Chapter 1: Getting Started with Econometrics

1. Greetings

You have already completed a calculus course and a statistics course, along with a good dose of economic theory, so you already know quite a bit about the nature of this course. You know that social scientists and business practitioners often conduct analysis by expressing ideas in the symbols of mathematics, then using statistics to make estimates of those symbol's values in the real world. Econometrics will teach you more about this process. Econometrics draws together statistics, mathematics, and economic theory, aiming to discover what we can about economic culture by careful measurement and applied statistics.

Consider that last sentence. Isn't it a bit odd that we'd sit down to analyze human civilization by using the mathematical approach of the natural sciences? Yet this is the approach that dominates modern economics. I hope that applied statistics has not seemed a tedious, mechanical discipline to you, because it is actually near the core of one of the great debates the last half-century. People the world over have been asking how to decide which truth claims are warranted, whether truth claims are warranted only for individuals or can be considered binding on groups, and whether some persons have a privileged position in making truth claims. In the midst of that debate, economists have by-and-large clung to the idea that many important truth claims can be settled by mathematical analysis, careful measurement, and applied statistics.

I'd encourage you to think of econometrics as one approach to forming and warranting truth claims—more an exercise in *epistemology* than an exercise in logic or memorization. That should help you develop some wit about whether, why, and how the ideas of this course can be used in any particular situation.

2. Genesis of Econometrics

In this course you will be learning the language in which the vast majority of economic analysis is conducted, and that analysis has tremendous influence over our world. Where did these professional habits come from? Many would point to the publication of *The Theory of Games and Economic Behavior* by John von Neumann and Oskar Morgenstern in 1937. The authors asked why mathematics had not seen the same fruitful success in economics that it had achieved in the natural sciences. Rejecting the usual reasons (like the presence of psychological factors or difficulties in measurement), they present a vision of economic research characterized by careful empirical measurement, precisely formulated questions, and the use of mathematics and applied statistics.

But to keep perspective about the econometric approach that dominates the human sciences, we need to go farther back in time than 1937. This chapter* should give you a solid introduction to the events and ideas that formed the rise of econometrics, and introduce some of the criticisms of the econometric approach. You'll also encounter my basic goal in my teaching and practice of econometrics: forming this discipline in a way that maintains that there are binding truths to be discovered, while still allowing space for norms, beliefs and values to affect our work.

3. The long conversation: Dreams and Disappointments

Every nation or human community that hopes to survive and prosper must find a way to make peace in the face of deeply held personal differences. Values and beliefs are rarely identical within large communities, and a brief survey of recent history is enough to force sober reflection upon the person who thinks that these differences are trivial.

The social science community is one of these human communities that must come to terms with differences in values and belief among its members. This community is at the core of the enormous volume of human information that characterizes our time. This community therefore has great influence in shaping modern culture, from the most public issues like welfare reform and foreign policy, to more intimate topics like family planning and college admission. It is time to begin facing some difficult questions about this social science community: Do the values and beliefs of social scientists influence their work? If so, is there still hope of developing social sciences that

transcend personal differences, and are "true for everybody?" Or is the hope of making wise group choices via carefully ordered knowledge a vain hope, swamped by the stubborn individuality of personal differences?

One way of dealing with differences is to assume them away. It was once assumed that values and beliefs only mattered outside of the sciences, even the social sciences. Except for a few core values--clear reasoning, accuracy and truthfulness in recording data, and rapid public dissemination of results--science was considered the world of fact, and the scientist's other values were not to influence the science. This tight distinction between facts and values was thought to hold promise as one way of building culture independently of questions of value. But this view of science has been seriously questioned, especially during the last fifty years.

In this chapter we want to give an introduction to the professional conversation about just what kinds of valuing are required in the social sciences, what kinds of norms apply to the use of data and models in the social sciences. This will involve trying to make room within the social sciences for the consideration of values and beliefs, without making the social sciences relativistic or inconsequential. This chapter is therefore part of a much broader contemporary discussion of the proper place of values and beliefs within the academic disciplines, the effects of the Enlightenment upon culture, and the future of academic life. This is a robust and important discussion; one author has written of it as a battle for the soul of the university.[1] We cannot hope to consider here all of the vast literature on these topics, or even on the narrower topic of differing perspectives on science. But we will introduce some of the issues our disciplines must consider in this discussion by giving a broad historical context for the conversation about values, data, and models in the social sciences.

There are several spots from which we might trace the history of the high hopes that have been held for data, models, and formal mathematical reasoning. The Greek attempts to systematize logic and axiomatize geometry, an axiomatization that endured for over two thousand years, would be a good starting point. Developments of the middle ages, including the principle of Occam's Razor that informs so much of modeling, would be another. But our chief interest is in providing a context for the uses of data and models in the modern social and decision sciences. Thus our emphasis will be on the modern era, beginning with Descartes.

4. Dreams for Data and Models

The vision of using modeling, empirical observation and mathematics to find an objective, value-free method for understanding the world and resolving inter-subjective disagreements became the passion of Descartes and of the age he ushered in. For Descartes, the high hopes for mathematization were literally a dream, a mystic three-part dream on the evening of November 10, 1619, in which he believed the secret of nature had been revealed to him. Descartes

> awoke convinced that all of nature is a vast geometrical system. Thereafter he 'neither admits nor hopes for any principles in Physics other than those which are in Geometry or in abstract Mathematics, because thus all the phenomena of nature are explained, and some demonstrations of them can be given.' Differences among bodies are differences in shape, density, and motion..., and these properties are real and expressible in mathematical terms. On the other hand, such qualities as color, taste, warmth, and pitch are not real but are reactions of minds to the real, primary qualities. These... could be dismissed in an analysis of the real world because they are but illusions... Thus... shape... and motion in space and time are the source of all properties and are the fundamental realities. In Descartes' words, 'give me extension and motion and I will construct the universe.'... In brief, the real world is the totality of mathematically expressible motions of objects in space and time, and the entire universe is a great, harmonious, and mathematically designed machine.[2]

For Descartes, mathematics was not merely a useful approach to describing some kinds of knowledge; mathematics was thought of as the key to behavior, because nature itself is mathematical, subject to mathematical laws. Both Galileo and Roger Bacon speak of geometry or mathematical principles as the language in which the book of nature is written. Kepler affirms that mathematical laws are the true cause of events. For these thinkers

> the universe is mathematical in structure and behavior, and nature acts in accordance with inexorable and immutable laws.... We can understand now, said Descartes, why mathematical prediction of the future is possible; it is because the mathematical relationships are pre-existing... The mathematical interpretation of

> nature became so popular and fashionable by 1650 that it spread throughout Europe and dainty, expensively bound accounts by its chief expositor, Descartes, adorned ladies' dressing tables.[3]

Two generations after Descartes, Leibniz was seeking "characteristica universalis," a universal objective method to resolve "all human problems, whether of science, law or politics... rationally, systematically, by logical computation." Forms of this vision are with us yet in the social sciences, and require that mathematization be given priority in the disciplines that study human affairs.

One great hope of this movement was that careful observation and measurement would promote the formation of culture. The careful, dispassionate investigation of the universe was to bring progress to both our understanding and our experience of daily life. The work of Galileo, Newton and others of the era enabled remarkable progress on scientific fronts, and appeared to many in the seventeenth and eighteenth centuries to be facilitated by the concept that the cosmos was essentially a large, well-regulated machine. Alasdair MacIntyre, a professional observer of the effects of the enlightenment, summarizes the initial aims of enlightenment thinkers in this way:

> It was the shared belief of the protagonists of the Enlightenment...that one and the same set of standards of truth and rationality -- indeed of right conduct and adequate aesthetic judgement-- was not only available to all human beings qua rational persons, but [these standards] were such that no human being qua rational person could deny their authority. The central project of the Enlightenment was to formulate and to apply those standards.[4]

Thus the enlightenment claims were initially that there <u>are</u> universal standards of truth and right answers to ultimate questions; that these answers are available to everyone through the use of reason with no need for special revelation or other sources of "values" beyond reason; and that these ultimate answers have the force of undeniability (that is, they "force themselves" on the conversation in a way that can not be reasonably denied).

Initially it was believed that this conception did not require a prior commitment to an atheistic or naturalistic cosmos. The world's order was viewed as God's own mathematical order, such that the rational study of this order was akin to studying God's own word or intentions. For Descartes, whose November dream involved visitations by the Blessed Virgin, nature's laws are orderly and predictable because of the eternal stability of God's will[5]:

> One thing is clear: not only was there in some intellectual leaders a great aspiration to demonstrate that the universe ran like a piece of clockwork, but this was itself initially a religious aspiration. It was felt that there would be something defective in Creation itself...unless the whole system of the universe could be shown to be interlocking, so that it carried the pattern of reasonableness and orderliness.[6]

Yet it was not very long until the limits of reason's authority were being pressed by the mainstream of intellectuals. For many, universally accepted standards for all truth and right did *not* seem to be forthcoming from reason. A sharper distinction emerged between the truth, ethics and beauty that *are* describable and attainable in public discourse through careful observation (such as scientific claims, or legal arrangements to protect property), and the values, opinions, and convictions that were considered private and subjective, and hence awkward for public discourse.[7]

For some, private beliefs seemed to be not merely benign personal relics, but capricious and superstitious impediments to careful observation, reason and advancement. Universal moral truths might exist, but directly linking them to our sensory experiences appeared unlikely to them; since these moral truths could not be empirically verified, skepticism emerged that we could ever have genuine knowledge of them. Hume is probably the best recognized speaker at this turn in the conversation, advocating a straightforward <u>empiricism</u> as the direction for intellectual endeavor. Much of the ensuing conversation about data and models departs from a conviction that universal values exist, available through reason and observation; instead, the observable and measurable becomes the focus of investigation.

This growing emphasis on empirical evidence to the exclusion of other considerations can be associated with a generally *naturalistic* view of the work of science. One well-known observer expresses the skeptical mood that motivated naturalistic empiricism:

> Science was born of a faith in the mathematical interpretation of Nature, held long before it had been empirically verified... The turn to experimentation was an anti-rationalist movement, a movement away from the unending and hitherto profitless speculation of a waning religious spirit and away from religious dogmatism so often proved wrong.[8]

D.C. Phillips has pointed out that the phrase "naturalism" suffers from an overabundance of interpretations, from the Romantic emphasis on submission to nature, to non-experimental methods in social science, to various forms of nudism.[9] But our (philosophical) meaning refers to

> ...a scholar who attempts to explain phenomena that occur within the realm of the physical universe in terms of concepts and explanatory hypotheses that themselves refer to this same "natural" realm; in other words, the naturalist eschews explanations in terms of (literally) super-natural or meta-physical entities.[10]

For scientists operating within this account there is no God, at least none that matters to our work as scientists and analysts; we are free (in fact, under obligation) to be methodological atheists. Whereas Descartes exempted both God and the human soul from the mathematics of the motion of objects, for many working within the empiricist framework there is strictly deterministic (or possibly probabilistic) causation in the universe. Persons may then be thought of as an element of this deterministic cosmos: our love, our thought and language, our religion, our philanthropy and social orderings are interpreted as expressions of our basic unity with non-human nature.

5. Some Implications

These themes eventually gave birth to several characteristic ways of doing the social and decision sciences. One is the conception that models originate from the raw materials of value-free, objectively measured facts, where a strong distinction is held between facts and values. For instance, most of modern economic analysis is conducted under the presumption of a strong division of positive from normative issues. Another characteristic habit of the modern social sciences has been the interpretation of love, marriage, education and altruism as responses that endure because of their survival value; evolutionary drives toward fitness are also seen as forces behind literature, mathematics, humor or morality.[11]

Marx gave a different but enduring account of the naturalistic forces presumed to be driving human history, with implications for the ways Marxists view human art, morality, work, insanity, law enforcement, literature, religion, accounting, and management science. Skinner and Freud also gave fundamentally naturalistic accounts of human behavior.

And the ascendancy of mathematics in the social sciences in our century is no doubt in part a reflection of mainstream acceptance of some of the naturalistic empiricist worldview. John Stuart Mill and Herbert Spencer are often credited with influencing the human studies in this direction,[12] though a more enduring and fundamental influence was likely the work of Auguste Comte and his account of *positivism*.[13]

Comte's argument that the empiricist methods of natural science can be borrowed by the social sciences begins with the claim that the central methods of science are the only methods that create real knowledge:

> All competent thinkers agree with Bacon that there can be no real knowledge except that which rests upon observed facts. This fundamental maxim is so evidently indisputable if it is applied, as it ought to be, to the mature state of our intelligence.[14]

Comte did not claim that only measurable things could exist or be true, but did believe that absolute truth about origins or the "hidden causes" behind the things we sense is unknowable and unobtainable, and therefore not worth the search. Thus for Comte science is limited to the study, through reason and observation, of the regularities or laws that characterize observable phenomena. Sensations, or sense-data, are the elements of knowledge on which one may rely, and there is no good reason to think that anything but sensation actually exists.[15] Comte does not accept religious or meta-sensory explanations for empirical phenomena, since the ideas in these explanations can not be justified by the data. Thus classical positivism encourages religious skepticism. Science might be a means toward generalizing about our sensations, as long as one avoids careless inferences about causes. [16]

Classical positivism led, by the 1920s and 1930s, to Logical Positivism, which was especially influential in North America. Logical positivism is best known for advocating the "verifiability principle (or criterion) of meaning."

Statements that can not be verified (and, in principle, refuted) by direct sensory experience are held to be meaningless, and statements are only meaningful if empirically verifiable[17]; if it can not be sensed, it can not be discussed. For example, consciousness is not observable, but behavior is. Unobservable items can not be subjected to tests; thus for a logical positivist theories about consciousness are both unscientific and meaningless, but theories about behavior are not. From this perspective verifiable direct sense experience is theory-free, neutral, and foundational, the proper object of science. Even "theories" or models may fail to meet these standards, since they may be generalizations that can not be directly sensed. Some logical positivists were therefore skeptical about the standing of theories as knowledge.

We should point out that, as we are about to see, the label "positivist" is often used too casually, and does not include everyone impressed by scientific achievement, nor all those who do numerical research, nor everyone who expects some support for claims that are advanced.

6. Objections to the Dream: Anti-realism

The Dream of a mathematized analysis transcending personal differences has encountered serious objections since the 1950s, some of which we are about to review. But we should begin by remembering that there has always been an intellectual counterpoint to the dominant theme we have developed so far. Whereas we have been emphasizing the so-called *realist* instinct and its influence in the sciences, there has also been, to varying degrees in different eras, an *anti-realist* rejoinder. Instead of tending to view humans as passive observers or sensors, one could tend toward the view that we persons are ourselves the agents who determine the structure and nature of the cosmos.[18]

On this view, things external to the person (such as cars, managers, census data) do exist, but their existence and structure *as these things* is not their own, waiting to be verified; it is granted them by the thought processes of humans. The basic structure of the cosmos is licensed by the way the human mind constitutes that cosmos. Why do we recognize anything as "car," rather than merely "3000 pounds of metal and plastic" or "moving object on smooth surface?" How do we know that a change in shape does not make a car into a non-car, but does make a bottle into a vase? Why do we know the difference between "manager" and "worker," when both are, in an objective sense, identical natural items of flesh and blood? What makes some numbers about people "census data," and other similar numbers "anecdotes" or "credit reports" or "attendance figures?"

So for antirealists the fundamental architecture of the world, its space and time, the division of reality into objects and assignment to objects of relevant properties, the divisions between fact, truth, error, and guess, the differences between necessary and sufficient and possible and probable--these distinctions are not necessarily properties of the cosmos or of things in the cosmos, but are the result of human mental creativity. Even the difference between existence and nonexistence might be viewed as a distinction that we humans bring to the world, not something that exists externally, waiting to be discovered.

Hence the appellation "antirealist:" Without human interpretive activity, there might not be anything true or false, likely or unlikely, limited or abundant, filling space or passing time. Things are not "real" outside of our experience and interpretation of them. Humans are the measure of all things.

And does this mean that there is some "general human consciousness" that structures the world so that we all agree what a "car," "manager," and "census" are, or do we each create our own cosmos? Since numbering elements of reality is an activity of the person, not the cosmos, there may be no good answer to the question, unless one can presume that there are some structures, unconstructed by the mind, that are common to all human minds. Thus antirealism seems bent toward relativism, not only in what we normally recognize as ethics, but in the ways we use and interpret language, manipulate symbols, decide what to do, and model or categorize the world. In the hands of an antirealist, modeling might be thought of not as a means of discovery, but of self-expression (or, for skeptics, manipulation); statistical methods might be tools not of learning, but of advocacy.[19]

Now that realism and antirealism have been introduced, consider how differently the two views think about objectivity and subjectivity. The realist tradition has thought of knowledge as something that is built up from either

our uninterpreted experience of the world (like sense-data) or our ability to reason. We then aim to form generalizations around the dispassionate observation of these objects, withholding judgement and keeping our natural likes and dislikes out of the way. An objective view of the external reality develops from the professional community, outside ourselves, relatively unscathed by our own framework or preferences. Here there is an attempt to establish a basis for truth that is independent of persons, intersubjective but beyond or without personality.

But for a person with antirealist instincts, there is no fundamental external reality for us to confront with reason or observation. Observation itself is motivated by a prior ordering of the world, and it is difficult to see how these prior orderings can be challenged by evidence, when the theory itself determines which evidence counts.

7. Disappointments with the Dream

While both positivism and various forms of antirealism have competed for the attention of the social sciences, it is clear that in the long run positivism has been more influential. The grand program envisioned by Descartes and Leibniz was influential in the formation of the modern social sciences. Much of the empirical work in the social and decision sciences, represented in most mathematical-methods textbooks and in the work of most practitioners, still operates as if it were the value-free confrontation between theories and objective facts, by which we are led ever more deeply into truth.[20]

Yet much of the perceptual psychology and philosophy of science underlying Descartes' and Leibniz's program is considered discredited even by those who are not anti-realists, especially among the last two generations,[21] though much of the practice of the social sciences has not yet responded to these developments. In order to complete this chapter of introductions to the conversation about just how values, data, and models should interact in the social sciences, we present some basic notes about the decline of positivism as an intellectual force. We do this by briefly considering Thomas Kuhn and Karl Popper.[22] After discussing the contributions of these two leading critics of positivism, we will be in a much stronger position in the rest of the book to consider how best to approach the principled use of data and models in the human and social sciences.

8. Post-Positivism

Popper is known for his advocacy of a so-called non-foundationalist attitude toward what humans can claim to know. Along with Popper, many would agree that there is no absolutely dependable foundation within human thought---not reason, not empiricism--for the claims we make, such that one could be so certain of a position that all opportunity for changing one's mind in the future would be rejected. In particular, sense-experience is not a solid foundation, as it is influenced by the very theories we hope to challenge with it. All of our claims to know something must be tentative:

> The question about the sources of our knowledge ... has always been asked in the spirit of: "What are the best sources of our knowledge--the most reliable ones, those which will not lead us into error, and those to which we can and must turn, in case of doubt, as the last court of appeal?" I propose to assume, instead, that no such ideal sources exist--no more than ideal rules--and that all "sources" are liable to lead us into error at times. And I propose to replace, therefore, the question of the sources of our knowledge by the entirely different question: "How can we hope to detect and eliminate error?"[23]

This is not to say that there is no truth outside ourselves to be discovered. In responding to those (whom he here calls “idealists,” in the philosophical sense) who emphasize that theories are developed by fallible analysts, Popper argues that there is indeed a truth outside the observer to be discovered, and that theories should aim to be true descriptions of the external world and its regularities:

> ...[Theories should be] genuine conjectures--highly informative guesses about the world which although not verifiable (i.e., capable of being shown true) can be submitted to severe critical tests. They are serious attempts to discover the truth... even though we do not know, and may perhaps never know, whether it is true or not.... Theories are our own inventions.... This has been clearly seen by the idealist. But some of these theories of ours can clash with reality; and when they do, we know that there is a reality; that there is something to remind us of the fact that our ideas may be mistaken. And this is why the realist is right.[24]

Yet Popper admits the difficulty of knowing whether we have actually discovered something that is true:

> The status of truth in the objective sense, as correspondence to the facts, and its role as a regulative principle, may be compared to that of a mountain peak which is permanently, or almost permanently, wrapped in clouds. The climber may not merely have difficulties in getting there--he may not know when he gets there, because he may be unable to distinguish, in the clouds, between the main summit and some subsidiary peak. Yet this does not affect the objective existence of the summit...The very idea of error, or of doubt...implies the idea of an objective truth which we may fail to reach.[25]

Thus one may not know if one is really near the truth, but the possibility of being nearer or farther away still can serve as a *regulative principle or ideal*. There is no use giving up and concluding that any claim is as good as any other. Some claims are more warranted than others.

If our preconceptions and theories always color our observations, then what is the best the community of scholars can do in judging which claims are nearest the truth? Popper argues that scientific claims must be falsifiable. It is no use inductively putting together generalizations or theories from sources (like reason or data) that were alleged to provide a firm foundation. Better to pay relatively little attention to the sources for the theories, and instead turn attention to whether their implications are testable, and if so whether these tests falsify the claim being made.[26] For Popper, this is the only kind of inquiry that can qualify as science.

> So my answer to the questions "How do you know? What is the source or basis of your assertion? What observations have led you to it?" would be "I do not know; my assertion was merely a guess. Never mind the source, or the sources, from which it may spring...But if you are interested in the problem which I tried to solve by my tentative assertion, you may help me by criticizing it as severely as you can.[27]

In fact, too much concern with justifying the basis of scientific work may actually be harmful:

> ...we cannot rob the scientist of his partisanship without also robbing him of his humanity, and we cannot suppress or destroy his value judgements without destroying him as a human being and as a scientist. Our motives and even our purely scientific ideals... are deeply anchored in extra-scientific and, in part, in religious valuations. Thus the "objective" or the "value-free" scientist is hardly the ideal scientist.[28]

For Popper, objectivity is not within the ability of any individual. Objectivity is a characteristic of the group rather than the individual; it is the result of the process of submitting one's work to critical review by peers. It is to be pursued in the context of justifying or falsifying results, not the context of discovering or proposing new approaches.[29]

So Popper's non-foundationalist ideas and his realism lead to an emphasis on falsifiability.[30] This attempt to falsify theories has the unfortunate potential to catch us in a circular trap: It is clear that the theories scientists hold will influence their decisions about which data are counted as relevant to science. Theories direct the scientist's attention toward some topics and measures, away from others. Then if a particular theory becomes the convention of a scientific community, practitioners' attention might be directed away from data that would falsify the mainstream theory. These nonconformist data become "outliers" or "noise" in the data set, or the data that would falsify the theory may never be generated in the first place. The profession can fall into a "group-think" culture that reinforces itself through its professional standards. Thus data alone, analyzed without considering the professional context that generates them, can not be the rock-bottom arbitrators between believable and unbelievable.

This leads to the importance of the work of Thomas Kuhn. If data actually provided a solid foundation for scientific work, one would expect knowledge to grow slowly through the layering of discovery and theorizing. But actual science is dynamic, subject to fits and starts; theories are overthrown, old data are reinterpreted in new ways.[31]

Kuhn interprets this dynamism of science as an interplay between *normal* and *revolutionary* science. The scientific community usually does its normal science within some particular mental framework that directs one's attention to certain concepts, data and problems. Data are not pure sense stimuli, but are the result of a process of classification and measurement. Data are judged useful and theories are judged fruitful or nonfalsified relative to a current set of presumptions in the discipline-- a latent consensus regarding which data are relevant to which questions, which regularities require explanation, which things are natural order and which others are deviations, and which

assumptions and questions are reasonable. Data that do not confirm the current paradigm, or that would falsify part of it, may not enter the discussion. Thus theories carry with them a worldview, a *Weltanschauung* that colors one's judgement about the presumptions, interests and framework of other theories.

Scientific revolutions, changes from one kind of normal science to another, occur when there is a *paradigm shift.* The fundamental way in which the community views the world changes; the concepts, data and problems that preoccupy the community are altered. Revolutions are normally triggered by the admission of events that cannot easily be reconciled to the current paradigm of normal science. The professional consensus about the conventional paradigm erodes, the community endures a period under several competing paradigms, and a new candidate for consensus emerges. The new paradigm is expected to be logically incompatible with the former consensus, generally involving different values and standards. In effect one *Weltanschauung* is replaced by another.[32]

> Scientific revolutions are...those non-cumulative developmental episodes in which an older paradigm is replaced in whole or in part by an incompatible new one.[33]

So Kuhn is clearly not a positivist; science is ultimately more a matter of persuasion than of observation and proof. Is he therefore an antirealist? Can anyone step outside of one's own paradigm to critically view the world through a different one? One might argue that, if different paradigms were incommensurable, with our meanings depending in a radical way upon our paradigm, we would each be trapped in our own judgements, values and standards. These would be nearly unchallengeable from within the paradigm. No paradigm could be judged superior, since such judgements and even the language of observation must be made from within some paradigm. There would be no neutral observation language, set of questions to be answered, or standard for good science in the face of identical phenomena. If different paradigms were not mutually intelligible, it would not make sense to ask which is more persuasive about a given point; each paradigm would be left with its own truth.

This kind of absolute relativism seems unpersuasive to many[34] and bears a difficult burden of proof: It must show that, unlike everything else, it is true for everybody. Kuhn appears not to be such a relativist. Two practitioners from different paradigms see different things when looking at the same event, but there is a real event to be observed, and in practice there exist large shared vocabularies across paradigms to describe the event.
As he put it,

> Though the world does not change with a change of paradigm, the scientist afterwards works in a different world.[35]

Nevertheless Kuhn's work has sometimes been presented as an anti-realist approach to the social sciences. This may be due to his initially-loose use of the word "paradigm." Though it is the central concept in Kuhn's thesis, several reviewers have pointed out that he uses it in twenty-one different ways, some of which are not mutually consistent.[36] Some uses correspond to a *Weltanschauung*, while others clearly do not.[37] Thus

> the truth of the thesis that shared paradigms are (or are behind) the common factors guiding scientific research appears to be guaranteed... by the breadth of the term 'paradigm'. ... Kuhn's view is made to appear convincing only by inflating the definition of 'paradigm' until that term becomes so vague and ambiguous that it cannot easily be withheld, so general that it cannot easily be applied, and so misleading that it is a positive hindrance to the understanding of some central aspects of science. [38]

Kuhn has responded by indicating that the unfortunate term "paradigm" blended two separate notions: *exemplars* and *disciplinary matrixes*. Exemplars are particular instances of work that are accepted by the scientific community as models for how a particular subject should be approached. Disciplinary matrixes are the shared items that allow professionals to communicate clearly and reach a professional consensus. These include shared symbols, values, and beliefs in exemplars.

Normal science therefore proceeds within a common disciplinary matrix or *Weltanschauung*. Though it cannot be fully stated, it would include ideas about how the basic items in the world interact with each other and with our senses and measurement instruments, what questions are important about these items, and what methods are appropriate in pursuing these questions. Students learn this matrix by studying the part of it that is easily made

explicit and archetypical, the exemplars. Exemplars are well-known, characteristic applications of the community's theories to the community's subject; they give the community its archetypes and metaphors for how good scientific work is done.

A scientific revolution is a shift of thinking, in which factions of practitioners begin to hold up new exemplars as the archetypes of good science. This leads the revolutionary factions to prize different questions, cite different data, form a different disciplinary language, and in general hold different professional values. A full revolution occurs when the entire community embraces the new disciplinary matrix, with different research agendas, language, values, and standards.

A revolution may not happen automatically just because a new theory fits some observations more closely than the old theory. The new theory may still be judged to raise less significant questions, give less substantial answers, or be less fruitful in advancing the discipline. The new theory may not become a convincing model or archetype of how to do productive science.

9. From Principles to Practice

We have argued that the practice of the social and human sciences is still heavily influenced by positivism, even though the basic hallmarks of positivism have been discredited. In raising questions about positivism, Popper and Kuhn have explored intermediate positions between classical positivism and antirealism. Our discussion has reviewed several themes that have gained currency with the decline of positivism: Though truth-claims in the social and human sciences must be somewhat tentative, objectivity can still serve as a regulative principle toward which one strives. In pursuing objectivity, we should pay special attention to the process through which ideas are established and error is identified and eliminated. Throughout the process, one must remain open to the possibility that the entire framework of analysis may be misdirecting one's attention.

How could the daily work of practitioners incorporate these themes? This is a question we pursue in the rest of the book. We will walk step-by-step through the topics and practices that form the standard introductory econometrics course, seeking at each point to also make a beginning in sifting the practices and habits of the social and human sciences.

* This is a revised version of Chapter Three from *The Uses and Misuses of Data and Models: The Mathematization of the Human Sciences*, which I wrote with James Bradley. The endnote references refer to the bibliography of that book.

1. Marsden.

2. Kline, 106-107.

3. Kline, 105, 107.

4. Quoted in Neuhaus, 15. For a full discussion of MacIntyre's views on the topic, see MacIntyre, 1981, Chapters 4 and 5, or MacIntyre, 1988, Chapter 12.

5. Kline, 108.

6. Butterfield, 119.

7. See, for example, Kant for a classic rendition of the connection between the public reason of scholarship and the private reason of the religious sphere.

8. Kline, 109.

9. Phillips, 36.

10. Phillips, 36.

11. See, e.g., Bergstrom, 58.

12. See, e.g., Mill, Sixth book, Chapter 3, and Spencer, 1855.

13. We will discuss Comte, Popper, and Kuhn in some detail in this chapter. For each we try to outline his conception of the method, scope, and source of knowledge of science.

14. omte, 4.

15. ee, e.g., Popper, 1985, 106.

16. There is some circularity in the reasoning here. Since we can not directly sense or experience theories and laws and generalizations, a classical positivist should have some skepticism about the possibility that theories are a legitimate subject of science. Yet Comte makes such generalizations the aim of science, perhaps as a shorthand way to refer to direct sensory experience--what we might call "operational definitions." John Dewey and William James approach this problem by arguing that we can directly experience theories and generalizations and "possible" objects; these are not mere constructions.

17. Or, in the case of math and logic, statements can be meaningful if they are analytic.

18. Kant's Critique of Pure Reason is sometimes identified as a modern genesis of this view, though as always identifying any particular person as an anti-realist will raise objections from some.

19. It is possible to recognize the antirealist voice in some schools within the social and decision sciences. Richard Rorty has emerged as a contemporary widely-read popularizer of some of these approaches. Some forms of "advocacy research," scholarship that seeks support for the advocacy of some group or cause, also are in debt to antirealism. And, as we shall see in Chapter 5, the approach to measurement that characterizes much of psychometrics has a highly antirealist flavor.

20. One might offer the interest in qualitative research as a counter-example. But our reading is that qualitative researchers are concerned that careful observation be done (rather than rough-riding into a situation with too-easy generalizations) and that appropriate measurement indexes be relied upon (rather than forcing every trait to be represented by a cardinal scale). Qualitative researchers may still be giving too little attention to the weaknesses of positivism.

21. One wonders why this situation of professional inertia surrounding discredited ideas persists. One explanation argues that positivism has been "institutionalized," as the philosopher of science Hillary Putnam puts it. We expect this is partly because of the use to which social science has been put by the institutions of public policy since the 1950s (see Chapter Nine), and partly because positivist methods grant more cumulative knowledge than the more interpretive alternatives. There also may be financial incentives in favor of positivism, such as the rationalization of business activities it allows and promotes. This is probably clearest when it takes the form of computer technologies.

22. A helpful discussion of these authors is spread throughout Phillips' book.

23. Popper, 1968, 25.

24. Popper in Lewis, 115, 117.

25. Popper in Lewis, 226.

26. Popper's emphasis on falsifiability is sometimes countered with the Duhemian hypothesis: In practice, any test of a particular theory requires simultaneous reliance on a host of other assumptions and theories. Thus if the experiment appears to falsify the theory, we can not really be sure if the primary theory should be rejected, or if one of the collateral theories or assumptions is at fault. Thus any theory might be "insulated" from falsifiability.

27. Popper, 1985, 53.

28. Popper, 1976, 97.

29. We might add here that, since falsification of a theory is possible but confirmation is not, Popper argues it is unwise for a community to hold one mainstream theory and exclude all others. A large number of conjectures/theories should mark the scientific community. For Popper, this is how science progresses--not through the gradual inclusion of new observations under an expanding orthodox theory, but by testing many competing conjectures. The terms used by one theory can still be understood within other theoretical frameworks and by practitioners who do not accept the theory, and at least some questions are straightforward true-or-false issues; so theories can be compared and falsified by experiments, and knowledge can grow.

30. This is not to say, with the logical positivists, that non-falsifiable claims are meaningless. They may still be true, but they are not science, because they are not subject to falsification; they can not enter the process by which we authorize a conclusion as "objective," that is, warranted because it has not yet been falsified. So an idea can be true, but not objective, because it is not scientific. An idea could also be scientific and objective (not yet falsified), but prove later to be untrue. Neither objective (falsifiable) nor subjective (non-falsifiable) ideas are necessarily closer to the truth, but at least objective ones can be submitted to a rigorous review process that seems to give them a wider warrant.

31. Data also fail as the ultimate foundation for some science because scientific theories extend to unobservable realities (like subatomic structures).

32. We might wonder whether, in the social and decision sciences, there is a draw-able distinction between normal and revolutionary science. Does "normal" science ever occur, with a broad consensus on the discipline's scope and methods, or are social and decision sciences in a state of perpetual pluralism, not cumulatively achieving closure on basic paradigm questions? If the latter, then Popper's hope that a large number of conjectures should mark a scientific community is fulfilled, and the need for Kuhnian consensus-revolutions is partly overcome.

33. Kuhn, 1962, 91.

34. See, e.g., Newton-Smith or Siegel.

35. Kuhn, 1962, 120. See also 128 or Section X.

36. See, e.g., Masterman or Shapere.

37. See, e.g., Suppe, 1974, 136.

38. Shapere, 385, 393.