

# Abducting Economics

James J. Heckman and Burton Singer

James J. Heckman\*

University of Chicago

Department of Economics

University of Chicago

1126 East 59th Street

Chicago, IL 60637

Phone: 773-702-0634

Email: [jjh@uchicago.edu](mailto:jjh@uchicago.edu)

Burton Singer

University of Florida

Emerging Pathogens Institute

University of Florida

P.O. Box 100009

Gainesville, FL 32610-0009

Phone: 352-273-9572

Email: [bhsinger@epi.ufl.edu](mailto:bhsinger@epi.ufl.edu)

**JEL codes:** B41, C18

**Keywords:** abduction, surprise, empirical economics, learning from data

\*Corresponding Author

**Session:** Learning From Data in Economics

**Chair:** James J. Heckman

**Discussants:**

Angus Deaton

Lars Hansen

John Rust

Burton Singer

Abduction is the process of generating and choosing models, hypotheses and data analyzed in response to surprising findings. All good empirical economists abduct. Explanations usually evolve as studies evolve. The abductive approach challenges economists to step outside the framework of received notions about the “identification problem” that rigidly separates the act of model and hypothesis creation from the act of inference from data. It asks the analyst to engage models and data in an iterative dynamic process, using multiple models and sources of data in a back and forth where both models and data are augmented as learning evolves.

The goal of empirical economics is to learn from data. But what constitutes admissible evidence? How best to learn from it? This paper addresses these fundamental questions.

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.

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 paper advocates a strategy for reacting to surprise. Economists should *abduct*. Abduction is the process of generating and revising models, hypotheses and data analyzed in response to surprising findings. This process of learning was first analyzed by the polymath Charles Sanders Peirce who described it in the following way: “*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)

\* This research was supported in part by: NIH grants, NICHD R01HD054702, and NIA R24AG048081, the Army Research Office for support under MURI Grant #58153-MA-MUR, Prime Award #W91 INF-11-1-0036; the Human Capital and Economic Opportunity Global Working Group, and funded by the Institute for New Economic Thinking; and the American Bar Foundation. The views expressed in this paper are solely those of the authors and do not necessarily represent those of the funders or the official views of the National Institutes of Health. We thank Steven Durlauf, Itzhak Gilboa, Michael Greenstone, Tim Kautz, Larry Samuelson, and Richard Robb for useful comments.

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. 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 analysis of data. The data analyzed need not necessarily be numerical in nature. To quote the master: “*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 Doctrine**

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. 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. 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.

The successful abductor immerses himself 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.<sup>1</sup> No procedure is offered for revising this

---

<sup>1</sup> See Friedman (1953), footnote 11. That essay is a manifesto for abduction.

inventory and developing 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: (i) conceptualizing the phenomenon to be explained in mathematical terms that include all aspects of potential explanations. (ii) Implementing the formulation in (i) in what can be regarded as an exhaustive hypothesis generator. This is a program capable of imagining every conceivable explanation for the observed phenomenon. (iii) 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 features (i)—(iii) 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.<sup>2</sup>

## V. Some Examples

Most successful empirical studies in economics are based on some form of abductive reasoning. The literature on the consumption function is a rich source of examples. Friedman's classic study is a model of abductive inference (Friedman, 1957). Diverse data were analyzed and differences reconciled using and extending basic economic theory. Not a single *p*-value is reported in what many consider one of the most influential empirical studies in the history of economics. Instead, it reports a running dialogue with data, models and with new models that emerged from his immersion in a vast array of data.

Gary Becker was a master of abduction. Over his lifetime, he iterated between models and evidence to build his influential edifice. Becker adjusted his theories in light of new evidence and then tested other implications of those theories on new data sets (Heckman, 2015).

Another example of the abductive process is the work of Donohue and Heckman (1991), who addressed the complex question of whether the 1964 Civil Rights law advanced the economic position of African Americans. Multiple factors were at work at the same time: (a) a tight labor market fueled by the war in Vietnam and policies in the 1960s; (b) the advancing level of education of African Americans; (c) the Civil Rights Act and the civil rights movement. Using numerous historical data sets, as well as examining multiple outcomes and clues from newspaper stories and contemporary accounts joined with basic economic analysis, they

---

<sup>2</sup> In ongoing work, we 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.

establish the case for a powerful beneficial role for federal government activism. No single bit of evidence is decisive. It is the ensemble of evidence and the substantiation of additional hypotheses that makes the story compelling.

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.

The study of economic history is a rich source of examples. Acemoglu and Robinson (2012) present an extensive abductive analysis investigating sources of success and failure of nations. There are many other good examples of abductive activity.

## **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.<sup>3</sup> 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.

### References

Acemoglu, Daron, and James Robinson. 2012. *Why Nations Fail: The Origins of Power, Prosperity, and Poverty*. New York: Crown Business.

---

<sup>3</sup> See Katz and Singer (2007).

- Darden, Lindley. 2002. "Strategies for Discovering Mechanisms: Schema Instantiation, Modular Subassembly, Forward/Backward Chaining." *Philosophy of Science* 69 (S3):S354-S365. doi: 10.1086/341858.
- Donohue, John J., and James J. Heckman. 1991. "Continuous versus Episodic Change: The Impact of Civil Rights Policy on the Economic Status of Blacks." *Journal of Economic Literature* 29 (4):1603-1643.
- Doyle, Arthur Conan. 1914. *The Valley of Fear*. New York: George H. Doran Company.
- Feigenbaum, Edward A. 1978. "The Art of Artificial Intelligence - I. Themes and Case Studies of Knowledge Engineering." Proceedings of National Computer Conference.
- Friedman, Milton. 1953. "The Methodology of Positive Economics." In *Essays in Positive Economics*, edited by Milton Friedman. Chicago: University of Chicago Press.
- Friedman, Milton. 1957. *A Theory of the Consumption Function*. Princeton, NJ: Princeton University Press.
- Gilboa, Itzhak, Larry Samuelson, and David Schmeidler. 2015. *Analogies and Theories: Formal Models of Reasoning*. Oxford, UK: Oxford University Press.
- Gilboa, Itzhak, and David Schmeidler. 2001. *A Theory of Case-Based Decisions*. Cambridge, UK: Cambridge University Press.
- Guillemin, Jeanne. 1999. *Anthrax: The Investigation of a Deadly Outbreak*. Berkeley: University of California Press.
- Heckman, James J. 2015. "Gary Becker: Model Economic Scientist." *American Economic Review, Papers and Proceedings* 105 (5):74-79.
- Katz, Rebecca, and Burton Singer. 2007. "Can an Attribution Assessment Be Made for Yellow Rain?" *Politics and the Life Sciences* 26 (1):24-42.
- Peirce, Charles Sanders. 1934. "Pragmatism and Pragmaticism." In *Vol. 5, Collected Papers*, edited by Charles Hartshorne and Paul Weiss, 117. Cambridge: Harvard University Press.
- Popper, Karl Raimund. 1959. *The Logic of Scientific Discovery*. London: Hutchinson.