

## Does Macroeconomics Need Microeconomic Foundations?

*Sergio Da Silva*

*Federal University of Santa Catarina, Florianopolis*

### **Abstract**

I argue that it is microeconomics that needs foundations, not macroeconomics. Preferences need to be built on biology, and, in particular, on neuroscience. In contrast, macroeconomics could benefit from rationalizations of aggregate economic phenomena by non-equilibrium statistical physics.

Special issue [Reconstructing Macroeconomics](#)

**JEL:** B22, B41, C82, D87

**Keywords:** Microfoundations; neuroeconomics; econophysics

### **Correspondence**

Sergio Da Silva, Graduate Program in Economics, Federal University of Santa Catarina, Florianopolis SC, 88049-970, Brazil,  
e-mail: [professorsergiodasilva@gmail.com](mailto:professorsergiodasilva@gmail.com)

*I thank the referee, the anonymous reader, Peter Sinclair (Bank of England and University of Birmingham), and Michael Lovell (Wesleyan University) for helpful comments. Mike told me that this paper reminded him of Bob Solow's remark that he would "rather be ad hoc than wrong." I also acknowledge financial support from the Brazilian agencies CNPq and CAPES (Procad).*

## 1 Introduction

Does macroeconomics need micro foundations? I presume, without having seen an opinion poll, that most economists think so. Here, I will challenge this presumed consensus and document some weaknesses in the common arguments that favor micro foundations. I will then argue that it is microeconomics that needs foundations, not macroeconomics.

Let me begin by recalling that the notion that macroeconomics should be based on microeconomic first principles became widespread after the Lucas critique (Lucas 1976). (See Janssen 2008 for the motivations behind this in the late 1950s and 1960s). The criticism was addressed to the use of large-scale macro econometric models then commonly employed to help policy making. Take monetary policy, for example. A central bank that adjusts its instrument interest rate hopes to affect all the nominal interest rates of the economy and thus the real interest rates. After all, inter-temporal consumption and investment expenditures depend on real rates. Here, the central bank assumes that the private sector's expectations of inflation are under control, but the problem is that they are not. Worse, people can react so as to make the policy unfeasible. Since the parameters of the macro econometric models of the time depended implicitly on people's expectations of policy decisions, they were unlikely to remain stable as policymakers changed policy.

The econometric criticism can be translated into purely theoretical terms. Consider one model of the macro economy where investment and labor demand are derived from the present value of net revenues of firm owners in a perfectly competitive environment (Scarth 1988). To get the present value, one has to resort to the discount factor  $\frac{1}{1+r}$  for every time period, where  $r$  is the real interest rate. If monetary policy can affect the real interest rate, it can also alter the investment and labor demand functions being derived. However, the econometric estimates of such functions cannot be used for policy purposes precisely because one needs new estimates of them every time the central bank shifts the policy instrument. This policy will work only if people do not react to the central bank's changes of the nominal interest rate  $i$ . However, people are likely to alter their expectation of inflation  $\pi^e$  as the central bank changes  $i$ . Because  $r = i - \pi^e$ , it is also unlikely that people will maintain a constant  $r$ .

The same rationale extends to consumers making inter-temporal decisions and to the interaction between firms and consumers in the labor market (Scarth 1988). First order conditions of a micro-founded macro model of this type can generate consumption and money demand functions along with the Phillips curve. As for the consumption function, it is the subjective marginal rate of substitution between present and future consumption that matters. However, this rate should remain invariant to macro policy shifts if policy is to be successful. If consumers also respond to policy changes, the Lucas critique applies. In the actual data, however, consumption and money demand functions may remain stable in the presence of policy shifts (Lindé 2001). This suggests that, although the Lucas critique may be in principle indisputable, its empirical relevance can still be questioned (but see Lubik and Surico 2006). The implications of the Lucas critique will be addressed below along with four other arguments that favor micro-founded macro models.

## 2 Arguments for Microeconomic Foundations

*Argument 1. The Lucas critique can be preemptively removed if one employs macroeconomic models with explicit microeconomic foundations.*

This argument is commonly suggested after presentations of the Lucas critique, but it is false. It is not guaranteed that the Lucas critique can be preemptively removed if one employs macro models with explicit micro foundations. The Lucas critique has no theoretical implications. At the time of his criticism, Lucas himself had observed that the question of whether a particular model is structural is empirical, not theoretical (Lucas and Sargent 1981). However, the critique has often been strictly interpreted as having theoretical consequences.

Thus, after the Lucas critique macroeconomic research was reoriented toward models with explicit expectations and “deep” parameters of taste and technology. These models were to be invariant to policy shifts. Examples include not only derived first-order conditions (such as those sketched above), but also general equilibrium models with explicit optimization and new Keynesian models.

As it happens, explicit expectations models can also be scrutinized empirically with tests of cross-regime stability. The tests show that even such macro models underpinned with micro foundations can sometimes be subject to the Lucas critique. What is more, some forward-looking models from the recent literature may be even less stable (and thus more susceptible to the Lucas critique) than their backward-looking counterparts (see Estrella and Fuhrer 2003 and references therein).

In contrast, empirical autoregressive macro models without explicit expectations were expected to be plagued by parameter instability. After all, popular monetary VARs, as an example, consider lagged representations of the economy as invariant structural models. The same goes for other non-expectational autoregressive macro models commonly employed in monetary policy analysis. Yet such kinds of model are widely considered to be useful for analyzing monetary policy. Why? Because VAR and non-VAR macro models without explicit expectations are often stable empirically (see Rudebusch 2005 and references therein).

In the end, what we can learn from the empirical tests of the Lucas critique is that no theoretical models can a priori prevent policy-parameter instability from occurring. This is not unexpected since the Lucas critique has no theoretical implications whatsoever.

*Argument 2. Microeconomic first principles are policy-invariant.*

The quest for first principles to underlie macroeconomics presumes that those principles are policy-invariant. However, there is no such thing as policy-invariant microeconomic first principles.

The Lucas critique applies to any shifts being predicted, not only policy shifts. Model forecasts may exhibit instability across time when shifts in policy regimes occur, but they can also be unstable if any behavior being predicted changes. If forecasts from a model are to be useful, the parameters must be invariant to changes in the entire expectations generating process, which involves any shifts being forecasted, not only

policy shifts. Lucas focused on policy invariance, but his criticism can be deepened along these lines.

In terms of the example in the Introduction, a policy change can alter the real interest rate being used in firms' inter-temporal calculations, but the policy (and for that matter any other change being forecasted) also modifies the rate of inter-temporal substitution being used by consumers. It is unreasonable to assume that this rate should remain invariant in the presence of changing forecasts. Because both the real interest rate and rate of inter-temporal substitution in consumption should be functions of expectations, every forecast made corresponds to a different real interest rate and a distinct rate of inter-temporal substitution. Here, one can even extrapolate and think of the multiplicity of equilibria that may occur due to the different beliefs held by individuals about the future behavior of others. If there are multiple equilibria, it is impossible to know how the economy will react to any particular government policy (Rotemberg 1987).

Thus, there is no way to specify first principles (such as the rate of inter-temporal substitution in consumption of the example) that are dependent on expectations and at the same time invariant to either policy or any behavior being forecasted. This implies that one must only check for model stability, regardless of the concern with invariant first principles. This means the focus should be on econometrics rather than economic theory.

As it is a purely econometric issue, one cannot learn a priori whether observed shifts in either policy or any behavior being forecasted are large enough to significantly alter the current model representation of economic variables. Similarly, one cannot learn a priori how agents form their expectations of future events. The adaptive versus rational expectations debate ends up useless. The stability or instability of a macro model is an empirical, not a theoretical issue. (See Estrella and Fuhrer 2003 for more on this.)

Also, the failure to reject stability across observed shifts in historical data does not guarantee stability in the presence of shifts that have not yet occurred. To complicate matters, the nature of econometric tests is such that one cannot prove stability; one can only fail to reject stability (Estrella and Fuhrer 2003).

*Argument 3. New Keynesian macroeconomic models are founded on sound microeconomic first principles.*

One common modeling strategy applied in most new Keynesian macro models is to justify the traditional "ad hoc" Keynesian assumption of sticky prices using monopolistic competition. After all, if some individual firms set prices, they should operate under, say, the market structure of monopolistic competition. This is so because it is hard to think of a Walrasian auctioneer keeping prices rigid (Rotemberg 1987). However, though monopolistic competition is part of any microeconomics syllabus, it is hardly a first principle. First principles have to be identified inside consumer choice theory, where the axioms about preferences are stated. Market structure is a feature of the economy as a whole.

The individual consumer of axiomatic choice theory makes his optimal consumption decision in an environment where transactions occur in markets – large markets to be precise, such that consumer purchases cannot affect prices. The consumer then considers all the market prices as set. Yet, if there are markets, it is implicitly assumed

that there is at least one seller in addition to the consumer. However, firms enter the stage only after consumer theory is complete, and then the discussion of their power to set prices takes place. The absence of power occurs under perfect competition, it is argued, and monopolistic competition is just another such environment where firms have some power to set prices. Thus, the market structure of monopolistic competition cannot be a micro first principle simply because it is not an ingredient of fundamental value theory.

When providing a deeper reason for prices to be rigid, new Keynesians either (Rotemberg 1987) (1) tell stories of individual firms with explicit costs for changing price, or (2) directly restrict the frequency of price adjustment. As for (1), only small price rigidities at the individual firm level are required to generate large output changes in the aggregate. This happens because the profit functions of individual companies that set prices are horizontal at the individual optimum price. Small deviations from the optimum price lead to negligible losses for the individual firms, but they also lead to large aggregate output swings (Rotemberg 1987). Though insightful in justifying why price rigidity is not implausible, reasons (1) and (2) are not compelling enough to overcome the hard fact that keeping prices flexible is cheaper (Rotemberg 1987). Telling the familiar story that “small menu costs of individual firms can generate large business cycles” sounds over-elaborated. In any case, all of the rationales in (1) and (2) assume, of course, that the underlying market structure is either monopolistic competition or any differentiated-product imperfect competition setup. (See Janssen 2008 for an in-depth analysis of the new Keynesian stories of micro foundations, and also for the views of post-Keynesians and Austrian economics.)

Why rely on firms, rather than consumers, to justify sticky prices? New Keynesians could have taken a different path. As they have specialized in macroeconomics, they may be unaware of the alternatives to axiomatic choice theory, such as the challenge posed by experimental economics and its theoretical consequences. New Keynesian macroeconomics could still be rooted in first principles, but not those of either core axiomatic theory or expected utility theory, its extension to risky choices. Why not try prospect theory? This theory’s hallmark is that individual behavior is not the expected result of a choice, but arises from consumer asymmetric response to gains and losses. One implication is precisely the fundamental Keynesian notion that individuals will respond more to price increases than to price reductions. This is so because the loss associated with a price increase is valued more than the gain accruing from a price reduction, which means that demand elasticity is different for increases versus reductions in price. A price increase alters the quantity demanded more, and thus the demand elasticity for price increases should be larger, making the price stickier downward. Another advantage of seeking micro foundations in prospect theory is the finding that the theory seems to be tuned to the functioning of the brain (Trepel et al. 2005), an issue to which I will turn next.

Even if the micro foundation chosen looks appropriate, it is the very quest for micro foundations that is misleading and doomed to fail.

*Argument 4. There are well-established microeconomic first principles.*

At present, there is no such thing as well established micro first principles because consumer choice theory is only axiomatic, and preferences are not specified to reflect how the human brain actually works. Axiomatic choice theory is not rooted in neurobiology.

In terms of the brain processes involved, all rational-choice models of optimization implicitly assume that behavior is the result of decisions that are both controlled and rational and thus occur in the cerebral cortex (Camerer et al. 2005). However, decisions can also be automatic and emotional. Behavior is then the result of four kinds of decision processes that may either cooperate or compete. Axiomatic choice theory as it stands today cannot explain every kind of choice behavior because it considers only the equilibrium special case of brain processes involved in rational and careful deliberation. Yet even as a special case, current axiomatic choice theory may be unsatisfactory because the cortex also receives inputs from automatic and emotional brain processes. For instance, emotions are intrinsic to rational decision making (Bechara and Damasio 2005). Moreover, there is also the mediation of hormones and other biological characteristics that are known to bound behavior.

Axiomatic choice theory needs to be entirely rebuilt to account for the recent insights from “neuroeconomics” (as above) as well as the anomalies found by experimental economists (Ariely 2008) that will be confirmed by neuroeconomics. More generally, preferences should be consistently rooted in biology (see Robson 2001 for the details).

Axiomatic choice theory was developed under the constraint that utility could not be measured objectively (Camerer et al. 2005). The concepts of ordinal utility and revealed preference provided a scientific detour where measuring utility was unnecessary. Revealed preference theory equated unobserved preferences with observed choices. However, observed choices can also reflect brain processes that are neither rational nor thoughtful, as observed. Thus, revealed preference cannot validate axiomatic choice theory. Neuroscience has now made it possible to measure utility objectively (Camerer et al. 2005, Platt and Huettel 2008). Functional magnetic resonance imaging and other techniques are currently being applied to make a comprehensive mapping of the cerebral regions involved in choice (Platt and Huettel 2008). This endeavor will give us a detailed picture of how choice works in the brain. I predict that it is only a matter of time before economists rebuild choice theory taking into account such discoveries.

Thus, it is microeconomics that needs foundations. Preferences need to be built on biology, and, in particular, on neuroscience. In contrast, macroeconomics does not need micro foundations – an issue that I will discuss next.

*Argument 5. The behavior of microeconomic units is relevant for the building up of macroeconomic models.*

To start, I invoke the Sonnenschein-Mantel-Debreu theorem of general equilibrium economics (Sonnenschein 1973). General equilibrium is an example of microeconomics for the economy as a whole. The theorem states that a system of excess demand functions of an economy with many agents is not restricted by rationality assumptions

regarding the demands of the individuals in the economy. Thus, microeconomic rationality assumptions have no macroeconomic implications. I think this theorem can be extended to the proposition that every kind of behavior on the part of microeconomic units is irrelevant for macroeconomics.

In economics, there are concepts that cannot make sense at the same time in both micro and macroeconomics. Thus, the mirage of a unified economics without the split between micro and macro is illusory. One striking example is money. Money does not matter at all for individual choice, but it is almost everything in macroeconomics. One result of axiomatic choice theory is that demand functions are homogeneous of degree zero in prices and income. Only relative prices and real income affect utility-maximizing behavior. The only role that money plays is as a unit of accounting: the consumer has no money illusion.

In contrast, macroeconomics is about the role of money in causing temporary business cycles. This occurs because purchases and sales can be separated in time as money serves as a store of value. Money causes temporary departures from the classical Say's law through credit (money advanced against future production) or money hoarding; these are the ultimate causes of booms and recessions. Macroeconomics is all about what will happen as Say's law does not hold "in the short run." One reason why money will never be satisfactorily justified on a microeconomic basis is that the very concept only makes sense relative to the economy as a whole. Money is a social construct; it is the joint creation of the whole society. Thus, it is external to any particular individual, and one individual's will does not matter. In this sense, money affects individuals the same way as any natural phenomenon does.

In classical economics, there is already an incipient division between micro and macroeconomics (see Sowell 1974 for a masterful exposition). Take Say's law again, a principle that Keynes considered to be correct only "in the long run." Say's law is the founding principle of macroeconomics and it holds true regardless of individual preferences or choice. Purchasing power can only be created by production, the principle goes, and there can be nothing in circulation capable of creating or destroying purchasing power. Credit only anticipates purchasing power as today's credit is tomorrow's debt, and one can only pay off a debt if he eventually produces. Hoarding cannot destroy purchasing power, but only postpone its eventual use. As such, the supply of the production in markets has already automatically created its own demand (purchasing power) (Sowell 1974). Keynes launched macroeconomics by stating that, while this principle holds true, the separation between purchases and sales provoked by money can generate potentially long-lasting booms and recessions. However, individual choice does not matter in either Say's law or the macroeconomics of Keynes.

Classical "microeconomics" can be thought of as the controversies over the origin of value (cost of production versus utility). A consensus over value theory inaugurated modern economics with the marginalist revolution. Here, value ended up explained by scarcity, that is, both costs and utility. Goods have value as they have utility and are also limited in quantity. The consensus was about microeconomics, not macroeconomics. The validity of Say's law, as observed, holds regardless of microeconomics. So do other principles of classical macroeconomics, such as the quantity theory of money and Ricardian equivalence; at first, these do not need to depend on individual choice.

Thus, macro behavior was in classical times, and should continue to be, based on “social atoms” (Buchanan 2007) with no free choice. Theoretical progress in macroeconomics can be boosted by learning how to anticipate the patterns that emerge naturally when many social atoms interact. Macroeconomics is about the behavior of a large number of micro units, and as such, a statistical physics approach to the macro system as a whole is appropriate. In macroeconomics, one needs to think in terms of complex patterns, not people. By learning how to manage such patterns, one could be more effective in making macro policies. The existing science that best tackles the complexity of macro systems is statistical physics.

As for microeconomics, the field should try to progress by continuing to focus on individual choice because we now have the means to make real progress in that direction by resorting to the advances of neurobiology (as observed). Here, there is no contradiction between individual freedom of choice and the existence of physical laws for the economy as a whole. Patterns can exist at the mass level, even while individuals continue to make free choices. But choices are constrained by what the group does (Buchanan 2007).

In natural sciences, such as physics, biology, chemistry, and ecology, a different approach is often considered to be necessary when one focuses on macro systems made up of a large number of micro units. In such a case, the precise behavior of a micro unit is considered irrelevant. For the macro system as a whole, the statistical approach is thus often employed. This attitude can also be adopted by economists. One common argument opposing this idea is that performing empirical analyses of economic data is not equivalent to experimental investigation in physics because it is not possible to carry out large-scale experiments in economics that could falsify a theory. However, this limitation is also present in well-developed physics areas, such as astrophysics, atmospheric physics, and geophysics (Mantegna and Stanley 2000). Economists could make progress by creating their own experiments using methodologies from these areas. In fact, this is already being done actively by economic physicists (Mantegna and Stanley 2000), but such an “econophysics” agenda has remained almost unnoticed by economists.

The Sonnenschein theorem also has implications for microeconomics. For instance, equilibrium may not be unique in cases with many interrelated markets. This can be interpreted in our terms by saying that the microeconomics of interrelated markets is susceptible to the same treatment as that given to macroeconomics, that is, a statistical physics approach. In a way, much of current microeconomics is actually macroeconomics. Apart from consumer choice theory, much of the remaining micro theory also aims to explain features of the economy as a whole. In this respect, econophysics is also currently studying behavior in interrelated markets.

From another angle, macroeconomics is about the dynamics of aggregate variables averaged over many individual variables. As such, micro-founded macroeconomics is also likely to suffer from the problem of aggregation. The aggregation issue may be as important as the Lucas critique, but is generally neglected in micro-founded macroeconomics (Scarth 1988). Most economists operate as if the controversy of Cambridge had not taken place. One phantasmagoric result of the controversy was “reswitching,” that is, the fact that a particular technique can be the lowest-cost one at both high and low interest rates but not at intermediate interest rates. This led to the conclusion that microeconomic theory has macroeconomic implications only under



rather restrictive assumptions. Aggregation problems are not only important for capital goods, and there is nothing special about aggregating capital as opposed to labor or output (Bliss 1975). Aggregation problems also arise for consumer goods and assets. Aggregation across individuals is also a problem. For example, when testing for the Lucas critique, if one employs aggregate data it is tacitly assumed that the aggregator function is invariant to changes in the policy regime. The problem is that the aggregators depend on the policy regime to about the same extent as do expectations (Geweke 1985). So why overemphasize the Lucas critique while completely neglecting the aggregation problem?

Yet there is a related, all-mainstream problem. Micro-founded macroeconomics is about the analysis of optimization of a “representative agent” that averages over all heterogeneous agents. The behavior of the representative agent is then extended to the analysis of the economy as a whole. The problem is that heterogeneous agents cannot be successfully replaced by the representative agent even if all the heterogeneous agents are utility maximizers (Kirman 1992). The representative agent and the individual agents themselves may actually behave in tandem. Despite that, micro-founded macroeconomics operates by assuming that the differences in agents and idiosyncratic micro shocks cancel each other out such that aggregate behavior can be represented by average behavior, that is, the behavior of the representative agent.

In physics, the attitude of finding it legitimate to concentrate on averages can be justified if there is self-averaging. In particular, the representative agent can be rationalized by a Poisson model because in such a framework, as the number of agents becomes large, the model coefficient of variation approaches zero (Aoki and Yoshikawa 2007a). In the Poisson model, agents become homogeneous because they face the same unchanged instantaneous probability that a shock will hit them. In other words, different shocks come from the same probability distribution. However, even if the number of agents is large, macroeconomic behavior cannot be represented with averages because macroeconomics exhibits the property of non-self-averaging (Aoki and Yoshikawa 2007a). This means that a size-dependent random variable of the model presents a coefficient of variation that does not converge to zero as model size goes to infinity. Non-self-averaging implies that the representative agent simply does not exist because the focus on averages is unjustified.

Expectations as well as agents should be heterogeneous. This can be illustrated with reference to the El Farol bar problem (Arthur 1994). Suppose that one hundred people must decide independently each week whether to show up at their favorite bar (El Farol in Santa Fe). If someone predicts, say, that more than 60 will attend, he will avoid the crowds and stay home. If he predicts fewer than 60, he will go. No “correct” expectational model can be assumed to be common knowledge. If all use a model (say, rational expectations) that predicts that few will go, all will go, thereby invalidating the model. If all believe that most will go, no one will go, invalidating the belief. Expectations will be forced to differ; that is, they should be necessarily heterogeneous.

Rather than relying on the representative agent, macroeconomics can be rebuilt based on the explicit interaction between heterogeneous agents. One such an attempt is called “emergent macroeconomics” (Delli Gatti et al. 2008). It offers methods from recent advances in agent-based computational modeling for the building up of macro models in which business cycles and economic growth emerge from the interactions of a large number of heterogeneous agents. Here, aggregate phenomena emerge

spontaneously from the interactions of individuals attempting to coordinate their actions on markets; that is, macroscopic regularities emerge from the microscopic behavior of social atoms. Aggregate behavior is due to emergence rather than to micro rules (Schelling 1978).

Another attempt can be dubbed “statistical macroeconomics” (Aoki and Yoshikawa 2007b). Here, macro models are also made up of a large number of agents and explicitly address the stochastic dynamic and combinatorial aspects of the interactions between agents. Equilibria are considered as statistical distributions, not fixed points. One result is that equilibrium is not always possible even if prices are flexible.

The property of non-self-averaging of macroeconomics means that averages cannot represent individual agents (as observed). Other economic phenomena resulting from the interaction of agents, such as income and wealth distribution, firms’ and cities’ size distributions, stock market returns, trading volume, and international trade, just to name a few, also show the property of non-self-averaging. The average cannot represent all agents. What is more, there is no typical scale in phenomena that exhibits non-self-averaging. Lack of typical scale can be described by non-Gaussian power law distributions, and econophysicists are uncovering a large number of empirical regularities in economics that follow power laws (Gabaix 2008). If a phenomenon is governed by a power law, averages cannot represent the entirety, there is no typical scale for it, and thus there is no qualitative difference between large and small scales.

Economics has historically received conceptual inputs from physics. Central economics concepts, such as that of equilibrium, originate in physics. The more recent wave of influence, however, comes from disequilibrium, not equilibrium, statistical physics. It is the physics of “emergence” and “self-organized criticality.” It is not unexpected that most, but not all (Krugman 1996), mainstream economists will react with skepticism. Skeptics can wait for the practical fruits of an econophysics field run by physicists alone, but some may join the enterprise now.

### **3 Concluding Remarks**

I have related five major arguments that I think are implicit in the modern quest for micro foundations for macroeconomics. They are as follows:

- (1) The Lucas critique can be preemptively removed if one employs macro models with explicit micro foundations.
- (2) Micro first principles are policy-invariant.
- (3) New Keynesian macro models are founded on sound micro first principles.
- (4) There are well established micro first principles.
- (5) The behavior of micro units is relevant for the building up of macro models.

I have argued that such arguments are flawed, and my case was made by simply resorting to the already existing literature. Incidentally, I tried to justify neuroeconomics and econophysics as promising routes for value theory and macroeconomics respectively.

An incipient distinction between micro and macroeconomics was already present in classical times, and there is no reason to pursue a unified economics today. Rather, for the first time ever, we now have the means for economics to become a booming science similar to what biology is today. This may become a reality if economists eventually (1) embrace the old distinction between micro and macro, (2) contribute to providing foundations for preferences in neuroscience, and (3) open their minds to rationalizations of aggregate economic phenomena by non-equilibrium statistical physics.

In one pessimistic future scenario, the quest for the neurobiological basis of preferences and the statistical physics approach to macroeconomic problems will continue over the next quarter century in much the same way as they have so far, by adding further layers of complexity to a literature that is already difficult to follow. However, the developments may take a distinct route. In one optimistic scenario, economists may soon be practicing a dramatically different type of science than we have experienced over the past 25 years. Surely much of this change will be apparent at the technical level. Yet, ultimately, the more fundamental change will be conceptual.

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