

What did it take for Lucas to set up ‘useful’ analogue systems in monetary business cycle theory?¹

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Abstract: This paper provides a look into what Lucas meant by the term ‘analogue systems’ and how he conceived making them useful. It is argued that any model with remarkable predictive success can be regarded as an analogue system, the term is thus neutral in terms of usefulness. To be useful Lucas supposed models to meet further requirements. These prerequisites are introduced in two steps in the paper. First, some properties of ‘useless’ Keynesian macroeconometric models come to the fore as contrasting cases. Second, it is argued that Lucas suggested two assumptions as the keys to usefulness for he conceived them as referring to genuine components of social reality and hence as true propositions. One is money as a causal instrument and the other is the choice-theoretic framework to describe the causal mechanisms underlying large-scale fluctuations. Extensive quotes from Lucas’s unpublished materials underpin the claims.

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Introduction

This paper is about how and why Lucas insisted on the use of money and the neoclassical choice-theoretic framework as assumptions to construct useful analogue systems in his business cycle theory. Although rarely used explicitly the terms ‘analogue system’ and ‘analogy’ played a key role in Lucas’s methodology

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in the heyday of his monetary business cycle theory. As he argued economics must aid in assessing the effects of alternative economic policies. Societies, however, are complex and experimenting on them is expensive, dangerous and unethical. Economics thus must rely on various analogies.³ Some of them are of historical character. If it is known what effects a given change triggered under specific conditions in a society the effects of a similar change to expect elsewhere can be inferred. The use of such analogies is limited as it is only the effects of past events that can be speculated about in this way. Economists can get around this obstacle by building mathematical models with analogies between reality and theory (Lucas, 1988/2011, p. 4). The analogy holds and renders a model an analogue system if the model imitates as closely as possible the time series behaviour⁴ actual economies show during business cycles (Lucas, 1977, p. 11, 1980a, p. 697).

Besides good empirical performance there is a further requirement that has become an iconic feature of Lucas's economics: to place macroeconomics on microfoundations. However, their nature is contentious. Boumans (2005, pp. 92–96) claims that Lucas had nothing to do with assumptions beyond their ability to facilitate good empirical performance in the models they underlie. On this account Lucas's assumptions being unrealistic and belonging to the model worlds only are purely of *as-if* character—quite a Friedmanian (1953/2009) viewpoint.⁵ Arguing that “Lucas defends himself by asking to be judged not on the realism of the hypotheses but on the usefulness of his assumptions”, Vercelli (1991, p. 130) also relates analogue systems to predictive performance and regards Lucas's assumptions as Friedmanian untrue propositions.⁶ Likewise by

³ Lucas expressed permissive ideas on analogies. For him an analogy is supposed to be useful for a specific problem, including scientific puzzles, and to this end, no similarity between the target and the model is needed. As he argued based on experiences we gained by using a given chair, we are justified to infer that we can replace a light bulb while standing on another one. What is more this analogy supports us in extending these positive experiences to tables. If an analogy holds it relates two different things (such as a chair and a table, or a society and a model) behaving alike in similar situations (Hand-written notes. Lucas, 1960–2004. Box 27. ‘Adaptive behavior, 1985–1986’ folder).

⁴ When it comes to pinpointing the features models ought to mimic Lucas (1977, p. 9) refers to those co-movements of aggregative time series that Mitchel (1913, 1927, 1951), Burns and Mitchell (1946) and Friedman and Schwartz (1963) aptly documented.

⁵ As-if assumptions have a long history in economics with Friedman's positivist methodology as a most prominent example. For Friedman (1953/2009), assumptions, when used properly, help save the phenomena only, while the real properties of the modelled things are dispensable. This is a stance that pinned the instrumentalist label on Friedman (Wong, 1973).

⁶ To see how close a parallel Vercelli draws between Lucas and Friedman suffice it to recall some of Friedman's (1953/2009) claims, such as “the only relevant test of the validity of a hypothesis is comparison of its predictions with experience” (pp. 8–9) or “[t]ruly important and significant hypotheses will be found to have ‘assumptions’ that are wildly inaccurate descriptive representations of reality, and, in general, the more significant the theory, the more unrealistic the assumptions” (p. 14).

saying that for Lucas a “theory is concerned with imaginary constructions, [so] it is avowedly non-realistic”, De Vroey (2011, 2016, pp. 179–180) understands Lucas’s analogue systems as mere fictions the aim of which is to mimic time series dynamics to save some selected phenomena of societies and, at the end of the day, to help us predict how an economy responds to certain shocks. De Vroey repeatedly underlines that Lucas’s assumptions are always false—so false that Friedman in his methodology proved to be more realist than Lucas ever was. By contrast, Hoover (1995) referring to Herbert Simon’s influence on Lucas sees more in analogue systems than mere useful fictions. As Hoover argues good predictions can admittedly live on unrealistic assumptions, though every phenomenon to be modelled implies a tiny set of real properties that are to be preserved in minimalist descriptions (Simon, 1969/1996, p. 8). Lucas’s assumptions are thus unrealistic for good empirical performance requires one to focus on only a highly limited number of real characteristics.

In what follows it is demonstrated that assessing and building analogue systems Lucas concentrated on two key assumptions: *money* as the most plausible trigger of large-scale fluctuations and the *decisions* of optimizing agents through which money exerts its cyclical effects. As the main message of the paper it is argued that Lucas insisted on these presumptions for he conceived them as true propositions: for him large-scale fluctuations stemmed from agents’ responses to monetary shocks. Some parts of this story are well-known, the primary attention below is thus paid to why and how Lucas imputed elements of reality into his descriptively unrealistic assumptions and to some causal implications. Extensive quotes from Lucas’s archives underpin the claims. As will be seen his unpublished texts effectively complement the publications, where typically he devoted only some scattered and succinct remarks to these problems.

First, Section 1 explains how Lucas considered predictive performance when distinguishing useful and useless analogue systems. Sections 2–4 point out that Lucas regarded money as the trigger of business cycles that worked through decisions of rationally optimizing individuals not for the sake of empirical performance but for the fact that he understood real agents as adjusting to changing macroeconomic conditions through informed decisions. By considering some methodological arguments Section 5 calls attention to some causal consequences. There it is argued that unrealistic assumptions may stem from various attitudes towards the truth of theoretical propositions. Although both denying the need for truth and insisting on a very tiny set of real properties to be preserved in assumptions lead to descriptively unrealistic models, only in the latter case is there any chance for conscious efforts to think in causal terms. Last Section offers some brief concluding remarks.

1. Problems with useless analogue systems

To learn more about the crucial components of useful analogue systems a viable strategy is to start with the misgivings Lucas voiced about useless models. In this respect his invective against Keynesian macroeconometrics, especially its Klein-Goldberger variant, is highly informative.

In a series of papers from the second half of the 1970s, Lucas, partly accompanied by Sargent, explained why Keynesian models were unlikely to predict the effects of alternative policy scenarios despite their past empirical success. As Lucas argued one could not expect future reliability as long as the forecasts neglected the behavioural effects of policy measures and regarded the superficial behavioural parameters as invariant (Lucas & Sargent, 1979, p. 6; Sargent, 1977, pp. 2–3). Policy interventions may break past behavioural rules—even if they are detected as stable for a long time. To sort out this problem Lucas (1977, p. 12) suggested that economic analysis dig down to the level of the genuinely stable economic primitives like taste and technology to predict policy-induced outcomes on this solid basis.

Lucas's criticism against Keynesian macroeconometrics is abundantly recorded in the archives. In the excerpt below,⁷ very instructively, he discusses the case in the “useful-useless” dyad, our primary concern:

Keynesian economics [...] offered a way to go from a set of sample moments (variances, covariances, autocovariances [...]) to policy options available to society—“trade-offs”. [...] We observe that government spending and unemployment have been negatively correlated in the past (think of WW's I and II). We use this correlation to estimate the change in unemployment to be expected from an increase in government expenditure in the future. That's all there is to the multiplier—there is nothing deeper. [...]

Difficulty is this: no reason to believe that correlations exhibited in past data will continue to obtain under new policies. Old correlations may contain no useful information on future trade-offs. I say “may” but situation is worse than this: now [we] know that multipliers for aggregate monetary, fiscal policy are useless. (Lucas, 1960–2004, Box 13. ‘Lectures notes, 1979–80’ folder) (emphasis in original)

Besides repeating Lucas's well-known arguments against Keynesian macroeconometrics this excerpt also tells a lot about analogue systems. Lucas (1980a, pp. 696–697, 704) refers to a wide range of theories as analogue economies, regarding any model having good imitation capacities as analogue theory.⁸ By

⁷ Lucas prepared these notes for his lecture at Ohio State University and his Marion O’Kellie McKay Lecture at the University of Pittsburgh both held in 1980, so these drafts are from the same period as his misgivings published in the second half of the 1970s.

⁸ Just for the sake of good order it is worthwhile to remember that Lucas applied the words *model* and *theory* as interchangeable terms (Lucas, 1980a, pp. 696–697).

this standard Keynesian macroeconometrics also falls into this category (Lucas, 1977, pp. 11–12; 1980a, p. 701). On this ground Lucas in this draft could draw a sharp distinction between *useful* and *useless* analogue systems (Lucas, 1976, pp. 19–20). In the case of behavioural changes triggered by policy interventions (or, in a broader context, any changes in the environment), previous trade-offs ought not to be expected to persist. Models disregarding this particularity cannot be reliable and *useful* despite their showing good empirical performance otherwise.⁹ The term 'analogue system' is thus neutral in terms of usefulness.

Arguing along these lines Lucas (1994) draws attention to the spurious causal assumptions of the Klein-Goldberger framework as a related problematic aspect. Keynesian macroeconomic models of the 1950–60s generally presumed large-scale fluctuations to stem from shocks to private spending. This concern was born earlier. Back in the 1970s Lucas devoted a longer and more fully elaborated train of thought to the discussion of the causal failures of the Klein-Goldberger model. These arguments remained unpublished, but being highly illuminating they are worth quoting at length—the more so as they shed some light on a problem Lucas (1977, pp. 10–11) was laconic about in publication.

What are the causes of business cycles? [...] [I]t is [a] question that anyone trying to model economic time series has to ask, in one form or another. [...] The first attempt to deal with it in the context of an explicit economic model was in Adelman and Adelman's simulations of Klein and Goldberger's econometric model of the United States. [...]

In the Klein-Goldberger system [...] there is a definite sense in which one can say that business cycles are caused by "autonomous" [...] fluctuations in various components of private spending. Since the variance of the error terms in investment equations are, in models of this type, much larger than consumption errors, one can sharpen the conclusion to the statement that business cycles are caused by autonomous fluctuations in investment demand. (Lucas, 1960–2004, Box 13. 'Barro, Robert, 1974, 2000, undated' folder)

In general, models contain causal hypotheses so different variables emerge in different models as triggers of business cycles. He goes on:

This substantive conclusion of Klein, Goldberger, Adelman and Adelman is, of course, of great interest [...]. Their work was also a great advance meth-

⁹ Lucas (1977, p. 11, fn. 18) hastens to add that even a theoretical equations or systems of equations may have good fit on data (Snowdon & Vane, 2005, p. 287). These models, however, are also subject to Lucas's critique so they have only limited acceptability. On this basis Lucas joined in a debate with Sims on the empirical merits of vector autoregressive models. As Lucas underlined having no explicit theory offers no way out of the need for allowing for fixed parameters to change (Galbács, 2020a, pp. 127–134).

odologically, or at least terminologically: A variable is said to cause business cycles (in the context of a particular, simulatable model) if setting its error variance equal to zero eliminates them in simulations. [...]

This notion of cause has the advantage of being fully operational. [...] If one can forecast the errors in the causative shock [...], policies can be designed that will, in the context of the model, offset them. This is the Klein-Goldberger model, fluctuations in autonomous private spending flows can be offset by changes in taxes and government spending, stabilizing (though perhaps not fully) real output and employment. Of course, the prime motivation of Klein and Goldberger's work was to gain the ability to do this. (Lucas, 1960–2004, Box 13. 'Barro, Robert, 1974, 2000, undated' folder)

Here Lucas refers to the simulations Adelman and Adelman (1959) performed on the Klein-Goldberger model.¹⁰ The Adelmans first ran the model deterministically (i.e., without stochastic shocks) that resulted in a quick convergence towards an equilibrium real output. No sizeable oscillations but a complete absence of business cycles emerged. Second, they built realistic variances upon the error terms for exogenous government spending components. Results bore close similarity to the outcomes of the deterministic session. Finally, they put realistic variances to the error terms for the private sector spending equations. In the latter case variability in real output and employment bearing resemblance to real-world fluctuations emerged. Based on these results, as Lucas argued, it was possible to draw the inference that business cycles could be eliminated in a Keynesian fashion through effective fiscal remedies. This fiscal bias was explicit as the Klein-Goldberger model contained a plethora of fiscal instruments ranging from direct government investments or the play with business taxes through income redistribution and running comprehensive social security systems by which governments could enhance private spending (De Vroey & Malgrange, 2012). However, this was a conclusion and a policy suggestion which Lucas harshly rejected.

2. The keys to usefulness: Money and the choice-theoretic framework

To fix the causal failures of useless Keynesian analogue systems Lucas suggested two key assumptions: money as the trigger of large-scale fluctuations and the use of the choice-theoretic framework to analyse business cycles as the outcomes of the decisions of rationally optimizing individuals.

¹⁰ It is noteworthy that Irma Adelman (1968, p. 268) discussed analogies in the same neutral way as Lucas did later, where the term referred to the similarity in behaviour between a real economy and its simplified and simulatable analogue system.

In his published writings from the 1970s Lucas time and again emphasizes monetary instability as the most plausible trigger of business cycles (Lucas, 1977, pp. 23–24; 1981, p. 16). Money is so powerful an instrument that no other candidates were likely to account for the large-scale swings in macroeconomic activity. Referring to Friedman and Schwartz's (1963) *Monetary History* and Friedman's (1968) presidential address, Lucas (1972; Lucas & Rapping, 1969a, 1969b) took Friedman's two neutrality theorem as facts of life. Although after the 1970s when the earlier loud monetary noises faded away he curtailed the scope of his monetary business cycle theory, money has never ceased to be a pervasive causal factor. Flying in the face of the emerging real business cycle literature, Lucas (1989/2013, pp. 296–297, 1994, pp. 12–14) still believed that money mattered—if business cycle theory can go without money it is because with the elapse of time monetary policy has become less erratic and hence business cycles have come to be more modest (Lucas, 2003, p. 11, 2004, p. 23). By the twilight of his career monetary business cycles had lost their typical character but still there was a set of macroeconomic phenomena, money-induced fluctuations, including the 2008 crisis, that could still not be explained in non-monetary theories (Lucas, 2013, p. xxiii).

It is also money that implies the choice-theoretic approach. Agents use prices as the source of information and price dynamics, at least in part, has monetary origins. Changes in the money stock give signals agents need to respond to by making decisions. Money contributes to a confusion that agents face and here lies the theoretical problem. To conciliate long-run neutrality and short-run non-neutrality economics must show how decisions under imperfect information conditions differ from full-informed decisions (Lucas, 1972/1981, p. 92). The problem can only be settled in the choice-theoretic framework where money has a key role and where decision rules are traced back to stable preferences. Lucas (1977, p. 15; 1981, pp. 4–7) thus strongly believed that choice theory had no alternatives in understanding business cycles:

There has been much scholarly dispute about Friedman and Schwartz's interpretation of the 1929–33 period, and given the difficulty of drawing causal inferences from nonexperimental data of this sort, perhaps this is unavoidable. But what are the other candidates? What possible forces, other than the well-documented monetary collapse, could have induced the millions of independent decision makers in this modern industrial economy to have reduced their joint production of goods and services by 34 percent over a four year period? If changes in the money supply did not induce these events, then something else did. What was it? (Lucas, 1960–2004, Box 13. 'Barro, Robert, 1974, 2000, undated' folder)

As Lucas strikingly underlines it is reality that suggests understanding business cycles in choice theory as a monetary phenomenon. This combination of money and choice theory and the resulting monetary business-cycle theory

proved to be an enduring constituent of Lucas's economics. He was dissatisfied with real business cycle models depriving money of its key role in triggering business cycles. As a sign of Prescott's influence on him Lucas later switched to a more refined form of the choice-theoretic framework but tried to re-introduce money into the updated theory. Money and choice-theory were still key parts of a useful business cycle theory (Lucas, 1987, pp. 6, 32–33), which had remained on Lucas's research agenda for a long time. Lucas (1989/2013; Lucas & Woodford, 1993) applied a new market structure and an information deficiency reminiscent of his 1972 island model but the underlying story remained the same: unexpected monetary disturbances trigger real swings and the Phillips curve fades away in the long run.¹¹ The scope of money and choice theory, however, extends beyond business cycle theory (Alvarez, Lucas, & Weber, 2001; Lucas, 1980b, 1982; Lucas & Stokey, 1983). At the same time there are choice-theoretic models without money (Lucas, 1988, 1990; Lucas & Atkeson, 1992), but here the real effects of monetary instability are off the radar.¹² However, it only expresses the diversity of problems. Lucas (2003, p. 3) kept regarding money as a real-life cyclical factor compelling agents to adjust in real terms through decisions.

3. Elements of reality as building blocks for theorizing

As we have just seen Lucas suggested the notion of money affecting the economy through agents' decisions for he believed they belonged to reality as core elements. But there is more to this problem. It is still reality where the fine details of the decision problem come from—agents are influenced by money when making decisions on labour supply and production. As Lucas (1977, p. 16) puts it, “we know from much evidence” the basic tendencies in decisions and the list of circumstances agents consider—facts properly documented in various surveys, experiments and other forms of direct observation (Lucas, 1980a, pp. 710–712). These are the details that underlie the postulated labour supply function and, by carrying over the same decision problem, the production response of islanders (Lucas, 1981, p. 7). In his published works Lucas normally provides only some sketchy remarks on how agents decide (Lucas, 1977, pp. 16–17; Lucas & Rapping, 1969a, p. 730, fn. 711), but dwells upon the problem in some notes in the archives. In these lengthy fragments, as an introduction, first he repeats his insistence on the choice-theoretic framework which must be defined by assumptions in line with the evidence we have on

¹¹ Lucas's monetary business cycle theory is still active as a starting point for ongoing research (Fratto & Uhlig, 2020; Smets & Wouters, 2007).

¹² A version of Lucas and Atkeson (1992) contains money, but only for the sake of facilitating trade, while monetary shocks to the economy are assumed away (Lucas, 1992).

individual decision making (Lucas, 1960–2004, Box 13. 'Barro, Robert, 1974, 2000, undated' folder). Then in the same fragments he turns to some observable behavioural tendencies all based on the intertemporal substitutability of labour and leisure:¹³

We know [...] that the wealthier people are the less hard they work. This can be seen by comparing rich to poor societies, the U.S. today, say, versus the U.S. a century ago or versus India today. People in rich societies enter the workforce later in life, retire earlier, take longer and more frequent vacations, and work shorter weeks [than] people in poor countries. Those with large non-labor incomes work less than others in the same society with lower income from capital. Leisure—defined broadly to include all activities other than working for pay—is a normal good.

In this description of reality there is a place even for unanticipated changes relevant to understanding individual reactions to surprise monetary policy shocks:

There is [...] enormous latitude as to when one works. We concentrate our work effort in peak-earnings years: When leisure years are added, they are added at the beginning (a year or so of goofing off after or during college, say) or at the end (early retirement) when we aren't worth as much on the market as we are in our 30s and 40s. [...] Within the year, everyone concentrates his work effort during peak times. Workers in the construction trades substitute winter for summer vacations. People in retailing work long hours in December, short hours in July. [...] Unpredictable peaks have the same effects as predictable seasonals. Everyone in a manufacturing establishment works long hours when a big order comes in unexpectedly: vacations are postponed, people don't get "sick" as often, overtime hours are put in [...].

As a further characteristic employees dislike too frequent switches between different activities:

A third feature of observed work patterns is that people like work (and leisure) time to come in chunks. We like fifteen vacation days in one three week period, not scattered through the year. We put in forty hours in five eight hour pieces, not seven six hour days, or twelve siesta-broken half days. Even within a day, we like blocks of time: writing in the morning, teaching and committee busywork in the afternoon. There are setup costs, large (like a two-hour commute or a three day drive to the Rockies) and small (like the fifteen minutes it takes to get back into a problem one hasn't thought about for a while) that make it wasteful to change activities too frequently.

¹³ Elsewhere Lucas also refers to lifelike agents. The theoretical portrayal of workers as decision makers that McCall (1970) or Lucas himself painted (Lucas & Prescott, 1974) is supposed to grab the essential features of the decision problem workers face (Lucas, 1987, p. 57).

The micro-level insights with which Lucas fed his economics, as he argued, were obvious and evidently given parts of the socio-economics universe:

These three features of working life [...] are well known to anyone who walks through the world with his eyes open. We do not need econometricians to “test” these observations. Neither do we need theorists to determine whether this sort of behavior follows from standard axioms of rational behavior: It is perfectly easy to imagine a rational agent who reacts to a wind-fall wealth increase by working harder, or who likes to allocate his time by engaging in hundreds of different activities every microsecond.

This is a very complex problem however. The good thing is that as Lucas (1986, p. S401) points out there is no need for us to take all aspects of behaviour into account. In the related drafts Lucas provides a more detailed reasoning:

it is clearly not a serious strategy [...] to try to model any process of decision making by codifying all that is really going on. Even the most detailed “protocols” compiled by questioning decision makers [...] about their thought processes capture, and are intended to capture, only a tiny fraction of what is in fact being thought. [...]

Any operational model of any decision making process [...] will necessarily be highly abstract – it will leave almost everything out. (Lucas, 1960–2004, Box 27. ‘Adaptive behavior, 1985–1986, 2 of 2’ folder)

Theory is supposed to focus upon only a small part of the decision maker while other aspects are superfluous. In summary:

Trying to model explicitly this entire [decision making] process, really an entire human personality, would surely be a lunatic enterprise and I do not propose to undertake it. (Lucas, 1960–2004, Box 27. ‘Adaptive behavior, 1985–1986, 1 of 2’ folder)

Referring to Simon’s (1969/1996) distinction between the way an agent actually works (i.e., his inner environment) and what he does (i.e., his outer environment), Lucas in these drafts claims that minimalist, rudimentary or super-abstract descriptions of the former will do when it comes to understanding the latter. The result is a tight notion of theory which is supposed to be highly abstract and mimic only the relevant aspect of facts.¹⁴ Using the example of a firm Lucas sheds light on why we do not need to know much:

The question involves the way a large collection of people—a corporation—alters its decisions in response to changes in its environment. Yet the economic answer makes no reference to who these people are, how they are organized to interact, who in the group is responsible for which decisions.

¹⁴ Lucas (1988, p. 5) maintained these ideas even outside his monetary business cycle theory.

My guess is the most economists, even specialists in investment theory, have no idea what goes on in the accounting, legal or financial department of a business firm. (Lucas, 1960–2004, Box 27. 'Adaptive behavior, 1985–1986, 1 of 2' folder)

Only those elements of the inner environment *must be* preserved as propositions that are really indispensable and key to modelling a given aspect of the outer environment—everything else *must be* left out.

Lucas's strategy is thus to find the core choice problem in its simplest form that suits a given theoretical puzzle. In reality the labour supply decision, Lucas's foremost interest, is dependent upon current and expected real wage through a number of channels. For instance the real wage affects the households' child-bearing decisions hence population size; the participation rate and the number of hours an employee offers as his labour supply (Lucas & Rapping, 1969a, p. 726). A worker resolves this allocation problem by making decisions.¹⁵ What is more the labour supply decision is a part of a multi-dimensional setting. When making his labour supply choice, the worker may be assumed to consider a lot of different activities: work, leisure time, job search or even sleeping and eating (Lucas, 1981, p. 4). However, Lucas (1972/1981, p. 92) identifies the core problem in how current and expected wages and prices affect current and future consumption and leisure—thus narrowing down the theoretical decision problem to the tiny core of the real decision plays a crucial part right from the beginning. Likewise given the direct link between employment and output with an unchanging stock of capital and technology there was no need for Lucas (1972) to model labour supply and production as outcomes of distinct decisions. Output dynamics can entirely be traced back to changes in the labour supply.

4. Two instances for reality-based key assumptions

Occasionally Lucas further underlines that his key assumptions regarding the conditions of the decision problem come from reality. In this respect two letters are most instructive. The one is related to Shiller's (1984) review on Lucas

¹⁵ In turning choice theory to business-cycle modelling, especially in emphasizing how optimizing agents substitute expectations for information deficiencies (Lucas & Sargent, 1979, p. 8), Lucas received inspiration from Phelps (1970, pp. 6–9). A part of Phelps's prototypical application was the case for regarding informed decisions as a real basis of the adaptation mechanism agents run (Phelps, 2007, pp. 544–545). In his Nobel-bio, Phelps (2006) makes an even clearer manifesto, saying that he was one of those "who wanted macroeconomic models to have lifelike actors whose expectations and beliefs were causal forces". In Chicago, Becker (1976, pp. 13–14) and Stigler (1946, pp. 13–14; 1979, p. 3) also argued for the interpretation of neoclassical choice theory as a highly realistic description of the core of human behaviour.

and Sargent's (1981) compilation. Shiller's assessment of the "rational expectations revolution" was rather lukewarm in the paper. He admitted that the rational expectations approach had become the chief principle in empirical macroeconomics though he remained sceptical. By behaviourist standards it seemed an eccentric, if not bizarre, assumption as it attributed more to economic agents than they were factually capable of. Information is expensive to collect and process in the quantity necessary for acting rationally at the level the theory assumed, so people rely on simple heuristics which they only infrequently modify. Lucas replied in a letter:

You have got to be right [...] that 'most individuals behave in accordance with simple rules of thumb which are only rarely reevaluated.' It has always intrigued me that Muth hit on his formulation at Carnegie Tech at the time when 'behavioral' economics was at [its] peak there. In the introduction to his original paper, Muth [...] insists that his hypothesis does not assert that rationality characterizes the 'scratch work of entrepreneurs.' Whatever may be said of his successors, I think it is crystal clear that Muth was trying to push 'rationality' to an extreme not in naive ignorance of parallel behavioral work, but in full knowledge of it, at the then current center of behavioral work in economics.

Muth was right I think, that what promise economic theory offers is precisely guidance as to what will happen at those [rare] points at which people are compelled by events to reevaluate the rules of thumb they use. At such points, the kind of codified rules of thumb psychologists record are useless. Your point that economics is bad psychology is well taken but it does not follow that psychology is good economics. (Lucas's letter to Robert J. Shiller. February 16, 1983. Lucas, 1960–2004, Box 5, '1983, 2 of 2' folder)

Lucas alludes to the flip side of the usual behaviourist arguments. Experimental psychology draws a distinction between the slow and fast forms of thinking (Kahneman, 2003, 2011). In normal times of unproblematic everyday conditions intuitive fast thinking provides reliable decision schemas agents follow in their automatic operations—this is the way of thinking Shiller refers to. However, there are cases where such rules turn out to be wrong and following them proves ineffective, thus slow thinking must intervene by overruling—this is the point Lucas makes. It is exactly the routines that make it possible for the social sciences to distil behavioural patterns showing some stability. Here Lucas offers a behaviourist context to interpret the way he applied the rationality assumption. When agents need to adjust to policy actions prior rules become outdated (Lucas, 1976) and agents must act rationally by resorting to slow thinking to find their new rules of thumb. By the same token to discriminate between nominal and real price signals also requires decision even if agents do not have the time necessary for relying on slow thinking. Agents need to respond before they can collect and process all the necessary information so

in their everyday actions they cannot but rely on heuristic rules (Lucas, 1972). However, when agents realize some systematic efforts of economic policy to exploit expectation errors stemming from incomplete information and the use of simple decision heuristics they deliberately and consciously adjust their behavioural rules—slow thinking thus intervenes.

It is beside the point whether rationality dominates everyday behaviour (it does not) as Lucas applied it to cases (changes in the social setting) where routine actions turn out to be suboptimal, and where rationality has no alternatives. In such instances rationality does work in reality. This way Lucas conciliated rationality with everyday heuristics and confined the former to cases where it is needed to overwrite the latter. Results in experimental economics further strengthen this argument. Vernon Smith and others showed how agents thrown into an unknown environment make rational efforts to build up the rules of behaviour (Caginalp, McCabe, & Porter, 2003, pp. 4–5; Smith, Suchanek, & Williams, 1988, p. 1148).

The other letter is from some correspondence with Costas Azariadis, Lucas's former doctoral student at Carnegie-Mellon University (1969–1973). In his letter of October 19, 1976 Azariadis objected to a technical nuance of the island metaphor that randomly allocates producers across markets. For Azariadis it seemed nonsense to assume an agent located on a market with favourable demand conditions to be ready to leave. In lieu of the spatial dimension Azariadis suggested the distribution of demand over time. In his reply Lucas explained what the metaphor actually meant:

One has to take my spatial set-up metaphorically or it is crazy. By “forcing” people to leave good markets, I just wanted to capture the fact (which I think is obviously present in reality) that there are transitory demand and supply shifts. (Lucas's letter to Costas Azariadis. October 25, 1976. Lucas, 1960–2004, Box 3. '1976, 1 of 2' folder)

This informal explanation is in close accord with a footnote from the same period, where Lucas (1975, p. 1120, fn. 1128) describes the island metaphor as a device not to look into maritime affairs but to highlight how agents act and interact in unclear and unexpected situations. Implicitly here Lucas deciphers a representational code in the sense Shech (2015, 2016) applies the term. Even if a model contains wholly fictitious or idealizing assumptions (Chakravartty, 2007, pp. 187–192; Psillos, 1999, p. 29), just like the idea of agents randomly allocated across islands, it is still possible to represent existing parts, mechanisms or aspects of reality. To make a fictitious assumption refer to an element of reality a representational code is needed that clarifies what part of reality is highlighted by which part of the related model.¹⁶ The paradigmatic example

¹⁶ Without a code an assumption may seem to have nothing to do with reality—this is the ground upon which Cartwright (2007, p. 227) criticized Lucas's spatial metaphor.

is the representational code that connects the system of two pens on a table with tankers in a harbour. To set up this code the user actively utilizes the rules of mapping a 3D-space into two dimensions and, on this basis, how a spatiotemporal position of a real object can be represented on a 2D map and how to extrapolate the trajectories pens show to infer the positions of ships on the sea. Such codes also aid in circumscribing the sets of meaningful inferences. A code instructs users how to interpret the model so some possible inferences come to be unsound—like the inference that strings of swings are massless just because they are assumed to be so in theory (Contessa, 2007; Suárez, 2004). Likewise, the code has nothing to do with the colour or material of pens, so red metal and green plastic pens perform equally well when it comes to representing on the table the trajectories of ships of whatever colour and material. Accordingly, here Lucas precludes the most obvious reading, and establishes the representational relationship between an aspect of reality (transitory shifts on markets) and his model (reallocating agents between markets). As a result, a fictitious detail can represent a key element of reality.¹⁷ When unravelling the island model by means of the code it is not necessary to read the theory literally. Only that part of the spatial metaphor plays a role that forces agents into unexpected situations. As Lucas points out real agents acting on real markets face changing business or trade conditions from time to time. This is the very aspect of reality Lucas wanted to represent with his island metaphor. Islanders finding themselves on new markets can be taken to stand for everyday agents facing unexpected and confusing market signals.

5. Discussion: Causal consequences of the truth of assumptions

The aim of the final part of the paper is to shed light on some implications of Lucas's insistence on some key elements of social reality as assumptions. In what follows Lucas's stance is characterized as fundamentally different from Friedman's related ideas, so the framework here is the Friedman–Lucas contrast that was called into play in the introduction.

This contrast comes up naturally as assessing Lucas's achievements in comparison to Friedman is commonplace in the existing literature. In theoretical and economic policy terms Lucas's insistence on the neutrality theorems and shock-free monetary policy stands in focus which is a ground for emphasizing

¹⁷ It cannot be taken for granted that every fictitious assumption involves an appropriate representational code. For tractability reasons Lucas (1975) assumed that expectations are pooled among traders so the average values describe all agents' predictions. Lucas was highly dissatisfied with this solution and regarded it as temporary only (Lucas's letter to Edi Karni. October 18, 1976. Lucas, 1960–2004, Box 3. '1976, 1 of 2' folder).

the similarities between Lucas and Friedman. Lucas (1981, pp. 1–2; De Vroey, 2016, p. 197) himself also admitted some parallels in these regards. By contrast methodology is the bed for some crucial discrepancies—also acknowledged by Lucas (Snowdon & Vane, 2005, p. 286). These differences stand out along the Marshall–Walras frontier: Lucas offered his neo-Walrasian dynamic stochastic general equilibrium approach as an alternative to Friedman's Marshallian methodology (De Vroey, 1999). At the same time Lucas is widely supposed to have subscribed to Friedmanian principles regarding the untruth of assumptions. So at the bottom-line Lucas appears to have endorsed Friedman's major economic policy conclusions and imputed Friedmanian untrue and unrealistic assumptions into a Walrasian setting.

In his methodology Friedman (1953/2009) suggests that the truth of assumptions should play no role in theory assessment. Consequently predictive performance is the only meaningful aspect and assumptions might be untrue assuming that reality behaves *as if* presumptions were true. Assumptions matter inasmuch as the theory produces accurate enough predictions. Following Wong (1973) today these principles are labelled as instrumentalism. As Caldwell (1980) points out, Friedman as a predictivist regarded the truth of assumptions as of secondary importance: they might be true but truth is neither a requirement nor a concern.¹⁸ Based on this relationship to reality Mäki (2009) elaborated a realist reading of Friedman's methodology. This rendition, however, is built on an unusually loose definition of scientific realism (Chakravartty, 2017a; 2017b, pp. 3387–3388). As Mäki (2008) argues any theory that *might* be true deserve realists' commitments. As Friedman did not prohibit but simply disregarded the truth of assumptions the Mäkian realist Friedman and the instrumentalist Friedman are the same person.¹⁹ Here the truth-likeness of theories is only a bonus beyond empirical success. An extreme version of this principle is attributed to Lucas allegedly saying that assumptions belonging to the model-worlds only and have nothing to do with reality (De Vroey, 2016, p. 177). It is a radical form of instrumentalism (following Caldwell's (1992) terminology in its noncognitive form) that by ignoring all other aspects wholly subordinates assumptions to predictive performance.

The similarity of methodologies, however, is only superficial. It is true of both that selecting assumptions is driven by predictive purposes: good assumptions lead to good predictions. Some further characteristics of the preferred assumptions also make a difference. Friedman (1953/2009, pp. 19–20) suggests a trial-and-error approach: of the alternative assumptions the one is to be

¹⁸ As seen money as a plausible trigger for large-scale fluctuations is such a case (Hammond, 1996).

¹⁹ Friedman himself endorsed the instrumentalist reading and disparaged any attempts to accuse him of realism (Boland, 2010). Even methodologists remained sceptical about the idea of a realist Friedman (Mariyani-Squire, 2017; Reiss, 2010).

found that performs the best. Friedman sets no truth requirements, the range of candidate assumptions is thus unconfined. Even wholly fictitious ideas may lead to well-performing models—like the assumption of leaves as rational utility maximisers. If the best-performing model happens to be true,²⁰ it is a lucky coincidence but no theory ought to be preferred just because it is supposed to succeed in grasping how reality works.

Lucas links assumptions to empirical performance by distinguishing short- and long-run reliability and argues that the former by no means implies the latter. The problem of assumptions comes up when he declares: only certain assumptions lead to long-run reliability. When specifying them Lucas set truth requirements: he expected money as a cause, rationality-based choice theory, or the idea of stochastic shocks to markets to work well as assumptions for he regarded them as referring to genuine components of social reality. For Lucas assumptions thus must be truth-like or verisimilar, even if they are descriptively untrue and unrealistic and empirical performance stems from their truth-value. He saw no contradiction between descriptive minimalism or high levels of abstraction and idealization on the one hand and truth-likeness on the other and found no implication between descriptive falsity and untruth—an attitude modern philosophy of science attested (Mäki, 1994a, 1994b). When forming this attitude there is room for choice or following personal commitments. Accordingly while Friedman rendered the relationship between truth and predictive success as only accidental, Lucas derived empirical performance from verisimilitude or plausibility—while both opted for descriptively ill-performing presumptions.²¹ By supposing implication between truth-likeness and empirical success, however, Lucas subscribed to a different tradition of scientific realism where seeking truth is an explicit goal (Putnam, 1975).

Lo and behold there is thus more to this problem than taking a stance regarding truth and unrealisticness. In a basic creed for his microfoundations project Lucas (1980a, pp. 710–712) suggested microfoundations so as to make individual characteristics play a key role in understanding some supra-individual (group- or society-level) phenomena (Duarte & Lima, 2012). In modern parlance this is a structuralist endeavour: microfounded macroeconomics is no more than an attempt to see how agents behave in structures they form by their relations (Galbács, 2020a; Kincaid, 2008; Ross, 2008). As Lucas argued if

²⁰ This truth is always qualified. According to modern history and philosophy of science our best or mature theories deserving realist commitments are only partially or approximately true (French & Ladyman, 1999; Worrall, 2012). This is a stance to be distinguished from the naïve and superseded belief, according to which our theories are true.

²¹ Ranging from pure abstractions through idealizations supported by representational codes there is a wide array of different isolative strategies to preserve real properties. With a few and special exceptions isolation implies descriptive inaccuracy (Chakravartty, 2007, pp. 187–192), just as in the case of untrue assumptions where, by contrast, retaining real characteristics is not a purpose.

individual behaviour is known (and it was as early as in Lucas's time, thanks to the abundant micro-level evidence), by compelling the so defined representative agents to interact in a well-specified environment we hope to understand how macroeconomies work. Friedman (1953/2009) also discusses how to use microfounded theories in modelling supra-individual outcomes. It is doubtful, however whether the different attitudes towards the truth of assumptions lead to the same chances in causal understanding. As some structuralist philosophies have recently pointed out requirements on assumptions have effects of the explanative capabilities of models where related parts such as agents and other entities form a complex whole. Individual characteristics are crucial as it is they that establish how individuals behave in interactions and hence what overall behavioural tendencies or causal chains emerge (Chakravartty, 1998). If one wants to causally understand in terms of individual properties such as preferences a given aspect of how a society works exactly those properties that are active in underpinning the relevant interactions and hence in carrying the relevant facet of the structure are needed—these are the causally active properties.²² Different properties belong to different structures, so a representation of a (facet of a) structure requires those properties to be retained that underpin it.

Consequently if such characteristics are neglected and assumptions do not refer to the properties, the environment and instruments of agents,²³ the resulting model can do no more than save some selected phenomena.²⁴ This is a case Friedman advocated under the instrumentalist banner. As Boland (1979) points out in itself it is a consistent and acceptable position provided one is willing to make do with the lack of answers to causal questions (Wong, 1973, pp. 323–324) or the uncertainty about the longevity of tendencies. As has been seen Lucas mounted his offensive against Keynesian macroeconometrics on these two fronts—and if he blamed those assumptions for implying spurious causal consequences it proves to be a conviction that also drives a wedge between him and Friedman. Lucas suggested finding the plausible causal fac-

²² When preparing for abstraction and idealization a theorist separates the active causal properties as directly relevant, less relevant (hence potentially omissible) and irrelevant in terms of the problem under scrutiny (Katzner, 2016). Thus there exist relevant and irrelevant subsets of causally active properties where “relevant” means “supposed to be relevant in terms of the problem under scrutiny” (Giere, 1999). Lucas tacitly built on this distinction between relevant and irrelevant facets, arguing that models are supposed to bear resemblance to real-world dynamics only in the relevant aspects (Lucas, 1960–2004, Box 13. ‘Directions of macroeconomics, 1979’ folder).

²³ In a series of papers, Hoover (2009, 2012) points out that macro is irreducible solely to agents and their interactions. By so doing he appropriately characterizes Lucas's island models, where agents form expectations regarding the general price level and by manipulating the money supply a supra-market government releases the nominal shocks to the island economies.

²⁴ The geocentric model predicts well that the sun rises in the East and sets in the West. A further example is the correlation between the number of new-born babies and the size of stork populations (Matthews, 2000).

tors (money) and mechanisms (individual decisions in the face of stochastic monetary and real shocks to markets) behind the relevant phenomena. This is far from a guarantee, though—there is still room for errors in theorizing, and changes in the social setting may call new causal mechanisms into existence. Lucas's career is a paramount example for the latter. Causal understanding, however, can only be built on real properties.

Conclusions

In this paper it is argued that Lucas regarded predictive success as only one requirement useful models must meet. In addition, Lucas suggested money as the plausible trigger of large-scale fluctuations and the use of the neoclassical choice-theoretic framework—in his view only these underlying assumptions could render any empirically successful model useful. When specifying the key assumptions Lucas built empirical performance on verisimilitude or plausibility. Predictive success thus did not take priority over other requirements. On the contrary Lucas expected his approach to lead to successful models due to his confidence in seizing the real causal processes in highly abstract ways. The results above thus contribute to the clarification of Lucas's methodological principles and emphasize his ambition to latch onto the way reality works.

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