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Lucas's Early Research and the Natural Rate of Unemployment

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LUCAS'S EARLY RESEARCH AND THE NATURAL
RATE OF UNEMPLOYMENT

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ABSTRACT

This paper builds a narrative on the early work of Robert E. Lucas Jr., in the late 1960's, which culminated in the modeling and testing of the natural rate of unemployment hypothesis. Lucas's modeling and testing of the natural rate can be found, respectively, in two papers: "Expectations and the Neutrality of Money" (Lucas, 1972a) and "Econometric Testing of the Natural Rate Hypothesis" (Lucas, 1972b). These papers are the synthesis of the two branches of Lucas's research at that time; one on labor market behavior and other on optimal investment by firms. This synthesis changed the way in which the natural rate of unemployment was originally elaborated by Friedman (1968a) and Phelps (1967, 1968), by modeling it in a general equilibrium framework with rational expectations and giving it a proper test. Lucas's research agenda synthesis in the late 1960's was the result of his close interaction with Phelps and Prescott, backed up by his pragmatic equilibrium approach to economics, concerning modeling, econometric estimation and testing. Phelps explicitly suggested a general equilibrium approach to Lucas's labor market modeling, while Prescott helped him in dealing with the rational expectations hypothesis.

Keywords: Robert Lucas; Early Research; Natural Rate of Unemployment

JEL Classification: B22

Lucas's Early Research and the Natural Rate of Unemployment

1. Introduction

This paper attempts to build a narrative on the early work of Robert E. Lucas Jr., in the late 1960's, which culminated in the modeling and testing of the natural rate of unemployment hypothesis. Lucas's modeling and testing of the natural rate can be found, respectively, in two papers: "Expectations and the Neutrality of Money" (Lucas, 1972a) and "Econometric Testing of the Natural Rate Hypothesis" (Lucas, 1972b). The natural rate of unemployment is a concept of major relevance in modern macroeconomics. It is part of the theoretical framework that guided scientific research and economic policy from the last third of the twentieth century onwards. The idea that the long-run level of unemployment is the result of real economic forces and, thus, cannot be determined by economic policy is older than this (cf. Simon 1936, 15), but had a specific momentum in the postwar economic literature.

Milton Friedman (1968) and Edmund Phelps (1967, 1968) are usually considered the proponents of the concept, while Robert Lucas is supposed to have given it a *rigorous* mathematical modeling (Lucas, 1972a) and a *valid* econometric testing (Lucas, 1972b).¹ These three Nobel Prize laureates in economics mention the discussion over the natural rate of unemployment as a relevant part of their researches in their Nobel Prize lectures. Friedman (1977) tells his story about the relation between inflation and unemployment in modern economics placing the natural rate of unemployment in its center. Phelps (2007: 545) mentions the natural rate of unemployment while describing his research in the 1960's and 1970's, while Lucas (1996: 671) also mentions the natural rate hypothesis as one of his concerns in the late 1960's and early 1970's.

¹ *Rigorous* and *valid* are characterizations given by Lucas himself to his modeling and to his testing of the natural rate of unemployment hypothesis, in Lucas (1972a: 104) and Lucas (1972b: 99), respectively.

In his Nobel Prize lecture, Lucas (1996: 671) gives equal credit to Friedman (1968) and Phelps (1968) for the formulation of the natural rate of unemployment hypothesis by referring to it as the “Friedman-Phelps natural rate hypothesis”, but claims that his introduction of rational expectations was crucial to model and to test it correctly, since the econometric tests that had rejected the “Friedman-Phelps hypothesis” in the late 1960’s depended on irrational expectations. I will show how Lucas was developing two different research agendas in the 1960’s, one on labor market behavior and the other on optimal investment by firms, that led him to model the natural rate of unemployment hypothesis in a general equilibrium with rational expectations framework and to give it a proper test. I will argue two things. First, that Phelps was Lucas’s true interlocutor in the labor market research agenda, despite Lucas’s recurring references to Friedman, and played a fundamental role in this branch of Lucas’s research by suggesting to him the adoption of a general equilibrium approach. Second, that Edward Prescott was Lucas’s partner in the optimal investment research agenda and played a crucial role in Lucas’s adoption of the rational expectations hypothesis as a forecasting rule for price formation by debating its actual theoretical meaning.

2. Lucas’s labor market research agenda in the late 1960’s

Lucas’s first work on labor market was his model with Rapping tested for the U.S., for the period from 1929 to 1965, which appeared in the September/October of 1969 edition of the *Journal of Political Economy*. Lucas and Rapping (1969a) tried to reconcile the apparent contradiction between an elastic labor supply in the short run with an inelastic labor supply in the long run by building a model that described the dynamics from short run equilibrium to long run equilibrium in the labor market. The authors also made an effort to understand the empirical negative correlation between inflation and unemployment – the

Phillips curve – in a purely supply-demand framework, leaving aside other possible explanations to this negative correlation, such as collective bargaining.²

The model proposed by Lucas and Rapping (1969a) assumes that the labor market is always in short run equilibrium, as a result of simultaneous workers' utility maximization – supply of labor - and firm's profit maximization – demand for labor. The workers form their expectations about future prices adaptively, through a weighed mean of the expectation of future prices made in the previous period and the prices of the current period. Bearing in mind that the prices tend to some kind of long run normal level, the workers incorporate these expectations into their labor supply function. Thus, it becomes rational for workers to raise their labor supply during inflationary periods, when the current price level is higher than the normal, because they think that the price level will be lower in the future – go back to its normal level. This kind of behavior creates a positive correlation between inflation and employment in the short run. It is only in the long run, when future prices' expectations are equal to current prices, that workers do not raise their labor supply, so short run equilibrium is the same as long run equilibrium and there is no tradeoff between inflation and unemployment at all.

It is no surprise that Lucas and Rapping's (1969a: 739) conclusion is very similar to the ones of Friedman (1968) and Phelps (1967, 1968), that the negative correlation between inflation and unemployment - the Phillips curve – is just a short run phenomenon and when

² More than ten years after the publication of the paper, Lucas (1984: 35-36) recollected how he came up with the idea of building a purely supply-demand model for the labor market and how he developed this idea with Rapping's assistance: "The labor part of macroeconomic models, in those days, was pretty disgraceful [...] Rapping and I knew some labor economics, and it's hard to get up in front of a class and talk nonsense deliberately. So we were trying to cook up simple supply and demand models which would fit what you see happening over business cycles. We got interested enough in that so that we thought we'd pursue it as a research topic [...] In the tradition of Friedmand (sic) and Lewis it is hard to think about labor markets without supply and demand. You have to tell how wages and employment arise from shifts in supply and demand curves [...] We were really developing a supply and demand model for employment and wages. Unemployment gets tacked on a side story. We introduced a Phillips curve to make contact with macroeconomic stuff. We wanted to make sure that the labor supply piece didn't assume away business fluctuations".

inflation is correctly anticipated the rate of unemployment reaches its long run equilibrium value, in a way that economic policy becomes ineffective in determining it.

Before finishing the paper, however, Lucas and Rapping (1969a: 748) call attention to two fundamental questions that should be taken into account in order to better understand the labor market behavior, but were not contemplated in the paper. The first is the analysis of the labor market behavior in a general equilibrium framework and the second is the process by which price expectations are revised. These two questions would become the centerpiece of Lucas's (1972a) modeling of the natural rate of unemployment hypothesis in his "Expectations and the Neutrality of Money". The issue about price expectations would be tackled with the introduction of rational expectations, an idea that Lucas was developing in another branch of his research agenda, with Edward Prescott. The general equilibrium approach to the tradeoff between inflation and unemployment would be strongly stimulated by Phelps's comments on Lucas and Rapping (1969a). I will argue that the general equilibrium approach to the tradeoff between inflation and unemployment was suggested to Lucas by Phelps and it was crucial for modeling the natural rate of unemployment hypothesis in Lucas (1972a).³

Despite citing the works of both Friedman (1968) and Phelps (1968) as references for their research, Lucas and Rapping (1969a) show personal gratitude only to Phelps for his comments in early versions of it. To Friedman (1968), the authors attribute the idea that there is no long-run trade-off between unemployment and inflation (p. 738). To Phelps (1968), they attribute a contribution to the Phillips curve debate in which the motivation is similar to the original ones by Phillips (1958) and Lipsey (1960), namely, the building of an out of equilibrium adjustment function for the labor market (p. 722, footnote 2). I will show that

³ The movement towards general equilibrium analysis in postwar economics comes from the neoclassical synthesis, through models that tried to incorporate aspects such as unemployment, money and time into the general equilibrium framework (Weintraub, 1985). We can say that Lucas's and Phelps's research were following this movement.

although Lucas was aware of both Friedman's and Phelps's contributions to the literature, it is only with the last that he was actually interacting with.

We can start investigating the interaction between Lucas and Phelps through an emblematic passage of a Lucas's interview in the 1990's, where he recollects the role played by Phelps in his research about labor market in the late 1960's:

“[Lucas:] My most influential paper on ‘Expectations and the neutrality of money’ [Lucas, 1972a] came out of a conference that Phelps organized where Rapping and I were invited to talk about our Phillips curve work. Phelps convinced us that we needed some kind of general equilibrium setting. Rapping and I were just focusing on labor supply decisions. Phelps kept on insisting that these labor suppliers are situated in some economy, and that you have to consider the whole general equilibrium looks like, not just what the labor supply decision looks like. That's what motivated me” [Snowdon and Vane 1998: 126].

There are evidences that indicate that this recollection is accurate. Lucas and Phelps's relationship and the sharing of their researches on labor market can be reconstructed through their correspondence, found in Lucas's archives.⁴ The first written contact between Lucas and Phelps that can be found in the Lucas's archives is a letter from the last to the former, dated from November 17th, 1967,⁵ in which Phelps shows interest exactly in the work Lucas and Rapping were developing on American labor market. Phelps anticipates and asks for a first draft of the paper, when completed. In his answer, dated from December 6th, 1967,⁶ Lucas did not refer to his paper with Rapping. Even though, in a letter dated from December 12th, 1967⁷, Lucas was invited by Phelps to give a talk about his work with Rapping in a seminar in the University of Pennsylvania, on February 9th, 1968. The title of the talk would

⁴ Robert E. Lucas Jr. Papers, 1960-2004 and undated. Rare Book, Manuscript, and Special Collections Library, Duke University, Durham, North Carolina, USA.

⁵ Lucas Papers, Box 1, file folder “1967”.

⁶ Lucas Papers, Box 1, file folder “1967”.

⁷ Lucas Papers, Box 1, file folder “1967”.

be “An Aggregative Model of the U.S. Labor Market, 1929-65”, according to a letter from Lucas to Phelps dated from January 18th, 1968.⁸ On April 4th, 1968, two months after the talk, Lucas sent a written version of his paper with Rapping to Phelps. The letter also contains some lines of thankfulness for the Phelps’s comments and for his qualification of their model as “fascinating”.⁹ That was the last correspondence with Phelps found in Lucas’s archives before the publication of his paper with Rapping in the *Journal of Political Economy*, in the September/October of 1969 edition.

However, in the meantime, in January of 1969, Phelps coordinated at the University of Pennsylvania the conference mentioned in Lucas’s recollection, where Lucas had the opportunity to present the final version of his paper with Rapping, while Phelps also presented his paper about labor market (Phelps, 1968, 1970).¹⁰ There is a passage in Lucas’s professional memoir (Lucas, 2001: 19) that mentions the book that came out of this conference, which goes in the same direction of Lucas’s recollection quoted before and serves as another indication that Phelps was responsible for motivating Lucas in placing his labor market model into a general equilibrium framework:

“In the introduction to the Phelps volume, Phelps had written that ‘...perhaps Lucas and Rapping are 180 degrees to the truth’, by which he meant that perhaps we should have emphasized income effects in our theory of employment fluctuations rather than the substitution effects we did emphasize” [Lucas, 2001: 19].

⁸ Lucas Papers, Box 1, file folder “1968”.

⁹ “Dear Ned:

Enclosed is Leonard’s and my labor market paper. We appreciate your plug, although the adjective “fascinating” which you apply to our model is an obvious hedge. Still, I guess I prefer it to ‘ludicrous’ or ‘bizarre’.

I doubt if any of your objections will be withdrawn on seeing the written version, but some of the material is more carefully developed than was possible orally. We would appreciate any further comments” [Lucas Papers, Box 1, file folder “1968”].

¹⁰ The conference held at the University of Pennsylvania gave origin to the book “Microeconomic Foundations of Employment and Inflation Theory” (Phelps *e al.*, 1970).

The quote “perhaps Lucas and Rapping are 180 degrees to the truth” cannot be found in the introduction of the Phelps volume (Phelps *et al.*, 1970), but Lucas does actually refer to a Phelps’s “180 degrees to the truth” remark in a letter¹¹ addressed to Phelps, on November, 7th, 1969 – only ten months after the conference at the University of Pennsylvania -, what gives credit to the recollection. More than just referring to the “180 degrees to the truth” remark, Lucas already mentions his new paper “Expectations and the Neutrality of Money” (Lucas, 1972a) – attached to the letter - and discusses both the adoptions of the rational expectations hypothesis and the general equilibrium approach with Phelps:

“Dear Ned:

The two enclosed papers are in a sense ‘spin offs’ from the conference in January. I would appreciate any comments you may have on either.

The paper ‘Expectations...’ [Lucas, 1972a] is, in part, an attempt to get at your ‘180 degrees to the truth’ remark on Leonard’s and my first paper [Lucas and Rapping, 1969a]. It didn’t seem to me possible to get at the question at the level of trying to decide which expectations hypothesis is most ‘reasonable’. So I tried to push the question back to assumptions on the nature of the underlying disturbances which create the forecasting problem in the first place.

The problem seems to be that of getting monetary expansion systematically linked, in fact or in people’s minds, with real demand changes. In a first attempt, I assumed that money entered only to finance real government expenditures (e.g. wars). To get a plausible positive inflation-real output relationship out of such a scheme, it is necessary to let income effects dominate – as you proposed – and to let expectations be sort of extrapolative. That is, the story goes: ‘inflation’ implies ‘high government demand’ implies (due to autocorrelation) ‘high future government demand’ implies ‘capital loss to labor suppliers and money holders’ implies (due to income effect) ‘increased labor supply’. The difficulty with this scheme is psychological: people perceive expansionary periods as bad, depressions as good. A second problem is the fact

¹¹ Lucas Papers, Box 1, file folder “1969”.

that most observed cycles occurred when government demand was too small a piece of the total to be a plausible triggering force.

So this formulation was scrapped in favor of the one described in the enclosed paper [Lucas, 1972a]’.

Lucas says, explicitly, that the paper “Expectations and the Neutrality of Money” (Lucas, 1972a) is a result of the discussion established in the conference organized by Phelps, in January of 1969, at the University of Pennsylvania. The paper was, indeed, an attempt to make the “180 degrees move to the truth” proposed by Phelps. This move would be a change in the explanation given to the empirical evidence of the positive correlation between inflation and employment: from a labor market model in which labor supply increases with inflation because workers believe that their work is better paid today than tomorrow, to a general equilibrium model in which labor supply increases in inflationary periods because agents cannot identify the source of the rise in the price of their goods, due to information problems, so they cannot distinguish between a favorable change in relative prices and a rise in the general price level.

It is a clear signal of the difference between Lucas’s relationship with Phelps and with Friedman that a letter¹² was sent to the last with, apparently, the same paper attached (Lucas, 1972a), in the same day of the letter sent to Phelps. If on the one hand Lucas discusses technical aspects of the paper with Phelps through a whole page, on the other hand he uses just a line and a half to ask for Friedman’s comments:¹³

“Dear Professor Friedman:

I would be grateful for any comments you may have on the enclosed paper”

¹² Lucas Papers, Box 1, file folder “1969”.

¹³ The difference in treatment to Phelps (“Ned”) and to Friedman (“Professor Friedman”) indicates that Lucas was closer to the first than to the second.

It shows how Lucas's research on labor market behavior was, indeed, being shared with Phelps but not with Friedman. There is no answer from any of them in Lucas's archives and there is no reference to any kind of Lucas's correspondence in the electronic finding aid of Milton Friedman Papers at Hoover Institution. Despite the lack of feedback from Phelps and from Friedman on "Expectations and the Neutrality of Money" (Lucas, 1972a), Lucas's archives give us vast material to reconstruct his other branch of research in the late 1960's, the one shared with Prescott, on optimal investment and rational expectations, which is also crucial to understand the modeling of that paper.

3. The rational expectations hypothesis in Lucas's research in the late 1960's

The first Lucas's published paper in which he refers to the rational expectations hypothesis is his "Adjustment Costs and the Theory of Supply", in the *Journal of Political Economy*, in August of 1967. Lucas (1967: 323, footnote 4) presents Muth's (1961) rational expectations - without actually using it in his model - as an alternative to the hypothesis that the actual price level would be maintained constant in the future, what he calls "static expectations". With the introduction of rational expectations, the future price level would be correctly anticipated by firms, instead of just being constant. In the same footnote, Lucas refers to his unpublished paper "Optimal Investment with Rational Expectations" (Lucas, 1966) for further appraisal on the adoption of the rational expectations hypothesis.

"Optimal Investment with Rational Expectations" (Lucas, 1966) was a development of the first two sections of a paper that Lucas presented in a symposium organized by Hirofumi Uzawa, at the University of Chicago, in August of 1966.¹⁴ In the version presented at the symposium, Lucas made two different analyses of optimal investment for firms: one

¹⁴ Letter to Uzawa dated from October 28th, 1966, in Lucas Papers, Box 1, file folder "1966".

for firms located in an industry with a dominant firm and the other for a firm located in a competitive industry. In both of them, he assumed only static expectations by the firms. However, in the updated version that became the unpublished Carnegie Tech working paper “Optimal Investment with Rational Expectation” (Lucas, 1966), the analysis was made under both static and rational expectations, but only for the competitive industry.

According to Lucas’s professional memoir (Lucas, 2001: 15-16), the discussion about the unpublished paper “Optimal Investment with Rational Expectations” (Lucas, 1966) that he established with Edward Prescott during the following years would give origin to the first published paper in which Lucas – with Prescott – used, indeed, the rational expectations hypothesis in a model: “Investment under Uncertainty”, of *Econometrica*, from September of 1971 (Lucas and Prescott, 1971). In this paper, the authors determine the behavior, through time, of investment, output and prices in a competitive industry with a stochastic demand. The rational expectations hypothesis implies that actual and anticipated prices have the same probability distribution. This way of modeling expectations must be interpreted as a technical device employed by the authors to deal with time series data and to allow for unrestrictive forecasts, putting aside the discussion about the process by which firms translate their current information into prices forecast (Lucas and Prescott, 1971: 660).

There are evidences that Lucas’s professional memoir recollection of his cooperation with Prescott is accurate. First of all, we have to have in mind that Prescott entered the Graduate School of Industrial Administration at Carnegie Institute of Technology as a graduate student in 1963, the same year that Lucas arrived there as an assistant professor. Prescott was, actually, Lucas’s student in the capital theory graduate course. Lucas was also a member of Prescott’s PhD dissertation committee, in 1967. It means that Lucas and Prescott were part of the same academic environment for five years. In this environment, they were exposed to Muth’s (1961) rational expectation hypothesis and got to know each other’s

researches.¹⁵ In 1967, Prescott was already an assistant professor at the University of Pennsylvania and from this period on we can reconstruct his cooperation with Lucas through their correspondence, found in Lucas's archives.

The first written contact between Lucas and Prescott that can be found in the Lucas's archives, in which they discuss their researches, is a letter from the last to the former dated from March 16th, 1968.¹⁶ Prescott mentions the talk they had at the faculty club of University of Pennsylvania, the month before, when Lucas first presented his paper on labor market to Phelps. He shows interest in working on the still unsolved question outlined by Lucas, on the behavior of an industry in which there was a dominant firm. Lucas wrote back on March 22th, 1968, agreeing in pursuing the dominant firm research further with Prescott. He enclosed two papers, one with the dominant firm model and other with the competitive industry model. The first is the unfinished one he had presented at the conference organized by Hirofumi Uzawa, in August of 1966, in which he used only static expectations, while the second is the unpublished Carnegie Tech working paper "Optimal Investment with Rational Expectations", where he uses both static and rational expectations. At that moment, the most important question for Lucas and Prescott was to solve the model for the industry with a dominant firm, while the expectations hypothesis underlying price formation seemed secondary.

According to Lucas (2001: 15), the dominant firm problem was never solved and had to be abandoned. On the other hand, the competitive industry model with rational expectations of "Optimal Investment with Rational Expectations" developed into "Investment under Uncertainty" and brought the expectations formation process to the center of the

¹⁵ In Hoover and Young (2011: 5), Lucas says that, by the time he entered GSIA, he already knew about Muth's (1961) paper. It does not diminish the importance of his interaction with John Muth and other professors and students of GSIA to explain his familiarity with rational expectations hypothesis.

¹⁶ Lucas Papers, Box 1, file folder "1968".

discussion. In a letter¹⁷ addressed to Lucas, dated from August 22nd, 1968, Prescott refers to “Investment under Uncertainty”, saying that the paper was overall well received at the 1968 Meeting of the Econometric Society, in Boulder, Colorado, but the rational expectations hypothesis had been motive of conflict among the participants. Some of them thought that perfect forecast in price distribution was an extremely strong assumption. So, Prescott suggested to Lucas, in the letter, that either they could use Muth’s definition of rational expectations to defend the hypothesis or they could argue that people had eventually learned about the true distribution of prices after participating in the market for a sufficient long period.¹⁸

In a letter¹⁹ addressed to Prescott, dated from December 2nd, 1968, Lucas mentions the effect caused by the presentation of the same paper in a symposium on uncertainty and capital theory, in Yale, in the end of November of 1968. Once again, the adoption of the rational expectations hypothesis had been motive of protest by the participants of the seminar: Most of the people thought that it was unreasonable and that they were not being honest by postulating equilibrium at each point in time. Basically, they wanted to know how firms obtained information to form expectations.

Nevertheless, these protests did not seem to have affected Lucas’s disposition to keep using rational expectations hypothesis in “Investment under Uncertainty” (Lucas and Prescott, 1971) and, later, in “Expectations and the Neutrality of Money” (Lucas, 1972a). As we saw from his long letter to Phelps, on November 7th, 1969 – quoted before -, Lucas was not really interested in discussing the reasonability of the rational expectations hypothesis in realistic terms. He had a more pragmatic and instrumentalist approach to the use of the rational expectations hypothesis. He was interested in building equilibrium models and in

¹⁷ Lucas Papers, Box 1, file folder “1968”.

¹⁸ In the published version of the paper, they chose to use Muth’s (1961) definition to justify the adoption of rational expectations hypothesis (p. 660, footnote 4 and p.664, footnote 9).

¹⁹ Lucas Papers, Box 1, file folder “1968”.

dealing with forecasting problems raised by the adoption of adaptive expectations. With adaptive expectations, actual and future prices would have very little chance to have the same distribution, what would make impossible for econometric forecasting. The adoption of rational expectations hypothesis assures that actual and future prices have the same distribution and, hence, allows for econometric forecasting.

4. The merging of Lucas's researches in the late 1960's

On October 22th, 1968, in the meantime of the discussion about the adoption of the rational expectation hypothesis in his paper with Prescott, Lucas submitted for publication his second paper on labor market - with Rapping. The paper titled "Price Expectations and the Phillips Curve" (Lucas and Rapping, 1969b) was developed immediately after the first one (Lucas and Rapping, 1969a), but was published before it, in June of 1969, in the American Economic Review. Lucas and Rapping (1969b) tested their Phillips curve still with adaptive expectations to the period between 1904 and 1965, in the U.S.. In this paper, as in the first one, there are references to Friedman (1968) and Phelps (1968), with special thanks to Phelps's comments on early versions of it. But what is most striking is that three months and a half before the submission of the paper, in a letter²⁰ addressed to Rapping, on July 8th, 1968²¹, Lucas had already shown his total dissatisfaction with the results obtained from the Phillips curve estimation with adaptive expectations:

"I guess I am now convinced that our original results (with lagged prices and unemployment) don't mean anything – except possibly as part of a general argument to the effect that estimating Phillips curve is more complex than is generally recognized. The newest results indicate that trying to account for effects

²⁰ Rapping had written to Lucas, previously, saying that he thought to be "...possible, as you suggested, to rationalize the presence of a lagged unemployment in our Phillips curve in terms of the search process" (Lucas Papers, Box 1, file folder "1968").

²¹ Lucas Papers, Box 1, file folder "1968".

on unemployment other than expectations simply by postulating serial correlation doesn't mean much either. This would seem to me to add urgency to the search for a model which incorporates sources of persistence in unemployment other than the persistence of expectations”.

Despite Lucas's complete frustration with the results, the authors decided to submit the paper and were emphatic about the ineffectiveness of the Phillips curve as a monetary policy weapon (p. 349). However, Lucas and Rapping's (1969b: 344) strongest criticism was really about the use of adaptive expectations, to which they attributed the existence of the long and short run tradeoffs between inflation and unemployment in the model, and that they claimed to be a theoretical deficiency.

One year and a half after his letter to Rapping, by the end of 1969, Lucas had already overcome his dissatisfaction with the adaptive expectations hypothesis in dealing with the tradeoff between inflation and unemployment by replacing it by the rational expectations hypothesis. During this period, the meaning of the rational expectations hypothesis was substantially debated by Lucas and Prescott – as shown before. During the same period, Lucas had also moved his analysis of the tradeoff between inflation and unemployment from a partial equilibrium labor market framework to a general equilibrium framework, as suggested by Phelps. Proceeding this way, Lucas had just tackled the two issues raised in his first paper with Rapping (Lucas and Rapping, 1969a: 748). The evidences for these complete change can be found in the long letter sent to Phelps, on November 7th, 1969 – quoted before -, with a copy of the brand new “Expectations and the Neutrality of Money” attached on it. There is the merging of Lucas's two research agendas in the late 1960's.

“Expectations and the Neutrality of Money” was first submitted to the American Economic Review on January 30th, 1970, suffering a “withering rejection” (Lucas, 1981: 10). That is an indication of how innovative and restricted to the knowledge of a small group of

economists was the technical approach present in the paper.²² It was finally submitted and accepted by the *Journal of Economic Theory* in the same year, and published in the April of 1972 issue of the journal (Lucas, 1972a).

In the paper, Lucas explains the positive correlation between nominal prices and real output. Monetary shocks have real effects in the short run because agents have information problems; they cannot distinguish whether the price change of their products is relative or absolute. In the long run, however, the neutrality of money applies. Lucas (1972a: 103-4) says that his work is similar to Friedman (1968a) and that it presents some of Friedman's (1968) propositions about the American economy in a rigorous way.²³ It is also said in the paper that another precursor of his work is Phelps (1968, 1970), because he shows, just like Lucas (1972a), the existence of the Phillips curve in a framework in which all the neoclassical postulates are assumed, except the perfect information one. Lucas (1972a: 104) argues that his concept of equilibrium is new, although it resembles the dynamic program one – the one used by Phelps (1967, 1968, 1970). His equilibrium prices and quantities are functions of the possible future states of the economy, what makes rational expectations more suitable than adaptive expectations to relate information available to the agents to their forecasts.

In a deliberated effort to make “Expectations and the Neutrality of Money” accessible to a larger audience, Lucas prepared, during the summer of 1970, a paper called “Econometric Testing of the Natural Rate Hypothesis” (Lucas, 1972b), which would be presented at the Fed conference “The Econometrics of Price Determination”, in Washington, D.C., in October of the same year (Lucas, 2001: 21). In the paper, Lucas (1972b: 90) admits that there is, indeed, a negative correlation, in the U.S. data, between inflation and unemployment and, so, poses two questions to be answered by the natural rate of

²² See Gans and Shepherd (1994: 172) for more details about this rejection.

²³ See De Vroey (2001) for details about the methodological differences between Lucas (1972a) and Friedman (1968).

unemployment advocates. The first is about econometric testing: if this correlation does not prove the existence of an exploitable tradeoff between inflation and unemployment, should the natural rate of unemployment be judged only on theoretical grounds? The second is about policy evaluation: if monetary policy cannot be evaluated by extrapolating this negative correlation, should quantitative policy evaluation be abandoned? According to Lucas (1972b: 91), the answers to these questions would depend on how one would translate the natural rate of unemployment hypothesis into theory.

The first device Lucas (1972b: 91 footnote 2) used to translate the natural rate of unemployment hypothesis into theory was to treat observed prices and quantities as the result of market clearing equilibrium. According to the author, the discussion whether observed prices and quantities are, indeed, market clearing outcomes creates more heat than light. So, one should simply assume that they are market-clearing outcomes for two basic reasons: first, because the alternative hypothesis (non-market equilibrium) would bring logical difficulties to the analysis; and, second, because it would allow dealing with intertemporal substitution and expectations questions, by eliminating the standard dynamical prices and quantities adjustment (*tâtonnement* process).

The second device used by Lucas (1972b: 95-6) was the adoption of the rational expectations hypothesis to determine expected prices. With this kind of expectation, a relation between actual and expected prices is established in a way that the expectation of the difference between actual and expected prices equals zero. That's why rational expectations hypothesis is equivalent to natural rate of unemployment hypothesis itself, by construction.

Based in a model that contains these two devices, Lucas (1972b) answers the two questions posed to the natural rate advocates. First, the natural rate hypothesis can also be judged on empirical grounds, through a test on the parameters of a model that contains simultaneous equations not only for inflation and unemployment, but for policy too. Second,

evaluation could be made comparing the values of the parameters of the models containing different policies. In short, policy should be part of the model and should be tested *with* inflation and unemployment. It should not be derived *from* a model of inflation-unemployment tradeoff.

5. Conclusion

“Expectations and the Neutrality of Money” (Lucas, 1972a) and “Econometric Testing of the Natural Rate Hypothesis” Lucas (1972 b) are the corollary of Lucas’s research in the late 1960’s. These papers are the synthesis of the two branches of Lucas’s research at that time; one on labor market behavior and other on optimal investment by firms. This synthesis changed the way in which the natural rate of unemployment was originally elaborated by Friedman (1968a) and Phelps (1967, 1968), by modeling it in a general equilibrium framework with rational expectations and giving it a proper test.

Lucas’s research agenda synthesis in the late 1960’s was the result of his close interaction with Phelps and Prescott, backed up by his pragmatic equilibrium approach to economics, concerning modeling, econometric estimation and testing. Phelps explicitly suggested a general equilibrium approach to Lucas’s labor market modeling, while Prescott helped him in dealing with the rational expectations hypothesis. When Lucas managed to merge the rational expectation hypothesis into his general equilibrium approach, he was able to establish the macroeconomic framework in which the natural rate of unemployment and the negative correlation between inflation and unemployment could coexist.

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