

Introduction to Business Analytics

Harry J. Paarsch

Department of Economics

College of Business Administration

University of Central Florida

Orlando

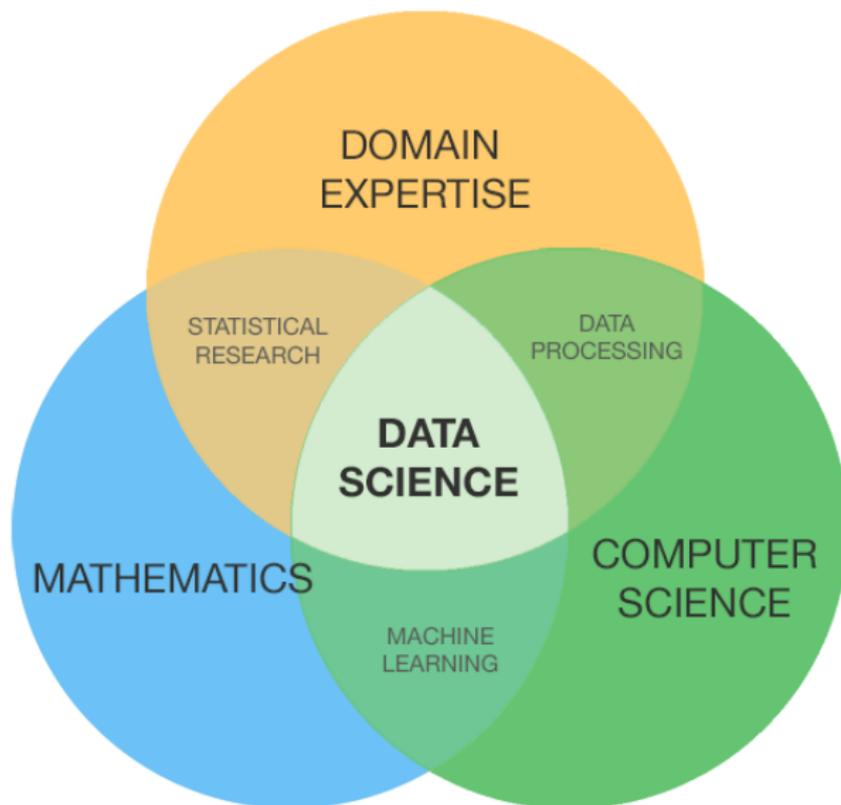
University of Victoria

20 September 2017

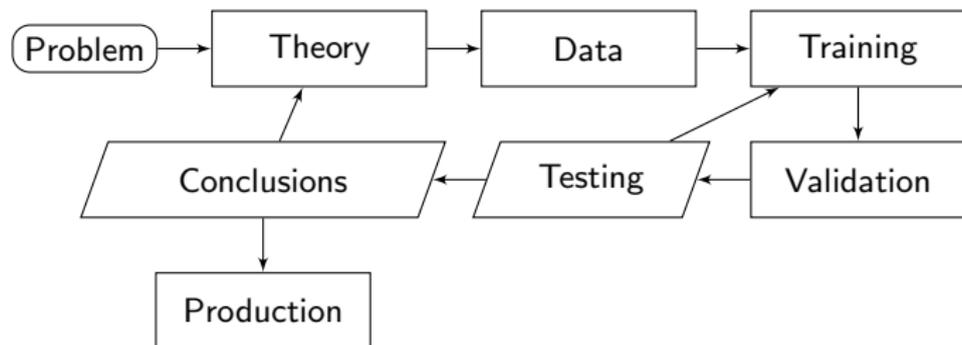
What is Business Analytics?

- ▶ Business analytics is an exciting new field of data science informed by computer science—specifically, algorithmics, databases, and programming—as well as numerical methods from applied mathematics.
- ▶ Methods from statistics—specifically, statistical learning—are important in business analytics as are methods from applied econometrics and machine learning.
- ▶ What makes business analytics different from other fields of data science (such as bioinformatics) is that it makes use of tools from economics, the imperial discipline of business. In particular, models of incomplete information, such as the models of adverse selection (in auctions) or moral hazard (in contract theory) are especially relevant in business analytics.

Venn Diagram of Data Science



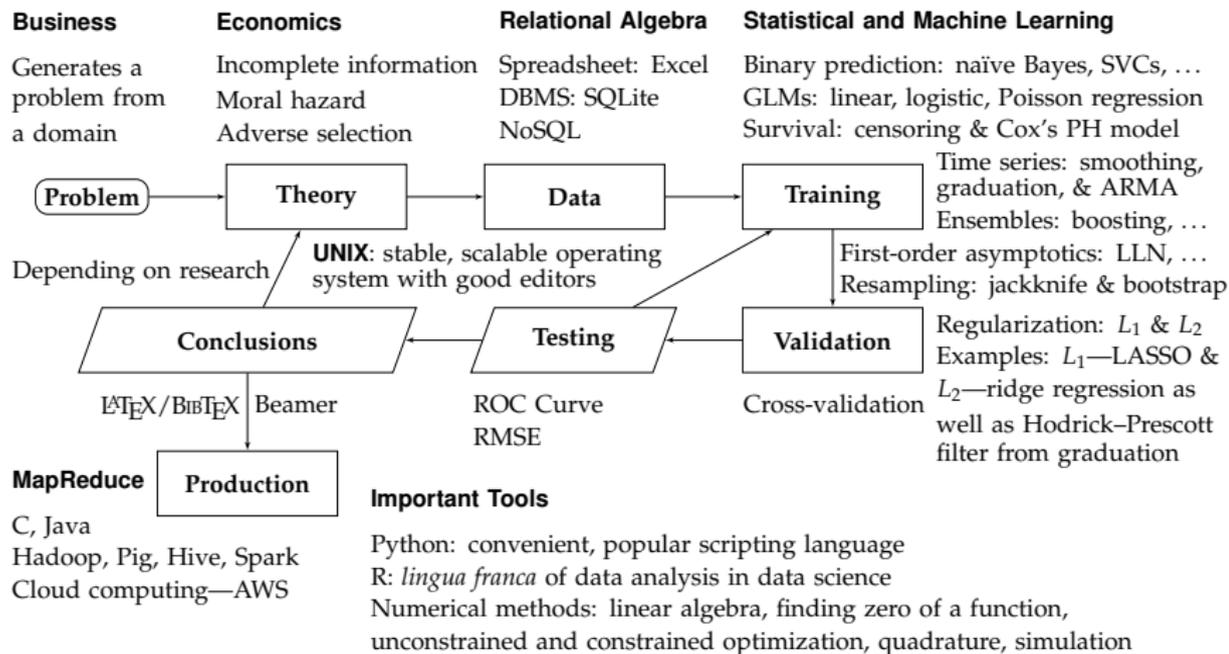
Business Analytics Process Flow



Process of Solving Problem in Business Analytics

1. Theory: in business analytics, you can often use the theory of incomplete information (for example, models of adverse selection or moral hazard) to put structure on the problem.
2. Data: the theory will then also inform you concerning data to gather and to organize data using, for example, a Spreadsheet as well as Python, and SQLite—perhaps even a NoSQL store.
3. Training, Validation, and Testing: theory can also inform you concerning which tools from statistical learning to implement in Python or R when train, validating, and testing empirical specifications.
4. Conclusions: only theory can provide an interpretation of empirical results required to make a business decision.
5. Production: having settled on an empirical specification, you can use C as well as Hadoop, Pig, Hive, and Spark and cloud computing (for example, AWS) to implement solution at scale.

Tools of Business Analytics



Parts of a Business Analytics Curriculum

1. Economics: multi-person decision theory, particularly under incomplete information;
2. Statistical Learning: theory of estimation and inference;
3. Numerical Methods: solving numerically for estimators using, for example, numerical linear algebra, but other methods, too;
4. Algorithmics: investigating complexity of algorithms to implement estimators and to conduct inference;
5. Databases: relational algebra and structured query languages;
6. Programming: implementing algorithms on computers.

Mathematics Required

First, and foremost, data science in general (so business analytics in particular) is a mathematical science. Trying to become a business analyst without some elementary training in mathematics would be like trying to become a dentist or a doctor without some basic training in biology. Experience has shown that you need to know the following:

1. Set Theory
2. Linear Algebra
3. Differential and Integral Calculus
4. Optimization Theory
5. Numerical Analysis
6. Graph Theory

Economics Required

1. Microeconomic Theory

i) Deterministic Economic Decision Problems

- (a) Cost Minimization
- (b) Profit Maximization
- (c) Consumer Choice
- (d) Equilibrium

ii) Theory of Incomplete Information

- (a) Adverse Selection
- (b) Moral Hazard

2. Game Theory

a) Non-Coöperative Games of Incomplete Information

- i) Auctions
- ii) Hidden Action Model

b) Mechanism Design

Probability and Statistics Required

1. Probability Theory: knowledge of different parametric models and their properties;
2. Estimation Theory: different estimation (training) strategies;
3. Inference Theory: methods to evaluating sampling variability;
4. Experimental Design: how to conduct A/B testing at scale;
5. Simulation Methods: how to use the computer when analytic methods are too arduous (or impossible) to perform at scale.

Numerical Methods Required

1. Numerical Linear Algebra
2. Find Zeros of Vector-Valued Functions
3. Unconstrained Optimization
4. Constrained Optimization, particularly Convex Optimization
5. Approximation Methods
6. Generating Pseudo Random Numbers
7. Quadrature, Cubature, Monte Carlo Methods

Computer Science Required

1. Algorithmics
2. Relational Algebra
3. Databases—SQL
4. Statistical Software—R
5. Programming—Python and C
6. Distributed and Parallel Computing—Scala, Spark

Ability to Argue and to Write

- ▶ Regardless of your focus, in order to be successful in business at any level, you will need to know how to argue and to write effectively.
- ▶ Having been successful in an introductory course in logic is very helpful.
- ▶ Having been successful in a basic course in scientific writing is essential.
- ▶ Having completed an honours (senior) thesis is a good indicator of the ability to argue and to write effectively.

In Summary

- ▶ As you can see, even though it could take a while, becoming a business analyst is relatively straightforward.
- ▶ Business analytics requires less formal training than some professions—for instance, accounting, law, or medicine, which require formal accreditation as well.
- ▶ Currently, however, few formal programs exist anywhere in the world.
- ▶ Many who practice business analytics have tried to develop their skills on-the-job.
- ▶ This takes time, and can result in considerable heterogeneity in outcomes.
- ▶ I have developed a master's level program focusing on business analytics delivered by the Department of Economics of the College of Business Administration at the University of Central Florida in Orlando.

Program Description

- ▶ The program is eleven months long; successful completion will earn you a Master of Science in Economic with focus on business analytics.
- ▶ The program is basically free in that each admitted, qualified candidate who is eligible to be a Graduate Teaching Assistant will be given a tuition waiver as well as a stipend.
- ▶ The economics department is a congenial place to work.
- ▶ The University has good plant and equipment.
- ▶ Orlando is a pleasant place in which to live.

First Semester Courses

1. **Microeconomic Theory I:** introduction to deterministic economic decision problems as well as equilibrium;
2. **Mathematical Economics:** how to cast economic decision problems using mathematics and then how to solve them using basic mathematics;
3. **Operations Research:** how to solve decision problems using mathematical programming on a computer;
4. **Introduction to Business Analytics:** how to embed the material from the above courses in a business ecosystem.

Second Semester Courses

1. **Databases:** how to use the relational algebra and a structured query language to organize data;
2. **Econometrics:** how to use econometrics and statistics to train, validate, and test empirical specifications in data science;
3. **Microeconomic Theory II:** introduction to the theory of incomplete information and game theory—in other words, multi-person decision theory;
4. **Behavioral Economics:** investigating deviations from neoclassical theory as well as how to exploit them using methods of business analytics.

Capstone Project

- ▶ The capstone project represents the culminating academic experience of the master's program.
- ▶ It provides students with a forum in which to develop, carry out, and write up research of a well-defined problem in business analytics using the tools developed in the program.
- ▶ Students will be required to pose a relevant, important problem in business analytics; develop the necessary economic theory to provide an interpretation of the empirical specification developed; gather and organize the relevant data; train, validate, and test the empirical specification; and write a report in which this research and the conclusions are presented in a convincing manner.

Main Product

- ▶ The two-course capstone sequence prepares students for the initial assignment that virtually every business analyst gets during the first month on the job: take an ambiguous problem; put interpretable structure on the problem using theory; gather and organize data; train, validate, and test the empirical specification; formulate the conclusions; and write-up the research in a concise, effective way.

Preparation

The following courses would be the ideal preparation for the program:

1. **Computer Science:** Introduction to Computer Science;
2. **Mathematics:** Calculus I, II, and III as well as Linear Algebra;
3. **Probability and Statistics:** Intermediate Probability and Statistics;
4. **Economics:** Intermediate Microeconomics, Mathematical Economics, Basic Econometrics, and Game Theory;
5. **Introduction to Business Analytics:** along the lines of the introductory textbook *A Gentle Introduction to Effective Computing in Quantitative Research: What Every Research Assistant Should Know*, by Konstantin Golyaev and myself. Cambridge, USA: MIT Press, 2016.

Course Numbers at Different Universities

Table 1

University	Comp. Sci.	Calc I	Calc II	Calc III	Lin. Alg.	Probability	Statistics	Int. Micro	Math Econ	Econometrics	GameThry
Colby	CS152	MA121	MA122		MA253		SC212	EC223	EC336	EC293	EC379
McGill	COMP 202	MATH 140	MATH 141	MATH 222	MATH 123	ECON 257D1	ECON 257D2	ECON 230	MATH 125	ECON 337	ECON 420
Queen's	CISC 101	MATH 123	MATH 124		MATH 112		ECON 250	ECON 310	ECON 255	ECON 351	ECON 455
Toronto	CSC108	MAT135	MAT136	MAT237	MAT221		ECO220	ECO206	ECO210	ECO227	ECO316
Western	CS 1026A/B	MA 0110	MA 1225		MA 1229		EC 2122	EC 2150	EC 2141	EC 2123	EC 2151
UVic	CSC 110	MATH 100	MATH 101	MATH 200	MATH 211	ECON 245	ECON 246	ECON 313	ECON 350	ECON 365	ECON 450
UBC	CPSC 103	MATH 105	MATH 106	MATH 200	MATH 221	ECON 325	ECON 326	ECON 303	ECON 420	ECON 425	ECON 421
SFU	CMPT 102	MATH 157	MATH 158		MATH 232	STAT 270	STAT 285	ECON 302	ECON 331	ECON 435	ECON 431
UCF	ECO 4443	MAC 2311	MAC 2312	MAC 2313	MAS 3105	STA 3032	STA 2023	ECO 3101	ECO 3410	ECON 4412	ECO 4400