Abducting Economics:
How to Learn from Surprises

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- The goal of empirical economics is to learn from data.

- But what constitutes admissible evidence?

- How best to learn from it?

- All analysts approach data with preconceptions.

- The data **never** speak for themselves.

- Sometimes preconceptions are encoded in precise models.

- Sometimes they are just intuitions that analysts seek to confirm and solidify.

- A central question is how to revise these preconceptions in the light of new evidence.

The Diversity of Goals in Empirical Research

- Empirical analyses in economics have diverse goals—all valuable.

- Some analyses advance knowledge by uncovering new facts or providing richer descriptions of old facts.

- Some seek to identify causal impacts of specific interventions as in the literature on treatment effects.

- Other analyses seek to understand the mechanisms producing outcomes with an eye toward interpretation and counterfactual policy evaluation.

- Some studies do all three.

- Common across all approaches is lack of formal guidelines for taking the next step and learning from surprising findings.

- There is no established practice for dealing with surprise, even though surprise is an everyday occurrence.

- Is there a best way to respond to empirical surprises?

- This lecture advocates a strategy for reacting to surprise.

- Economists should *abduct*.

What is Abduction?

- Abduction is the process of generating and revising models, hypotheses and data analyzed in response to surprising findings.

- This process of learning first analyzed by polymath Charles Sanders Peirce who described as follows:

"The surprising fact, C, is observed. But if A were true, C would be a matter of course. Hence, there is reason to suspect that A is true."
— Peirce (1934, p.117)

- He contrasts this form of inference with deduction, where conclusions are logical necessities.

- He also contrasts it with induction, which reports correlations between C and A, but provides no explanation (i.e., mechanism) for why an $A \rightarrow C$ nexus arises.

Peirce 1878

Deduction

Rule: All the beans from a bag are white.
Case: These beans are from that bag.
Therefore, Result: These beans are white.

Induction

Case: These beans are from this bag
Result: These beans are white.
Therefore, Rule: All the beans from this bag are white.

Abduction

Rule: All the beans from a bag are white.
Result: These beans are white.
Therefore, Case: These beans are from that bag.

- Abduction is different from falsification or corroboration (Popper, 1959).

- It moves descriptions of the world forward rather than just confirming or falsifying hypotheses.

- It is part of a process of discovery where model reformulation, revision of hypotheses and addition of new information are part of the process.

- *"Suspect"* is a key term in Peirce's ostensive definition.

- It makes explicit the fundamental uncertainty underlying any empirical exercise.

- Suspicion opens the door and encourages further discovery and investigation.

- Since analysts never know (in a purely logical sense) empirical conclusions, anything that confirms hunches or suspicions is fair game, although all evidence may not be equally weighted.

- Admissible evidence includes both received and revised theory and new facts.

- It is the interplay of theory and facts and the evolution of both in the process of generating new hypotheses that is the core of abduction.

- The abductive model for learning from data follows more closely the methods of Sherlock Holmes than those of textbook econometrics.

- The Sherlock Holmes approach uses many different kinds of clues of varying trustworthiness, weights them, puts them together, and tells a plausible story of the ensemble.

- It does not initially privilege any particular type of data or any particular mode of analysis of data.

- The data analyzed need not necessarily be numerical in nature.

> *"All knowledge comes useful to the detective... The temptation to form premature theories on insufficient data is the bane of our profession. I can see only two things for certain at present—a great brain in London and a dead man in Sussex. It's the chain between that we are going to trace."* — Sherlock Holmes in Doyle (1914, p.33 & p.43).

- A central feature of abduction is the quest for and construction of hypotheses and explanations, which are the most plausible candidates to account for an empirical phenomenon.

I. Recognizing Abduction as a Legitimate and Essential Practice Improves Current Econometric Practice

- The abductive approach to empirical economics is at variance with standard teaching in empirical economics.

- The dominant paradigm is classical (frequentist) statistics with its particular sets of rules for inference—a mish-mosh of R.A. Fisher p-values (testing against unspecified alternatives) and Neyman-Pearson statistics calibrated to balance Type I and Type II errors.

- Test statistics are reported as if the hypotheses being tested did not originate from the data being assessed.

- Also as if there was no pretesting.

- The rich literature on adjustment of test statistics for multiple hypothesis testing does not account for the **addition of hypotheses** (and evidence) to the mix through the process of abduction.

- Missing from current practice is recognition of the great benefit for knowledge of going back and forth with data—i.e., learning from it, revising hypotheses in light of it, augmenting it with fresh data and fresh theoretical insights and suggesting new interpretations, and formulating new hypotheses suggested by the collection of new data.

- Peeking at the data and formulating and building new models in the light of those views is an often-committed frequentist sin.

- If followed, proscriptions against that practice would tie the hands of the empirical analyst.

- Fortunately, they are usually ignored by more seasoned empirical economists, but are often taken literally by the young or those committed to a frequentist testing paradigm.

Enshrined Practice by Many Consulting Contractors

- One of the worst examples of frequentist dogma in action is the common practice in government-sponsored research requiring that investigators specify all of their models in advance of looking at the data.

- Randomists swear by it. "Pre-analysis plans": state in advance what hypothesis you seek to test.

- Surprise? No way to learn from surprise.

- Successful abductors immerse themselves in the data and the conceptual issues underlying its generation and its interpretation, and reports the results of this immersion to the reader.

- It is a public process where evidence, provisional models and methods are revealed and scrutinized.

- Abduction is a context-dependent *art form* in both practice and exposition.

- It requires considerable practice before it becomes a habit brought to data.

- Abduction is best learned through working directly with real empirical problems and through apprenticeship and debate, and not solely by reading textbooks or sitting through lectures.

- The process of successful abduction may unfold over a series of papers by any single investigator or may unfold through a dialogue across investigators.

II. Challenging Current Empirical Paradigms

- The abductive mode of thought challenges the currently influential framework of the "identification problem," which underlies both treatment effect and structural approaches.

- That paradigm starts with a model or set of admissible models and asks if they can be identified from, or are consistent with, the available data.

- Regardless of differences in what constitutes a model, identification analyses take its classes of admissible models as determined *before* an empirical investigation begins.

- Many analysts operating in this framework appeal to *a priori* theory.

- They define empirical economics to be the activity of testing (falsifying or corroborating) *a priori* models.

- This limited perspective defines the class of hypotheses to be considered as coming from an established inventory of ideas and propositions.

- The rigid separation of the processes of model generation and model testing—a central feature of the formulation of the identification problem—while analytically convenient—is artificial.

- No procedure is offered for revising models.

- Successful empirical economics presents an inventory of findings and develops new hypotheses/models in light of empirical rejections of old models or findings that suggest new models.

- This critical scientific step, which is intrinsically context-dependent, is currently outside the bounds of standard econometric theory, but not outside common practice.

III. Can Abduction Be Automated?

- Creating sets of candidate explanations and iterative strategies for generating them lies outside of the statistical/machine learning domain.

- It does, however, arise in the design of Expert Systems (Feigenbaum, 1978), where sequentially developing a tool with some capacity for discovery of new phenomena is an objective.

- But here, informal reasoning processes by the investigator are a central element in system design.

- Some insight about how abduction can be automated can be gleaned from three central features of Expert Systems with proven hypothesis generators and discovery capabilities.

- These are:

  1. conceptualizing the phenomenon to be explained in mathematical terms that include all aspects of potential explanations.

  2. Implementing the formulation in (1) in what can be regarded as an exhaustive hypothesis generator. This is a program capable of imagining every conceivable explanation for the observed phenomenon.

- Organizing the hypothesis generator to avoid duplication and irrelevance as it moves from one candidate explanation to the next.

- Heuristic search and evaluation are the key ingredients in arriving at plausible explanations.

- Under the broad umbrella of abduction, there is often an initial stage of many investigations, especially those into fundamentally new problems where informal, even vague, reasoning takes place as initial sets of hypotheses are formulated, and making rich descriptions of the phenomena being investigated play a crucial role in framing problems.

- These creative acts precede the use of formal logic of any stripe.

- It is a process rooted in psychology, with neurobiological underpinnings, that is not well understood at present.

- Studying the creative experiences of particular scientists in different disciplines on a variety of questions shows enormous variation in thought processes that accompany acts of creation (Darden, 2002).

- A basic tradeoff is operative in developing expert systems: the wider the class of phenomena to be explained, the worse is the system performance in getting to a credible solution.

- Linked to this issue, of course, is the question of how much *a priori* knowledge and in what subject-matter domains, needs to be supplied to the computer system in order to effectively carry out the desired abductions.

- Operationalizing this and dealing with the tradeoff issue in economics and in a diversity of real world problems in other domains is a vast agenda for the future.

- These challenges suggest a program of research that involves context-dependent systems, analogous to those in the physical and biological sciences, while simultaneously seeking general principles across problems.

IV. Do Bayesians Abduct?

- Bayesian readers will likely respond that learning from data is an integral part of Bayesian reasoning.

- They are correct as long as they describe learning about events that are *a priori* thought to be possible as formalized in some prior, however arrived at.

- More fundamentally, Bayesians have no way to cope with the totally unexpected (priors rule out "a surprising fact C is observed" if C is a complete surprise).

- Total surprise is the domain of abduction.

- Perhaps a better guide to learning is the non-Bayesian approach of Gilboa and Schmeidler (2001) and Gilboa, Samuelson, and Schmeidler (2015), who analyze responses to novel events by relying on their proximity to recombinations and extensions of past case histories and **received theory**.

- Heckman and Singer add a step to their procedures by having agents revisit—and reinterpret and concatenate—past cases (events) in light of empirical surprises to assemble interpretations of novel findings based on proximity to a reconfigured past.

V. Some Examples

- A study relevant to the study of COVID-19.

- Guillemin (1999) investigates the likelihood of Soviet biological war-making capacity exploiting an outbreak of anthrax in Sverdlovsk in 1979.

- Anthrax is an infection caused by the bacterium *Bacillus Anthracis*, which occurs naturally in soil, affects wild and domestic animals (e.g., cattle), and humans who either inhale anthrax spores or come into direct contact with infected animals.

- A weaponized version of anthrax is a dangerous biological warfare agent.

- The Sverdlovsk investigation weighed multiple sources of diverse data: biological information on local anthrax and its newspaper accounts, death records, observer reports, meteorological data, and imagery from overflights of the city.

- The analysts concluded that the Soviets were in violation of the international Chemical and Biological Weapons Convention, something Boris Yeltsin later admitted.

- **See Katz and Singer (2007).**

VI. Lessons for Empirical Economics

- The abductive approach to empirical economics advocates a process and a mindset.

- It privileges no source of data, style of research or mode of inference for learning about the economy provided the analyst produces useful knowledge that survives critical public scrutiny.

- It values factually-rich descriptions as major sources of knowledge.

- It favors using every piece of available information, despite varying trustworthiness of parts of it.

- However, it asks that analysts report, in a public way, how they weigh the diverse evidence.

- It encourages readers of such studies to form their own opinions and justify their own weights.

- It recognizes the provisional nature of knowledge

- The abductive approach encourages analysts to interact with all of the available data and theory to learn and to augment it.

- Testing and rejecting (or corroborating) any *a priori* hypothesis is only a stage of an investigation.

- Generating and testing new hypotheses in response to rejection of initial candidate hypotheses is the central feature of the process of providing defensible explanations for surprising phenomena.

- This approach addresses the problem of using the same data to formulate and test hypotheses.

- Analysts are advised to test provisional models on fresh data, possibly of a different character than the data used to formulate initial hypotheses, and to draw new testable implications from hypotheses that survive an initial stage of scrutiny.

- This opportunistic approach to knowledge will produce more true knowledge and fewer statistical artifacts arising from particular sequences of choices of analyzing data sets.

- It values replication of studies—currently a devalued activity.

- It looks for consilience across bodies of evidence and across studies instead of reporting results in isolation.

- It diminishes the value of any particular study but encourages further exploration and testing on multiple sources of evidence.

- It is a strategy for growing knowledge and not pretending to have it.