COURSE DATA

DATA SUBJECT

Code: 43801
Name: Demographic, non-parametric, dynamic analysis
Cycle: Master's Degree
ECTS Credits: 3
Academic year: 2025-26

STUDY (S)

Degree	Center	Acad. year	Period
2171 - Master's Degree in Actuarial and Financial Sciences	Facultat d'Economia	2	Second quarter

SUBJECT-MATTER

Degree	Subject-matter	Character
2171 - Master's Degree in Actuarial and Financial Sciences	Insurance	ELECTIVES

COORDINATION

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SUMMARY

The course Demographic, Non-parametric, and Dynamic Analysis is situated at the beginning of the second semester of the final year of the master's program. This course addresses both the need for theoretical and practical foundations developed in previously taught subjects, as well as its optional nature. Thus, the subject 'Quantitative Methods' (Subject I), through the 'Survival Models' course, is directly linked to this subject, as the former establishes the theoretical foundations as well as some specific procedures, such as graduation. The courses 'Programming in Visual Basic' (Subject 3) and 'Loss Models and Non-Life Insurance' (Subject 4) help us to introduce, among other content, some necessary programming notions for the development of the Demographic Analysis course.

Professionally, the course is useful because the content and skills that are fostered are directly applicable during professional practice, both in the business sector and in public service. In particular, it aims for students to acquire skills in how to obtain and manipulate raw information so that, by applying precise techniques and modelling theories, the results obtained are comparable and provide a firm basis for assisting in decision-making (e.g., preparing specific mortality tables, population estimations). For example, concerning those demographic aspects of greatest interest, such as the evolution of the general population to check the viability of the pension system, or mortality to adjust premiums and indemnities in specific products. Among the contents taught, the

following stand out: comparison of population structures, construction and graduation of dynamic mortality tables, preparation of population estimations, and calculation of loaded probability tables. All of this is done with a markedly practical approach, using accessible software and real, current data obtained from the National Institute of Statistics and other official bureau.

PREVIOUS KNOWLEDGE

RELATIONSHIP TO OTHER SUBJECTS OF THE SAME DEGREE

There are no specified enrollment restrictions with other subjects of the curriculum.

OTHER REQUIREMENTS

Proper assimilation of the course content requires an intermediate understanding of **descriptive statistics** and **classic probability models**. Some knowledge of **statistical inference techniques** is also advisable. Furthermore, for optimal benefit from the course, you should be familiar with concepts and procedures related to **survival models**.

COMPETENCES / LEARNING OUTCOMES

2171 - Master's Degree in Actuarial and Financial Sciences

Comprender y ser capaces de desarrollar las técnicas matemáticas y estadísticas que resultan relevantes para el trabajo actuarial: modelos de supervivencia, siniestralidad, tarificación, previsión y solvencia.

Conocer el código de conducta del Actuario así como las normas más relevantes de la práctica profesional.

Poseer las habilidades suficientes para participar en una conversación de negocios y estar capacitado para leer literatura actuarial al menos en dos de los idiomas oficiales de la Unión Europea.

Saber realizar una gestión integral del riesgo y alcanzar los conocimientos suficientes para dar respuesta a los riesgos actuales y a los que puedan surgir resultado del cambiante entorno económico, financiero y social, con vistas a dirigir y gestionar todo tipo de entidades financieras y aseguradoras.

Ser capaces de construir modelos adecuados al entorno económico empresarial a partir de las posibilidades que ofrecen las modernas tecnologías de la información y de la computación.

Students should apply acquired knowledge to solve problems in unfamiliar contexts within their field of study, including multidisciplinary scenarios.

Students should be able to integrate knowledge and address the complexity of making informed judgments based on incomplete or limited information, including reflections on the social and ethical responsibilities associated with the application of their knowledge and judgments.

Students should communicate conclusions and underlying knowledge clearly and unambiguously to both specialized and non-specialized audiences.

Students should demonstrate self-directed learning skills for continued academic growth.

DESCRIPTION OF CONTENTS

1. Introduction to Social Demography

1.1 Basic Demographic Indicators.

1.2 Natality: Maternity. Fertility. Sex ratio.

1.3 Mortality: Crude and specific rates. Survival. Life expectancy...

1.4 Population growth and structure indicators: Natural balance. Aging index, dependency ratio...

1.5 Nuptiality: Crude rates. Indicators of age at first marriage, separations, divorces.

1.6 Social scope: The National Institute of Statistics (of Spain).

2. Statistical Sources and Measurements of Demographic Growth

2.1 Statistical Sources and errors.

2.2 Measurements of demographic growth. Examples in human populations. Mean population, years lived.

2.3 Demographic growth models: The Logistic Model.

2.4 Crude and specific rates: rates, probabilities, and others.

2.5 Comparison of populations using rates. Standard population method. Type coefficient method. Other comparison procedures.

3. Mortality Analysis

3.1 The detailed mortality table. Biometric functions. Interpretation and use.

3.2 Other problems in mortality analysis: infant mortality and mortality at very old ages. Mortality by causes. Differential mortality.

3.3 Construction of a mortality table with R-software. The actuarial package.

4. The Biometric Model and Survival Laws

4.1 The biometric model.

4.2 Classic survival laws: Gompertz, Makeham,...

4.3 Survival laws valid for the entire age range: Gompertz-Makeham and Helligman and Pollard.

4.4 Dynamic models (a): concept and ad-hoc modeling.

4.5 Dynamic models (b): the Lee-Carter model. The "demographic" package in R-software.

5. Non-parametric Graduation

5.1 Graduation, Interpolation, adjustment.

5.2 Polynomial, logarithmic, potential, and exponential interpolation.

5.3 The sum method.

5.4 Smoothing techniques: moving averages, kernel estimation, and Wavelets.

6. Dynamic Mortality Analysis

6.1 General Dynamic Models

6.2 The Lee-Carter Model. Derived Types.

6.3 Other Dynamic Mortality Models: CBD, M5, M6, M7...

6.4 R-package for dynamic mortality: Demography, StMoMo...

7. Selected Mortality Tables. Tables with Multiple Causes of Exit.

7.1 Selected Mortality Tables: Coverages. Construction and Derivation of biometric functions.

7.2 Tables with multiple causes of exit and/or elimination: Disability. Practical and Rational Models. Generation of probabilities.

7.3 Loaded mortality tables: definition and uses.

8. Population Estimations

8.1 Methodology of the National Institute of Statistics (INE).

8.2 Short, medium, and long-term population estimations.

WORKLOAD

PRESENCIAL ACTIVITIES

Activity	Hours
Theory	15,00
Classroom practices	15,00
Total hours	**30,00**

NON PRESENCIAL ACTIVITIES

Activity	Hours
Attendance at other activities	3,00
Individual or group project	12,00
Independent study and work	12,00
Preparation of lessons	7,00
Preparation for assessment activities	5,00
Resolution of case studies	6,00
Total hours	**45,00**

TEACHING METHODOLOGY

The course methodology will be based on **active participation**, validating theories and methods studied in theoretical classes against **real information**, previously obtained from official bodies such as the National Institute of Statistics, Human Mortality Data Base, EUROSTAT, among others. Furthermore, the importance of studying and analyzing **current and research methodologies** will be highlighted, as well as seeking new applications through reading selected research articles.

In this way, theoretical content will be introduced through **participatory lectures**, reinforcing learning with the application of exposed theories to **updated real data**. This methodology leverages the benefits of the lecture format while fostering student participation and close interaction with the professor, promoting communication between them.

All content taught (theories and procedures) has a **markedly practical nature**. Thus, in practical sessions, students will be presented with real-life situations-with reduced complexity where required-so they can apply the theoretical concepts taught, thereby enhancing **meaningful learning**.

Special emphasis is placed on the need to **use various procedures to solve a problem**. This makes students aware of its importance for decision-making and for analyzing third-party studies. Particular importance is given to problem-solving through **scenario simulation**, for which different types of software are used (Ms Excel, R-software, Matlab, or Mathematica).

Communicating results and group discussion are part of the course's objectives, and those of the Master's program in general. To this end, students will complete tasks autonomously or in teams, which they will then present to their peers and the professor, defending their presentation and ideas.

The **use of research articles in different languages** (mainly Spanish and English) and the application of the techniques described therein will be part of the teaching-learning process, contributing to the student's comprehensive development and encouraging a positive attitude towards it.

Attendance at seminars and/or company visits will be promoted, for example, Professional Conferences, seminars by insurance professionals, researchers in the field, and so on.

EVALUATION

Due to the **specific and noticeably practical nature of the course**, provided the number of students allows, evaluation will be based on evidence of learning such as **attendance, participation, and attitude, along with the quality of the work developed**. To achieve this, emphasis is placed on **completing practical assignments based on real data**, which are structured in relation to the content presented in the course. Most of these practical exercises will be **guided by the professor** and will cover different aspects of the same phenomenon, with the aim that each student or work group complements the work of others.

All practical assignments will be **evaluated using different criteria** that measure adherence to the professor's requirements regarding minimum content, time, and presentation. However, the range of evaluation for the assignments will reflect the **degree of assimilation of the competencies** listed in this academic guide. Therefore, this evaluation will range from a minimum linked to the direct application of

techniques described in class, to their application to real data (more or less current, more or less processed), as well as the student's contribution, measured through the introduction of aspects and/or techniques not described in the fundamentals of each practical exercise, which denote personal or group contribution.

In cases where student attendance is **less than 70%** (no more than 40% absence in practical classes), the **final evaluation will consist of two parts**: one part will be a **synthesis test**; the second part will involve the **submission of one or more practical assignments** related to the scenarios presented in class and of similar complexity. The synthesis test will have a weight of no less than 60%, so the evaluation of the practical part will complete the grade with a weight not exceeding 40%.

For the evaluation of the course in the **second examination call**, the described system of a synthesis test and completion of the practical part will be applied, with the same weighting.

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