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Using *MS Excel* to solve and simulate the Life-Cycle/ Permanent-Income Model of Consumption and Saving☆

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ABSTRACT

The objective of this manuscript is to provide a simple guide to instructors and students on how to solve and simulate a discrete-time specification of the *Life-Cycle/Permanent-Income Model of Consumption and Saving* (LCPI Model) using only algebra and basic calculus. The solution and simulation procedure makes use of the simple computing environment in *MS Excel*. Understanding this process will enable students to operate and experiment with one of the preeminent models that is used in modern economic analysis. The dynamic LCPI Model in this manuscript includes a social security program to demonstrate some relevant applications of the solution technique and methods.

1. Introduction

Many fields within economics currently use rigorous models that require sophisticated dynamic mathematical techniques. Indeed, many of the standard economic models that are frequently taught in the classroom have generally been accessible to only advanced graduate students who possess a

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high-degree of mathematical preparation. However, Thaler (2000) states, "Each generation of scientists builds on the work of the previous generation. Theorems too hard to prove 20 years ago are found in graduate student problem sets today" (p. 140). This statement might also imply that many of the models requiring such sophisticated mathematical techniques are starting to "trickle down" to the undergraduate level. Given the progress of technology and of economics pedagogy, some instructors are starting to introduce such models to undergraduate students who are capable of the requisite, high-level mathematics.

One of the predominant models currently used to conduct modern macroeconomic research is the *Life-Cycle/Permanent-Income Model of Consumption and Saving* (LCPI Model). This model has a basis in the *Life-Cycle Hypothesis* of Ando and Modigliani (1963) and in the *Permanent-Income Hypothesis* of Friedman (1957, 1963), which were separately offered as models of household spending and saving behavior. The *Life-Cycle Hypothesis* essentially suggests that lifetime resources are taken into account when making consumption and saving decisions, and the *Permanent-Income Hypothesis* suggests that consumption is primarily dependent on permanent (average) income over the lifetime.[1] The widespread use of the LCPI Model to study consumption and saving behavior stems from the fact that the concept of utility maximization is central to economic theory, given that it follows from the basic axioms (assumptions) about economic rationality. The canonical way of characterizing utility maximization in dynamic, intertemporal settings is the LCPI Model. Yet, undergraduate courses in economics typically provide only a brief graphical or heuristic overview of this important framework. The likely reason for such cursory presentations of the model in undergraduate courses is that a decent level of mathematical proficiency is usually required of students. The tradeoff from a pedagogical perspective is that students usually gain only a superficial understanding of the model upon completion of an undergraduate degree in economics, without having received much opportunity to acquire meaningful experience in operating or experimenting with an important tool that is used to conduct economic research and policy analysis.

The objective of this manuscript is to provide a set of straightforward instructions on using *MS Excel* to solve and simulate the LCPI Model. The intended target audience of this manuscript is instructors and students of intermediate macroeconomics courses, and above. This is due to the fact that the only requisite mathematics needed to work with the discrete-time version of the model in this manuscript is a knowledge of basic calculus. To be more specific, students will have to know (or learn) how to use the method of *Lagrange* to construct a constrained optimization problem and to derive the conditions for a maximum (such knowledge is often at the command of undergraduate students in economics). Yet, students do not have to know how to derive explicit solutions to the LCPI Model, because this manuscript demonstrates that a numerical solution and simulation procedure can alternatively and easily solve the model by using a simple computing platform such as *MS Excel*. Understanding this process will enable students to experiment with one of the important models that is used to study many of the policy-relevant research questions that exhibit intertemporal tradeoffs. Indeed, three important applications of the methods in this manuscript are provided for illustrative purposes: the effects of social security participation on well-being, the effects of aging demographics on social security benefits and behavior, and the effects of increased taxation to preserve social security benefits given aging demographics.

2. The LCPI Model in discrete time

Time is discretely modeled and dates (or nodes) that separate and demarcate periods of the life cycle are indexed by t. The representative individual enters the workforce at date $t=0$, retires at date $t=T$, and exits the model (dies) with certainty at date $t = \overline{T}$. The dates of retirement and death are known and fixed in this presentation of the model, yet the setup could be augmented to include endogenous retirement selection and/or mortality risk for other potential applications. The individual inelastically supplies labor and earns a flow of gross wages at the constant rate of w during the working phase of the life cycle.[2] The individual pays social security taxes at rate θ while working, and

[1] See Speight (1989) and Deaton (1992) for additional details on the *Life-Cycle* and *Permanent-Income Hypotheses*.

[2] It is straightforward to adopt a more realistic wage-income flow that is time-dependent over the working phase. However, the assumption of a constant flow is used here to focus on the pedagogical objective of the manuscript.