.25	4.25
FTE Graduate Teaching Assistants	0	0	0	0	0
Headcount of Enrolled Students	22	20	17	18	59
Number of Certificates Granted	2	3	2	5	12

* Director Martin was on Leave

Appendix E: Quantitative Finance MS and Ph.D. Programs Data

Rank	School	MS Program Name	Tuition	Duration
1-5	Carnegie Mellon University	Computational Finance	$73,800	1.5 years
1-5	Columbia University	Financial Engineering	$47,160	1 year
1-5	Princeton University	Finance	$73,220	2 years
1-5	Stanford University	Financial Mathematics	$37,380	1 year
1-5	University of Chicago	Financial Mathematics	$44,892	1 year
6-10	Baruch College City University of New York	Financial Engineering	$11,040 (in-state) $20,700 (out-of-state)	1.5 years
6-10	Columbia University	Mathematics of Finance	$35,032	1 year
6-10	Cornell University	FE concentration	$37,050	1.5 years
6-10	New York University	Mathematics in Finance	$45,972	1.5 years
6-10	University of California at Berkeley	Financial Engineering	$50,402	1 year
11-15	Boston University	Mathematical Finance	$37,910	1 year
11-15	Georgia Institute of Technology	Quantitative and Computational Finance	$15,561 (in-state) $50,313 (out-of-state)	1.5 years
11-15	North Carolina State University	Financial Mathematics	$11,984 (in-state) $36,084 (out-of-state)	2 years
11-15	University of Illinois at Urbana-Champaign	Finance	$40,255	1 year
11-15	University of Michigan	Financial Engineering	$30,348 (in-state) $56,502 (out-of-state)	1.5 years
16-20	Claremont Graduate School	Financial Engineering	$59,427	1.5 years
16-20	Rutgers University	Mathematical Finance	$29,052 (in-state) $44,640 (out-of-state)	1.5 years
16-20	Rutgers University	Quantitative Finance	$42,080 (in-state) $69,364 (out-of-state)	2 years
16-20	University of Southern California	Mathematical Finance	$34,500	1.5 years
16-20	University of Toronto	Mathematical Finance	CAD 37,000	1 year
21-23	Florida State University	Financial Mathematics	$15,552 (in-state) $45,876 (out-of-state)	2 years
21-23	Kent State University	Financial Engineering	$21,552 (in-state) $32,070 (out-of-state)	1 year
21-23	Purdue University	Specialization in Computational Finance	$17,276 (in-state) $48,660 (out-of-state)	2 years

Of these 23 programs 8 are led by a Business School department (almost always a Finance department), 9 are led by Mathematics or Applied Mathematics departments, 4 are led by an Engineering Department (three being IE/OR), 1 by and Economics Department and 1 by a Statistics Department. We note that only one (Carnegie Mellon) of the top five programs are led by a business school, while two (Princeton and Cornell) are led by Engineering Colleges and two (Chicago and Stanford) are let by Mathematics departments. Of these 23 programs, 9 are 1-year programs, 9 are 1.5-year programs, and 5 are 2-year programs. The tuitions vary from as low as $11K in-state tuition and $21K out-of-state tuition (at Baruch College City University of New York) for public universities, as low as $35K for private universities, and as high as about $73K for private universities Carnegie Mellon and Princeton. The average in-state tuition for these programs is $35K and the average out-of-state tuition is $45K.

Ph.D. Programs in Quantitative Finance in the U.S.

There are only six such programs in the January 2010 survey by Global Derivatives, Inc., as follows:

Boston University	PhD Mathematical Finance	School of Management
Carnegie Mellon	PhD Mathematical Finance	Mathematics
Claremont Graduate Univ.	PhD Financial Engineering	Business School Program on hold
Florida State University	PhD Financial Mathematics	Mathematics
Purdue University	PhD Mathematics with focus on Computational Finance	Highly interdisciplinary, Math, Statistics, EE, Bus. School, Economics
University of Florida	PhD Quantitative Finance	Industrial and Systems Eng'g. with Math, Statistics, Bus. School

M.S. Programs in Quantitative Finance Abroad

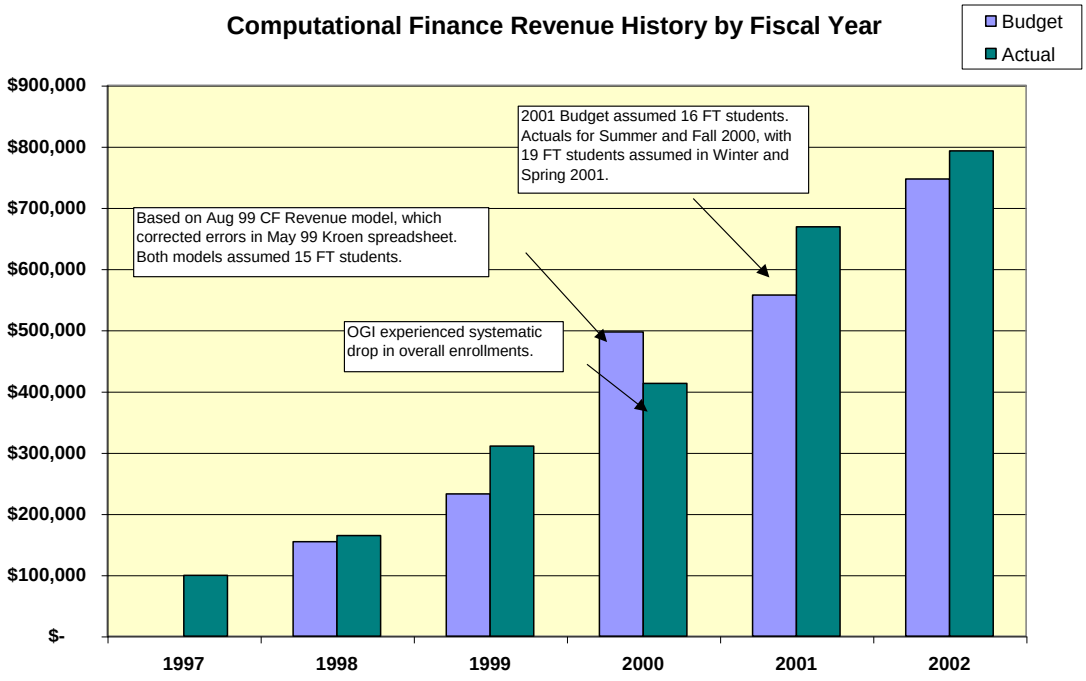
Whereas there were about 35 such programs in 2004 there are now about 99 programs in 71 universities, a more than doubling of programs with a geographic distribution provided in the table below.

Countries	# of Programs	# of Universities
U.K.	42	25
AustralAsia	16	11
Rest of Europe and Mid-East	29	26
Rest of World	12	9
Total	**99**	**71**

Ph.D. Programs in Quantitative Finance Abroad

We did not collect data on these.

Oregon Graduate Institute Computational Finance MS Revenue History



NOTE 1: 2001-2002 operating expenses were $620K, resulting in a profit of approximately $180K.

NOTE 2: Not long after 2002 the Oregon Graduate Institute (OGI) was subsumed by the Oregon Health Sciences University (OHSU) and OHSU forced OGI to become narrowly focused on Biomedical Engineering and Computer Science, and on Environmental and Biomolecular Systems. Since OHSU had no interest in supporting the Computational Finance MS program, its Director John Moody left and the program was terminated.

Appendix F: Course Offerings History 2004-2010

Quarter	Course	Instructor	Enrollment (for credit)	Evaluation (Median items 1-4)
Fall 2004	ECON 424 (as 483)	Zivot, E.	29	4.4
Fall 2004	STAT 591A	Martin, R.D.	11	4.1
Fall 2004	FIN 590	Hahn, J.	15	
Winter 2005	ECON 424	Yan, B.		3.6
Winter 2005	MATH/STAT 492	Burdzy, K.	22	
Winter 2005	STAT/BIOST 538	Stuetzle, W	15	3.9
Spring 2005	FIN 562	Duarte, J.	12	
Spring 2005	FIN 592	Duarte, J.	4	
Spring 2005	STAT 549 (as 593B)	Martin, R.D.	5	3.9
Fall 2005	ECON 424	Yu, W.	38	4.4
Fall 2005	STAT 547	Martin, R. D.	12	4.7
Winter 2006	FIN 562	Duarte, J.	17	
Winter 2006	FIN 590	Hahn, J.	8	
Winter 2006	FIN 592	Duarte, J.	6	
Winter 2006	MATH/STAT 492	Burdzy, K.	22	4.1
Winter 2006	STAT/BIOST 538	Meila, M.	8	4.1
Spring 2006	ECON 424	Zivot, E.	42	4.6
Spring 2006	STAT 549	Martin, R. D.	11	4.4
Fall 2006	ECON 424	Zivot, E.	37	4.2
Fall 2006	STAT 547	Osborn, D. (temporary)	14	3.6
Winter 2007	MATH/STAT 492	Gneiting, T.	22	3.6
Winter 2007	STAT/BIOST 538	Meila, M.	11	3.6
Spring 2007	FIN 562	Duarte, J.	16	
Summer 2007	FIN 590	Hahn, J.	10	
Fall 2007	ECON 424	Zivot, E.	45	4.7
Fall 2007	STAT 547	Basterfield, G. (industry)	11	
Winter 2008	FIN 592	Duarte, J.	7	
Winter 2008	MATH/STAT 492	Chen, Z.	27	
Winter 2008	STAT/BIOST 538	Meila, M.	8	3.4
Spring 2008	FIN 562	Duarte, J.	11	
Fall 2008	ECON 424	Zivot, E.	45	4.4
Fall 2008	STAT 591A	Martin, R.D.	4	5
Fall 2008	FIN 590	Gilbert, T.	10	
Fall 2008	STAT 547	Henniger, J. (industry)	7	
Winter 2009	MATH/STAT 492	Gneiting, T.	13	4.5
Winter 2009	STAT/BIOST 538	Richardson, T.	8	4

Spring 2009	FIN 592	Malatesta, P.	8	
Spring 2009	STAT 549	Martin, R.D.	7	4.6
Fall 2009	ECON 424	Zivot, E.	45	4.8
Fall 2009	STAT 547	Martin, R.D.	10	4.7
Winter 2010	FIN 590	Gilbert, T.	6	
Winter 2010	MATH/STAT 492	Pal, S.	17	
Winter 2010	STAT 538	Meila, M.	12	
Spring 2010	STAT 549	Martin, R.D.	15	
Spring 2010	FIN 562	Everitt, M. (industry)	8	
Spring 2010	FIN 592	Malatesta, P.	5	

Appendix G: Distribution of Students by Home Department 2009-2010

To give a feeling for the broad interdisciplinary nature of the CFGC program the table below displays the distribution of students by home department in three of the core courses (STAT547, MATH/STAT492 and STAT547) offered in 2009-2010.

DEPARTMENT	STAT 547 Fall 2009	MATH 492 Winter 2010	STAT 549 Spring 2010
ACMS		2	
AERO ENG'G		1	
AMATH	1		1
CSE ENG'G	2		2
EE ENG'G		1	2
ECONOMICS	4	1	4
FINANCE	2	3	2
IND ENG'G	1	1	2
MATH		6	1
PHYSICS		1	
STATISTICS	1	1	1
Total Students	**11**	**17**	**15**