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THE RECONCILIATION OF MICRO AND MACRO ECONOMICS

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THE RECONCILIATION OF MICRO AND MACRO ECONOMICS*

by

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Abstract: It is suggested that the appropriate structure for the reconciliation of micro and macroeconomics is an infinite horizon overlapping generations (OLG) model with many finitely lived natural persons and one infinitely lived strategic player without preferences whose choice rule is determined by the periodic political choice of the finitely lived players who are alive and politically strategically active at the time of choice. This player may be interpreted as government. There may also be a class of corporations with infinite lives and a decision rule.

In the steps from the finite horizon general equilibrium (GE) model to the overlapping generations model to a government guided overlapping generations model (GGOLG) it is suggested that even without exogenous uncertainty, if economic efficiency is to be attained it is logically and technologically necessary to introduce government, government money, credit, bankruptcy and inheritance conditions. Firms as corporate entities are legal but not natural persons. Their behavior may be determined by a game within the game.

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1. INTRODUCTION

Macroeconomic models of the economy are intrinsically dynamic. They are also frequently often considered to be ad hoc in some aspects. They are implicitly, if not explicitly institutional, they have at least consumer/ workers, producer/firms and government as agents. Government money and bank or private credit are often explicit. The models are implicitly open in time. Although not always spelled out, there appears to always have been a yesterday and a tomorrow is expected.

In contrast with the macroeconomic models the standard general equilibrium (GE) model is preinstitutional. It is suspended in a context free static world of production and exchange over a finite time horizon by individual agents in a moneyless institution free world. All individuals face an isolated one time optimization problem which can be viewed as selecting an optimal strategy in an appropriately related game in strategic form.

Yet in spite of the extreme simplicity and parsimony of the GE model it has considerable appeal for several reasons. In contrast with the macroeconomic models (abbreviated henceforth as MM) the GE models are high dimensional, handling many types of agents and goods and are logically consistent and complete offering an attractive picture of decentralized optimization.

It is clear that the Arrow-Debreu model has many features missing which are needed before it could be regarded as a means for providing the basis for macroeconomic theory. In the remainder of this article the steps needed to enlarge the economic analysis of GE to encompass the politico-economic concerns of the MM, are described.

There are five different types of enlargement of the GE model which are called for in our approach to macroeconomics. They are listed then discussed. They are displayed in Figure 1.

(1) A process model of exchange and of production and exchange (SMG).

(2) A GE model with international trade

(3) A GE model with an infinite horizon ($GE\infty$)

(4) A GE model with public goods

(5) A GE model with incomplete markets (GEI)

(1) The approach of Debreu (1959) and most subsequent authors working on GE models was to present an existence proof for efficient prices, not to specify any price formation mechanism or to even indicate the nature of a playable game.

The act of attempting to convert the GE model into a playable strategic market game (SMG) raises explicitly basic problems concerning the role of money and the meaning of "enough money" in an economy. These features have been discussed extensively elsewhere (Shubik, 1988).

(2) The control of the economy as a whole calls for the provision of a host of different public goods. However even without considering the usual array of goods and services provided by government the running of an OLG economy may require government and a financial system for efficiency and a society might wish to consider land as a public good. In keeping with a belief that if difficulties can be separated and studied individually it is usually desirable to do so; we deal only with government as a financial control system. After the structure of the GGLOG economies have been exposited then features such as public goods may be integrated into the framework.

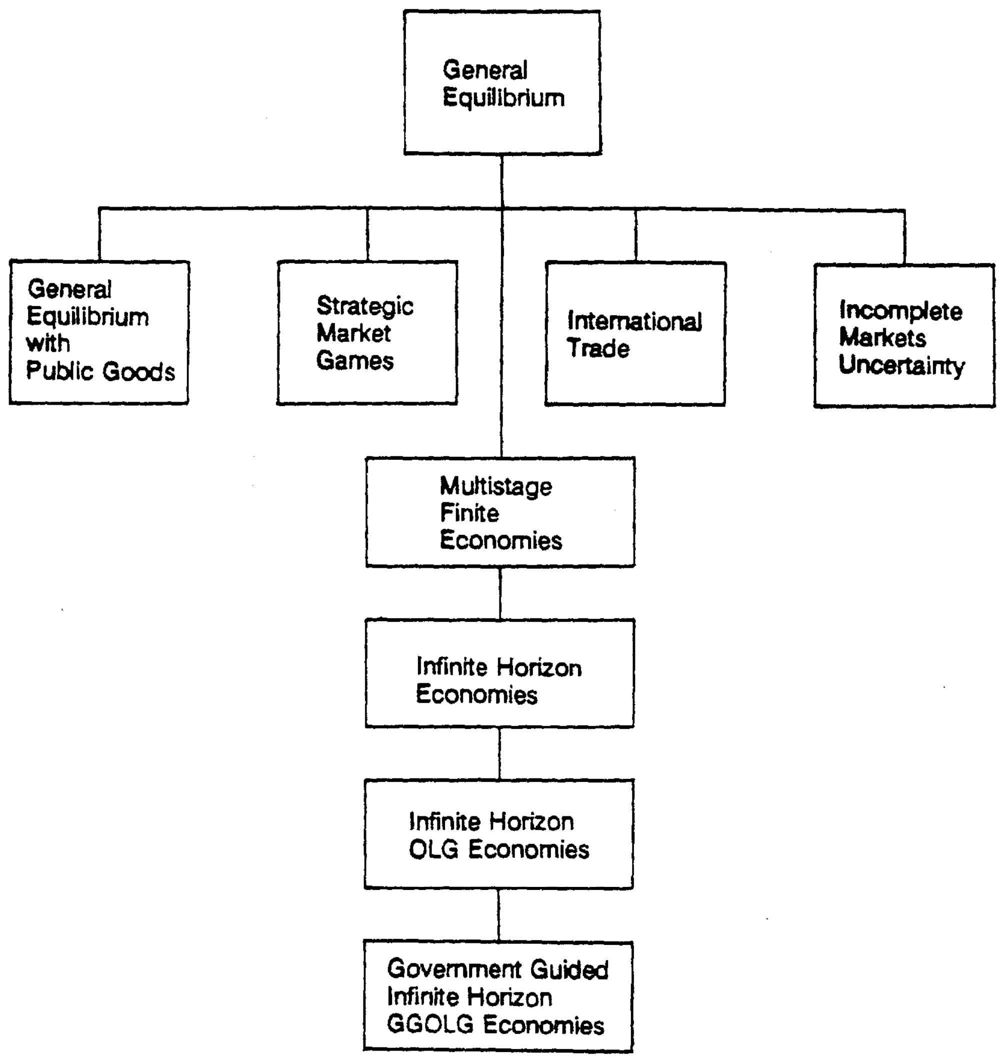

Figure 1

International trade calls for a consideration of at least two governments and the possibility for two or more national monies. Similarly the introduction of uncertainty with incomplete markets raises new conceptual problems in the enlargement of the scope of general equilibrium. However these too may be considered separately from the key question of how to extend in a logically satisfying manner the preinstitutional economic theory of general equilibrium to the political economy of macroeconomics.

We pursue the path which adds only consideration of time and dynamics. The extension of general equilibrium to many, but finite periods causes no extra conceptual problems if complete markets are considered. If exchange and production are viewed as a game of strategy with a finite number of players then new problems involving oligopolistic inefficiency and the complexity of the strategies of each individual appear.

If we go to the infinite horizon then new problems appear even for the extended general equilibrium model assuming a continuum of agents. In particular how do we define the utility functions or payoffs for both consumers and firms if both live forever? The usual answer is to introduce a discount rate where the firms maximize their expected discounted profit

$$\Pi_j = \sum_{t=1}^{\infty} \left(\frac{1}{1+r}\right)^{t-1} z_t$$

where z_t is the net revenue in period t. The consumers are assumed to maximize $\sum_{t=0}^{\infty} \beta^{t-1}\varphi(x_t)$ where x_t is the vector of goods consumed by the individual during t.

All agents are assumed to live forever. Logically there is nothing wrong with the assumption, that individuals live forever. Factually it appears to be a poor assumption about natural persons. Also the need to "balance the budget only at infinity" leads to problems with the possibility of "Ponzi financing" where debts are continually rolled over and never paid back.

A model that is closer to reality has overlapping generations of finitely lived agents, and this is where the potential for the construction of models for political economy which yield an understanding of the role of institutions, begins.

2. OVERLAPPING GENERATIONS: NATURAL AND LEGAL PERSONS

2.1. Allais and Samuelson

In their seminal works on overlapping generations both Allais (1948) and Samuelson (1958) suggest a role for government. In Samuelson's work verbal reference is made to both government and the role of money, but no formal effort is made to model government as an active agent or player. In contrast in a lengthy appendix (around 115 pages) Allais carries out a calculation with old and young agents, firms and government all introduced explicitly.

A possibly unsatisfactory aspect of this trailblazing exercise is that the justification for the goals of the two sets of potentially infinitely lived players, the firms and the government is not made clear.

Since the advent of the pioneering work the literature on overlapping generations models has proliferated. The survey by Geanakoplos (1987) covers much of it. When a government is considered the opportunity appears to construct models and raise questions concerning the national debt, social security and a host of other welfare and macroeconomic problem.

2.2. Infinitely Lived Agents

At a formal level Muller and Woodford (1988) investigate a mixed model with a set of agents with finite lives and a set of players with infinite lives.

They suggest utility functions of the form: $\sum_{t=0}^{\infty} \beta_j^t \varphi(x_t^j)$ for the infinite players. There are three interpretations of the infinite players. They are the government, corporations and dynasties. Both the government and corporations are legal persons with infinite lives. Dynasties can be offered as a justification for this utility function where one might argue that a "superplayer" is composed of a set of finitely lived individuals each of whom regards the utility functions of future generations to be part of his own.

There is a modeling problem with the dynasty view of an infinitely discounted utility function. When generation t shows a concern for generation $t+1$, this concern may be manifested in a desire to leave an inheritance for $t+1$ such as $10,000 or the house or a family heirloom. It might also involve generation t's concern for the utility or values obtained by $t+1$. An empirically and logically easier and more satisfactory view of intergenerational concern is that the bequestor is concerned with his desires to make the bequest and not its utility to the recipient. If this view is adopted then we must abandon the dynasty interpretation of the infinite utility function.

If we interpret the two types of infinite agents as firms and government we must raise the question as to why we wish to ascribe to them utility functions of the form:

$$(1) \qquad \phi_j = \sum_{t=0}^{\infty} \beta_j^t \varphi(x_t^j) \quad \text{with} \quad 0 \le \beta_j < 1 .$$

The first answer might be mathematical convenience. This form gives us bounded values. But, upon reflection, we observe that they are not "natural persons" and there is a question as to whether the attribution of a utility function to these entities is called for or is necessary.

A player in game of strategy is characterized by a strategy set and a payoff function. A solution of a game involves the specification of some sort of choice rule usually based on some operation by the player on his strategy set. This operation may involve the player's attempt to maximize his payoff function. But in order to describe a game of strategy it is not necessary that an individual who is a strategic player has a utility function. Instead it could be equipped with a <u>choice rule</u> which instructs it as to what to do in all circumstances. Even though the player may have an infinite life the decision rule whereby it advances into the future may be based on a finite set of arguments. It is suggested here that an appropriate way to incorporate government and corporations into an overlapping generations model is to introduce them as infinitely lived strategic players without utility functions but with a decision or choice rule determined by the real persons. For simplicity in the discussion firms will be considered later and our remarks are concentrated on the modeling of government which is controlled by the real persons. Figure 2 suggests the scheme for an overlapping generations economy containing three types of agents. They are: (1) the young, (2) the old and (3) the government. The first two, the real or natural persons, can be regarded as many in number, possibly most conveniently represented by a continuum of agents and the third is a single large atom.

At point of time $t = 0$ there are two generations alive, those born at time $t = -1$ and $t = 0$. Government as well as the live agents must select its move at $t = 0$. A reasonable restriction on its choice rule is that it depends at most on all of the decisions of all of the natural persons alive at $t = 0$. The idea of a government plan will be discussed later.

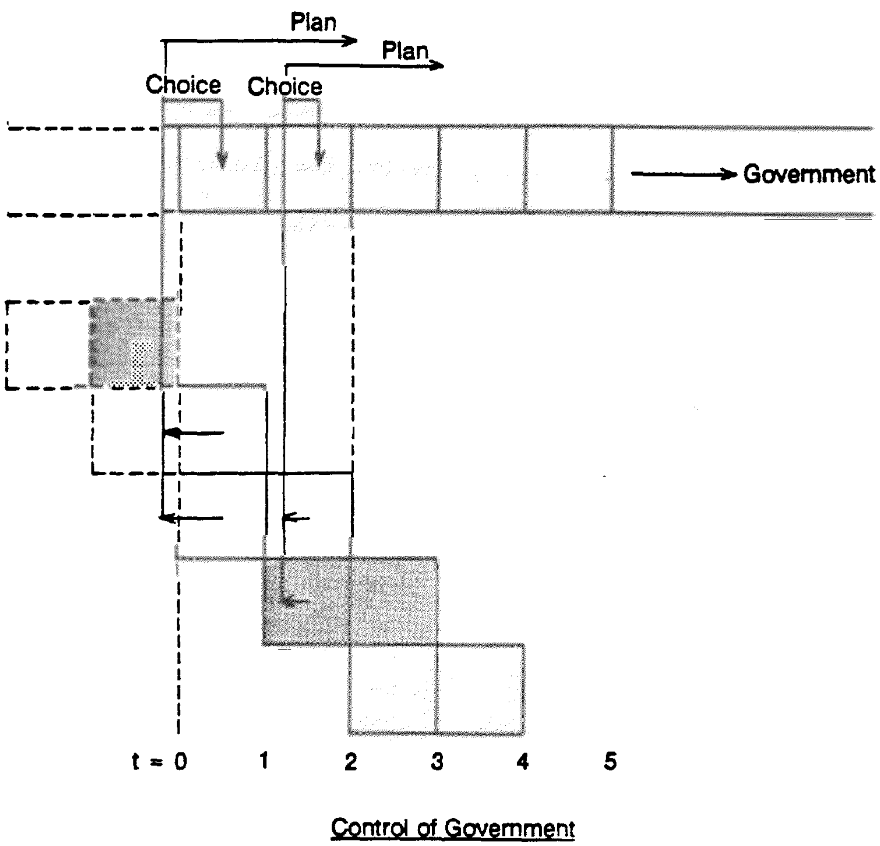

Figure 2

At time t there are two generations alive, those born at $t-1$ and those born at t. They are concerned with maximizing their welfare where an individual born at time t is assumed to have a utility function of the form:

(2) $$u_t = \varphi(x_t^t, x_{t+1}^t)$$

where x_t^t may be interpreted as a vector of resources obtained by a representative individual born at time t.

We may consider that an individual born at t has a set of strategies

S_t . Part of any strategy is an action, message or instruction that he sends to the government each period.

Heuristically the actions of the government at time t might depend on cultural, historical, social, political and economic factors. If (both for ease and parsimony) we choose to model the agents as nonsocial, nonhistorical individualistic local maximizers we then have the most unfavorable and simplest set of conditions to examine the possibility that there may be structures where the needs of future generations could be served by the selfish behavior of the living.

One way of trying to explain cooperative behavior and institutional structure is to try to start with the individuals alone without any societal context whatsoever. For example we might start with an analysis of repeated plays of an abstract 2 × 2 matrix game. We do not follow this approach here as there is a way to split the study of institutions into two parts and to consider them sequentially. The first step may be regarded as a comparative analysis of institutions in the sense that one takes as given an institution called government whose strategy set and decision rule are given. We then consider the outcome of a game played in the context of these rules. Having considered politico-economic or economic efficiency within the context of the given institution we may then wish to ask a separate question. That is how did the institution evolve in the first place and how is its structure modified.

Even if one is studying equilibrium conditions in an abstract game one must be careful to consider how general and how relevant and accurate is the abstraction of the biological, anthropological, cultural, historical, sociological, legal, political and economic context of the game. A way to avoid spurious or dubious generality is to specify the institutional structure within which the game is to be played.

At equilibrium much of the institutional structure may not be apparent because much of its function is to be a carrier of process and this is best seen out of equilibrium.

2.3. Government Policy and Choice: Social Welfare and Strategy

In formal game theory it is important to keep in mind the distinction between move and strategy. A move is a choice made at a specific information set. A strategy is a plan which describes contingent choices over a sequence of moves. When finite games are studied in strategic form it is assumed that players select strategies and their commitments are firm.

Government behavior can be considered in terms of both moves and strategy, but the more appropriate words are choice or action and policy or plan. We may regard a government at any particular point in time as carrying out two activities. It sets taxes, subsidies, fixes the money supply, controls the central bank rate of interest and manages the national debt, as well as taking action on many items of social welfare entailing public goods and services. The government also announces or otherwise indicates policy. Thus it indicates that it has a program or plan over the next few years to raise taxes and to lower the public debt.

Empirically we may observe that most governments, at any point in time, appear to have some form of plan, but the plan is continually updated, modified or otherwise changed. There is often a considerable skepticism held by the public concerning the plausibility that the stated plans of the government at time t will be consistent with its actions at time $t+1$. Yet in human affairs, even if policy changes in the future there is a perceived need that it be announced in the present, if only to provide some indication of the gap between promise and fulfillment.

When one looks at governmental planning and policy, at least at a level of explicitness it does not appear to be particularly long term. At most one suspects that it stretches no longer than between administrations. In a democratic society comprised of selfish individuals it is reasonable to accept as an upper bound on the length of any announced plan, the lifetime of the youngest strategically active individual.

Figure 3, which contains more detail than we will be using in the remainder of this discussion suggests roughly the divisions of political and economic activity of a natural person assumed to live to 75.

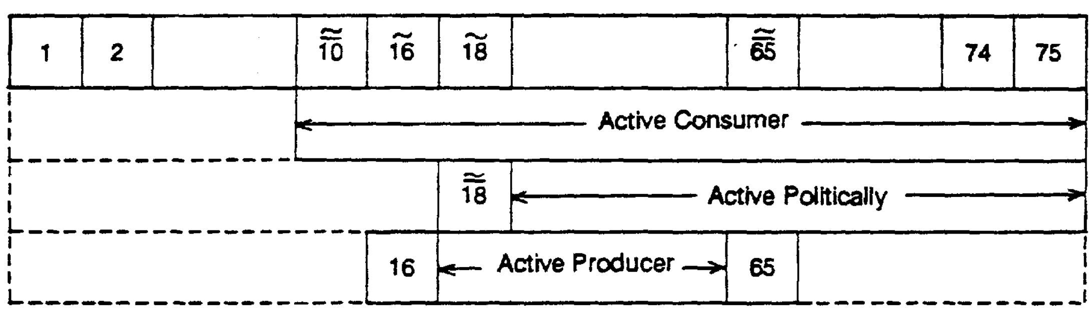

Figure 3

Discretionary spending of the young may be economically significant even before they start to earn. The political franchise of an individual lasts even after economically productive activity.

Referring back to Figure 2 we may become somewhat more formal as follows.

Let the set of actions available to the government at time t be A_t, a specific action is $a_t \in A_t$. Let P_t be a set of plans one of which announced by the government at time t $p_t \in P_t$ is a specific plan.

Both the action and the announced plan of the government at time t may be regarded as functions of the moves of the old and young natural persons at time t. Thus

$$a_t = f_1(m_t^{t-1}, m_t^t) , \quad p_t = f_2(m_t^{t-1}, m_t^t) .$$

We might require that a_t and p_t be consistent, i.e. at least your current actions are consistent with your current plan. We might wish to impose consistency between overlapping plans but for an evolutionary theory that may not be a logical necessity.

If the government is an artificial player and all of the natural persons are small relative to the society as a whole then the strategy of each individual will be relatively simple and consist of a sequence of moves dependent upon the state of the system at the end of each previous period.

A review of Figure 2 shows one cross-hatched cell which indicates the young who will be born in the future when those who are alive and young today will still be alive. Thus in the game that is played in the space of the lifetimes of those who are alive today there will be three natural persons as well as government. There are two ways to take into account the influence of the newborn who will be of strategic relevance to those currently alive, one can make a general behavioral assumption replacing them by an expectation on their behavior, or one can make a special assumption which tries to deal with the full structure of the potential infinite regression in the strategic interlinkage of the overlapping generations. We return to this in Section 2.5.

Returning to the consideration of government as an artificial player.

It has been suggested that we may regard its choices as based on the choices of the real persons. A simpler assumption is that they are based on the characteristics of the real persons rather than their actions. This in essence provides for a society with a government guided by a social welfare function.

2.4. The Game within the Game: Artificial Players and Politicians

In the model described in Section 2.3 government is described as an artificial player. There is a somewhat different and more complex mode for modeling government as a game within the game (see Downs, 1957, Shubik, 1984, Ch. 22). For example we might consider the strategy set of what government can do to be given by some form of constitution, but the selection of a move by government to be the result of a game played by a set of fiduciaries, politicians or bureaucrats who have been elected or appointed to act or play in the political and bureaucratic game which in turn determines the move of government.

A model of representative government or government by bureaucrats suggests government as more than a direct artificial player, but a device whose moves are the outcome of a game of strategy among an elite. We note, but do not attempt to deal with this level of complexity at this time.

2.5. Expectations

Figure 2 and the example below are utilized to attempt to specify the need for the introduction of expectations if a forward solution to the progression of the political economy is attempted.

Let the overall set of strategies of an individual born at time t be S_t. For simplicity we assume that a government announces only its moves and that at time t a move by government is determined by $f(s_{t-1}, s_t)$.

We now describe the payoffs to three live players but include, in part, strategic inputs from five. Consider the game at $t = 0$

$$\pi^{-1} = \Pi^{-1}(\hat{s}_{-2}, s_{-1}, s_0, f(\hat{s}_{-2}, s_{-1}), f(s_{-1}, s_0)) \tag{3}$$

$$\pi^{0} = \Pi^{0}(s_{-1}, s_0, s_1, f(s_{-1}, s_0), f(s_0, s_1))$$

$$\pi^{1} = \Pi^{1}(s_0, s_1, \tilde{s}_2, f(s_0, s_1), f(s_1, \tilde{s}_2)) .$$

Referring back to Figure 2 there are two boxes, one with square hatching involving generation -2 and one with cross hatching for generation 2. If we wish to consider the game played today including all those alive in the span of a generation as strategic players then we must supply two sets of information, one historical and the other involving expectations. We need to regard as datum what player -2 did in period 1 when he was old. This is relevant to the payoff of player -1. This is denoted by $\hat{s}_{-2}$.

Player 1 will live only half of his life in the game at $t = 1$. His actions will be influenced by his expectation of the actions of player 2 at time 2 thus we need as datum to be able to fill in the information to account for the cross-hatched square. That is the relevant part of the strategy for player 2. This is noted by $\tilde{s}_2$.

The assumptions made in defining the three player game are that the payoff characteristics of player 1 are known to -1 and 0 before he is born and the strategic choice of player 2 is known to player 1 before player 2 is born.

Where these assumptions come from must be accounted for by the invocation of parsimony, a normative argument or a theory of the formation of expectations possibly supported by observation or as an implication of a psychological or social-psychological theory.

3. OPTIMIZING AND BEHAVIORAL MODELS

3.1. Stationarity, Optimization and the Disappearance of Time

An aesthetically pleasing theory of multigenerational economic behavior might call for consistency of expectations combined with some criterion of optimality.

If we make the assumption that all generations are identical and that all enter with the same endowments as their ancestors, without trying to patch up a local optimization process with history and expectations assumed exogenously we might search for stationary solutions which yield consistent expectations over the infinite horizon. The assumption of the existence of a stationary (or cyclical) solution is tantamount to the eradication of time from the problem. The expectation of what future generations will do is born out. The optimization problem involving a countable infinity of strategic variables is replaced by a finite cycle.

We need to contemplate the full knowledge and information requirements of this view of overall optimization. Table 1 suggests several of the relevant factors.

	Plausible	Weakly Plausible	Unlikely	Comment
knowledge of own utility function		√		assumed as best of workable assumptions
knowledge of utility function of other contemporaries		√		modified by use of introspection aggregation and proxy variables such as excess demand
knowledge of own strategy	√	√		need to define optimization but doubtful over more than a few years
knowledge of strategies of other contemporaries			√	highly implausible except in long term oligopolistic competition
knowledge of moves of others				empirically reasonable in some aggregate form
knowledge of goals of future generations			√	obtained by symmetry assumption: "They are like us"
knowledge of strategies of future generations			√	can be obtained by symmetry assumptions together with simplifications due to looking at stationarity
knowledge of size and power government	√			

TABLE 1

The assumptions that an individual knows his own utility function and strategy are relatively strong but will not be challenged in detail here, beyond observing that a better picture for even those individuals who have been schooled in normative theory is that at most the planning horizon is a few years and the plan is updated in a year or even sooner.

The knowledge of the strategies of other contemporaries can be high in long term one on one competition; thus in markets with two or three long lived firms they may try to form a picture of each other's strategies from a history of moves and verbal statements. In mass societies, however, at best, individuals form views of aggregates. The aggregate form may be justified or rationalized by introspection ("they are like me") or by some conception of "the average."

In essence individuals may see the moves of others or some composite outcome (such as the stock market closing prices), but it is difficult, if not impossible to deduce strategies of others in mass markets.

Invoking some form of continuity and genetics together with symmetry one might argue that children or grandchildren might be assumed to be relatively similar to their parents. It is even feasible for five generations to be alive simultaneously, possibly six or even seven might be biologically feasible (a birth at 17-20 and an age of 102-120) but this is suggestive of an extreme upper bound on any individual's conscious concern for further generations and their actions.

If we limit, by assumption, the ability of live natural players to include in their plans knowledge or foreknowledge beyond their own lives then we only allow optimization equations of type (3) which involve a bound to the number of strategic variables and an explicit need for expectations in contrast with processes where the argument for each payoff function involves a countable infinity of variables.

It appears that an attractive reason for assuming the similarity of future generations and concentrating on steady state, cyclical repetition of states or smooth growth is that not only is the mathematics more tractable than otherwise, but in essence a problem involving an infinite number of strategic variables is mapped into one with a finite number.

The need to plug in expectations as is indicated in Figure 2 and equations (3) is satisfied by the assumption that like agents in like circumstances will act the same way. Infinite time disappears and is replaced by a stationary cycle when similar circumstances are postulated.

The last item in Table 1 is government. It is reasonable to assume that most individuals concerned with the economy more or less know of the government's actions. Furthermore if government is large and influential (for example: taxes and subsidies might be bigger than 15 percent of GNP) a key factor in the dynamics of the economy will be government.

3.2. Expectations and Evolution

There is a literature showing how many interactions or trades between two partially informed agents will lead to consistent estimations (see Geanakoplos and Polemarchakis, 1982). The stationary or cyclical state OLG or GGOLG solutions are also characterized by consistent expectations among all agents. But this does not rule out other solutions. An individual agent may die having found out that his expectations were not met but it is too late to correct his previous actions. Thus invocation of the convergence of expectations may not be relevant if the period is not long enough.

As long as there is some rule of behavior given to supply the expectations indicated in Figure 2 then each generation has enough for a forward decision process. The infinite horizon solution with intergenerational consistent expectations is only one of many finite behavioral solutions available. Because of the assumptions of regularity concerning population and resources the aggregation from an infinite to a finite number of variables is straightforward and the chances for a stationary state or cycle consistent with the need for individuals to plan for no more than a lifetime or two,[1] are good.

The dynamics of the system has optimizing natural persons who, by their strategies constantly set the parameters of their own environment. But to even well define individual optimization for a forward solution even for a proposed rational decisionmaking criterion requires an assumption concerning expectations.

Government at its simplest is a set of rules; at a more complex level is a game within a game. Yet we observe societies evolve and decay and this involves the change of government structure, not merely a change in the value of parameters. A way to model this is to build several levels of games within the game. Thus, for example, although the election of representatives might be by simple majority vote every two years, there may be a constitutional amendment requiring a ninety percent majority which is considered every ten years.

In essence the formulation of the OLG model as a playable game requires the specification of rules which among other features specify the structure of the artificial players. These set parameters such as the money supply a rate of interest. But we may also contemplate a game with rules governing how to change the rules.

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[1]Two lifetimes (not two generations) covers all those who can interact strategically at any point in time. The interaction of the oldest and youngest is characterized by $k-1$ periods of history and $k-1$ periods of expectations relevant to now for the living.

3.3. An Aside on Population

Economics and demography are highly related but different topics. In particular demographic considerations are called for to supply several of the basic gaps implicit in the assumptions concerning economic growth models, especially when OLG models are considered. Undoubtedly there are economic components to intergenerational transfers of assets and to conscious decisions by prospective parents as to how many children they wish to have. But biology and society, instinct, nature and nurture all play their roles. An adequate model of a political economy with overlapping generations needs to reflect the explicit assumptions about the motivation for new population and the factors determining resource transfer between the old and young.

The easiest assumptions are of a constant or constantly growing population given exogenously with no explanation or suggestion of motivation. These assumptions have been made here. The easiest assumptions concerning inheritance and other intergenerational transfer is that of perfectly selfish individuals who choose to give away nothing. This minimizes the biological and societal links postulated and enables us to concentrate on the efficacy of governmental actions in providing for interlinkage.

It is important to note a distinction between general equilibrium type of modeling and game theoretic modeling even where the mathematics utilized to examine equilibrium is virtually identical. In particular even if we assume no inheritance, in the game, in disequilibrium an individual might die before arranging for a net worth of zero at death. In order to well-define the game there must be a rule specified for the disposal of accidentally left over assets.

Over the course of history many governments have attempted to influence population growth by economic means including subsidies for or taxes on the number of children. The study of growth calls for an explicit description of the economic aspects and some assessment as to their relative importance or unimportance in economic development.

4. CORPORATIONS AS ARTIFICIAL PLAYERS

4.1. Business and Not-for-Profit Institutions

Most modern societies have three distinguishable types of corporate institutions they are government, business firms and not-for-profit organizations such as churches, universities, charities and various cultural organizations. We have discussed some of the aspects of government. The consideration of not-for-profit organizations is postponed; here we concentrate on the business firm.

The individually owned firm poses no problem in modeling. We may assume that the owner attempts to maximize his utility over his lifetime. But it is fairly obvious that for technological reasons vast aggregates of physical and financial capital and individuals form jointly owned corporations of considerable size. Unlike government or not-for-profit organizations the suggested purpose of the business corporation is explicitly economic and the nature of its strategic variables are for the most part economic. In particular the firm in contrast with natural persons does not act as an ultimate consumer and lives forever. It buys, manufactures or otherwise transforms its inputs and it sells most of its outputs. Most (but not all) of its transactions are monetary. Two key questions that must be answered are what is meant by profits and do business corporations attempt to maximize profits?

The share an individual has in government is more or less implicit, the shares held of a corporation are explicitly defined. The corporation is an artificial person whose decision is meant to be some selection from its choice set determined by the actions of its current stockholders as interpreted or influenced by management. A cynical; but easy way to model both government and corporations is to consider that citizens and stockholders have no influence. This is suggestive of models of oligopoly and plutocracy. The institutions are games within the overall game run by small sets of natural persons who are the real players accountable to none other. In contrast we might wish to specify the conditions under which stockholder control results in some appropriate form of profit maximization.

We may wish to avoid considering oligopolistic behavior by postulating a continuum of firms, possibly of several types. We may imagine that the stocks of the same type are sold from a mutual.

A firm is assumed to buy inputs, produce, sell outputs, borrow and deposit and pay dividends.

4.2. Time and Production

In economic models with OLG and production, time plays a critical role. A taxonomy of goods is called for to stress that there is a theoretical basis for many casual business distinctions. Table 2 is suggestive of some of the basic distinctions.

	Producible	Storable	Moveable	Production Time	Length of Life	Depreciation
consumer good	2	2	2	3	4	4
producer/consumer	2	2	2	3	4	4
production good	2	2	2	3	4	4

TABLE 2

Leaving aside factors such as indivisibility, there are 3 basic types of goods from the view point of production and consumption and 384 different categories for each. They are

Producible	yes	no
Storable	yes	no
Moveable	yes	no
Production Time	less than, equal to, greater than a life span	
Length of Life	less than, equal to, greater than a life span or ∞	
Depreciation	(1) None; (2) one "hoss" shay; (3) linear; (4) exponential	

Empirically as a good first order approximation all but a few of the categories exist. However, fortunately, probably only a few dozen of the over 1000 possibilities are of major concern to a general theory of government guided overlapping generations.

Gold and land emerge as the two infinite lived nondepreciating assets. Labor is a production/consumption good with many special properties. Land and existing works of art are essentially nonreproducible. Large machines are essentially producer goods with no direct consumption value. Many food items such as salt or milk may be used for final consumption or as productive inputs.

The length of a productive process is often difficult to define and measure. For example many cathedrals have taken several hundreds of years to build. Yet the delays appear to have been primarily financial, social and political rather than technological. The great wall of China appears to have been built in fits and starts for such the same reasons. Yet when one includes major buildings, dams, machines it is difficult to find examples of production processes requiring more than a generation, let alone a lifetime. But the length of time it takes to manufacture an item and the length of time it lasts are critical items in forging intergenerational links in a world with selfish individuals. If you "cannot take it with you," in one way or another the next generations will get your assets. If it takes longer than a lifetime to build, the only motivation for nonaltruistic individuals to start to produce a capital good would be an expectation that they can successfully sell intermediate product.

In actuality there are buildings and other assets which last longer than a lifetime (although when maintenance and part replacement are accounted for definitional problems appear--"this old axe has lasted for a hundred years with five new handles and seven new heads").

Regardless of whether production processes and the length of life of assets last more or less than an individual life the possibility for a host of cyclical equilibria appears where the length of the cycle may be related to the relative primes of human life, length of the production process and length of life of capital goods.

4.3. Income and Capital Accounts and Profit

A standard chestnut of economic theory and accounting involves the distinction between capital and income accounts. Fisher (19) stressed this distinction, but not in the context of a formal closed model of the economy. This distinction emerges as a "rules of the game" necessity if we are to well define the concept of profit. If a firm maximizes profit, how is it defined? In general equilibrium theory with a finite horizon the definition is simple. It is the difference between the value of all outputs and inputs. In essence there is no time hence no distinction between long and short term profits.

A natural way to define short term profits is to consider the value of outputs minus imputs plus the value of ending stocks minus starting stocks. The starting value of stocks including physical and financial assets.

4.4. Control: Artificial Players and Real Fiduciaries

The most that the choice rule of the corporation depends upon is a set of actions by current stockholders if we view the corporation as purely a mechanism. If in contrast we believe that a better model is a game within a game, then the choices of the firm are influenced by the strategic behavior of management whose strategy sets are constrained by the stockholders.

5. MACROECONOMICS, INSTITUTIONS AND DYNAMICS

5.1. Institutions and the Rules of the Game

In order to model the politico-economy as a playable game the rules of the game must be sufficiently explicit to be able to describe the state of the system under all circumstances. Thus in essence the rules are the carriers of process and can be regarded as defining institutions and instruments.

There may well be a deep philosophical question as to how the first institutions emerged from the prehistory of savages, but for the purposes of understanding the functioning of a modern political economy the institutions are best taken as given. Institutions evolve and laws change, but as already noted one can construct rules for the change of rules. The sequence of games within games provides for an evolving system driven by finitely lived natural persons who may be characterized as following optimizing behavior.

Questions of economic optimality and equity can be well defined in the context of the institutions assumed. Once time is a feature of the analysis and process must be described there is no institution free political economy. From the viewpoint of macroeconomics comparative studies of different rules of the game or different institutional structures around the economy are worth investigating. But we can also attempt to select a minimal set of rules basing our criteria on logical requirements, efficiency and parsimony. thus we may even attempt to well define the minimal set of instruments required for government control of the economy. Consideration of optimality requires the invention of outside money in an OLG model to complete the double coincidence of wants. But if there is any fluctuation in the economy the amount of outside money must be varied thus there must be a device for increasing and decreasing this supply. Taxes and subsidies alone would suffice. The presence of a national debt manipulated by the buying and selling of bonds is another alternative, or one could contemplate a mixture of both.

A clear feature in the type of models postulated here is that although there may be economic factors which decide political control, there is a clear separation between economic and political control mechanisms. In particular it is apparent that the use of a price system has little if anything to do with the motivation of the political structure.

5.2. Macroeconomics and Mathematical Institutional Economics

Money and financial institutions arise from a combination of logical, technological and optimizing conditions required for efficient trade. Once the instruments and institutions have been invented they take on a life of their own. In particular they provide a government with the weapons to control the economy.

Macroeconomics has been regarded as somewhat *ad hoc* and theoretical as compared with general equilibrium theory. It is suggested here that when *process models* of exchange and production are considered financial instruments must be invented. But when overlapping generations are considered *outside money* is required for optimality and this in turn calls for the description of government as a logical necessity. But even if we limit ourselves to an economy without public goods the control of production and exchange via the money supply and interest rate may be in the self interest of the natural agents. Thus the concept of macroeconomics emerges, not as institutional *ad hocery* but as a necessity to provide control and direction to an overlapping generations economy. General equilibrium provides only a small part of this more general schema.

There is no way that assumptions concerning expectations can be avoided in attempting to solve an OLG model, thus there is no pure optimization. At the least a behavioral assumption such as rational expectations must be made in order to well define the individual optimization.

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