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No. 126, 1984

**AN EASY FIXUP OF THE FLAW IN LUCAS'
"NEUTRALITY OF MONEY"**

by
Harald Lang

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AN EASY FIXUP OF THE FLAW IN LUCAS' "NEUTRALITY OF MONEY".

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The reader is assumed to be familiar with the papers |1| and |2|. The purpose of this note is to point out that the apparent flaw in |1| is very easily fixed.

All references are to |1|. The "error" consists of the fact that lemma 1 (p.111) does not seem to establish a one-to-one correspondence between p and x/θ . But it actually does, as the following proposition shows:

Proposition. Let $p(x,\theta)$ be defined and continuous for all (x,θ) in some open, convex subset of the first quadrant, and assume that

$$x_1/\theta_1 \neq x_0/\theta_0 \quad \text{implies} \quad p(x_1,\theta_1) \neq p(x_0,\theta_0)$$

Then the converse is also true, i.e.

$$p(x_1,\theta_1) \neq p(x_0,\theta_0) \quad \text{implies} \quad x_1/\theta_1 \neq x_0/\theta_0$$

Proof. Suppose the contrary, i.e. there exists (x_0,θ_0) and (x_1,θ_1) such that, say

$$p(x_1,\theta_1) > p(x_0,\theta_0) \quad \text{and} \quad x_1/\theta_1 = x_0/\theta_0$$

Note that this implies $(x_0,\theta_0) \neq (x_1,\theta_1)$. Now, by continuity, there exists (x'_1,θ'_1) close enough to (x_1,θ_1) such that $x'_1/\theta'_1 \neq x_1/\theta_1$ and $p(x'_1,\theta'_1) > p(x_0,\theta_0)$. Take next any real number p in the open interval determined by $p(x_0,\theta_0)$ and the minimum of $p(x_1,\theta_1)$ and of $p(x'_1,\theta'_1)$. Again by continuity, there exists (x',θ') in the open segment $((x_0,\theta_0), (x_1,\theta_1))$, and (x'',θ'') in the open segment $((x_0,\theta_0), (x'_1,\theta'_1))$ such that

$$p = p(x',\theta') = p(x'',\theta'')$$

Clearly, however,

$$x'/\theta' = x_0/\theta_0 \neq x''/\theta''$$

which contradicts the assumption of the proposition. Q.E.D.

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One problem remains, however. The right hand side of Lucas' equation (4.2), being a conditional expectation, is a function of (x, θ) defined only almost everywhere. The definition of an equilibrium price function $p(\cdot)$ should thus be that (4.2) holds for almost every (x, θ) . The implication of this is that lemma 1 may fail to hold at points where the joint density of (x, θ) vanishes.

The easiest way to deal with this difficulty is to assume that the joint density function of (x, θ) is strictly positive on some open, convex set, and zero outside. E.g., if x and θ are independent, then each of them should have a density function which is strictly positive on some open interval and zero outside. Whether the uniqueness property of an equilibrium price function holds without any assumption on the density of (x, θ) remains, to my knowledge, an open question. We should finally remark, however, that in case $x=1$ (or $\theta=1$) with probability 1, the converse of Lucas' lemma 1 is immediate, and thus Lucas' theorems 2 and 3 remain true in all cases.

ACKNOWLEDGEMENTS.

I am very much indebted to an anonymous referee for this Journal. First of all, he extended my proposition from the case in which $p(x, \theta)$ was assumed to be continuously differentiable. The proof given here is due to him. Furthermore, he pointed out the necessity to consider the density of (x, θ) .

Finally I wish to thank Bo Axell for introducing me to the papers |1| and |2|.

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