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Editors

Is Science Compatible with Free Will?

Exploring Free Will and Consciousness in the Light of Quantum Physics and Neuroscience

Springer

Chapter 15
Are Economics Laws Compatible with Free Will?

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Abstract I argue that determinism at the aggregate level of economic behavior is compatible with uncertainty at the individual level, and that the latter results essentially from individual free will.

Keywords Economics • Free will • Uncertainty

15.1 Introduction

Are economics laws compatible with free will? Such was the question I was challenged with in preparation for the Social Trends Institute (STI) meeting, *Is Science Compatible With Our Desire for Freedom*, Barcelona, October 2010. I am going to be quite frank: this is not a question that economists frequently consider. Or, to put it differently, the great majority of economics researchers will reply that the answer is trivially yes. However, as one digs deeper into the philosophical issues at stake, one realizes that things are not as simple as they seem at first.

In this short paper, I do two things. First, by drawing a parallel with the physics dichotomy of classical mechanics and quantum mechanics, I show how determinism at the aggregate microeconomics level is compatible with uncertainty at the individual microeconomic level. Second, I argue that uncertainty at the individual microeconomic level is observationally consistent with various theories of human behavior, which may or may not make room for free will. Third, I compare the level of predictability (or lack thereof) of behavioral sciences to that of nonbehavioral sciences, arguing that model complexity, rather than human freedom, is the main explanatory factor.

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A. Suarez and P. Adams (eds.), *Is Science Compatible with Free Will?: Exploring Free Will and Consciousness in the Light of Quantum Physics and Neuroscience*,
DOI 10.1007/978-1-4614-5212-6_15,

Before getting into these three main points, however, I offer for the benefit of readers less acquainted with economics a brief summary of its core elements: the homo economicus model.

15.2 Homo Economicus

Neoclassical economics is largely based on a model of man where rational thought is given to alternatives and decisions are made optimally. This is commonly known as the "homo economicus" model. Mill, J. Stuart, the source of the term, defined the economics approach as follows:

> [Political economy] does not treat the whole of man's nature as modified by the social state, nor of the whole conduct of man in society. It is concerned with him solely as a being who desires to possess wealth, and who is capable of judging the comparative efficacy of means for obtaining that end. (Mill 1836)

Mill and fellow philosopher Bentham, J. went further by proposing the concept of "utility" as the measure of satisfaction that an individual derives from a certain choice or state of the world. The "homo economicus" model could then be rephrased as a process where choices are made in order to maximize utility.

A few decades after Mill proposed the homo economicus model, F. Edgeworth claimed that developments in "physio-psychology" would eventually allow for the direct measurement of the utility mapping. He even coined the term "hedonimeter," the instrument to measure an individual's utility (see Colander 2007).

Edgeworth did not live to see anything close to a "hedonimeter," and it became generally accepted that utility could not be measured or observed directly. The core of neoclassical economics then became largely an axiomatic, deductive process. The basic axiom is that each individual is endowed with a set of preferences, a choice set which is a totally ordered set,[1] and that the individual always chooses the maximum point from that set.

In this context, utility is mainly used as a construct for describing an individual's preferences and actions. In fact, although utility cannot be directly observed, it can be indirectly measured. Based on actual choices made by an individual and based on the above axiom of optimal choice, one can uncover a mapping that gives the value (utility) of each option faced by an individual.[2] This simple idea, which is fairly intuitive though not trivial to prove, was developed by Samuelson and is known as the theory of revealed preference (see Samuelson 1938).

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[1] That is, a set of options together with a "preference" binary relation that is transitive, antisymmetric, and total.

[2] Note that this mapping is only unique up to a monotonic transformation. For example, if I say that each of my possible options give me twice as much utility as before, then my optimal choices remain the same.

This is in essence the nature of economics as a behavioral science. Notice that homo economicus is essentially a deterministic model. However, as Stuart Mill points out in the above quote, the homo economicus model is purposely a partial treatment of "man's nature." As such, it would be imprudent to derive conclusions regarding human freedom from the fact that we use a deterministic model. I next turn to this issue in greater detail.

15.3 Heisenberg Uncertainty and Behavioral Uncertainty

Are economics laws compatible with free will? My best answer is to strike an analogy with physics. As M. Heisenberg rightly pointed out,

> Almost 100 years ago, quantum physics eliminated a major obstacle to our understanding of [the issue of freedom and determinism] when it disposed of the idea of a Universe determined in every detail from the outset.

What does this mean in practice? At the scale of planets and at many intermediate scales, quantum effects are of second order, and the deterministic laws of classical mechanics apply reasonably well. In fact, much of what is currently taught at engineering school is still largely drawn from classical mechanics. In other words, there are a series of systems that may safely be treated as "deterministic" even though we know that deep down there is a fundamental source of randomness and unpredictability. More formally, the above statement corresponds to the *correspondence principle*, first formally enunciated in Bohr [1920].

Mutatis mutantis, the same can be said about economics models: at an aggregate level, we may safely treat them as approximately deterministic and "exact" models, even though at the individual level there is a lot of residual randomness. For example, the body "automobile buyers in California" may be treated very much in the same way as a planet would be treated in physics (a body with predictable, deterministic behavior responding to outside influences). However, the body "automobile buyers in California" is composed of individual buyers who, like quantum particles, behave in ways that are at least apparently random.

Let me continue to illustrate the idea with the example of automobile purchases.[3] Suppose there are I individuals ($i = 1, \ldots, I$), each of whom must choose between J different car models ($j = 1, \ldots, J$). A car model may be described by a series of K quantifiable characteristics ($k = 1, \ldots, K$). Examples of car model characteristics might be size, fuel efficiency, acceleration, and so on. Finally, each individual i may be characterized by a series of D demographic indicators $d_{i1},\ldots,d_{iD}$. For example, d_{i1} might be household size or income level.

[3] For a deeper treatment of this type of models, see for example Train [1986].

A typical economic model of consumer choice starts from the notion of individual utility, in our example a measure of how much car model j is worth to consumer i. Suppose that

$$U_{ij} = \sum_{k=1}^{K} \beta_k(d_{i1}, \ldots, d_{iD})\, c_{jk} + \epsilon_{ij} \tag{15.1}$$

In this equation, U_{ij} measures the utility that model j gives consumer i; c_{jk} measures model j's performance along dimension k (e.g., how much car model j possesses the characteristic k, where k may refer to things like size or acceleration—or price, a particularly important characteristic); $\beta_k(d_{i1}, \ldots, d_{iD})$ measures how an individual with demographic characteristics $(d_{i1}, \ldots, d_{iD})$ values performance dimension k. For example, an individual with a large household will value more a larger car, whereas an individual with lower income will value more a car with better fuel efficiency. Finally, ϵ_{ij} measures residual utility of the match between individual i and model j. I will come back to ϵ_{ij} later; in fact, this residual component will be central to my discussion of the relation between economics laws and free will.

As mentioned in the previous section, a basic law of rational economic behavior is that each individual chooses the best option given the information the individual possesses. In the present case, and assuming that each individual knows the values of each car model characteristics c_{jk}, individual i chooses car model j' such that $U_{ij'} \geq U_{ij''}$ for all $j'' \neq j'$.

The formal statement of the above individual-aggregate behavior pattern (random behavior at the "atomic" level and deterministic behavior at the aggregate level) is a statistical convergence theorem, basically the law of large numbers.

Suppose for simplicity that ϵ_{ij} is a random variable with an extreme-value distribution, that is, with c.d.f. $F(\epsilon) = e^{-e^{(a-\epsilon)/b}}$.[4] It can be shown that as the number of individuals tends to infinity ($I \to \infty$), then the fraction of individuals choosing j converges almost surely to

$$x_j = \frac{1}{I} \sum_{i=1}^{I} \left(\frac{\exp\left(\sum_{k=1}^{K} \beta_k(d_{i1}, \ldots, d_{iD})\, c_{jk}\right)}{\sum_{\ell=1}^{J} \exp\left(\sum_{k=1}^{K} \beta_k(d_{i1}, \ldots, d_{iD})\, c_{\ell k}\right)} \right)$$

The deterministic nature of the above model can be explained as follows. For a given distribution of demographic characteristics in the population, and for given preference functions β_k, each car's market share is "deterministically" induced by the car's vector of characteristics $\mathbf{c}_j = (c_{jk})$ (including price) vis-a-vis the other cars' vectors of characteristics, $\mathbf{c}_\ell$, where $\ell = 1, \ldots, J$.

[4] This distributional assumption is particularly helpful in that it leads to closed-form expressions for market shares. For other distributions, only numerical solutions can be obtained. Nevertheless, the qualitative points I am making are still valid.

The probabilistic nature of the above model, in turn, can be explained as follows. For a given individual, even if one measures with precision the vector of demographic characteristics $\mathbf{d}_i = (d_{i\ell})$, there is considerable uncertainty as to which car model the consumer will choose. All we can do is to determine the probability of choosing model j, which is given by

$$P_{ij} = \frac{\exp\left(\sum_{k=1}^{K}\beta_k(d_{i1},\ldots,d_{iD})\,c_{jk}\right)}{\sum_{\ell=1}^{J}\exp\left(\sum_{k=1}^{K}\beta_k(d_{i1},\ldots,d_{iD})\,c_{\ell k}\right)}$$

15.4 Uncertainty, Measurement Error, and Free Will

There are of course important limitations in my parallel between physics (from quantum mechanics to classical mechanics) and economics (from individual behavior to aggregate behavior). First, the precision of measurement and prediction in the aggregate is considerably weaker in economics than in the physical sciences. In the physical sciences, the values of the relevant parameters can be determined with great precision, almost with arbitrary precision. In economics, by contrast, the values of β_k can only be obtained by statistical estimation based on historical data, a rather poor substitute for laboratory experimentation.

Second, whereas the functional forms that make up a physics model tend to be derived from a coherent conceptual framework, in economics there is a lot of arbitrariness in the choice of particular functional forms. For example, there is nothing in economic theory to indicate that the utility function (15.1) ought to be linear in the βs, or that the error term ϵ distributed according to a particular c.d.f.

More important, the source of randomness in individual behavior in economics is quite different from Heisenberg-type randomness: it is based on individual freedom, not on the behavior of individual particles. Even if I were to know everything about the history of a particular individual, I would still be unable to predict with certainty the individual's behavior when faced with a choice among J alternative options.

This is not an innocuous statement. In fact, uncertainty caused by measurement error and uncertainty caused by genuine free will are to a great extent observationally indistinguishable. In other words, one might argue that the reason I am unable to predict economic behavior is that I really don't know *everything* about the individual's history, possibly including minute details about the individual's brain activity.

Above I mentioned Edgeworth's dream of a "hedonimeter," something he was never able to see in his time. Today, however, we have tools that provide us with an abundance of data regarding the "physio-psychology" process that Edgeworth had in mind. As a result, Neuroeconomics—a combination of psychology, economics, and neuroscience—has emerged as a recent effort to understand, at the most basic level, how individuals make economics decisions. The idea is to measure and record brain activity at the moment of evaluation and decision making, specifically when an individual must choose between various economic options.[5]

The contribution of neuroeconomics can be thought of at different levels. First, it provides additional individual characteristics that contribute to an individual's choice (i.e.,, it increases the dimensionality of the vector $\mathbf{d}_i$ introduced above). Second, neuroeconomics offers a critique of the economics deliberative model, that is, the fundamental assumption that individuals make rational choices among alternatives. In fact, emotions and automatic responses play a crucial role in human decision making—as psychologists have known for a long time. More important for our present purposes, neuroeconomics provides a "platform" for a theory of deterministic human behavior: the idea that the only source of ϵ uncertainty is measurement error; the idea that if we are able to measure brain activity well enough, then economic behavior will be predictable.

I disagree with this view. I believe there is an irreducible degree of uncertainty which results from each individual's free will. I don't think economists can prove this—and for the reasons described above, I don't think it really matters a great deal from an economics practice point of view.

15.5 Freedom and Predictability

A common complaint faced by economics and economists is that they utterly fail when it comes to predicting events; and a common justification for such failure is that economics deals with "objects" that are endowed with free will (as opposed to nonbehavioral sciences, which deal with nonbehavioral phenomena). I will now try to argue that, notwithstanding fundamental differences between behavioral and nonbehavioral sciences, the "predictability gap" is not as great as many think, and moreover is not primarily caused by the behavioral element, as many argue.

Before talking about the important differences between behavioral and nonbehavioral sciences, it is worth to talk about what they have in common. Scholars who want to understand the world do so by building models, some more formal than others but nevertheless models: conceptual frameworks with various objects, parameters, variables, and relations. Among the great variety of models and realities to be modeled, I find it useful to distinguish between:

(a) Simple models, where a small number of objects and relations are considered; and complex models, where a large number of objects and relations are modeled.[6]

[5] See Glimcher [2003] and references therein.

[6] I am aware that the term "complexity" is frequently used in different senses (as in "complex dynamic systems"), but I could not think of a better term in the present context.

Table 15.1 A taxonomy of models, with examples

	Simple	Complex
Nonbehavioral	Heat and pressure lab experiment	Weather forecasting
Behavioral	Automobile sales	Global economy

(b) Nonbehavioral systems, where no animal or human behavior is involved; and behavioral systems, where either animal or human behavior is involved.

This two-dimensional classification leads to a matrix of possible models, which I illustrate in Table 15.1. In it, I suggest examples for each cell. Take the first row. Any elementary Physics 101 lab experiment would make a good example of something to study with a simple nonbehavioral model. Weather forecasting, by contrast, involves a large number of variables, objects, and relations, though it still deals primarily with nonbehavioral patterns.[7]

Consider now the second row, where I propose examples from economics, one of the leading behavioral fields of study. First, the study of consumer choice of automobile purchases (as described above) provides a good example of a reality to study with a simple model. "Simple" is a relative term: compared to a physics lab experiment there are many more variables to consider in a consumer's purchase decision; but by economies standards this is still a relatively simple decision. Contrast that to analyzing the global economy (e.g., will the world's economies fall into a "double-dip" or will we get out of the current recession? And if so, how soon?). Now we are dealing with a truly complex system, very much like the weather.

My point is that the degree of predictability varies more along the horizontal dimension than it does along the vertical dimension. In other words, it is more difficult to predict the weather than it is to predict automobile purchases.[8] This is not to deny the fundamental difference between nonbehavioral and behavioral models, namely human freedom. Rather, it restates the principle that I mentioned earlier that the law of large numbers provides an analogue in economics to the correspondence principle in physics (roughly, that in the limit quantum mechanics turns into "deterministic" classical physics).

15.6 Concluding Remarks

My main point is that the statistical regularity of aggregate economic behavior is compatible with irreducible uncertainty and unpredictability of individual behavior; and that the latter results from individual free will. In many ways, the point I am

[7] I deliberately avoid models of climate change so as to skirt the issue of human intervention.

[8] As the joke goes, God created meteorologists so that economists looked respectable. (There are, naturally, several versions of this joke, including the one where the roles of economist and meteorologist are reversed).

making about economics can also be made about other human and social sciences. The reason for my particular focus is that, among the social sciences, economics is the field that comes closest to the idea of a deterministic model of the sort offered by classical mechanics.

Finally, the idea that the individual will provide an irreducible source of uncertainty is not exclusive to human behavior. As Heisenberg [2009] points out, animal behavior "cannot be reduced to responses" and thus cannot be predicted based on a deterministic model. But by the same argument developed above, this does not negate the possibility that aggregate animal behavioral is essentially deterministic.

Acknowledgements An earlier draft was presented at the STI meeting, *Is Science Compatible With Our Desire for Free Will*, Barcelona, October 2010. I am grateful to the meeting's participants, Bob Doyle in particular, for comments and suggestions. Alas, I remain the sole responsible for errors and shortcomings.

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