

Data Science and Data Analytics (WS 2025/26)

International Business Management (B. A.)

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September 5, 2025

This document provides the course material for Data Science and Data Analytics (B. A. – International Business Management). Upon successful completion of the course, students will be able to: recognize important technological and methodological advancements in data science and distinguish between descriptive, predictive, and prescriptive analytics; demonstrate proficiency in classifying data and variables, collecting and managing data, and conducting comprehensive data evaluations; utilize R for effective data manipulation, cleaning, visualization, outlier detection, and dimensionality reduction; conduct sophisticated data exploration and mining techniques (including PCA, Factor Analysis, and Regression Analysis) to discover underlying patterns and inform decision-making; analyze and interpret causal relationships in data using regression analysis; evaluate and organize the implementation of a data analysis project in a business environment; and communicate the results and effects of a data analysis project in a structured way.

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1 Scope and Nature of Data Science

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1.1 Defining Data Science as an Academic Discipline

Data science draws from and interacts with multiple foundational disciplines: * Informatics / Information Systems * Computer Science (algorithms, data structures, systems design) * Mathematics (linear algebra, calculus, optimization) * Statistics & Econometrics (inference, modeling, causal analysis) * Social Science & Behavioral Sciences (contextual interpretation, experimental design)

1.2 Significance of Business Data Analysis for Decision-Making

- Supports evidence-based strategic, tactical, and operational decisions.
- Reduces uncertainty in forecasting, pricing, resource allocation, and risk management.
- Enables performance measurement and continuous improvement.
- Facilitates customer understanding, personalization, and retention strategies.

1.3 Emerging Trends

Key technological and methodological developments shaping the data landscape: * Evolution of computing and data processing architectures. * Digitalization of processes and platforms. * Artificial Intelligence (AI), Machine Learning (ML), and Deep Learning (DL). * Big Data ecosystems (volume, velocity, variety, veracity, value). * Internet of Things (IoT) and sensor-driven data generation. * Cloud computing and elastic infrastructure. * Blockchain for distributed trust and data integrity. * Industry 4.0: cyber-physical systems and automation. * Remote and hybrid working environments: collaboration, distributed analytics, governance.

1.4 Types of Analytics

- Descriptive Analytics: What happened?
- Predictive Analytics: What is likely to happen?
- Prescriptive Analytics: What should we do?

2 Data Analytic Competencies

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2.1 Types of Data

- Cross-sectional data
- Panel (longitudinal) data
- Time-series data
- Geo-referenced / spatial data
- (Potentially) streaming / real-time data

2.2 Types of Variables

- Continuous (interval/ratio)
- Count
- Ordinal
- Categorical (nominal / binary)
- (Possibly) compositional or hierarchical structures

2.3 Conceptual Framework: Knowledge & Understanding of Data

- Clarify analytical purpose and domain context.
- Define entities, observational units, and identifiers.
- Align business concepts with data structures.

2.4 Data Collection

- Identify internal and external sources.
- Acquire via APIs, databases, surveys, sensors, or third-party vendors.
- Assess provenance, licensing, and ethical considerations.

2.5 Data Management

- Organize: schema design, naming conventions.
- Clean: resolve duplicates, inconsistencies, missingness.
- Convert: type casting, normalization, encoding.
- Curate: maintain lineage, documentation, metadata.
- Preserve: backups, versioning, retention policies.

2.6 Data Evaluation

- Plan analyses aligned with objectives and stakeholders.
- Conduct exploratory, inferential, and predictive procedures appropriately.
- Evaluate robustness, reliability, and validity.
- Assess limitations, bias, and ethical impact.

3 Applications in the Programming Language R

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3.1 Core tidyverse Tooling

Explore fundamental packages: * **dplyr** for data manipulation (filter, mutate, summarise, joins). * **tidyr** for data reshaping (pivoting, nesting, separating, unnesting). * **ggplot2** for layered grammar-based visualization. * (Optionally) **readr**, **purrr**, **stringr**, **forcats** for ingestion, functional iteration, text, and factor handling.

3.2 Data Visualization Principles

- Choose encodings appropriate to variable types.
- Emphasize clarity: reduce chart junk; apply perceptual best practices.
- Support comparison, trend detection, and anomaly spotting.

3.3 Detecting Outliers and Anomalies

- Rule-based methods (IQR, z-scores).
- Robust statistics (median, MAD).
- Model-based or multivariate detection (e.g., Mahalanobis distance, clustering residuals).
- Distinguish errors vs. novel but valid observations.

3.4 Dimensionality Reduction

- Motivation: mitigate multicollinearity, noise, and curse of dimensionality.
- Techniques: Principal Component Analysis (PCA), Factor Analysis, (optionally) t-SNE / UMAP (for exploration).
- Interpretability vs. compression trade-offs.

3.5 Data Exploration and Mining

- Structured EDA workflow: question → visualize → quantify → refine.
- PCA for variance structure.
- Factor Analysis for latent constructs.
- Regression Analysis for relationships and predictive structure.
- Clustering (k-means, hierarchical) for pattern discovery (if included).

3.6 Causal Inference with Regression Analysis

- Distinguish association vs. causation.
- Model specification and confounding control.
- Assumptions: linearity, independence, homoskedasticity, exogeneity.
- Interpretation of coefficients and marginal effects.
- Sensitivity and robustness checks.

4 Literature

All references for this course.

4.1 Essential Readings

Békés, G. and G. Kézdi (2021). *Resources for Data Analysis for Business, Economics, and Policy*. <https://www-cambridge-org.eux.idm.oclc.org/highereducation/books/data-analysis-for-business-economics-and-policy/D67A1B0B56176D6D6A92E27F3F82AA20/resources/instructor-resources/F57C5762D1593E72250729668A08A53B>. https://github.com/DrBenjamin/Analytical-Skills-for-Business/blob/c2ec1b2061c7dc36200977cfd58daf6020c1c774/literature/B%C3%A9k%C3%A9s_Data%20Analysis%20for%20Business%2C%20Economics%2C%20and%20Policy_2021_First%20Day%20of%20Class%20Slides.pdf/?raw=true }

Evans, J. R. (2020). “Evans, J. R. (2020). Business analytics’.

Huntington-Klein, N. (2025). *The Effect: An Introduction to Research Design and Causality*. <https://theeffectbook.net/>.

Wickham, H., M. Çetinkaya-Rundel, and G. Grolemund (2023). *R for Data Science (2e)*. <https://r4ds.hadley.nz/>.

4.2 Further Readings

Irizarry, R. A. (2024). *Introduction to Data Science: Data Wrangling and Visualization with R*. <https://rafalab.dfci.harvard.edu/dsbook-part-1/>.

Kumar, U. D. (2017). “Business analytics: The science of data-driven decision making.’

M., Ç. and J. Hardin (2021). *Introduction to Modern Statistics*. <https://www.openintro.org/book/ims/>. https://github.com/DrBenjamin/Analytical-Skills-for-Business/blob/491a9a84dd0227aab44e0a6db7e6330830a/literature/Introduction_to_Modern_Statistics_2e.pdf/?raw=true.

Pochiraju, B. and S. Seshadri (2019). *Essentials of Business Analytics*. Ed. by B. Pochiraju and S. Seshadri. Vol. 264. <https://link.springer.com/10.1007/978-3-319-68837-4>. Springer International Publishing. ISBN: 978-3-319-68836-7. DOI: 10.1007/978-3-319-68837-4. <https://github.com/DrBenjamin/Analytical-Skills-for-Business/blob/c2ec1b2061c7dc36200977cfd58daf6020c1c774/literature/Essentials%20of%20Business%20Analytics.pdf/?raw=true> }

Vaughan, D. (2020). “Analytical skills for AI and data science’.

<https://learning.oreilly.com/library/view/analytical-skills-for/9781492060932/preface01.html#idm46388898852872>.