***Non-Renewable Resources and Disequilibrium Macrodynamics***

This 1978 Stanford dissertation has been republished by Routledge (London and New York), as Volume 9 in the Routledge Library Editions: Environmental and Natural Resource Economics, 2018.

Nobel Laureate and Emeritus Professor Robert Solow kindly wrote a preface for the new edition of the book.

I wrote a short introduction placing the dissertation in its historical context.

Both of these pieces appear below.

# PREFACE

Robert Solow

Robert Marks's book provides a full and careful analysis of an economy in which there are three markets—for labor, for energy and for produced output—whose prices are given and, at least temporarily, fixed. In consequence, some actions are impossible, even if they are desirable and feasible in budgetary terms: at these prices, some buyers may be unable to buy as much as they would like and can afford, and some sellers may be unable to sell as much as they would like and can produce. Even so, some kind of order is possible, and the job of the economist is to describe the possibilities.

Those unsatisfied demands and frustrated supplies will no doubt put some pressure on "fixed" disequilibrium prices, and eventually they may move. They may even move in the general direction of conventional supply-equals-demand equilibrium, though we do not know that. Nevertheless, if prices adjust slowly, real economies will spend a lot of time in disequilibrium situations, with some unsatisfied buyers and sellers, and analysis like that in this book will be useful in understanding what is going on.

I think that is the case, and I thought so in the 1970s when "disequilibrium" economics of this kind captured the interest and imagination of economists, including obviously Robert Marks. I thought it was a mistake when that interest dwindled, and little or no further development occurred. Why was that? Well, prices are not fixed. Disequilibrium theory needed to be completed by a theory of slow price-change. But that is a tall order, and even more difficult in a model world in which there are latent ("notional") demands and supplies not easily expressed. That theory has not yet appeared. In addition, the fashion in economics was swinging toward more optimistic equilibrium-based versions of macroeconomics. (Opinions differ about whether that was such a good idea.) And there may have been other reasons; lines of causation in intellectual history are not usually very clear.

In any case, here is Marks's work revived, and at a time when the energy sector of the economy carries a lot of interest. Between climate change and the need to reduce the burning of fossil fuels on one side, and the uncertain development of renewable energy sources on the other side, here at least is an economic model that aims to deal with disequilibrium in energy markets.

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## Author's Introduction to the Republication

As Professor Emeritus Robert M. Solow remarks in the Preface, there are fashions in economic theory. In the 1970s and early 1980s, a number of theorists, starting with Barro and Grossman (1971), began to examine general-equilibrium models that included non-market-clearing exchange. The motivation for this was that prices do not move instantaneously from one full-employment equilibrium position to another, while trade nonetheless occurs in the meantime. As my dissertation explores, allowing economic agents to buy and sell at non-market-clearing prices (or before prices have adjusted to equilibrium, if they ever do), leads to separate regimes, characterised by whether each market is a buyers' (excess supply) or a sellers' (excess demand) market. A macro model with three markets — two inputs, labour $N$ and resource (energy) $R$, and one output $Y$ — results in eight possible regimes, as outlined in Table 3.1 in the dissertation.

An agent's behaviour in one market may be constrained by the states of the other two markets he is trading in. These spillovers mean that the comparative statics of these regimes differ, so that it is not possible for agents in a constrained market to choose their position on a choice-theoretic supply or demand function.

In a survey of New Keynesian Economics published in 1990, twelve years after this dissertation was finished, Gordon (1990) remarks that: "An interesting aspect of recent U.S. new-Keynesian research is the near-total lack of interest in the general equilibrium properties of non-market-clearing models." In the U.S. "that effort is viewed as having reached a quick dead end after the insights yielded in the pioneering work" of Barro and Grossman (1971, 1976), building on the earlier contributions of Patinkin (1965), Clower (1965), and Leijonhufvud (1968).

Gordon explains this lack of interest as the consequence of a research focus, instead, on explaining sticky wages and/or prices by combining rational expectations with maximizing behaviour at the level of the individual agent. As he puts it, "Any attempt to build a model based on irrational behaviour or sub-optimal behaviour is viewed as cheating." U.S. theorists, he says, believed that it was premature to examine the broader theoretical considerations of non-market-clearing trading before the partial equilibrium problems of sticky prices are solved. Another fashion?

Forty years later, the profession understands, from behavioural economics, that irrational expectations and non-optimal behaviour are widespread, and partial equilibrium models incorporating these are emerging. But the results from the work on non-market-clearing exchange from forty years ago has not been revisited and insights from this work have been lost; no general-equilibrium models, such as the model presented in this work, have been developed recently.

Following Barro and Grossman's work, the line of research evolved in the hands of Malinvaud (1977), Mueller and Portes (1978), Benassy (1975), Grandmont (1982) and Marks (1979, 1983). Almost all of these researchers are Europeans, even if they studied at U.S. universities. But in treating this line of research with disdain (in Gordon's words), and instead focussing on the "micro foundations models as the prerequisite for macro discourse," U.S. theoreticians have, argues Gordon, overlooked the central message of the non-market-clearing trade models, which is that the failure of one market to clear imposes spillover constraints on agents in other markets.

For example, when firms in a recession experience a fall in sales at the going

price, this excess supply of output spills over into a fall in labour demanded at the going real wage and a fall in resource (energy) demanded at the going real price of resource (energy). (Assuming zero short-run elasticity of substitution of resource for labour in production.)

In such a model, agents are not in a position to choose the amount they work or produce as output varies over the business cycle, and so the constrained amount that they do work or produce cannot be interpreted as tracing movements along a choice-theoretic labour supply curve or production function. This also holds for the suppliers of resource in our model with three markets.

Traditional theory holds that prices adjust quickly to excess supplies or demands, resulting in the rapid disappearance of any disequilibrium. But Leijonhufvud [1968] and Malinvaud [1977] questioned the adequacy of this theory in describing the short-run behaviour of modern market economies. The work below is my contribution to studies on the consequences of relaxing the assumption of rapid price adjustment.

The model includes three markets (for output, labour, and resource flow), with the assumption that quantity adjustment in each market in response to unbalanced supply and demand is much more rapid than price adjustment: in his survey of temporary general equilibrium theory, Grandmont (1982) characterises this kind of model as an example of "temporary equilibrium with quantity rationing," since adjustments take place in every period at least partially by quantity rationing. (Solow and Stiglitz [1968] describe a model in which quantity and price adjustments occur at comparable speeds.) In Chapter 3, we do not consider price adjustment, but treat prices as given: the speed of adjustment of prices in response to excess demand or supply can be thought of as being imperceptible in the period under analysis. (The analysis resembles that of the "fix-price" method of Hicks' [1965].)

The purpose of this model was to develop a "quasi-equilibrium" where real prices were constant, while nominal prices changed, in order to model a market for non-renewable (exhaustible) energy — such as oil. The Hotelling criterion (Hotelling 1931) was another fashion in economic theory, overtaken perhaps by concern about the finite nature of the natural environment to absorb the by-products of the combustion of fossil fuels for energy.

Clower [1965] and Barro and Grossman [1971, 1976] built models which relax the assumption of market-clearing exchange, that the amount supplied or demanded ex ante by each economic agent at the going price in each market equals ex post the actual amount traded. Exchange can occur at "false," or non-market-clearing prices. This relaxation means, first, that quantities traded cannot be determined simply by reference to market-clearing conditions (rather, the actual trading process must be examined), and, second, that agents will in general be constrained in any market by conditions they experience in other markets: their demand (and supply) functions will no longer be unconstrained, notional schedules, but will be constrained, effective schedules (Clower [1965]), and quantities will be rationed.

There is no reason to expect that the effective schedules of any agent constrained in different markets will be mutually consistent: in an economy with rationing, ex ante supplies and demands are tentative, and it is no longer optimal for the agent to determine all his schedules at a stroke. Following Benassy [1975], we let the effective demand (supply) schedule of an agent in a market be the demand (supply) he will choose by

maximizing his expected utility or profit subject to his budget constraint and to the quantity constraints he perceives in the other markets: he does not take into account any constraints he might experience in the market considered.

There is thus a coordination problem: in aggregating individual schedules, we need to build a model in which there is consistency among individual actions. Malinvaud [1977] argues that there are three general properties necessary for the existence of quasi-equilibrium, in which for the given real prices quantities have no further tendency to move. First, trades balance: for each good the sum of purchases equals the sum of sales. Second, there is no involuntary exchange: no agent is forced to buy more than he demands or to sell more than he is willing to supply. Given the second property, an agent will be in one of four mutually exclusive states in a market: he will be a constrained (unconstrained) buyer if his demand exceeds (equals) his purchases; he will be a constrained (unconstrained) seller if his supply exceeds (equals) his sales. Third, there cannot exist both a constrained buyer and a constrained seller in the same market, for, were this the case, each would be able to make an advantageous trade. That is, there is one and only one market for each commodity, and all agents have free access to this market.

Given these three properties, the target amount traded in any market will be determined by the "short" side of the market (that is, it will equal the lesser of the amounts supplied and demanded), and agents on the "long" side of the market will be constrained in their transactions, implying some means of rationing. The market for any commodity is then in one of three states: it can be balanced (with clearing and no rationing), or a sellers' market (with constrained buyers), or a buyers' market (with constrained sellers). We assume that the pattern of rationing does not affect the aggregate levels of the effective demands and supplies in the economy. (With this assumption and those of fixed supply of labour and of resource flow, we sidestep the conclusions of Hildenbrand and Hildenbrand [1978] that there is no sound foundation for the non-market-clearing comparative statics propositions derived by Malinvaud [1977].)

We assume that there is no inventory accumulation. (Blinder [1981] and Green and Laffont [1981] discussed the implications of this for non-market-clearing analysis.) Further, we assume that costs of quantity adjustment are zero, which excludes the possibility of levels of output or inputs independent of prices or sales: firms set output to be equal to sales at all times and minimize the costs of the input factors given this level of output.

There are different responses in the level of employment across the regimes. From Table 3.5 we see that a rise in the real resource (energy) price will tend to decrease employment in the regime SC (Malinvaud's "classical unemployment"), but will tend to increase employment in the regime DC (Malinvaud's "Keynesian unemployment") (at least for Cobb-Douglas technology); it will not affect employment in any other regime. (See Table 3.1 for the regime definitions.) (Malinvaud [1977] claims that this distinction was responsible for much confusion in the policy debates of the 'thirties.) In an extension of Chapter 3, Marks (1983, Table 3) shows that a fall in resource (energy) supply will tend to reduce employment in regime RC, to increase it in regime DRC, while not affecting it in other regimes; and a fall in autonomous demand for output will tend to reduce employment in regimes DC and DRC, but will not affect it in other regimes.

In Chapter 4, the dissertation does allow nominal prices to respond to unbalanced

supply and demand in a closed economy, by extending the model to include Walrasian price adjustment using two possible formulations; Solow [1980] does this for an economy with completely elastic resource supply. In Chapter 5, we explore expectations of prices, the supply of resources (energy), and the Hotelling principle.

In a paper examining the implications of different assumptions concerning the relative speeds of price and quantity adjustment in the output and labour markets, Corden [1978] attempts to allocate "responsibility" for unemployment—whether the government or households (through the autonomous demand for output), or "big business" (through the price of output), or trade unions (through the wage). In an analogous manner we could ascribe unemployment in, say, the SC regime of classical unemployment to the cost of input factors: if either the real wage or the real resource price fell, output and employment would increase; a fall of the real wage in regimes DC (of Keynesian unemployment) and RC would likewise increase employment. But it is difficult in our model, with two variable input factors, to ascribe "responsibility" for unemployment to any single group. Rather, the regime in which the economy finds itself is a function of the supplies and real prices of resource and labour, the exogenous demand for output, and the degree of leakage of aggregate demand.

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