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Endogenizing government policy variables and synthesizing quantitative economic policy modeling and rational expectations hypothesis

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Endogenizing government policy variables and synthesizing quantitative economic policy modeling and rational expectations hypothesis

by

Myung Joon Cha

A Dissertation Submitted to the

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I. INTRODUCTION

In recent decades, there have been developments in economic theory and empirical study of endogenizing public policies. Governments intervene in developed or developing countries or centrally planned economic countries in economic systems; to achieve governmental goals, to influence the private sector's behavior, or to manage domestic system and international trade directly. (Rausser and Stonehous, 1978). Much of the governmental behavior is often treated as a passive, exogenous, force in macroeconomic models. When we consider macroeconomic fluctuation, however, it is obvious that macroeconomic fluctuation today is so intimately connected with government polices that realistic explanations and forecasts of macroeconomic fluctuations require that government behavior be analyzed as an integral part of the fluctuations. This means that it is useful to treat the government as an endogenous rather than as an exogenous actor in the macroeconomic system (Lindbeck, 1976, p. 11).

We know that all economic decisions, virtually, other than the trivial, involve time (Shaw, 1984, p. 9). So we often need some expectations about economic variables to make decisions. Perhaps economic forecasts, either for short-run or long-run must be conditional upon governmental policy variables. Differences between various short-run economic forecasts often depend less on internal functioning of the private sector than on different assumptions of future polices (Rausser, Lichtenberg, and Lattimore, 1982, p. 548). Therefore, there exists, possibly, a simultaneous interaction between governmental setting of policy variables and the response of private sector behavioral units. Given the feedback relationships among governmental policy-makers and the private sector, in the long-run, especially for forecasting purpose, it would seem essential to endogenize both private and public sector behavior related to a particular system.

The formulation of government policy consists of a series of subprocess: the subprocess of setting policy and subprocess of implementation. The process of setting policy can be defined as the specification of an area of government intervention, the determination of general goals and specific targets for that intervention, and the choice of instruments to be considered permissible for use in achieving the stated goals. A policy is a set of goals and instruments drawn from the larger set of goals and instruments available to the government. The process of implementation can be defined as the choice of policy instrument levels given the policy set.

The theory of quantitative economic policy (QEP) was pioneered by Tinbergen (1961) and others and extended by Theil (1961) and others; see, for example, Fox, Sengupta, and Thorbecke (1966). This theory grew out of the need encountered during the great depression of the 1930s and during the post-World War II reconstruction and demobilization to provide national governments an operational method that they could use to stabilize their economies. It has been extended to other areas like economic development.

This QEP theory reached its maturity before the Muthian rational expectations hypothesis (REH) had a significant effect on the economic profession. The QEP rationalizes the public policy process. It assumes all people, those in the private sector and in the public sector, are rational, informed, and goal directed. However QEP fails to account for effects of economic agent's expectations of public policy choices upon their behavior.

The REH assumes that the public sector is rational, informed, and goal oriented, and that individuals in the private sector are goal oriented in their behavior, myopically (or tunnel visioned) rational, and informed. These individuals have a good deal of information about the operations of the private sector. Muth (1961, p. 316) wrote "expectations, they are informed predictions of future events, are essentially the same as the predictions of the relevant economic theory." Economic theory does not explain or predict future political events or public policy choices. It leaves that job to political scientists. From its very beginning, most work on the REH has ignored the work on the QEP and treated the operation of the public sector as exogenous or stochastic.

In the REH, the public sector makes policy choices that have predictable effects (through economic theory) upon the private sector. But most REH work does not try to explain these choices. The QEP, on the other hand, does treat public choices as endogenous; it considers effects of private decisions upon public choices.

Both QEP and REH are of value, but each is incomplete and it is worthwhile to synthesize the two. Taylor (1979) tried to synthesize the QEP and the REH and derived optimal monetary policy rule. This study discusses some possible assumptions underlying both the QEP and the REH and presents some possible syntheses that differ from Taylor's in the context of political economy. This study casts doubt on the validity of the claims to conceptual superiority of the REH, and questions some of the conclusions of the REH. This study also demonstrates the existence of possible internal contradiction in the assumptions of the QEP models.

Crotty (1973) pointed out that econometric estimation procedures of macroeconomic models with assumption that the policy variables are exogenous rather than endogenous may be subject to important specification error. To show the specification error and how the policy variables are endogenously determined, he assumed that the government has a preference function which orders possible outcomes related to a set of economic instruments and goal variables. Crotty used "the Theil's framework to demonstrate explicitly the serious nature of the specification error that may arise if the preference function underlying government policy is ignored in macroeconometric work" (p. 1025).

When we have an interest in analysis of government policy rules, the synthesis of the QEP and the REH allow us to derive differences between econometric regressions with government preference function and without, a difference that was ignored in Taylor's synthesis. This study will call these differences specification errors as Crotty did. The synthesis of the QEP and the REH also allow us to investigate Lucas' (1976) well known critique of econometric policy evaluation under the assumption of endogenizing government policy variables.

For purpose of this study, chapter II through IV survey literature. Chapter II will survey both macro and microeconomic literature which stress endogenous government behavior. Chapter III will review Theil's QEP framework which gives us the mathematical background to analyze optimal decision rules under constraints. Chapter IV will briefly review concept of rational expectations and its applications to macro and microeconomics, summarize rational expectations model, and present some possible assumption about predictions of exogenous variables and of policy variables. Chapter V will present some assumptions underlying the QEP and the REH, discuss some possible syntheses of the QEP and the REH, derive specification errors, test the validity of the claims to conceptual superiority, investigate Lucas' critique, and show internal contradictions of QEP models. Chapter VI will present an empirical study using Taylor's simple U.S. macroeconomic model and then make numerical comparisons of the possible syntheses and test theoretical specification errors that arise when endogenized policy variables are treated as exogenous variables. From the numerical comparison of the syntheses, it is expected that we could find optimal policy rules according to the underlying assumptions. Chapter VII will derive conclusions of this study.

II. ENDOGENIZING POLICY VARIABLES

A. Political Macroeconomics

1. Theories

Today's political choices affect our economic life as a consumer and/or producer. Much of the literature tries to develop the political-economic relationship and find the political role in the formation of government macroeconomic policy. One macro political-economic model is presented in Figure 1, where there exists an interdependent relationship between government and private sectors. The government sets the economic policy and this policy is implemented by the state bureaucracy. Capitalists, that is private firms and consumers, take part in the economy through capitalist market system. The economic performance affects the private sector's economic life and the electorate's votes.[1] In this framework some noneconomic factors like ideology[2] of the party and non-economic welfare and public provisions have an important role. Much of the literature of political-economy focused largely on the attempts to make government policy actions endogenous and to identify politically motivated business cycle (Hibbs, 1981).

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[1]There are some empirical studies on peoples' voting behavior. Fiorina (1981) found that economic conditions and evaluation appear to have both short- and long-term affects on the vote. Personally experienced and/or perceived economic effects have indirect effects on the vote, that is effects channeled through evaluation of government executive performance, through the formation of future expectations, and through modification in party identification. For more detail, see also Kinder and Mebane (1983) and Borooah and van der Ploeg (1983, chapter 3).

[2]Ideology means political party positions or lines in this study. Ideology is a important element in determining votes for a specific political party. This topic is beyond our subject. For more detail about ideology see Navarro (1984, Part 3).

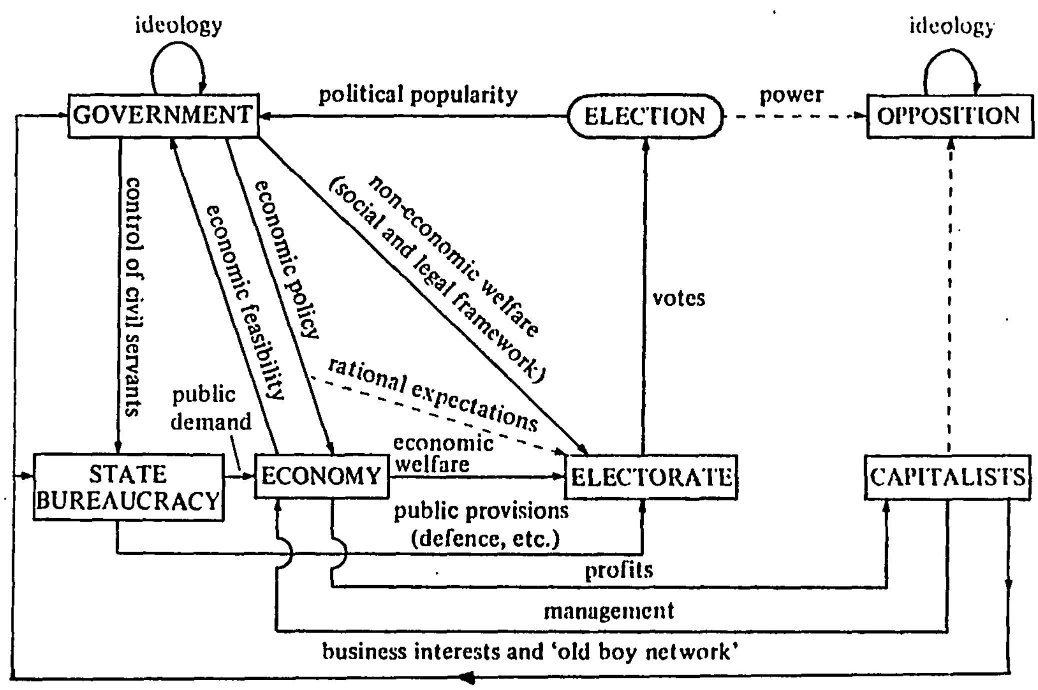

Figure 1. Political economic structure (Borooah, Vani K. and Frederick van der Ploeg, 1983)

A number of literature deals with the political aspects of policy formation and examines the interplay of political and economic forces that combine to generate what is termed the political business cycle. The assumption underlying the presumed existence of such a cycle is that government authorities, by adopting proper policies, are able to influence economic outcomes. Given that these economic outcomes will, in turn, affect its political popularity, government authorities interested in re-election may attempt to manipulate the economy so that periods of economic strength occur prior to elections and periods of economic weakness are confined to years when electoral popularity is not so vital (Borooah and van der Ploeg, 1983). These politically motivated policies would then generate that cycle of booms and slumps termed the "Political Business Cycle."

The orthodox theory of economic policy views the government as a benevolent dictator who implements economic policies, such as unemployment, inflation, income growth, balance of payment, etc., in an attempt to promote social welfare. It is concerned with how the government should behave to improve social welfare, so it has a normative character. The orthodox theory, however, ignores the fact that a government has objectives of its own manifested in its ideology and its attempts to secure re-election which may well differ from the social welfare objective. Positive theories that describe how the government actually behaves are needed and provided by political economics (e.g., Kalecki, 1973; Nordhaus, 1975; Lindbeck, 1976; Frey, 1978, 1983; Tufte, 1978; Hibbs and Fassbender, 1981; Monroe and Levi, 1983).

2. Empirical studies

Most empirical studies of the political macroeconomics focus on the potential for a politically motivated business cycle.[3] Nordhaus (1975) used U.S. data for period 1947-1972 to test the hypothesis that during an electoral period the unemployment rate should rise during the first half of the period and fall during the remaining half. The result of his test indicates strong conformity with the theory for the elections of 1948, 1952, and 1956 with unemployment falling sharply before elections and rising after elections. Unemployment was falling before the 1964 election, rising sharply after the

[3]The basic assumption of the political business cycle framework is that there exist a short-term trade-off relationship between inflation rate and unemployment rate, that is, the Phillips Curve.

1968 election, and falling before the 1972 election. It is interesting to note that two elections for which the pre-election pattern do not fit the theory, 1960 (Eisenhower) and 1968 (Johnson), are years in which the incumbent party lost the election. The economic program during the first Nixon administration was a textbook example of planning for the political business cycle. The Nixon's "game plan" resulted in a recession during the early part of the administration and unemployment rose from 3.4 percent in late 1968 to 6.0 percent in late 1970.[4] The announced plan of the administration (in the 1971 Economic Report of the President) was then to return to 4.5 percent unemployment by late 1972, that is by the 1972 election. Nordhaus' general conclusion was that a perfect democracy with retrospective evaluation of parties would make decisions biased against future generations. Moreover, within an incumbent's term in office, there is a predictable pattern of policy, starting with relative austerity in early years and ending with the gifts right before elections.[5]

Tufte (1978) tested for an electoral-economic cycle in twenty-seven western democratic countries and found evidence of its existence in 19 of 27 countries; in those 19, short-term accelerations in real disposable income per capita were more likely to occur in election years than in years without elections. Combining all the experiences of the 27 countries over the period of 1961-1972 reveals that real disposable income growth accelerated in 64 percent of all election years compared to 49 percent of all the years without elections. Furthermore, for those 19 countries whose economies ran

[4]Most economist felt that this drastic recession would make substantial inroads on the rate of inflation.

[5]Nordhaus also tested that the hypothesis for other countries. His overall results indicated that for the entire period a political cycle seems to be implausible as a description for Australia, Canada, Japan, and the UK. Some modest indications of a political cycle appear for France and Sweden. For three countries--Germany, New Zealand, and the United States, the coincidence of business and political cycle is very marked (Nordhaus, 1975, p. 186).

faster than usual in election years, the effect was substantial: real disposable income growth accelerated in 77 percent of election years compared with 46 percent of years without elections. His fundamental point of the aggregate evidence is that 70 percent of the countries showed some signs of a political business cycle.

Tufte also explained the relationship between the electoral cycle and economic policy. He found some examples of expansionary fiscal policies during booms immediately before general elections. Examples are Germany in 1965 and the UK in 1955 and 1965: the conclusion is somewhat weakened by the fact that some counter examples, of restrictive actions immediately before general elections, can be found, such as the increase in direct taxes in Sweden in 1960 and in the UK in 1965, as well as the introduction of the surcharge in the U.S. in 1968. In the U.S. historically the supply of money has increased more rapidly in the two years before presidential elections than in the two years following. For example, changes in the biennial growth rate in money stock (M1, currency plus demand deposits) have shown a strong relationship with presidential elections, especially when Eisenhower years are excluded. Out of five presidential terms, except during the Eisenhower years, for the period of 1948-1976, there have been four occasions in which rate growth of money supply has increased two years prior to the presidential election and one occasion in which it decreased. There have been four occasions in which rate of growth of money supply has decreased after the presidential election year and one occasion in which it increased. He found that the United States has experienced two types of political economic cycle: a two year cycle of acceleration and deceleration in real disposable income, and a four year presidential cycle of high unemployment early in the term followed by economic stimulation, increasing prosperity, and reduced unemployment late in the term. The real income cycle is especially the product of election year increases in transfer payments, administrative adjustment of the timing of beneficiary payments, and decreases or postponements of taxes. Thus election year enhancement of real disposable income is significantly a political and a bureaucratic concern.

MacRae (1977 and 1981) tested which assumption, myopic or strategic assumption, did a better job of explaining macroeconomic policy as reflected by the unemployment rate under the hypothesis that the government acts as if voters are myopic with a horizon no farther than the end of the election period. In all election periods, the relative inflation-unemployment weight is greater under the assumption of myopic electorate than under the strategic assumption. Similarly, the associated steady state short-run relative weight and inflation goal are higher under the myopic hypothesis than under the strategic hypothesis.

MacRae concluded that there is a potential for a politically motivated business cycle with relatively high unemployment and inflation at the beginning of election period and then relatively low unemployment and inflation at the end of presidential period. However, there is only limited evidence in the U.S. of a potential for the cycle because the strategic hypothesis did a better job of explaining excess supply in the second Eisenhower, Nixon, and Nixon-Ford administration and the myopic hypothesis did a better job only in Kennedy-Johnson and Johnson administrations.

Paldam (1983) proposed an alternative theory of political business cycle different from Nordhaus-MacRae cycle version. In his previous study (1981), the main thrust of the alternative theory is that the pressures operating on government are so strong that they can not really plan four years ahead for their re-election. Instead, when they assume power they simply try to implement their policy, that is they attempt to redeem their campaign promises. This effort creates an expenditure boom which leads to relatively large economic growth in the year after the election, which is the first year to be influenced by the new government. The boom causes prices to escalate in the third year, and to regain control of the economy, the government tightens up expenditures somewhat toward the end of that year. The pattern that results is almost reverse of the optimal one. He concluded that the theory of the electoral cycle should be of a more endogenous nature where the short-term political pressures, especially mass political pressures, dominate the medium-term planning.

Dinkel (1981) examined the relationship between economic conditions and voting behavior and found that the relationship had not been conclusively demonstrated. The basic assumption of all political business cycle models is that government authorities wish to be re-elected. In particular, if its re-election is uncertain, government authorities adopt economic policies that would be rejected otherwise. For political business cycles to occur, it is only necessarily that government believes that it could win votes from a policy. Since no one can know in advance how people will vote, a government will use all possible policy instruments to ensure re-election, even if economic conditions only have a weak effect on voting behavior.

Alt and Chrystal (1981) studied British fiscal policy under the "revealed preference" tradition, in which one infers the motivation of governments from assumptions about, and systematic evidence, of their behavior. They used three stage least squares to estimate a model in which government consumption, transfer payment, government investment, and government revenue were endogenous variables. They provided new estimates of the political popularity functions and policy functions in British.

Potts and Luckett (1978) presented a monetary policy function, which is a function of unemployment, prices, economic growth, and the balance of payments. They concluded that the Federal Open Market Committee does seem to base its policy actions, in part at least, on the macroeconomic objectives of full employment, price stability, and economic growth and that the Federal Reserve's ordering of priorities among the goals does appear to be influenced by the political tempo of the times.

3. Summary

Much of the literature of theory and empirical studies related to the political business cycle can be summarized as Figure 2. For example, unemployment rate or inflation rate has decreased during the second half of the election term but has increased during the first half of the election term. To be re-elected through great popularity, an incumbent regime could manipulate policy choices to generate a business cycle. In this context, government's policy measures are determined endogenously. The literature and ideas on political aspects of economic policy provide many valuable insights into the behavior of government. However, existing theories of political economics suffer from some defects. First. most studies relate popularity to economic performance in an ad hoc manner and lack a satisfactory theory of voting behavior. Second, the public sector is usually not separated into the component which does not depend on electorate for survival, for example, the state bureaucracy, monetary authorities, and the part which does not depend on re-election, for its survival, the legislative and executive branches. There exists, in fact, conflict between these components of the public sector, which so far has been ignored. Third, previous studies of political economic reaction functions for state expenditure and taxes specified these independently of each other and without reference to a complete macroeconomic model. Fourth, previous studies of the politically motivated business cycle focus on the political trade-off between inflation and unemployment and ignore

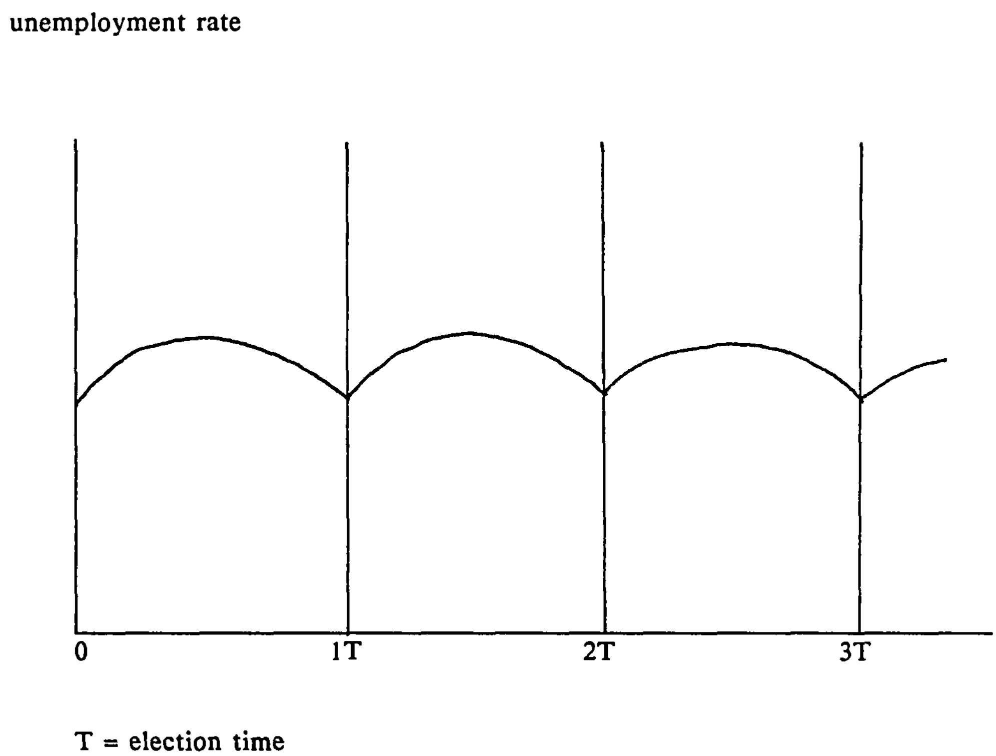

Figure 2. Political business cycle

popularity. Finally, previous analysis of the stability of political economic system (see Fassbender, 1981; Ordeshook and Shepsle, 1982) have failed to take account of the discontinuous nature of reaction functions based on satisfying theory.

From the above empirical studies about politically motivated business cycle,[6] we may derive general conclusion that there is an interdependent relationship between political and economic forces. Thus government authorities could manipulate economic

[6]Beyond those empirical studies, Frey (1978) found that in twenty-one out of twenty-seven democracies over the period 1960-1972 the growth rate in real disposable income was higher in election year than in nonelection years. The clearest evidence is Israel. For other empirical evidences, see Alt and Chrystal (1981) and Frey and Schneider (1978 and 1981).

policy variables to maximize popularity and so could be re-elected in the election. In this context, government policy variables are no longer exogenous variables, rather they are endogenous variables.

B. Political Microeconomics

1. Theories

a. Governmental intervention Governmental intervention in economic system, as forms of income supports, supply control, or barriers to trade, is common phenomenon regardless of economic system, capitalist or socialist, developed countries or developing countries. In the microeconomic theory, there are two points of view about governmental intervention in economic system, negative view point and positive view point. The viewpoint of the former is that governmental intervention causes distortions in both domestic and international system (Abott, 1979 a; Brandow, 1977; Rausser and Stonehaus, 1978). The effects of public intervention, such as income support, supply control, price subsidy, or trade barriers, are pervasive. Many of these policies have direct effect of transferring wealth from taxpayers or consumers to individual producers while transferring risk in the opposite direction. Other redistribute wealth and risk within the private commodity systems among various participants along a vertical commodity chain. All these policies assuredly distort traditional market price mechanism (Rausser, Lichtenberg and Lattimore, 1982; Russel, 1983).

The viewpoint of the latter is that governmental intervention is necessary to achieve a maximum value of the social welfare function (Ladd, 1986). In a society which has merit goods,[7] universal hedonists, externalities in production, public goods, persons who apply existence value (sacred values in sociological terms) and persons who care about equity or distributive justice, public intervention is necessary to achieve a maximum value of the social welfare function because this maximization requires that each individuals' marginal rate of substitution differ systematically from the social marginal rate of transformation. According to the microeconomic theory of perfect competitive market, each firm's price ratio equals its marginal rate of substitution and each consumer equate his/her marginal rate of substitution to the same price ratio. It is, however, difficult to say that there exist perfect competitive market in the real world, rather above six situations do exist in the world. Therefore we may say that the competitive are not efficient and do not maximize any social welfare function. The existence of any one of these six situations requires governmental intervention in market system in order to maximize a social welfare function.[8]

b. Liberal-pluralist approach This framework concentrates on forces shaping the distribution of income and wealth in the private sector and focusses principally on the policy setting process and on the relationship between policy makers and voters, in particular under the assumption that legislators are assumed to simply transmit voter

[7]The term of "merit wants" stemmed from Musgrave (1959). Merit wants represents a means of providing consumer information, of allowing for alternatives, and of compensating for an individual's lack of information concerning the impact of his actions on other people, in an individual choice framework. And the concepts accounts for such things as compulsory education laws and taxes on "merit bads", as possible cigarettes and liquor, in an imposed choice framework. The concept of "merit goods" does not mean the same things as "public goods", they may be private goods according to Pazner (1973).

[8]We can apply theory of the second best to investigate the cost of refusing to interfere with markets when these six conditions exist.

preference; and the possibility that legislators might have interests of their own is not considered.

Individuals have an interest in redistributing income from others to themselves. They are presumed to enter into voter coalitions to express their demand to politicians. Politicians are motivated by voters and thus satisfy such a demand in order to increase their probability of election (see Downs, 1957; Buchanan and Tullock, 1962). As Stigler (1970) argued, "as income has become a widely usable basis for income and expenditure programs, both the extent of government activities and their income redistribution (from higher income level to lower income level) will grow."

In a real world, there exist some goods that can not be redistributed like health and human capital and generally individuals are risk averse. Hence, imperfect markets and moral hazard prevent the emergence of private markets that spread the risk of disastrously low incomes (Arrow, 1963). Voters may choose to provide such insurance through the political marketplace. Basically private or social insurance for income interruption is provided via governmental intervention.[9] The lower income groups have a higher demand for such insurance than higher income groups; as a consequence, the higher income groups must be bribed with premium (tax) reductions to persuade than to enter the insurance contract. Musgrave's prudent humanitarian model (Musgrave, 1968) said that social insurance emerged as a device to force compulsory saving on the less prudent and lower income individuals and to protect the prudent and higher income individuals.

The seminal work of Hochman and Rodgers (1969) introduced the Pareto optimal income redistribution formulation which in essence transformed issues of distribution

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[9]The net contribution rate of higher income individuals would be greater under a private insurance formation but lower under public welfare schemes.

into a question of efficiency. One variant of this formulation specifies that donors of taxes derive utility from income levels of transfer recipients. Hence, the donors are consequently prepared to support transfer schemes. To donors with similar utility functions, the commodity, "increased incomes of the poor," is a collective consumption good - an efficient quantity of which can be provided through the governmental sector.[10]

Thurow (1973 and 1975) developed a formal job competition model and a theory of income redistribution. His model is built upon four empirical observations drawn from the U.S. economy: (i) income inequalities fell considerably during the Great Depression (Pre-Second World War period) and remained stable after the War; (ii) the political popularity of minimum wage policies; (iii) the political acceptability of adequate transfer income floors for those who are disabled and elderly and thus unable to work; and (iv) the political popularity of income transfers to those who are able to work, even if they cannot find employment. In Thurow's model, individual workers who may differ in their views of economic justice have reached a consensus that justice is linked to relative incomes. Thus the well-being of many of the members is tied directly to a normative appraisal of relative incomes. The government is directed to implement policies to achieve such desired distribution of income if market mechanisms fail to do.

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[10]This framework predicted redistribution of income to lower income individuals from higher income individuals; some variations of this framework suggest that the largest transfer would be made to the poorest while smallest transfer would be made to the less poor. If, over time, the income differential between donors and recipients remain constant, then size of the redistributive tax transfer will remain constant.

c. Economic regulation approach This approach was initiated by Stigler (1970) and Peltzam (1976) formalized Stigler's pioneering work and generalized a number of his important results. This regulation framework concentrates on the behavioral effects of changes in constraints under a regime of stable power relationships. The regulator desires to maximize the "majority" defined by the number of potential voters in the beneficiary group times the probability that a beneficiary will grant support[11] less the number of potential voters in opposing groups times the probability that those who are "taxed" will oppose. Peltzam's most critical assumption is that the wealth of each number of the potential opposing group is a decreasing function of the transfer tax and his general proposition that wealth is not totally inelastic with respect to taxes has important implications for the evaluation of the whole range of government redistributive policies.

The choice facing the regulator involves the amount that he asks the beneficiary group to spend in campaigns, lobbying, etc., to mitigate opposition as well as the amount that he bids for a total dollars transfer to the beneficiary group. To optimize for each of these choice variables, it is assumed that the ratio of the beneficiary group to the total population is less than unity. The regulator's choice problem is not limited to selecting the size of the interest group to benefit or tax but includes the selection of an appropriate structure of benefits and costs.

d. Interest groups and conflict resolution approach This approach admits both economic and political markets and a process for resolving conflicting goals. In

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[11]The probability of support from the beneficiary group is specified to be a function of per capita net benefit. This per capita net benefit measure includes dollar spend by beneficiaries in campaign funds, lobbying, and the like to mitigate opposition and the cost of organizing direct support of beneficiaries.

economic markets, the desired quantities traded by buyers and sellers are equilibrated by the price mechanism, while in political markets the levels of powers exercised by conflicting groups are balanced through adjustments in the stock of social claims. Political markets are presumed to be in equilibrium whenever the stock of legal instruments and flow of political rewards adjust to the point where neither politicians nor the supporters or opponents wish to alter any variable which affects the form or shape of governmental intervention. Through the interaction among economic and political markets, participants in one market can create economic rents in another markets. In essence, economic groups compete in political markets over the distribution of income through tariffs, subsidies, bureaucratic policies, judicial processes, regulation, and so on.

Brock and Magee (1978 and 1979) employed non-cooperative game theory to investigate general equilibrium in both economic and political markets. Their 1978 study analyzed the interaction of economic and political markets. This study assumed an economy consisting of individual agents, politicians, firms, and goods which are produced and either consumed or used as inputs. In this framework governmental intervention leads to losers who would be willing to pay up to certain amount to prevent the intervention, while gainers would be willing to offer up to a certain amount in order to secure the intervention, where each of these two amounts is defined as variation in income required to make individuals indifferent between two political equilibria.

Their 1979 study employed a non-cooperative game theory with politicians acting as Stackelberg leaders. In their analysis, tariffs are used throughout as the exemplary redistributive policy. Three types of industry lobbies are investigated, the concentrated industry, the regulated industry, and the self-policed industry. In a two-politician and a two-lobby game, opposing lobbies with perfect information leads to the protectionist lobby contributing only to the high tariff politician. Each competing politicians try to maximize their probabilities of election. These probabilities are function of campaign contributions from lobbies and the politicians tariff positions. The political market equilibria that are obtained from this formulation, regardless of whether information is perfect or imperfect, have the properties that increased political power by a tariff lobby always cause one politician to increase while the other politician decreases his tariff position, that the average tariff position of two politicians may either rise or fall with increased power by the tariff lobby, and that increased lobbying power will augment the range between the tariff positions of two politicians when the high tariff politician increase his position and vice verse when high tariff politician decrease his position.

Becker (1983) presented a theory of the political redistribution of income and of other public policies that built on competition among pressure groups for political favors, which are defined by occupation, industry, income, geography, age, and other characteristics.[12] Active groups produce pressure to raise their political influence, where all influences are jointly determined by the pressures produced by all groups. The political budget equation between the total amount raised in taxes and the total amount available for subsidies implies that the sum of all influences is zero, which has a significant effect on the competition among pressure groups. Political equilibrium depends on the efficiency of each group in producing pressure, the effect of additional pressure on their influence, the number of persons in different groups, and the deadweight cost of taxes and subsidies. An increase in deadweight costs discourages pressure by subsidized groups and encourages pressure by taxpayers.

[12]For political pressure group approach, see also Posner (1974).

Chappell (1982), however, did not agree with the idea that interest pressure groups would affect policy decisions. He developed a model to explain Congressmen's voting decisions and contributions to congressmen from interest groups by using simultaneous Probit-Tobit model. He concluded that contributions of interest groups have no significant impact on congressmen's voting decisions. Votes are most often decided on the basis of personal ideology or the preferences of constituents.

2. Empirical studies

On the basis of conceptual political microeconomic background of endogenizing governmental behavior, a series of empirical studies estimated the governmental policy preference or criterion functions and estimated policy instrumental behavior equations. These empirical studies focused on the interrelationship between the public sector and private sector.

a. Estimation of criterion functions In the specification and estimation of criterion functions for policy formation, various approaches are developed. First, Keeney and Raiffa (1976) developed the multiattribute utility analysis which was specifically advanced as a method of formalizing trade-offs between objectives under uncertainty. Taking the existing preference structure of the decision maker as given, they proceed to elaborate a method by which this structure can be made explicit. The key concerns of the procedure are the measurement of the objectives and the explication of trade-off between objectives under the assumptions of preferential independence and utility independence among multiple objectives or attributes. This analysis can be formed as

$$KU(Y) + 1 = \prod_{i=1}^{n} [Kk_i U_i(Y_i) + 1]$$

where, K and k_i are constant and $U_i(Y_i)$ is the conditional utility function of the i-th attribute. If the preferences over lotteries on all attributes depend only on their marginal probabilities and not on their joint distribution, then we have additive independence and the multiattribute utility function assume the additive form:

$$U(Y) = \sum_{i=1}^{n} K_i U_i(Y_i).$$

Second, Rausser and Freebrairn (1974) presented set of criterion functions in which public decision making is treated as a bargaining process between a finite number of centralized public decision making groups and/or individuals. They used the revealed preference approach to determine weights associated with various preference measures or objectives. It is not concerned with individual utilities but with measurable quantities. Much like the consumer preference function, it may be revealed by policy actions and hence is observable. They define this function as a policy preference function.

They employ revealed preference to capture the estimated parameters. For objective or preference measure y_{it}, the marginal policy preference relation is

$$Wy_{it} = k_{it} + 2K_{it}y_{it}$$

where the objectives y_{it} are observable and the coefficients (k_{it}, K_{it}) can be constructed by revealed preference. It is then a simple matter to derive the marginal rate of substitution, Wy_{it}/Wy_{jt}. They measured the marginal rate of substitution for aggregate producer income and the negative of consumer expenditure.

The contribution of the Rausser-Freebairn analysis is the use of the revealed preference approach to determine weights associated with various preference measures or objectives. They empirically investigate U.S. beef import quotas in an attempt to ascertain the weightings of consumers' and producers' welfare implicit in past governmental policy decisions. The method they use is to assume that a given policy represents an equilibrium maximization of the policy maker's criterion function. This method allows Rausser and Freebairn to infer the weights appearing in the criterion function via the revealed preference approach. This approach, of course, requires that the public decision making process be rational and consistent.

Third, Zusman (1976) applied revealed preference approach to N-interest groups. The policy equilibrium is characterized as the outcome of an N-person game. The concept of equilibrium employed in this game is Harsany's generalization of the Nash cooperative game solution to an N-person game. The solution concept implies that the entire cooperative game can be broken into two distinct components. The first is a noncooperative subgame in which agents bargain to arrive at a division of the final payoff. The division made is determined by the relative strength of the agents and the coalition they form. Once the division of the final payoff is determined in the first subgame, the second cooperative subgame ensues. In this subgame, all agents jointly strive to maximize the size of the total payoff as this will also maximize each agent's and/or coalition share. At the equilibrium, the payoff is divided up according to the result of the first subgame; the distribution process may involve side payment in each phase.

The final equilibrium is found by maximizing the size of total payoff. As such, it is on a political economic frontier which can be defined as

$$\max_{x} \sum_{i=1}^{n} H_i U_i(X)$$

where $U_i(X)$ is the i-th interest group's utility; $X = (x_0, x_1, \ldots, x_n)$ is the vector of all groups' actions; and H_i are the relative weightings derived from the assumptions of additive utility and the optimality of government policy, this is equivalent to

$$\underset{H_i\ x_0}{\text{MinMax}} \sum_{i=1}^{n} H_i[U_i(X_0) - U_i(\hat{X}_0)]$$

where $\hat{X}_0$ is the observed level of policy instruments. The weights, H_i, can be thus be found by solving the nonlinear programming problem

Max V

subject to $V \leq U_i(X_0) - U_i(\hat{X}_0)$, $i = 1, 2, ..., n$

and the economic constraint structure.

Zusman employed this method to investigate the Israeli sugar industry assuming an additive utility function for each interest group. The groups were the government, the Israeli labor federation (representing consumers), and sugar producers. Each of these three groups are assumed to have a utility function which is separable in the benefits and costs imposed by the sugar subsidy and in the cost of exerting effort to influence the level of this subsidy.

Fourth, Schim van der Loef and Harkema (1979) attempt to incorporate uncertainty into the heart of the policy-making process and developed Theil's (1974) Random Rational Behavior with revealed preferences. They argue that decision-makers should not be viewed as agents optimizing some function under certainty. Instead of looking at governmental behavior as optimizing a deterministic criterion function, they argue that this behavior is more accurately characterized as random rational behavior. The objective of the government under this hypothesis is to minimize losses from deviations from policy instrument targets. They proposed a quadratic criterion function, in both policy targets and instruments, to be maximized subject to a linear constraint system of reduced form equation.

In suggesting a revealed preference methodology for the estimation of criterion function parameters under random rational behavior. They propose a quadratic criterion function in both policy targets (Y) and instruments (X).

$$W(X,Y) = a_n'X + b_n'Y + 1/2(X'A_nX + X'C_nY + Y'1C_nX + Y'B_nY)$$

to be maximized subject to a linear constraint structure

$$Y = R_nX + S$$

where Y is the np vector of policy targets, X is the nq vector of policy instruments, and S is a vector of order pn of linear combination of current and lagged exogenous variables and pre-first period lagged X and Y. An expected loss function is then derived on the assumption of first period error followed by the correct decision:

$$L(X_t, \hat{X}_t) = -1/2(X_t - \hat{X}_t)'Q^{-1}(X_t - \hat{X}_t)$$

where $\hat{X}_t$ is the optimal value of instrumental variables derived from constrained maximization process and Q is the leading (qxq) submatrix of K_n^{-1}, where

$$K_n = A_n + R_n'C_n + C_nR_n + R_n'B_nR_n$$

b. Estimation of behavioral equations Examination of government policy formation is equivalent to the direct estimation of instrumental behavior equations. There are various approaches to estimate the parameters of these equation systems and to quantity the criterion functions. They extend our understanding of the policy formation process, especially with respect to verifying the endogeneity of government policy decisions. They also support the conceptual link between policy choices and interest group preferences. Most of this work has concentrated on partially reduced form estimation. It can be classified into two general categories. The first category concentrates on the policy formation process. The explanation and prediction of government policy determination are major purposes of such studies. These models are represented by policy behavioral equations in which the underlying structure admits the simultaneous determination of all policy instruments. The second category has concentrated on the private sector, stressing the inclusion of policy determination as a means of improving the performance and predictability of such private sector models. Feedback effects from the private sector to policy formation and vice versa have been of special interest. The resulting models have generally had a market orientation in which one or more policy instruments have been embedded. Equations for the policy instruments have been included in the conceptual or theoretical frameworks but are eliminated or treated as predetermined in the empirical models that have been constructed. Studies of Rausser and Stonehaus (1978), Camm (1976), and Reed and Ladd (1983) for policy analysis belong to the first category and the studies of Lattimore and Zwart (1979), Lattimore and Schuh (1976), and Abbott (1979 a and b) belong to the second category.

Rausser and Stonehaus (1978) specified policy behavioral equation system which was largely determined by the authors' beliefs as to the nature of policy formation. In their study of Canadian dairy industry, they take as a working hypothesis that the policy formation process is some sort of bargaining game between interest groups in society. Policy instruments such as target returns and support prices for dairy products are the dependent variables represented by proxies for consumer, producer, and government agency interests. The coefficient estimates are highly reasonable and tend to conform the importance of those factors in the process of policy formation. One of the most important endogenous variables is the aggregate market-sharing quota. Each explanatory variable entering Rausser and Stonehaus' "Endogenous Dairy Policy Behavioral Equations" plays a specific role; net target return is a proxy for producer's welfare; assumed processing margin represents processor's interests; change in government stocks and government deficit are proxies for taxpayers' interests; the consumer price index is a proxy for consumer concerns; and lagged quotas represent the government's major reference point. Their quarterly forecasting model of Canadian dairy sector consist of 24 endogenous policy variables including the above explanatory variables. They conclude that the specification of behavioral equations for both private and public sectors allows comprehensive long and short-run forecasts to be made not only of supplies, demands, and prices, but also of the important government policy variables. Hence the basic conclusion is that for agricultural commodity markets which exhibit a high degree of governmental intervention, specification of the correct structural form depends on responses of both the private and public sectors, together with their feedback effects.

Camm (1976) developed a price theoretical model of market discrimination to isolate variables affecting the size of rents and to determine their impacts. The set of independent variables is composed principally of factors affecting supply and demand elasticity. It includes such variables as national demand elasticity, percentage of acreage devoted to the crop of interest, share of production under order, farm value, and variability of crop size. A linear probability model is used to estimate the effect of these variables on whether a marketing order was in effect in 1966.[13]

Reed and Ladd (1983) developed an economic explanation for endogenous governmental restrictions on trade in feed grains. The explanation is provided by using an econometric model that contain three submodels: (i) one submodel derives demand for feed grain imports as the excess demand over domestic supply; (ii) a trade

[13]Camm's study of marketing order derived from Stigler's theory of regulation. The view is that the imposition of a marketing order creates rents for producers, hence the demand. The greater the rents, the greater the demand for regulation. The probability that marketing order will be imposed should thus increase as the transfer of income grows.

barrier submodel postulates that the government maximizes a utility function that incorporates the benefits and costs of trade barriers for feed grain; (iii) a livestock sector submodel allows the domestic feed grain market to influence the domestic livestock industry. They found that Spain and the UK had domestic feed grain prices that differed systematically from the cost of imported feed grains. These countries followed domestic policies that insulated domestic feed grain prices from fluctuation in world feed grain prices. Because imports depend on domestic prices, it follows that the world price or the cost of importing feed grain is not the most appropriate price to include in import demand for feed grains. Their results also indicate that the difference between domestic price of feed grain and the cost of imported feed grains depends on market conditions in the importing country. Real per capita income, the volume of feed grain imports, and the lagged domestic prices of feed grains. Their results confirm that feed grain imports are affected by a nation's livestock sector. But the livestock sector is not an exogenous determinant of feed grain prices and imports; feed grain markets affect the livestock inventories. They concluded that econometric studies of feed grain imports need to construct models of the importing country's domestic economy that measure two-way interactions between feed grains and livestock sectors and that allow for public policies that insulate domestic prices from world prices.

Lattimore and Schuh (1976) attempted to integrate endogenous policy formation into models of private market response. The pertinent policy objectives are identified and used to isolate factors which may have a causal relation on the choice of instrument levels. As conditions in the markets under consideration clearly affect the correct level of policy instrument for a given objective, these specifications generally include feedback effects from the market to the policy formation process.

The estimated parameters are used for forecasting purposes and to test hypotheses about the structure and objectives of government intervention.

To find degree of governmental intervention, they take world commodity market as an example, that is, they illustrate the resulting price distortion for an individual importing country. Prior to the imposition of distorting policy, the domestic price (DP) should equal to the world price (WP) when the latter is valued at the equilibrium free trade exchange rate and transaction costs are taken in account. The two prices will diverge after the policy has been imposed. The difference between the two prices, I = DP - WP, can be thought of as measuring the degree of government intervention. This intervention takes the form of tariffs, nontariff barriers, quotas, export subsidies, producer subsidies, dumping, and undervalued exchange rates. They have examined Brazilian government intervention in the beef market. They hypothesized that an objective of government policy is to hold down consumer prices, especially those affecting middle income consumer, who are seen as politically important. The instrument used to accomplish this goal is the overvaluation of the exchange rate for these commodities. The level of intervention is specified as a function of the free market import price, the rate of increase in the general price level, and the overall balance of payments position. The policy intervention equation was estimated as one equation in an independent block of a large simultaneous equation model of the Brazilian beef industry. They found that coefficients are significantly different from zero for both import price and for the rate of increase of general consumer price level. These results tend to support the hypothesis that the effective subsidy is based on political motivations.

Abbott (1979 a and b) attempted to use an endogenous policy formation model to test series of hypotheses about government intervention in the international grain markets. He specified a model of endogenous determination of the relevant policy instrument levels such as consumer prices, producer prices, and stocks released which are posed as functions of world prices, domestic production, foreign exchange flows, stocks at hand, etc. His model is a simultaneous reduced form representation of some unspecified model of government policy formation. His hypothesis that a partial adjustment mechanism exists is borne out in a number of cases, especially among the developing countries as Brazil, Mexico, Colombia, India, Thailand, Philippines, and Egypt. This evidence lends support to the contention that maintaining stable domestic prices is an important policy consideration for many of these countries. Such a conclusion, however, rest on a weak statistical foundation. The standard errors of the estimates are rather larger, and a fair number of the estimated coefficients either have perverse sign or exceed the hypothesized upper bound.

Lattimore and Zwart (1979) have incorporated endogenous determination of government policy into their forecasting model of the world wheat market. Using specification derived from Lattimore and Schuh (1976) and Abbott (1979 a and b), they set up an estimating model for the determination of producer prices and consumer prices. The domestic price instruments, in local currencies, are postulated to be related to the world price, the exchange rate as a proxy for the rate of foreign exchange, the rate of inflation, and open stocks. The equations were incorporated into a spatial equilibrium framework which in turn was used for forecasting. Since the model was only used for forecasting, few implications for the policy formation are offered, and no direct tests of the underlying specification are conducted.

There are a number of other studies of endogenous policy measures. Huffman and McNulty (1985) hypothesized that agricultural extension input is an endogenous variable. From a political economic model of competitive interest groups, they derived a behavioral relationship for the public provision of county agricultural extension. A similar empirical study about expenditure on agricultural experiment station has done by Huffman and Miranowski (1981). Von Witzke (1986) studied the supernational European Community (EC) decisions on the common agricultural policy and indicated that the supernational EC decisions are endogenous and could largely be extended by past income growth and the development of budgetary expenditure prevailing at the time of the price decisions. The empirical results corroborate the hypothesis that Monetary Compensatory Amounts are integral part of common price decisions.

3. Summary

There are various studies on the interdependence of microeconomic performance and microeconomic policy. Each characterized theoretical approach focusses on one distinguishable viewpoint about endogenized governmental behavior. The theory of economic regulation concentrates on the election process; the liberal-pluralist approach concentrates on the legislative choice process with some reference to the election process; and the interest groups and conflict resolution approach concentrates on the election and bureaucratic choice process.

Empirical studies proceed by directly estimating policy instrument behavioral equations or by estimating the criterion functions. Given the constructed criterion functions and an appropriate constraint structure, policy instrument or choice equations can be derived. None of the criterion functions approaches surveyed, however, seem entirely adequate for estimating the effects of power exertion on the final determination of policy and the relationship between policy alternatives and the generation of political effort. Various empirical results on redistribution of wealth may also confirm, or fail to confirm, the various policy formation models and policy determination models.

Finally, it is to recognized that normative or traditional welfare analysis in microeconomics must give some emphasis to implementation. Practically, meaningful policy analysis must incorporate positive notions of policy formation. This requires the explicit recognition of political markets and their role in distribution. Ultimately, an operational policy focus should lead to an integration of normative and positive analysis of endogenizing government behavior in the political microeconomics.

III. THEIL'S QUANTITATIVE ECONOMIC POLICY MODEL

The theory of quantitative economic policy (QEP) was pioneered by Tinbergen (1961) and others and extended by Theil (1961) and others; see e.g., Fox, Sengupta, and Thorbecke (1966). It grew out of the need encountered during the great depression of the 1930s and during post-World War II reconstruction and demobilization to provide national governments an operational method that they could use to stabilize their economies. It has been extended to other areas: most notably economic development.

The elements of a flexible-target model are (i) the public policy maker's preference or welfare function, W, (ii) target variables, which are indirectly but purposefully influenced by the policy maker, (iii) instrument variables, which are the means available to the policy maker for achieving their objectives (e.g., maximizing his popularity to be won in next election) and whose values are determined directly by the policy maker, (iv) irrelevant and data variables, which are not required in this study., (v) a quantitative model consisting of empirical relationships among the variables. Examples of instrument variables are price support level of corn, personal income tax rates, tariff rates, unemployment compensation levels, etc. Exemplary of target variables are unemployment rate, inflation rate, corn farmers' income, GNP, balance of trade, etc.

One way to study policy rules in macroeconomic models is to confront the optimal decision rules with change in the constraints which the policy maker has to face. Theil (1964, chapter 8) discussed optimal decision rules under the constraints in structural and reduced form equations. By assuming a linear relationship between instrumental variables and endogenous variables, Theil's reduced form restriction is, as a matrix form,

$$Y = RX + S \tag{3.1}$$

where Y is (nx1) of endogenous variables which are indirectly but purposefully influenced by the policy maker, X is (mx1) of instrument variables which are the means available to the policy maker for achieving his objectives and whose values are determined directly by him and of irrelevant variables which measure side effects in which the policy maker is not interested, S is (nx1) of disturbance term, and R is (nxm) of coefficient and describes the influence of X on Y, so R can be said to measure the effectiveness of the exogenous variables with respect to endogenous variables (noncontrolled) variables.

Theil's Lagrangian function for maximizing the welfare function W(X, Y) subject to reduced form equations is

$$W(X, Y) - \lambda'(Y - RX - S) \tag{3.2}$$

where λ is a column vector of Lagrangian multipliers. The specific formulation of W that has been frequently used is the quadratic

$$W(Y,X) = (Y - Y^*)'V_Y(Y - Y^*) + (X - X^*)'V_X(X - X^*)$$

where Y^* and X^* are vectors of desired target levels. W is a quadratic disutility function in deviations of actual from desired levels and its value is minimized.

Minimization gives, then,

$$\partial W/\partial X + R'\lambda = 0$$
$$\partial W/\partial Y - \lambda = 0 \tag{3.3}$$

where $\partial W/\partial X$ and $\partial W/\partial Y$ are the column vectors of the marginal welfare of instruments and noncontrolled variables, respectively. Substituting $\lambda = \partial W/\partial Y$ into $\partial W/\partial X + R'\lambda = 0$ gives

$$\partial W/\partial X + R'\partial W/\partial Y = 0 \tag{3.4}$$

For the second-order (stability) conditions, consider the matrix

$$W = \begin{bmatrix} W_{xx} & W_{xy} & R' \\ W_{yx} & W_{yy} & -I \\ R & -I & 0 \end{bmatrix} \tag{3.5}$$

which is obtained by bordering the matrices of second-order derivatives of the welfare function. Then the second-order conditions are the followings: Take an arbitrary principal minor of order (n+1) in the matrix of second derivatives of W. Border this minor with the corresponding elements of the multiplicative structure. The result is a principal minor of order (2n+1) of the matrix W, where additional n elements come from derivatives of W with respect to constraint, (3.1): for example:

$$\begin{bmatrix} \partial^2 W/\partial x_1{}^2, & \partial^2 W/\partial x_1 \partial y_1, \ldots, & \partial^2 W/\partial x_1 \partial y_n, & r_{11}, \ldots, r_{in} \\ \partial^2 W/\partial y_1 \partial x_1, & \partial^2 W/\partial y_1{}^2, \ldots, & \partial^2 W/\partial y_1 \partial y_n, & -1, \ldots, 0 \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot \\ \partial^2 W/\partial y_n \partial x_1, & \partial^2 W/\partial y_n \partial y_1, \ldots, & \partial^2 W/\partial y_n{}^2, & 0, \ldots, -1 \\ r_{11}, & -1, \ \ldots, & 0 & 0 \ldots, 0 \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot \\ r_{n1}, & 0, \ \ldots, & -1 & 0 \ldots, 0 \end{bmatrix}$$

For maximization this minor should have the sign of $(-1)^{n+1}$. Furthermore, when it is bordered by another row and column of W such that a principal minor of order (2n+2) results, it should have opposite sign.

Questions might be asked about effects on optimal values decided by policy maker if the coefficients changes. For example, in demand theory, what is the effect on the quantities bought of given changes in the coefficients of the budget constraint, i.e., of changes in prices and income. This question might be equivalent to the question, "What are the decision errors when decision maker use erroneous coefficients in the reduced form equation as constraints." This question leads us to an appropriate insight into the dependency of the optimal instrument values on the coefficients of the constraints, i.e., on R and S. This dependency can be written as

$$X^{o} = X(R, S)$$

$$Y^{o} = Y(R, S) \tag{3.6}$$

where X^{o} and Y^{o} is the policy makers optimal value of X and Y, respectively, as functions of the coefficients of the constraints. These equations are called "Optimal Reaction Functions". These functions will exist in a range of values of the elements of R and S if W has a conditional maximum for any constraint Y = RX + S. Then all (m+2n) equations on (3.3) and (3.1) can be written as below;

$$\begin{aligned}
&\partial W/\partial x_1 + \dots + r_{11}\lambda_1 + \dots + r_{n1}\lambda_n = 0 \\
&\quad \cdot \qquad\qquad \cdot \qquad\qquad \cdot \quad \cdot \\
&\partial W/\partial y_1 + \dots - \lambda_1 = 0 \\
&\quad \cdot \qquad\qquad \cdot \qquad\qquad \cdot \\
&r_{11}x_1 + \dots + r_{1m}x_m - y_1 = -s_1 \\
&\quad \cdot \qquad\qquad \cdot \qquad\qquad \cdot \\
&r_{n1}x_1 + \dots + r_{nm}x_m - y_n = -s_n
\end{aligned} \tag{3.7}$$

Differentiation of the system (3.7) with respect to any source s_j gives

$$\begin{aligned} \partial x_h/\partial s_j &= |W_{m+n+j,h}|/|W| \\ \partial y_i/\partial s_j &= |W_{m+n+j,m+i}|/|W| \end{aligned} \qquad (3.8)$$

where $|W|$ is the determinant of W and $|W_{i,j}|$ is the cofactor of the (i,j)-th element of $|W|$. Further, differentiating with respect to r_{jk};

$$\begin{aligned} \partial x_h/\partial r_{jk} &= (-x_k)|W_{m+n+j,h}|/|W| - (\lambda_j)|W_{k,h}|/|W| \\ \partial y_i/\partial r_{jk} &= (-x_k)|W_{m+n+j,m+i}|/|W| - (\lambda_j)|W_{k,m+i}|/|W| \end{aligned} \qquad (3.9)$$

These equations (3.8) and (3.9) explain the effect on optimal decision values when there are changes of errors or coefficients in the constraints. In other words, the decision errors occurred when decision maker use incorrect error terms and/or coefficients.

The further analysis will be simplified by the introduction of more convenient notation. Let us partition the inverse of W according to

$$W^{-1} = \begin{bmatrix} (XX) & (XY) & (X.) \\ (YX) & (YY) & (Y.) \\ (.X) & (.Y) & (..) \end{bmatrix} \qquad (3.10)$$

Partitioned multiplication $W^{-1}W = I$ gives then the following nine matrix relations, most of which will be used below;

$$
\begin{aligned}
&(XX)W_{xx} + (XY)W_{yx} + (X.)R &&= I \\
&(XX)W_{xy} + (XY)W_{yy} - (X.)I &&= 0 \\
&(XX)R' - (XY)I &&= 0 \\
&(YX)W_{xx} + (YY)W_{yx} + (Y.)R &&= 0 \\
&(YX)W_{xy} + (YY)W_{yy} + (Y.)I &&= I \\
&(YX)R' - (YY)I &&= 0 \\
&(.X)W_{xx} + (.Y)W_{yx} + (..)R &&= 0 \\
&(.X)W_{xy} + (.Y)W_{yy} - (..)I &&= 0 \\
&(.X)R' - (.Y)I &&= I
\end{aligned}
\tag{3.11}
$$

Obviously

$$(X.)' = (.X) = [\,|W_{m+n+j,h}| / |W|\,] = -[\partial x_h/\partial s_j]$$

$$(Y.)' = (.Y) = [\,|W_{m+n+j,m+i}| / |W|\,] = -[\partial y_i/\partial s_j]$$

Write $(xx)_{hk}$ for the (h,k)-th element of the submatrix (XX) and similarly $(xy)_{hi}$, $(x.)_{hi}$, etc. The equations (3.8) and (3.9) become then

$$
\begin{aligned}
\partial x_h/\partial s_j &= -(.x)_{jh} \\
\partial y_i/\partial s_j &= -(.y)_{ji}
\end{aligned}
\tag{3.12}
$$

and also

$$
\begin{aligned}
\partial x_h/\partial r_{jk} &= -x_h(.x)_{jk} - \lambda_j(xx)_{kh} \\
\partial y_i/\partial r_{jk} &= -x_k(.y)_{ji} - \lambda_j(xy)_{ki}
\end{aligned}
\tag{3.13}
$$

Thus, by (3.12) if an error in a constraint varies, instrument variable x_h also varies. Because the instrument variable and the error are correlated, x_h is not exogenous. This is an internal inconsistency in Theil's work.

IV. RATIONAL EXPECTATIONS HYPOTHESIS

A. Rational Expectations

Most behavioral equations depend critically on expectations about current and future economic variables. In the past, the adoption of various ad hoc assumptions about the expectation formation process has allowed development of simple economic models whose dynamic properties might be analyzed. Still ad hoc assumptions are troubling for they are arbitrary. The recent work on the Rational Expectations (RE) has received considerable attention because it seems to rely on a good optimizing principle, that is individuals should not make systematic mistakes in forecasting the future.

The original hypothesis of RE was postulated by Muth (1961). Emphasizing the role of information, Muth stated (1961, p. 316);

> Expectations, since they are informed predictions of future events, are essentially the same as the predictions of the relevant economic theory. At the risk of confusing this purely descriptive hypothesis with a pronouncement as to what firm ought to do, we call such expectations "rational."

The concept of RE provides a method of interpreting decision makers' use of available information in making decisions. RE for a particular variable or a specific model is a mathematical expectation conditional on available information. This information consists of all available observations on the variables in question and on related variables at the time the forecast is made.[14]

---

[14]Gowdy (1985-86) distinguished Weak RE Hypothesis (REH) and Strong REH. The former means that each agent will make the best use of all available information (Gomes, 1982). The latter means that expectations about relevant economic variables will be correct on the average, that expected values of certain variables will be concentrated around the values predicted by economic models, and that predictions made by the economic agents will be stochastically correct in the sense that any errors

An assumption of RE is that individuals effectively use all available information. Information resulting from continuous search activity is readily available and used by intelligent transactors in executing current decisions and in forming their anticipations of the future. This does not mean that transactors share identical global information sets. Rather they possess localized information distributed throughout the market mechanism[15] (Wibble, 1984-85). The basic starting point for RE is that the individuals in the economy correctly and efficiently use all available information[16] (Gowdy, 1985-86).

The Rational Expectations Hypothesis (REH), thus, implies that individuals will collect and analyze a determinate amount of information in formulating their expectations if they are maximizing their, say, welfare. However, it does not imply anything about perfect foresight because individuals will be subject to a some uncertainty. Also it does not imply that RE will always be correct.[17] Rather it is claimed that individual economic agents will not make systematic expectation errors indefinitely, because they will ultimately learn from experience and modify their process of expectations formation. REH does not imply that all economic agents have an intricate knowledge of economics and carry with them a detailed model of how the

---

are independent of the information used (Lucas, 1977; Sargent, 1973; Muth, 1961).

[15]Global information is approximated by the average price and quantity observed in any particular market since information is localized and limited in scope. If information is deficient and inadequate, then the RE can be supplemented with another optimizing theory, that is search theory. Search theory suggest that transactors subjectively estimate the marginal benefits and costs of collecting information and search until the expected net marginal benefits are zero (see, Stigler, 1961).

[16]Initial RE view ignored costs of obtaining information, that is it was assumed that all information is available at negligible cost.

[17]Economic agents could imperfectly use available information when agents lack the requisite decision skills to always perfectly respond to information regardless of how difficult their decision problems might be.

economy actually behaves and possess a complex model of the economy in order to learn to avoid making systematic expectation errors.

B. Rational Expectations and Macroeconomic Policy

As the REH became the most popular method for generating expectations in a recent decade, appropriate econometric methods were introduced to test the REH in macroeconomics, especially in the field of stabilization policy [see, Lucas (1973, 1975, 1977), Frenkel (1977), Barro (1977, 1978), Sargent (1973, 1976), Hall (1978), McCallum (1976 a and b), etc.]. Since expectations are not observable, an econometric exercise, which assumes that economic agents know the structure of the model for entire sampling period, may give credence to the view that RE imagines economic agents to be, in Arrow's words, "superior statisticians capable of analyzing the future general equilibrium of the system". Furthermore, Sargent and Wallace (1976) give some reasons for using the REH approach to econometric modelling: (i) it is consistent with the finding that large parts of macro-econometric models typically fail tests for structural change, (ii) it can be used to supply an alternative identifying restriction, and (iii) it forces one to specify exactly the horizon over which the expectations are cast and what variables people are assumed to see: these are two things that most macroeconometric models ignore. The RE models under the symmetric information structure have a typical characteristic such that if economic agents fully understand how the economy actually operate, then any anticipated changes in economy policy would result no changes in real economic variables.[18] For

[18]Taylor (1975), however, argued that monetary policy can influence real economic variables during periods in which inflationary expectations are transitional. Under the assumption of RE that economic agents have learned from their previous incorrect

example, it is assumed that an economic agent fully understands the quantity theory of money summarized in the exchange equation. If he is informed that the government intends to increase the money supply by 10 percent in current fiscal period, but at the same time it is announced that some autonomous discovery of crude oil in Ames, Iowa, has increased output by 10 percent, he will logically be held to conclude that there will be no impact on prices (Shaw, 1984). Generally, it is true for those who believe the quantity theory of money, PQ = MV,[19] however, it is not true for others who are not informed about government policy announcement or does not understand the quantity theory of money.

Thus, in the context of political business cycle (see Figure 2), there is no scope for vote-maximizing policies when economic agents are rational and possess complete information about the structure of the economy and the policy rule adopted:

> Incumbent governments cannot, even if they so desire, regularly manufacture booms during the latter portion of their elected terms. Prices may be bid up and inventories drawn down, but output and employment will be unaffected. The argument assures (i) that departures of the unemployment rate from its natural level are initiated by expectation errors and (ii) that expectations are formed rationally in the sense of Muth. Under these conditions Phillips-type relations may exist but will not be exploitable by monetary and fiscal authorities: regular attempts by the authorities to manufacture election-time prosperity will be anticipated by private consumers and firms, and the real effects negated (McCallum, 1978, p. 504).

The government authorities could have an impact on real outcomes and vote-maximizing strategies become feasible when private sector agents do not have complete

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predictions ignores the transition period during which new information affects new beliefs. Though the public's optimal predictions of the inflation rate eventually converge to a RE equilibrium, in the interim these predictions behave like adaptive expectations with a time varying coefficient of expectation depending on the precision of the monetary policy. Thus, by choosing a suitable time path for policy, the monetary authorities can achieve desired levels of unemployment during the transition.

[19]Where P = price level; Q = output level; M = amount of money supply; and V = velocity of money.

information, when markets do not clear instantaneously, when economic models are nonlinear, when the forecast errors are biased and correlated, or when government economic policy affects the natural rates (Borooah and van der Ploeg, 1983, and Minford and Peel, 1983).

As a summary of RE model and macroeconomic policy, as far as it concerns endogenous government policy choices, it is assumed that the information structure is hierarchical[20] in the RE model. The available information set for the private sector is different from the available information set for the public sector. Any competitive group, for example, corn producers, could influence policy making processes by lobbying in the USDA or on the Capital Hill to increase, say, corn price support. They know other groups, tax payers, consumers, or other industry organizations, are also lobbying to secure own interests, however they could not recognize other group's relative lobbying power or strategies because the competition among interest groups is noncooperative in nature. However, government authorities encounter all of the interests of all private groups, understand their rules of behavior, consider their own political economic goals, and select policy choices expecting responses of the private sector to their choices. So, it may be recognized that policy choices are determined through a "policy filter" (see Figure 3).

The filtered policy measures are announced to the private sector and the private sector reacts to announced choices and predicts future policy measures. Therefore,

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[20]See Townsend for hierarchical information structure (1983, pp. 555-562).

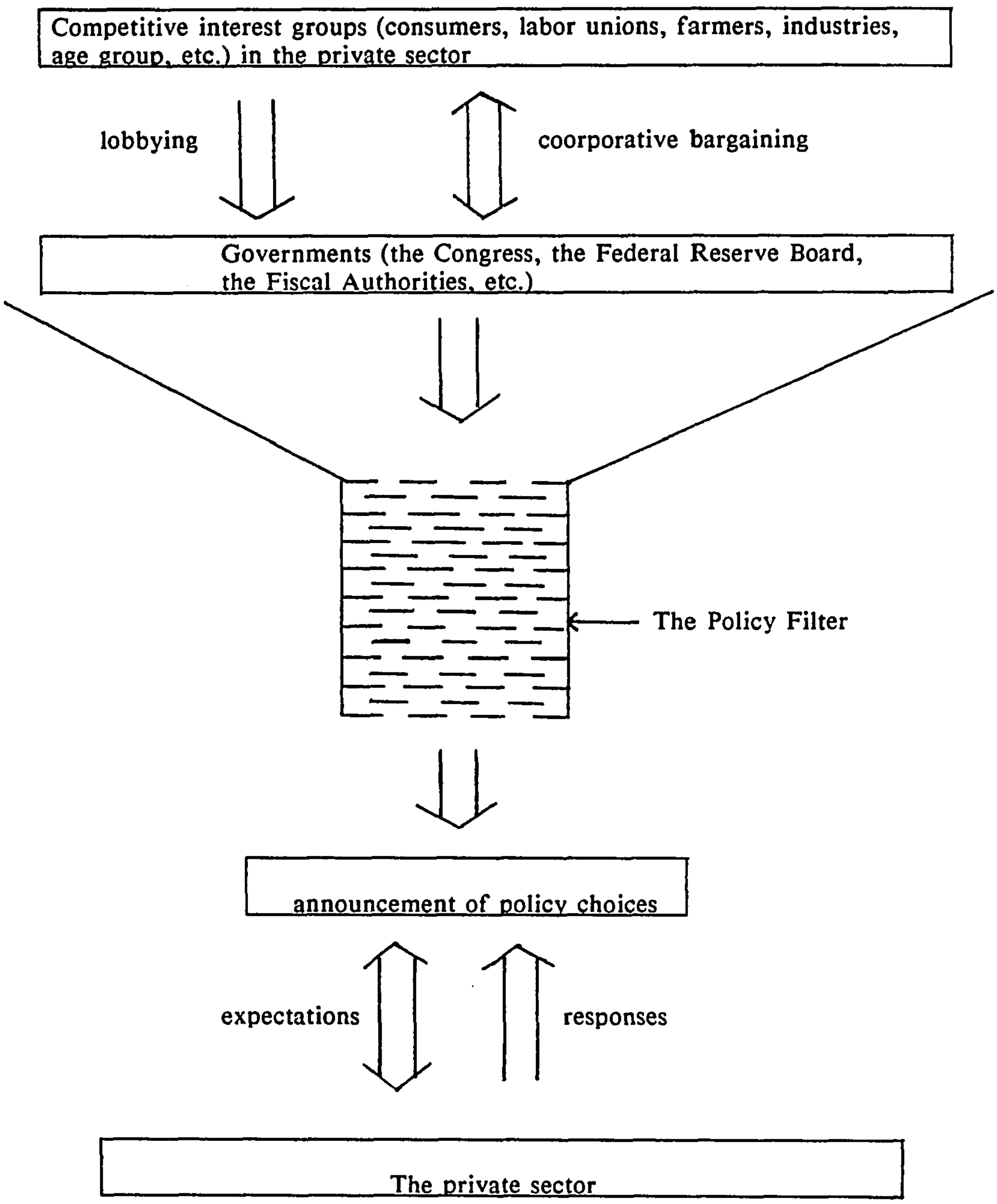

Figure 3. The policy filter

it is assumed that the available information set for the private sector is a subset of the information set for the public sector. This assumption of a hierarchical information structure is one of the source for explanation why there exist economic fluctuation in the real world and is more practical than the assumption of symmetric information structure, which argue that unexpected policy choices or forecasting errors affect on the real economic variables.

C. Rational Expectations and Microeconomics

1. Rational expectations equilibrium

To solve a microeconomic problem such as a firm's supply response, a neoclassical economist often postulates a representative firm maximizing some constrained objective function. One method to solve this problem is mathematical programming. However the context of RE framework provides a systematic way to incorporate the effects of uncertainty about future prices. Typically this involves assuming that the agent wishes to maximize discounted expected profit subject to technological constraints. For this example, the solutions generate a set of equilibrium stochastic processes. An equilibrium that satisfies the constraints of the stochastic optimization problem is known as a Rational Expectations Equilibrium (REE) because the representative firm is assumed to forecast particular variables by taking conditional mathematical expectations using stochastic process actually governing those variables.

Microeconomics textbooks explain how market prices provide signals to the market participants, which facilitate the allocation of resources to their best use. Most studies about REE are related to the role and the efficiency of information and the conditions for existence of REE.

Grossman (1981) showed that RE models are radically different from Walrasian models in an economy where traders have diverse information. In a world subject to random shock, it will be the case that economic agents acquire (or at least attempt to acquire) information about future realization of the shocks. Different agents may have access to different information. The fact that information is distributed throughout the economy has the potential to cause a misallocation of resources relative to what would be the case if all agents know everything. Thus, unlike what occurs in a Walrasian equilibrium of an economy with heterogenous information, if there is a complete set of insurance markets and each person's utility is additively separable over time, then there exists a REE which gives the consumers the same allocation as if each consumer has access to all the economy's information. In a world with diverse information about the future which affects current prices, the Walrasian equilibrium does not lead to allocations which are the same as if each trader had all of the economy's information. In the long-run, markets will not clear at the Walrasian equilibrium prices because traders observing these prices will extract information and thus revise their demands. However, in an economy where traders have diverse information, the REE allocations are the same as if each trader has all of the economy's information. He also showed that as long as there are complete markets and additively separable utility, there will exist some REEs which cannot be Pareto dominated by a fully informed planner.

Bray (1981) analyzed a model of a futures market in which both pure speculators and producers participate. She assumed that traders who have constant absolute risk aversion form RE about the return on holding futures (the basis) and the amount producers will produce and that the agents who produce the commodity, which is sold on the spot market, are also futures traders. Their decisions on futures trades are affected by their beliefs about both the spot price and their own output. If the futures price is a sufficient statistic for information which is gathered about the spot price, there is no incentive for dealers to seek such information if it is costly.

She concluded that the price does not, in general, provide information which is equivalent to complete information, and derived two theorems. The first theorem establishes that there is a REE in which prices are a sufficient statistic if and only if the artificial economy (fully informed economy) prices are a sufficient statistic. However, if there are two sources of uncertainty, residual uncertainty about the spot price and random endowments of physical output, the futures price is not, in general, a sufficient statistic. The second theorem establishes that if there is information about only one side (either demand side or supply side) of the spot market, the only REE, in which price is a linear function of the private information, is the sufficient statistic equilibrium. However, this theorem has serious limitations in dealing with the possibility of equilibria is a which the price in nonlinear function of the information variables.

Jordan and Radner (1982) introduced several topics in the general equilibrium theory of RE. They defined the term REE as a situation in which traders correctly forecast the probability distribution of future prices. Their two equilibrium conditions for RE are: (i) prices must clear markets and (ii) traders must have the correct expectations conditional on prices and their private information.

A sound foundation for applying the concept of REE to the predictions about market behavior requires the investigation of conditions that would ensure the existence and stability of REE. And this investigation has revealed a set of problems. First, if markets are incomplete, the existence of REE is not assured by the classical conditions of ordinary general equilibrium analysis. Second, the definition of REE is probably in need for some refinements that implying some restrictions on the price function and recognize that market transactions are typically spaced out in time, so that information revealed by the prices in any one transaction can only be used in subsequent transactions. Third, analysis of learning and stability needs to take account of the way that traders modify their market models in the light of experience, as well as of the usual problems of price adjustment in disequilibrium. Finally, since the acquisition of information is an activity that may require the expenditure of economic resources, the study of REE would treat the traders' nonprice information as endogenously determined, and would take account of the costs and benefits of information acquisition.

Blume and Easley (1984) studied a dynamic market process in which traders condition their beliefs about payoff-relevant parameters on past endogenously generated market data and current exogenous data. They modeled the dynamic market process as a recursive system. Their rationality hypothesis is that traders make correct use of exogenous data and predetermined data. Past market data may contain useful information without being sufficient for past private information. Estimates of payoff-relevant parameters from endogenously generated market data may ultimately be just as accurate as parameter estimates from exogenous data. They used statistical decision theory as a tool to characterize the limit behavior of the stochastic market process. Market process is informative if the beliefs of traders who do not receive exogenous information about payoff-relevant parameters converge almost surely to certain knowledge of the true parameter value. Their main result is that under standard regularity hypotheses, the generic market process is informative.

There are some studies about REE done by Townsend (1978), Allen (1981), Newbery and Stiglitz (1982), Frydman (1982), Laffont (1985), etc. There are also studies about learning process under RE done by Cyert and DeGroot (1974), DeCanio (1979), Bray (1982), Blume and Easley (1982).

2. Rational expectations and forecasting

When REH is applied to microeconomics, there is a question whether it is appropriate to test REH at the micro level? According to Muthian expectations, individuals should not make systematic mistakes in forecasting the future because prediction error must be uncorrelated with the entire set of information that is available to the individual at the time the prediction is made. However, various empirical studies of REH at the microeconomic level indicate individuals do make systematic errors. In the recent study Lovell (1986) demonstrates that the cumulative empirical evidence does not establish that the received doctrine of RE dominates alternative hypothesis about expectations and he concludes that the weight of empirical evidence is sufficiently strong to compel us to suspend belief in the REH.

Hirsch and Lovell (1979) analyzed the Manufacturers' Inventory and Sales Expectations Survey which was conducted quarterly by the U.S. Department of Commerce from late 1959 through 1976. They reported that the sales expectations of individual firms are biased, which contradict Muth's RE model: some firms are perennial optimists, generating overestimates of true sales, while others are perennial pessimist, usually underestimating sales volume. The REH asserts that the variance of actual realization will exceed the variance of forecasts and they found that for a sizable proportion of firms (about 35 percent of the 83 firms responded to the survey in the fourth quarter of 1964), sales anticipations have a larger variance than sales realized. They concluded that in empirical work the most appropriate assumption to make about expectations, when anticipations are not directly observable depends on the level of aggregation.

Two studies done by de Leeuw and McKelvey (1981 and 1984) exploited the evidence on the price expectations of business firms provided by the responses of the Year-end Survey of Business Expenditures on Plant and Equipment conducted by the Bureau of Economic Analysis since 1970. They (1981) reported that the expected price changes are somewhat more accurate than simply forecasting the same rate of inflation as the last year. They also found that the two rounds of OPEC oil price hikes caused major errors in the anticipated prices of goods and services sold. For example, the expected percent change in price in 1974 was only 5.3 percent while the actual hike was 16 percent; but for 1975 the expected inflation rate of 8.8 percent fell just short of the actual 8.9 percent. In their second study (1984), they worked with both individual firm data and with grouped data in order to mitigate the problem of errors in the variables. They found that the regressions of the actual rate of increase in the sales price on the anticipated change violate REH because the coefficients of anticipated price were substantially less than unity on both grouped and firm disaggregated data and sum of coefficients was not 1.0. The sum of coefficients should equal to 1.0 to indicate unbiased expectations. Expected price change is determined by a variety of variables, including lagged expected rates of inflation and recently observed changes in the rate of price change.

Leonard (1982) analyzed data on employer's wage expectations provided by the Endicott Survey on average starting wages for inexperienced college graduates. Data for eight occupational categories are collected from a sample of 170 large and medium sized corporations. Expectations appear to be biased downward, for in each of the eight occupational categories employers underestimate the wage they will have to pay new recruits because they underestimate demand for their products. Thus forecast errors are not explained by misperceptions of inflation or of either the expected or the unanticipated money supply change.

D. Rational Expectations in a Simultaneous Equation System

A typical macro-econometric model under the REH consists of a set of simultaneous equations describing the behavior of the components of the model. This section uses the following modofication of Wallis' (1980) or Fisher's (1982) REH model of a linear simultaneous equations system.

$$BY_t + A\hat{Y}_t + P_1X_{1t} + P_2X_{2t} + P_3X_{3t} = U_t \quad (4.1)$$

where Y_t and $\hat{Y}_t$ are (gx1) vectors of observed and expected endogenous variables, respectively; X_{1t} is (k_1x1) vector of exogenous variables whose future values are not known, X_{2t} is (k_2x1) vector of predetermined variables which contains time trends and seasonal variables whose future values are known exactly, X_{3t} is (k_3x1) vector of instrument variables whose future values are not known, thus future values of X_{1t} and X_{3t} must be predicted. A and B are (gxg) matrices; P_i is (gxk_i), for i = 1, 2, 3, matrix of constant coefficients.

Under the REH, expectations are essentially the same as predictions of the relevant economic theory and hence depend specifically on the structure of the relevant system describing the economy (Muth, 1961). Therefore, it is necessary to make some assumptions about the formation of expectations before parameters of the system can be estimated.[21]

Let I_{t-1} be the set of information available at time t-1. REH assumes that $\hat{Y}_t = E[Y_t | I_{t-1}]$. Taking conditional expectations of (4.1) and assuming $E[U_t | I_{t-1}] = 0$ yields

$$(B + A)\hat{Y}_t = - P_1\hat{X}_{1t} - P_2X_{2t} - P_3\hat{X}_{3t} \quad (4.2)$$

where $\hat{X}_{it} = E[X_{it} | I_{t-1}]$ for i = 1, 3. Solving expression (4.2) for $\hat{Y}_t$ and substituting the result into (4.1) expresses the model in terms of variables that are observable, or that become observable after specifying models for generating X_{1t} and X_{3t}.

$$\begin{aligned} &BY_t - A(B+A)^{-1}P_1\hat{X}_{1t} + P_1X_{1t} - A(B+A)^{-1}P_2X_{2t} + P_2X_{2t} \\ &\quad - A(B+A)^{-1}P_3\hat{X}_{3t} + P_3X_{3t} - U_t = 0 \end{aligned} \quad (4.3)$$

The reduced form of the system becomes

$$Y_t = MP_1\hat{X}_{1t} - B^{-1}P_1X_{1t} + (M - B^{-1})P_2X_{2t} + MP_3\hat{X}_{3t} - B^{-1}P_3X_{3t} + B^{-1}U_t \quad (4.4)$$

where $M = B^{-1}A(B+A)^{-1}$. The errors in rational expectations of Y_t, the difference between realized values of Y_t and predicted value, are

$$Y_t - \hat{Y}_t = B^{-1}P_1(\hat{X}_{1t}-X_{1t}) + B^{-1}P_3(\hat{X}_{3t}-X_{3t}) + B^{-1}U_t \quad (4.5)$$

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[21]A necessary condition for identification in this system is that there are more exogenous variables than anticipated variables (Wallis, 1980, p. 63).

From (4.2) through (4.5), it can be found that REH models depend on different assumptions about X_{1t} and X_{3t}. Some possible assumptions are presented.

1. REH.1

Wallis (1980) and Fisher (1982) have proposed using ARIMA models for generating X_{1t} and X_{3t}. It is sufficient here to use two first order autoregressive models

$$X_{1t} = f_1 X_{1t-1} + w_{1t} \tag{4.6}$$

$$X_{3t} = f_3 X_{3t-1} + w_{3t} \tag{4.7}$$

where w_{1t} and w_{3t} are white noise processes independent of U_t. The set of equations to be estimated is (4.3), (4.6), and (4.7). In REH.1, expressions (4.6) and (4.7) are assumed to hold for all time periods in the sample period (t = 1, 2, ..., T) and also to hold in the post sample periods (t = T+1, T+2, ...). Equation (4.3) imposes a number of restrictions on the coefficients, e.g., letting $G_i = A(B+A)^{-1}P_i$, it requires $P_i = (B+A)A^{-1}G_i$ for i = 1, 2, 3. It is not possible to obtain unique estimates of the structural parameters, A, B, P_i, without imposing these restrictions. Thus estimating the structural coefficients involves a complex, nonlinear estimation procedure (see Wallis (1980) for discussion of estimation methods).

2. REH.2

Taylor (1979) in effect assumed perfect foresight in predicting X_{1t} and X_{3t}:

$$\hat{X}_{1t} = X_{1t} \tag{4.8}$$

$$\hat{X}_{3t} = X_{3t} \tag{4.9}$$

for all t. This includes the situation in which the rule for determining X_{3t} is known and changes in a known way, e.g., (4.7) with $w_{3t} = 0$ and f_{3t} known holds for t = 1, 2, ..., T and

$$\hat{X}_{3t} = X_{3t} = FX_{3t-1} + Q \tag{4.10}$$

with F and Q known holds for t > T. Here, of course, the error in the rational expectations of Y_t is $Y_t - \hat{Y}_t = B^{-1}U_t$.

3. REH. 3

A third possibility, and the last one to be considered here is for (4.7), $X_{3t} = f_3X_{3t-1} + w_{3t}$, to hold during the sample period but for a different model, e.g.,

$$\hat{X}_{3t} = X_{3t} = FX_{3t-1} + Q \tag{4.11}$$

with F and Q unknown in the post sample period. Substituting (4.11) into (4.4) results in

$$Y_t = MP_1\hat{X}_{1t} - B^{-1}P_1X_{1t} + (M - B^{-1})P_2X_{2t} + MP_3FX_{3t-1} - B^{-1}P_3X_{3t} + MP_3Q + B^{-1}U_t \tag{4.12}$$

If we have estimated M, B, and P_3 and can guess F and Q, we can estimate (4.12) by replacing $MP_3\hat{X}_{3t} - B^{-1}P_3X_{3t}$ in equation (4.4) by $MP_3FX_{3t-1} - B^{-1}P_3X_{3t} + MP_3Q$ and computing MP_3Q. If, however, we have estimated the products MP_3 and $B^{-1}P_3$ but not its three component matrices M, B, and P_3 we can not estimate (4.12) from the sample data and *a priori* guess of the values of F and Q.

V. SYNTHESIZING QUANTITATIVE ECONOMIC POLICY MODELLING AND RATIONAL EXPECTATIONS HYPOTHESIS

The theory of quantitative economic policy (QEP) rationalizes the public policy process. It assumes all people, those in the private and in the public sectors, are rational, informed, and goal oriented. This theory reached its maturity before the Rational Expectations Hypothesis (REH) had a significant impact on the economic profession. The QEP fails to account for effects of people's expectations of public policy choices upon their behavior.

The REH assumes, under a hierarchical information structure, that the public sector is rational, informed, and goal directed, and that individuals in the private sector are goal oriented in their behavior, myopically (or tunnel visioned) rational, and informed. These individuals have a good deal of information about the operations of the private sector: Muth's relevant economic theory. Muth (1961, p. 316) wrote "expectations, since they are informed predictions of future events, are essentially the same as the predictions of the relevant economic theory." Economic theory does not explain or predict future political events or public policy choices. It leaves that job to political scientists. From its very beginning most work on the REH has ignored the work on the QEP and treated the operation of the public sector as exogenous or stochastic. In the REH, the public sector makes policy choices that have predictable effects (through "relevant economic theory") upon the private sector. But most REH work does not try to explain these choices. The QEP, on the other hand, does treat public choices as endogenous; it considers effects of private decisions upon public choices.

Both the QEP and the REH are of value, but each is incomplete and it is worthwhile to synthesize the two. Taylor (1979) tried to synthesize the QEP and the REH and derived optimal monetary policy rule. This chapter discusses some possible assumptions underlying both the QEP and the REH and presents some possible syntheses that are different way from Taylor's and that are in the context of political economy. This chapter casts doubt on the validity of some claims to conceptual superiority of the REH and questions some of the conclusions of the REH under the hierarchical information structure. This chapter also demonstrates the existence of an internal contradiction in the assumptions of the QEP models.

Crotty (1973, pp. 1025) pointed out that econometric estimation of macroeconomic models under the assumption that the policy variables are exogenous rather than endogenous may be subject to important specification error. To show what is the specification error and how the policy variables are endogenously determined, he assumed that the government has a preference function which orders possible outcomes related to a set of economic instruments and goal variables. Crotty used "the Theil's framework to demonstrate explicitly the serious nature of the specification error that may arise if the preference function underlying government policy is ignored in macroeconometric work" and concuded that ".... Therefore, the parameters of the economic model will have to be estimated jointly with those of the state preference function."

The synthesis of the QEP and the REH allow us to draw differences between econometric regression with government preference function and without, a difference that was ignored in Taylor's synthesis. This study will call these differences specification errors as Crotty did. The synthesis of the QEP and the REH also allow us to investigate Lucas' (1976) well known critique of econometric policy evaluation under the assumption of endogenizing government policy variables.

A. Synthesize QEP and REH

The total number of syntheses the QEP and the REH depends on the number of assumptions claimed in the QEP and the REH. The possible underlying assumptions are summarized as follows:

Value of X_{3t}	known to the private sector	A1
	unknown to the private sector	A2
Preference function	X_{3t} is not included	B1
	X_{3t} is included	B2
Time period	multi-period optimization	C1
	single period optimization	C2
Information	based on I_{t-1}	D1
	based on I_t	D2
Lagged dependent variables	included in structural equations	E1
	excluded from structural equations	E2

The first assumption about the value of X_{3t} has already been discussed. A1 and A2 assumptions are equivalent to the REH.2 and the REH.1, respectively. Both A1 and A2 treat X_{3t} as endogenous variables. The difference between A1 and A2 is awareness of contents of the policy filter (see Figure 3). The REH.1 assume that the private sector can not fully understand what goes on inside the policy filter, under the hierarchical information structure, so that the private sector makes predictions about policy rules according to (4.7). However, the REH.2 can be reinterpreted as assuming that the private sector is able to fully recognize what goes on inside the policy filter, so that it has perfect foresight about policy rules.

For the second assumption of formulation of the preference function, the endogenization of the policy variables claims that X_{3t} should be included in the preference function because X_{3t} is a part of the endogenous variables. There are some arguments for including the policy variables in the preference function. Theil (1964, p. 80) argued that the desired level of the policy variables affect the preference level directly and also indirectly via their influence on the noncontrolled variables. Okun (1972, pp. 128-134) pointed out that some policy variables may be preferred because they are less costly to use than others and there are costs of changing policies. Therefore, to incorporate influence of the desired level of policy instrumental variables on preference level and to reduce instrumental costs, it is necessary to contain the policy variables in the government preference function.

The third time period assumption for optimization will be discussed. Taylor's synthesis is based on assumption C1 and the synthesis #1 is based on C2. Alternative C1 is assumed to represent minimization (maximization) of undiscounted (or discounted) sum of expected social loss (welfare) over several periods while C2 is assumed to represent minimization (maximization) of social loss (welfare) in a single period. It should be noted that solutions Y_t, at any time period t under C1 might not be same as optimal solutions under C2, because C1 claims the sum of expected loss for whole period, and thus optimal solutions for X_{3t} under C1 may not be equal to optimal solutions under C2. The difference between solution value of X_{3t} is expected to show differences between multi-period government optimal behavior for policy choices and single period optimal behavior.

The fourth distinction depends on assumption about available information set, I. D1 assumes that the decision makers have no information about current period t, but have all possible information through t-1 period, I_{t-1}, to make decisions for current period. Under D2, the decision makers have all possible information through the current period, I_t, to make decisions. We should note that whether the disturbance term, U_t, is included in the available information set or not. Theoretically, if U_t is included in I_t under D2, this assumption means decision maker can make no errors at all, so this assumption is unrealistic. However, we may assume that decision makers have some partial information on U_t for the period t and this partial information on U_t can be used as a proxy for U_t. For example, we may think of the monetary policy rules based on yearly data. Unlike tax rules or price support programs for agricultural commodities, the monetary policy rules are determined through the fractional reserve banking system and nonuniform reserve requirements and can flexibly be adjusted several times, say, biweekly, monthly, or quarterly, within a year. In this case, we may assume that the policy makers have some information available late in year t on the value of U_t because they have observations on unexpected (expected) developments during part of the year. As another example, we may think of annual demand analysis of any specific commodity, say beef. Beef consumption occurs very often, daily or weekly. When we analyze annual beef demand we sggregate daily (or weekly) beef consumption in a year. Therefore, as far as we are concerned about U_t in the current information set, it represents partial information on U_t.

The fifth assumption is existence of lagged dependent variables in structural equation; E1, or nonexistence; E2. Under E1, we need to make assumptions on possible serial correlation problem among disturbance terms. Of course, there are other possible underlying assumptions, but this study ignores the others. Since there are five basic assumptions for synthesizing the QEP and the REH, there are $2^5 = 32$ possible syntheses. This section will discuss three syntheses out of 32 possible syntheses and present numerical comparisons of the syntheses in the next chapter.

1. Synthesis #1: A2-B2-C2-D2-E2

This synthesis will (i) use expressions (4.1), (4.6), and (4.7) to model the behavior of the private sector of the economy, and (ii) treat X_{3t} as a vector of the QEP policy instrumental variables. Treatment (i) is consistent with the common REH assumption of myopic rationality and information. Both (i) and (ii) are consistent with the QEP assumption that policy instruments are endogenous.

Consider the government preference function,[22] for a single time period,

$$E[W(Y_t, X_{3t}) \mid I_t] = E[1/2(Y_t - Y_t^*)'G(Y_t - Y_t^*) + 1/2(X_{3t} - X_{3t}^*)'H(X_{3t} - X_{3t}^*) \mid I_t] \qquad (5.1)$$

where G and H are symmetric weight matrices (gxg) and $(k_3 x k_3)$, respectively, and E denotes conditional expectations. This quadratic disutility function is assumed to be continuous and twice differentiable. To minimize (5.1), it is assumed that the government is facing the decision "environment" describing private sector's behavior

[22] In the context of political economy, it is assumed that if the government authorities could minimize this loss function, that is, stabilize price fluctuation (of corn), then they could maximize their popularity and thus could win in next election.

expressed as (4.1).[23]

Under the QEP, the government's optimal decision rules are stated subject to reduced form equation of (4.1). To obtain the reduced form constraints, substitute (4.7) into (4.4) and assume the private sector's expectations rule as $E[X_{3t} \mid I_{t-1}] = f_3 X_{3t-1}$ under the hierarchical information structure. Then (4.4) becomes

$$Y_t = MP_1\hat{X}_{1t} - B^{-1}P_1X_{1t} + (M-B^{-1})P_2X_{2t} + MP_3f_3X_{3t-1} - B^{-1}P_3X_{3t} + B^{-1}U_t \tag{5.2}$$

where $M = B^{-1}A(B+A)^{-1}$. Let λ' be a row vector of Lagrangean multipliers, and assume an interior solution. Then the first order conditions for minimizing (5.1) subject to (5.2) are

$$\partial L/\partial Y_t = G(Y_t - Y_t^*) - \lambda = 0 \tag{5.3}$$

$$\partial L/\partial X_{3t} = H(X_{3t} - X_{3t}^*) - P_3\mathcal{B}^{-1'}\lambda = 0 \tag{5.4}$$

$$\partial L/\partial \lambda = 0 \tag{5.5}$$

Define $D = (H + P_3\mathcal{B}^{-1'}GB^{-1}P_3)^{-1} \neq 0$ and D is assumed to be a nonsingular for unique solutions. Then the solutions for X_{3t} and Y_t are

$$\begin{aligned} X_{3t}^s = {} & DHX_{3t}^* - DP_3\mathcal{B}^{-1'}GY_t^* + DP_3\mathcal{B}^{-1'}GMP_1\hat{X}_{1t} - DP_3\mathcal{B}^{-1'}GB^{-1}P_1X_{1t} \\ & + DP_3\mathcal{B}^{-1'}G(M-B^{-1})P_2X_{2t} + DP_3\mathcal{B}^{-1'}GMP_3f_3X_{3t-1} + DP_3\mathcal{B}^{-1'}GB^{-1}U_t \end{aligned} \tag{5.6}$$

[23]This simultaneous equation system may include behavioral equations derived by optimizing process of private sector like demand function, consumption, supply function, etc., technical equations like production function, definitional equations or institutional equations like tax rules and regulations, and equilibrium conditions.

Let $N = (I_g - B^{-1}P_3DP_3'B^{-1\prime}G)$.

$$Y_t^S = -B^{-1}P_3DHX_{3t}^* + B^{-1}P_3DP_3'B^{-1\prime}GY_t^* + NMP_1\hat{X}_{1t} - NB^{-1}P_1X_{1t}$$
$$+ N(M-B^{-1})P_3X_{2t} + NMP_3f_3X_{3t-1} + NB^{-1}U_t \qquad (5.7)$$

It is assumed the second order conditions are satisfied.

It should be noted that optimal solutions for X_{3t} and Y_t are expressed as functions of disturbance term U_t. As mentioned earlier, inclusion of U_t term represents possesion of partial information on U_t. Also equation (5.6) shows that the assumptions of the QEP are internally inconsistent. The policy instruments X_{3t} are functions of U_t, hence are endogenous. This inconsistency with the initial assumption that policy instruments are exogenous is not a peculiarity of this synthesis. It is a feature of the QEP modelling. Theil's equation (3.12) is $\partial x_h/\partial s_j = -(.x)_{jh}$, where $(.x)_{jh}$ is an element of the inverse of the bordered Hessian. The vector S contains the disturbances from the structural equations. This equality shows that any variation in disturbances that affects s_j also affects the h-th policy variable. Consequently, x_h is not independent of the errors and is not exogenous.

To solve for Y_t, (5.7), (5.6) was substituted into (5.2). (5.7) is truly a reduced form equation; it does not include X_{3t}. The variable Y_t^S is identically the variable Y_t.

The errors in rational expectations of Y_t can be expressed, from (4.5), as

$$Y_t - \hat{Y}_t = Y_t^S - \hat{Y}_t = B^{-1}P_1(\hat{X}_{1t} - X_{1t}) + B^{-1}P_3(\hat{X}_{3t} - X_{3t}^S) + B^{-1}U_t \qquad (5.8)$$

Under the assumption of D1, $E[W(Y_t, X_{3t}) \mid I_{t-1}]$, that is $E[U_t \mid I_{t-1}] = 0$ and if it is assumed that $E[U_t | I_t] = 0$, then not only U_t terms in (5.6) and (5.7) disappear but also above argument about internal inconsistency of the QEP is no longer exist.

2. <u>Synthesis #2: A1-B1-C2-D2-E2</u>

A simpler synthesis of the QEP and the REH is obtained if (5.1) is replaced by,

$$E[W_t | I_t] = E[1/2(Y_t - Y_t^*)'G(Y_t - Y_t^*) | I_t] \tag{5.9}$$

which does not contain policy variables and (5.2) is replaced by, (5.10), employing the REH.2 assumption,

$$Y_t = (M - B^{-1})(P_1X_{1t} + P_2X_{2t} + P_3X_{3t}) + B^{-1}U_t \tag{5.10}$$

This is the kind of welfare function and constraint Taylor (1979) used. The first order conditions for minimizing W are expressions (5.3) and (5.5) and

$$\partial L/\partial X_{3t} = P_3'(M - B^{-1})'\lambda = 0 \tag{5.11}$$

The solution that minimizes expected W_t is easily obtained. A solution to (5.11) is $\lambda = 0$ and $Y_t = Y_t^*$ satisfies (5.3) condition and the constraints become

$$Y_t = Y_t^* = (M - B^{-1})(P_1X_{1t} + P_2X_{2t} + P_3X_{3t}) + B^{-1}U_t.$$

Therefore, the solution for the vector of government policy instruments is derived from

$$\begin{aligned} P_3'(M-B^{-1})'G(M-B^{-1})P_3X_{3t} &= P_3'(M-B^{-1})'GY_t^* \\ &- P_3'(M-B^{-1})'G(M-B^{-1})[P_1X_{1t} + P_2X_{2t}] - P_3'(M-B^{-1})'GB^{-1}U_t \end{aligned} \tag{5.12}$$

where $P_3'(M-B^{-1})'G(M-B^{-1})P_3$ is a (k_3xk_3) matrix and assumed to be a nonsingular. In most real life modelling situations, we expect $g > k_3$, the number of endogenous variables exceeds the number of the policy instruments. From (5.11) if $\lambda \neq 0$ and $P_3'(M-B^{-1})' = 0$, then the value of optimal solution for X_{3t} will be infinite.

It is well known that the optimal and unique solution for the linear-quadratic maxization problem exist when (i) the objective function is strictly concave and the feasible set is also convex and (ii) all variables, endogenous, exogenous, and decision variables, are bounded and closed set (see Chiang, 1984, chapter 12). Even though (5.9) excluded X_{3t}, vector of endogenized decision variables, (5.9) is concave and the constraint (5.10) is linear, the first order conditions may guarantee optimal solutions, because substituting Y_t in (5.10) into (5.9) still satisfies linear-quadratic optimization conditions. Again, under the assumption of D1, $E[W_t| I_{t-1}]$, the U_t terms in (5.12) disappear.

3. Synthesis #3: A1-B2-C2-D2-E2

Another possible synthesis of the QEP and the REH is to modify Taylor's preference function to include endogenized policy variables as in (5.1) with the same assumption about constraint as in Synthesis #2. The first order conditions for minimizing expected W_t subject to (5.10) are expressions (5.3), (5.4), and (5.5). In this case, the solution for the vector of policy variables is obtained from

$$\begin{aligned}[H + P_3'(M-B^{-1})'G(M-B^{-1})P_3]X_{3t} \\ = HX^*_{3t} + P_3'(M-B^{-1})'GY^*_t - [P_3'(M-B^{-1})'G(M-B^{-1})](P_1X_{1t} + P_2X_{2t}) \\ - P_3'(M-B^{-1})'GB^{-1}U_t \end{aligned} \qquad (5.13)$$

Since $[H + P_3'(M-B^{-1})'G(M-B^{-1})P_3]$ is a matrix of (k_3xk_3) and assumed to be a nonsingular, there exist unique solution for the vector of X_{3t}. Difference of the solutions for X_{3t} between the synthesis #2 and #3 is existence of H term in LHS and HX^*_{3t} term in RHS of (5.13). Under the D1, U_t term can be drop out from (5.13).

B. Specification Errors

From the synthesis #1, we may derive differences between econometric regression with government preference function and without. Equation (4.3) and (5.7) are treated as the estimable system of structural equations in the REH. To obtain a similar system to (4.3) from Synthesis #1, pre-multiply (5.7) by B, then

$$\begin{aligned} &BY^s_t + P_3DHX^*_{3t} - P_3DP_3'B^{-1'}GY^*_t - BNMP_1\hat{X}_{1t} + BNB^{-1}P_1X_{1t} \\ &\quad - BN(M-B^{-1})P_2X_{2t} - BNMP_3f_3X_{3t-1} - BNB^{-1}U_t = 0 \end{aligned} \tag{5.14}$$

It has already mentioned one source of specification bias present in (4.3) and (4.4) that is absent from (5.7) and (5.14): the policy vector X_{3t} appears in (4.3) and (4.4) but not in (5.7) and (5.14). Expression (4.3) is not a reduced form for the public sector, whereas (5.7) is. This specification error can be reinterpreted from an econometric viewpoint if we assume the economic agent has information about all current and past values of the variables. Then the endogenized policy variables, X_{3t}, are correlated with disturbance term. Thus, regression (4.3) or (4.4) results inconsistent estimators and the policy analysis based on inconsistent estimators may result in misleading policy advise to the government.

Theil (1961) introduced a definition of specification error which may occur on estimation of econometric model. Suppose that Hypothesis H_0 is true. If we omit any variables which are included in the true model or substitute some variables into the true model under alternative hypothesis, H_A, then the estimators under H_A, even they are unbiased estimators, differ from the estimators under H_0. Theil named this difference in assumptions as specification error and differences in estimates as specification bias.

According to Theil's definition, we can derive some specification errors. The first specification error in (4.3) and (4.4) is the exclusion of relevant variables; (5.7) and (5.14) contain X^*_{3t} and Y^*_t. A second source is inappropriate restrictions; the restriction on the coefficients in (4.3) are quite different from those in (5.14). It may simplify comparisons between them by noting that

$$\begin{aligned} BNM &= B(I_g - B^{-1}P_3DP_3'B^{-1\prime}G)B^{-1}A(B+A)^{-1} \\ &= A(B+A)^{-1} - P_3DP_3'B^{-1\prime}GB^{-1}A(B+A)^{-1} \end{aligned}$$

Restrictions on coefficients in (5.14) include some elements not even present in (4.3): namely G and H, and restrictions on coefficients of X^*_{3t} and Y^*_t. The restrictions in (4.3) are simpler than those in (5.14). For example, restrictions on P_3 in (4.3) involve only the coefficients of $\hat{X}_{3t}$ and X_{3t}. In (5.14) the restriction on P_3 involve all coefficients because P_3 is an element of D and of N.

Another difference is obtained from a comparison of (4.5) and (5.8). According to the REH, the difference between actual and expected values of Y_t is entirely due to random effects: errors in expected exogenous variables, and errors in the structural equations. Substitution (5.6) into (5.8) shows that the differences between Y^s_t and $\hat{Y}_t$ are not random errors. The difference is made up of several systematic components; X^*_{3t} and Y^*_t are two of them. Even if $\hat{X}_{1t} = X_{1t}$, $Y^s_t - \hat{Y}_t$ is affected by the difference between $DP_3 B^{-1'} GMP_1$ and $DP_3 B^{-1'} GB^{-1} P_1$. The difference $Y_t^s - \hat{Y}_t$ is affected by the levels of $\hat{X}_{1t}$ and X_{1t}. It is likewise affected by the levels of X_{2t} and X_{3t-1}.

C. Econometric Policy Evaluation: Lucas Critique

Lucas (1976) concluded about the structure of econometric models in his well known critique of econometric policy evaluation as follows:

> Given that the structure of an econometric model consists of optimal decision rules of economic agents, and that optimal decision rules vary systematically with changes in the structure of series relevant to the decision maker, it follows that any change in policy will systematically alter the structure of econometric models.

He also pointed out that

> If the policy change occurs by a sequence of decisions following no discussed or pre-announced pattern, it will become known to agent only gradually, and then perhaps largely as higher variance of noise. In this case, the movement to a new $\theta(\lambda)$ [modification of the behavioral parameters], if it occurs in a stable way at all, will be unsystematic, and econometrically unpredictable. If, on the other hand, policy changes occur as fully discussed and understood changes in rules, there is some hope that the resulting structural change can be forecasted on the basis of estimation from the past data of $\theta(\lambda)$ [where θ and λ represent fixed parameters of the economic structural equation and of the policy rules equation, respectively].

Lucas' criticism established an important step in the development of rational expectations and the evaluation of policy effectiveness. For example, Kydland and Prescott (1977) presented an implication of rational expectations for policy choices, that is, if policy makers are following one rule at one time, they may find it optimal to switch to another rule at some future time.

Under changing policy rules, Lucas found that the REH become implausible. For example, Lucas and Sargent (1981, p. xxxvii) pointed out that "if the private agents are confronted with a planned sequence ... of time-varying government rules, it is harder to imagine that agents can successfully figure out the constraints that they face. ... assumption of rational expectations is more plausible when agents are assumed to face a time-invariant ... sequence, and that more reliable predictions about the consequences of alternative regimes can be made under this assumption." In other words, if the assumption of rational choice in a stable world is inapplicable, then it is impossible for us to understand or predict the effects of policy change.[24]

In these points, above the REH.1 cast doubt on the validity of the claims to conceptual superiority of the REH and Lucas' critique of econometric policy evaluation, because the rational expectations specification, (4.7) is the improper way to specify the model. Whereas, the REH.2 does not cast doubt, rather it supports Lucas' critique. In other words, under the REH.1, the private sector does not fully understand inside the black box, (5.6), and makes myopic prediction rule for X_{3t}. Under the REH.2, on the other hand, the private sector can figure out inside the black box and thus make perfect forecasts of X_{3t}. Under the REH.1, proper account of changes in coefficient caused by changes in public policy requires knowledge of structural parameters; it cannot be done if we have only knowledge of reduced form parameters (see the previous discussion of the REH.3).

One of the virtues of the REH is claimed to be its ability to take proper account of changes in coefficients caused by changes in public policy. But this is a false claim to superiority in RE models that use the assumption of exogenous (or black box determination) of public policies to study an economy in which public choices are

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[24]Whiteman (1986) also pointed out that "if agent's rational expectations, particularly of future values of policy variables, are the only source of reduced form parameter variation ..., the parameters of the expectational difference equations are invariant to changes in policy rules. Thus, the policy problem can be viewed as one of maximizing the policy maker's objective function subject to a difference equation (or set of equations) which differ from ordinary difference equations (i.e., constraints) because of the presence of expectations." However, Sims (1985) argued that even under time-varying parameter assumption, Lucas' critique is critiqueable.

endogenous. This claim is derived from the following kind of argument. Substitution of (4.6) and (4.7) into (4.4) yields

$$Y_t = MP_1f_1X_{1t-1} - B^{-1}P_1X_{1t} + (M-B^{-1})P_2X_{2t} + MP_3f_3X_{3t-1} - B^{-1}X_{3t} + B^{-1}U_t + MP_1w_{1t} + MP_3w_{3t} \qquad (5.15)$$

If (4.7) is replaced by (4.11), the coefficient of X_{3t-1} changes to MP_3F and the equation acquires an added term MP_3Q. If we have estimated the elements of A, B, P_3, and f_3 and know F and Q, we can adjust the X_{3t-1} coefficient matrix from MP_3f_3 to MP_3F and can compute the product in MP_3Q. If, however, we have only estimated product MP_3f_3, and not its three component matrices, we can not adjust the X_{3t-1} coefficient matrix and cannot compute the new matrix MP_3Q.[25]

In order to predict Y_t under new structure, therefore, it is necessary to estimate all structural parameters, i.e., A, B, P_1, P_2, P_3, f_1, and f_3. To accomplish this it is necessary to model the formation of RE. This is a spurious claim to superiority for REH because it applies inappropriate restrictions to estimate an incorrectly specified model. When public policy choices are endogenous, changes in determination of public policy are represented by variations in Y_t^*, X_{3t}^*, G, or H, which affect Y_t^S and X_{3t}^S; replacement of (4.7) by (5.15) is simply the replacement of one specification error by another.

[25]Wallis pointed out that knowledge of the reduced form coefficients but not the structural coefficients is usually sufficient for the traditional econometric policy evaluation under unchanged structure (Wallis, 1980, p.71).

D. Summary

In summary, some claims to superiority of RE models and inferences from RE models about economic behavior are false when RE models that assume exogenous policy choices are applied to a world of endogenous policy choices. The claims may be true in RE models that broaden the assumptions of myopic rationality and awareness to allow agents in the private sector to have as much information about the public sector as they have about the private sector. But it is recognized from (5.15) that broadening the assumption will considerably complicate the statistical estimation process. It will also require us to improve our understanding of the public policy process.

The syntheses in this study contain a hierarchical information structure. The public sector is informed on the behavior of the private and public sectors; but the private sector is only informed about the private sector. In principle at least we can equalize the amount of information of the public and private sectors by integrating QEP, REH, and game theory. Then the outcome depends upon the kind of game assumed (see Chow, 1981).

The framework of endogenizing policy variables under the REH can be converted easily to dynamic policy game. When the policy makers formulate policies, they may be assumed to account properly for influence of policy choices on the private agents' expectations. In the REH model, expectations about endogenous variables, $\hat{Y}_t$, reflect proper account for the private sector's expectations about government's policy rules. In a well known linear-quadratic optimization problem, applying optimal control techniques to the policy makers is equivalent to solving one-person dynamic game to find the optimal strategy of the dominant player.[26] By redefining Y_t as a result of responses of the private sector to the government's policy choices, X_{3t}, the linear constraint (4.1) and (4.4) become a decision environment for the government authorities who want to minimize their loss function, say, (5.1). Under assumption of hierarchical information structure, the government sector is a dominant player and the private sector is a follower. Examples of such game are the macroeconomic policy games studied by Kydland and Prescott (1977), Taylor (1979), Chow (1981, ch. 15), Barro and Gordon (1983), etc., monetary policy game studied by Canzoneri (1985) and Canzoneri and Gary (1985), the resource extraction game of Hansen, Epple, and Roberds (1985), and duopoly noncooperative dynamic game of Kydland (1975).

Expression (5.7) and (5.8) from the synthesis of the QEP and the REH, are relevant to the issue of existence of political business cycles. According to them, the public sector can generate business cycles by varying the levels of elements of Y_t^* or X_{3t}^*, or by varying relative size of components of G and H.

[26]Sargent (1986, ch. 1 and 2) described an economy as a dynamic game between the public and private sector. Each element of a collection of decision rules (**h**) of private agents is itself a function that maps some private agents information at time t into his decision at that time. Some elements in a collection of element(**f**) that forms the "environment" facing private agents represent rules of the game or decision rules selected by the government, which map the government's information at some date into its decision at that date. The elements of **h** are partly functions of **f**. The mapping **h** into **f** represents "cross-equation restrictions" since each element of **h** and **f** is itself a decision rule or equation determining the choices of some variables under agent's control.

VI. EMPIRICAL STUDY

A. Taylor Model

Some possible syntheses of the QEP and the REH that differed in the underlying assumptions have been discussed. For empirical study, this study employed Taylor's (1979) simple macroeconomic model. Taylor investigated an econometric method for selecting macroeconomic policy optimal rule under the REH. He estimated a simple macroeconometric model of the U.S. and used this estimated model, then, to derive optimal monetary policy rules to stabilize fluctuations in output and inflation. Taylor's structural model is

$$y_t = b_1 y_{t-1} + b_2 y_{t-1} + b_3(m_t - p_t) + b_4(m_{t-1} - p_{t-1}) + b_5 \hat{\pi}_t + b_6 t + b_0 + u_t \tag{6.1}$$

$$\pi_t = \pi_{t-1} + r_1 \hat{y}_t + r_0 + v_t \tag{6.2}$$

$$u_t = n_t - q_1 e_{t-1} \tag{6.3}$$

$$v_t = e_t - q_2 e_{t-1} \tag{6.4}$$

where y_t is the log real expenditures measured as a deviation from trend, m_t is the log of money balances during period t, p_t is the log aggregated price level prevailing during period t, π_t is the rate of inflation defined as $p_{t+1} - p_t$, $\hat{y}_t$ and $\hat{\pi}_t$ are the conditional expectations of y_t and π_t, respectively, given information through period t-1, and n_t and e_t are random shocks to the output and inflation equations. The random vector (n_t, e_t) is assumed to be serially uncorrelated with mean zero and variance-covariance matrix M. Since the output equation, (6.1), includes two lagged dependent variables, there exist very little identifiable serial correlation in the error term u_t. However, the presence of real money balances in this equation suggests that the lagged shock from the price equation will change real balances in equation (6.1) as much as recurrent shock. But the first type of shock will have a much smaller effect on aggregated demand.

Since (6.1) and (6.2) include unobservable $\hat{y}_t$ and $\hat{\pi}_t$, it is required to take conditional expectations both sides of (6.1) and (6.2), given information through period t-1, then

$$\hat{y}_t = b_1 y_{t-1} + b_2 y_{t-2} + b_3(m_t - p_t) + b_4(m_{t-1} - p_{t-1}) + b_5\hat{\pi}_t + b_6 t + b_0 - q_1 e_{t-1} \qquad (6.5)$$

$$\hat{\pi}_t = \pi_{t-1} + r_1\hat{y}_t + r_0 - q_2 e_{t-1} \qquad (6.6)$$

Solving these equations for $\hat{y}_t$ and $\hat{\pi}_t$ and substituting the solutions into (6.1) and (6.2) gives reduced form equation as follows:

$$y_t = a[b_1 y_{t-1} + b_2 y_{t-2} + b_3(m_t - p_t) + b_4(m_{t-1} - p_{t-1}) + b_5\pi_{t-1} + b_6 t + b_5 r_1 + b_0 - (b_5 q_2 + q_1)e_{t-1}] + n_t \qquad (6.7)$$

$$\pi_t = a\{r_1[b_1 y_{t-1} + b_2 y_{t-2} + b_3(m_t - p_t) + b_4(m_{t-1} - p_{t-1})] + z_{t-1} + r_1 b_6 t + r_1 b_0 + r_0 - (r_1 q_1 + q_2)e_{t-1}\} + e_t \qquad (6.8)$$

where $a = (1 - b_5 r_1)^{-1}$.

It is should be noted that Taylor assumed that p_t is predetermined at time t in order to solve for $\hat{y}_t$ and $\hat{\pi}_t$. Also he assumed that the money supply, m_t, is predetermined: that the conditional expectation of m_t given information through time period t-1 is equal to m_t itself.

To estimate parameters of reduced form equations, (6.7) and (6.8), which form a vector autoregressive moving-average (VARMA) model with restrictions on the parameters, Taylor employed the Minimum Distance Estimation (MDE) method. And then he used these estimates to find optimal feedback control rules for money supply which aim to reduce the fluctuations of real output and inflation about average target levels.

For this purpose, Taylor assumed a quadratic preference function of the government as

$$W_t = E_0 \sum_{t=1}^{\infty} (1/2)[\lambda (y_t - y^*)^2 + (1 - \lambda)(\pi_t - \pi^*)^2] \qquad (6.8)$$

where y* and π* represent target levels for output and inflation, E_0 represents conditional expectations formed at period t-1, and $0 \leq \lambda \leq 1$. He focused on finding monetary feedback control rules to minimize the expected value of this loss function for the steady state stationary distribution of y_t and π_t. This is equivalent to finding a feedback rule to minimize the expected value of an undiscounted sum of such losses over an infinite time horizon.

Taylor's optimal monetary feedback rule is

$$d_t = g_1 y_{t-1} + g_2 y_{t-2} + g_3 d_{t-1} + \pi_{t-1} + g_5 e_{t-1} \qquad (6.9)$$

where $d_t = m_t - p_t - h_1 t - h_0$ (for the definition of h_1 and h_0, see Taylor, 1979, p. 1277-78). Under the assumption of time invariant parameters, he employed optimal control techniques developed by Chow (1975, p. 170).

Taylor used aggregated U.S. data over the period from 1953:I through 1975:IV. The particular series used for y_t, m_t, and p_t are the deviations of the log of real GNP from the log of potential GNP, the log of M_1, and the log of the GNP deflator, respectively, and all datum are seasonally adjusted. Taylor assumed the desired target values are given as follows: A logical target for y_t is the nonaccelerating inflation level of y_t given by the estimated values of equation (6.2). A target level for inflation would involve a welfare analysis which considers the benefits and costs of alternative average levels of inflation. In order to focus on the stabilization problem, Taylor assumed that such an analysis had been completed and that the optimal target rate of inflation was derived. There are several ways to determine the desired target level: Theil and Kloek (1960) used predicted values and Chow (1975) suggested using time path of index.

B. Estimation

1. Data

This study will use both annual data and adjusted quarterly data for all the variables for the sample period of 1954 - 1985. Barro and Rush (1980) made comparisons of annual and quarterly results for the effect of U.S. monetary policy on money growth, unemployment, output, and price. They found that there exist a close correspondence in the results for the money growth, unemployment, and output equations, but not for the price equation. For the price equation, a discrepancy between the annual and quarterly estimates was caused by the introduction of adjustment for serial correlation of residuals for the quarterly data. This introduction drastically altered the quarterly coefficient estimates.

The values of y_t will be detrended for steady state stationary distribution of y_t instead of employing the deviation of the log of real GNP from the log of potential GNP as Taylor did. The value of P_t is the log of implicit deflator of GNP derived by dividing the current dollar GNP (or component) by the constant dollar GNP (or component) and indexing these values on the base year of 1972. By the definition of π_t, $\pi_t = p_{t+1} - p_t$, π_t also has steady state stationary distribution. The value of m_t is the log of M1. The data sources for the variables are the Survey of Current Business (July edition) and the Business Statistics, 1984, published by the United State Department of Commerce.

The desired values for the y_t will be replaced with $(y_{t-1})(1+\pi_{t-1})$ by assuming government try to maintain at least same level of y_{t-1} in real term and the desired value of π_t will be replaced with the lowest inflation rate of any quarter in the previous year for both yearly data and quarterly data. The desired target value for m_t will be replaced with the predicted trend of m_t in both yearly and quarterly analyses.

2. Possible synthesis and estimation

For estimation of the rational expectations model, since the structural parameters are usually unknown, the expectations will not be observable and thus it will be necessary to substitute the restricted reduced form equations for the rationally expected variables. Typically, the restricted reduced form will be nonlinear function of the unknown structural parameters.[27]

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[27]In the case of unrestricted reduced form equations, if forecasts of exogenous variables are observable, then the forecasts can be treated as predetermined variables and a standard estimation method can be used. However, if the model contains expected endogenous variables, then the forecasts will not, in general, be rational as the forecasts fail to take into account all of the a priori information in the system

As mentioned already, this study has an interest in comparing various syntheses of the QEP and the REH with both annually data and quarterly data. Under the assumption that the monetary authority try to derive both yearly and quarterly optimal money supply rule, they may use realized disturbance terms of the previous quarters, in the quarterly analysis, as partial information for the disturbance term in the yearly analysis. However, for the quarterly data, the assumption D2 is unrealistic assumption. Therefore, there are eight possible synthesis for the annual analysis and four possible synthesis for the quarterly analysis.

To derive optimal decision rules according to the possible synthesis, it is required to know the values of the parameters of the relevant economic model. One way to derive optimal money supply rules, in the Taylor's model, is to regress equation (5.6), (5.12), and (5.13) according to the possible synthesis, as an one step procedure for optimal control rules, where parameters on the government preference function are incorporated. However, parameters on these equations are nonlinear and combinations of the structural parameters are very complicate. So it is required difficult restrictions on the parameters to obtain unique estimates of the structural parameters, which values are used to derive optimal decision rules. The other method is, as a two step procedure for optimal control rule, to regress reduced form equation (5.2) or (4.4) and then to derive optimal control rules for the policy variables which are function of parameters on the preference function and on the constraint and of the variables of the constraint by applying known parameters from the first step estimation procedure to the optimal money supply rules, (5.7), (5.12), or (5.13), according the possible synthesis. This second method is more convenient than the one step method because the combinations of the parameters on (5.2) are not

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and, as a result, the estimates will not be fully efficient (Wickens, 1982).

as complicated as those of (5.7), (5.12), and (5.13). Regression (5.2), that is, (6.7) and (6.8) in Taylor model, is a kind of limited information estimation procedure since regression of only (5.2) ignores information about the preference function, but this method may guarantee asymptotically consistent estimates. Thus this study will employ the second method.

Basically, estimation procedure for (5.2) depends on the underlying assumption of the synthesis and the time period of data employed. For example, under the assumption A1, where prediction of price level and money supply level in Taylor model are treated as predetermined, the estimable equation are (6.7) and (6.8). While under the A2, where the prediction of price level is treated as predetermined but prediction of money supply level is followed ARMA process, the estimable equation will be (6.7) and (6.8) with replacing m_t by $\hat{f}_3 m_{t-1}$, where $\hat{f}_3$ represent estimator of f_3.

When we analyze annual money supply rules along with quarterly rules, we may obtain partial information on U_t in annual analysis from realized residuals in quarterly analysis. Thus U_t in annual analysis can be expressed as a function of realized quarterly residuals as

$$U_t = \hat{u}_{tq} + s_t, \tag{6.11}$$

where $\hat{u}_{tq}$ represent realized errors in quarterly analysis, $\hat{n}_t$ and $\hat{e}_t$ in (6.7) and (6.8), and s_t is residuals with mean zero and variance V and is assumed serially uncorrelated. However, for convenience, U_t in annual analysis may be replaced with average realized residuals in previous four quarters by letting $s_t = 0$. In this study, we assume that yearly money supply rules is determined at the beginning of the year and then U_t is replaced with average realized errors in four quarters of previous year.

If policy rules is made at, say, August, 1, then $\hat{u}_{tq}$ is average realized residuals from the third quarter in previous year to the second quarter in current year.

3. Estimation procedure

As mentioned earlier, estimation procedure depend on the basic assumption for the possible synthesis. So this section will discuss the estimation procedure for (6.7) and (6.8) system as a proxy for estimation of (5.7), (5.12), and (5.13). Equation system (6.7) and (6.8) is a vector autoregressive moving average (VARMA) nonlinear in parameters. Because of lack of computer routines for nonlinear VARMA[28], this study will employ standard nonlinear estimation procedure by modifying Taylor's MA assumption of the stochastic structure of the random shocks, (6.3) and (6.4) to autoregressive (AR) disturbance -- Model 1 -- and to no transitory cross random shock -- Model 2.

a. Model 1 The first modified assumption of the MA error structure is AR disturbance structure as follows:

$$u_t = q_1 v_{t-1} + n_t \tag{6.12}$$

$$v_t = q_2 v_{t-1} + e_t \tag{6.13}$$

where $E[n_t e_t] \neq 0$ with variance-covariance matrix M, $E[n_t n_{t-i}] = E[e_t e_{t-j}] = 0$ for all i and j > 0, $E[n_t e_{t+j}] = E[e_t n_{t+i}] = 0$ for all i and j > 0, and $E[e_t] = E[n_t] = 0$. If we replace Taylor's assumption of MA error structure by an AR error structure, Taylor's underlying assumption an outside random shock in the inflation equation at

[28]Taylor used the Time Series Processor (TSP, version 2.7) computer routine.

time t-1 has transitory effect on output at time t still holds. Then, under this modified assumption, the estimable equations will be

$$y_t = a[b_1y_{t-1} + b_2y_{t-2} + b_3(m_t - p_t) + b_4(m_{t-1} - p_{t-1}) + b_5\pi_{t-1} + b_6t + b_5r_1 + b_0] + u_t \tag{6.14}$$

$$\pi_t = a(r_1[b_1y_{t-1} + b_2y_{t-2} + b_3(m_t - p_t) + b_4(m_{t-1} - p_{t-1})] + \pi_{t-1} + r_1b_6t + r_1b_0 + r_0) + v_t \tag{6.15}$$

Substituting (6.12) and (6.13) into (6.14) and (6.15), respectively, results

$$y_t = a[b_1y_{t-1} + b_2y_{t-2} + b_3(m_t - p_t) + b_4(m_{t-1} - p_{t-1}) + b_5\pi_{t-1} + b_6t + b_5r_1 + b_0] + q_1v_{t-1} + n_t \tag{6.16}$$

$$\pi_t = a(r_1[b_1y_{t-1} + b_2y_{t-2} + b_3(m_t - p_t) + b_4(m_{t-1} - p_{t-1})] + \pi_{t-1} + r_1b_6t + r_1b_0 + r_0\} + q_2v_{t-1} + e_t \tag{6.17}$$

From (6.15),

$$v_{t-1} = \pi_{t-1} - a\{r_1[b_1y_{t-2} + b_2y_{t-3} + b_3(m_{t-1} - p_{t-1}) + b_4(m_{t-2} - p_{t-2})] + \pi_{t-2} + r_1b_6(t-1) + r_1b_0 + r_0\} \tag{6.18}$$

By the Koyck transformation procedure, multiplying (6.18) by q_1 and q_2 and substituting these into (6.16) and (6.17), respectively, gives an estimable nonlinear equation system as follows:[29]

$$y_t = a[b_1y_{t-1} + (b_2-q_1r_1b_1)y_{t-2} - q_1r_1b_2y_{t-3} + b_3(m_t - p_t) + (b_4-q_1r_1b_3)(m_{t-1} - p_{t-1}) - q_1r_1b_4(m_{t-2} - p_{t-2})] + (ab_5+q_1)\pi_{t-1} - aq_1\pi_{t-2} + ab_6(1-q_1r_1)t + a(b_5r_1 + b_0) + aq_1(r_1b_0+r_0) + aq_1r_1b_6 + n_t \quad (6.19)$$

$$z_t = a\{r_1[b_1y_{t-1} + (b_2-q_2b_1)y_{t-2} - q_2b_2y_{t-3} + b_3(m_t - p_t) + (b_4-q_2b_3)(m_{t-1} - p_{t-1}) - q_2b_4(m_{t-2} - p_{t-2})]\} + (ab_5 + q_2)\pi_{t-1} - aq_2\pi_{t-2} + ab_6(1-q_2r_1)t + (a-q_2)(r_1b_0 + r_0) + aq_2r_1b_6 + e_t \quad (6.20)$$

We should note that multicollinearity among time variables (t) and (t-1) and constant term has already been remedied by replacing (t-1) by (t)-1 in the process of deriving equations (6.19) and (6.20).

b. Model 2 The second modified assumption is $q_1 = q_2 = 0$ in (6.3) and (6.4) and where $E[u_tv_t] \neq 0$ with variance-covariance matrix W, $E[u_tu_{t-i}] = E[v_tv_{t-j}] = 0$ for all i and j > 0, $E[u_tv_{t+j}] = E[v_tu_{t+i}] = 0$ for all i and j > 0, and $E[u_t] = E[v_t] = 0$. In this case the estimable equations are (6.14) and (6.15) themselves.

By the assumption of the model, that is, n_t and e_t and u_t and v_t are serially uncorrelated with mean zeros and variance-covariance M and W, respectively, we may employ the Seemingly Unrelated Regression (SUR) method for nonlinear equation system and the SAS/ETS computer routine is available for this nonlinear SUR. Appendix A and B present details on estimation procedure for the nonlinear model and nonlinear SUR method, respectively.

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[29]For justification of this procedures, see Johnston (1972, pp. 316-318).

4. Empirical results

Since this study employed Taylor's assumption about prediction of the implicit real GNP deflators, we need to discuss results of prediction of the money supply, M1. According to the REH.1, the quarterly and annual money supply are predicted using following equations, respectively,

$$\hat{m}_t = \underset{(-6.7)}{-.052} + \underset{(713.3)}{1.012} m_{t-1} \tag{6.21}$$

and

$$\hat{m}_t = \underset{(-6.2)}{-.214} + \underset{(165.8)}{1.049} m_{t-1} \tag{6.22}$$

where values in the parentheses are t-ratio under the null hypothesis that the parameter = 0.

The parameter estimators are reported in table 1 for the modified model 1 and 2 in 1954-1985 and for the Taylor model in 1953-1975 for comparison of the results. As can be seen, the estimators, in Taylor model, are significantly different from zero except the estimates of expected inflation rate in production equation in terms of t-ratio. However, the model 1 and 2 show some estimates are not significantly different from zero. These differences could stem from following sources: (i) Different sample period; Taylor used seasonally adjusted quarterly data for 1953-I to 1975-IV and the modified models employed seasonally adjusted quarterly data and annual data for 1954-I to 1985-IV. Thus it might said that the differences of the estimates between Taylor model and modified models could represent structural changes in the U.S. economy over different sample period. (ii) Different data source; Taylor's estimators based on the

National Bureau Economic Research (NBER) data base, but results of estimation of this study depend on the Department of Commerce data base. (iii) Different data; Taylor used deviations of log real GNP from log of potential GNP series which is revised estimate of the Council of Economic Advisers but this study detrended log real GNP by deviating actual log real GNP from the trend of log real GNP. (iv) Different assumption about error structure; Taylor assume MA process of disturbances but this study assume AR disturbance structure in the modified model 1 and no cross intertemporal relations of errors in the modified model 2. (v) Different estimation method and computer routine; Taylor used the minimum distance estimation method with the time series processor as a computer routine but this study employed nonlinear ordinary least squares and seeming unrelated regression method with SAS/ETS. Among above five sources, the first and the fourth sources may be main sources of the differences between estimators of the Taylor model and the modified models.

The estimates of b_1 and b_2 of all the modified models are significantly different from zero. The lagged values of y_t, y_{t-1} and y_{t-2}, can show the magnitude of the multiplier-accelerator effect. Since the absolute value of b_2 is smaller than that of b_1, we can rewrite, as an example, the quarterly modified model 1. under the REH.1, $1.111y_{t-1} - .121y_{t-2}$ as $.99y_{t-1} + .121(y_{t-1} - y_{t-2})$ then this represents the magnitude of the acceleration component which is added to the first-order autoregression.

Including lagged real money balances represent partial adjustment of these balances to changes in interest rates and income. Thus it is expected b_3 and b_4 have opposite signs and b_4 is smaller than b_3 in absolute value. Taylor's results satisfy these expectations. The modified models show that the signs of b_3 are opposite to signs of b_4 except quarterly modified model 2 under the REH.2 but they are not significant. Some absolute magnitudes of b_3 and b_4 do not follow theoretical

Table 1. Nonlinear estimates of the model[a, b]

Variable	Parameter	Taylor REH.2 Quart.	Model 1 REH.1 Quart.	Model 1 REH.1 Year	Model 1 REH.2 Quart.
Output equation					
y_{t-1}	b_1	1.167 (13.3)	1.111 (15.9)	1.157 (10.5)	1.105 (15.8)
y_{t-2}	b_2	-.324 (-3.6)	-.121 (-1.7)	-.337 (-3.9)	-.115 (-1.7)
m_t-p_t	b_3	.578 (3.3)	.038 (1.0)	.209 (1.9)	.021 (.6)
$m_{t-1}-p_{t-1}$	b_4	-.484 (-2.5)	-.045 (-1.2)	-.491 (-3.8)	-.027 (-.7)
$\hat{\pi}_t$	b_5	-.447 (-1.4)	.646 (7.2)	.486 (2.4)	.640 (7.2)
(t)	b_6	8.4(-5) (1.1)	5.1(-6) (.3)	1.2(-3) (2.6)	4.8(-6) (.3)
1	b_0	.072 (2.1)	-.005 (-.7)	-3.445 (-1.0)	-.006 (-.8)
Inflation equation					
y_t	r_1	.018 (3.1)	-.003 (-.8)	-.059 (-.8)	-.003 (-.8)
1	r_0	.001 (3.0)	.002 (3.2)	-4.964 (-1.5)	.002 (3.2)
Error structure					
e_{t-1}	q_1	.38	-.373 (-5.5)	.734 (2.1)	-.371 (-5.4)
e_{t-1}	q_2	-.67	-.50 (-6.3)	.477 (2.2)	-.497 (-6.3)

[a]Parentheses under estimators indicate t-statistic of the estimator.
[b]Parentheses after estimates represent multiplication of minus powers of 10, for example 8.4(-5) = .000084.

	Model 2			
REH.2 Year	REH.1 Quart.	REH.1 Year	REH.2 Quart.	REH.2 Year
1.064 (6.8)	1.251 (15.7)	1.204 (13.4)	1.254 (15.8)	.994 (12.1)
-.264 (-1.8)	-.257 (-3.2)	-.362 (-4.2)	-.259 (-3.7)	-.142 (-1.8)
-.463 (-2.5)	.035 (1.0)	.100 (1.2)	.003 (.1)	-.432 (-4.0)
.326 (1.6)	-.029 (-.8)	-.038 (-3.9)	.007 (.2)	.169 (1.4)
.49 (2.5)	.60 (8.7)	.738 (4.3)	.558 (8.1)	.809 (4.6)
9.1(-4) (1.9)	-2.4(-5) (-1.4)	5.5(-4) (1.2)	-2.2(-5) (-1.2)	1.6(-4) (.4)
.634 (.5)	-.011 (-1.7)	-.089 (-.2)	-.014 (-1.8)	.108 (.5)
-.017 (-.2)	-.589 (-.7)	-.006 (-1.6)	-.006 (-.7)	-.049 (-1.4)
-3.556 (-1.3)	.002 (1.2)	-1.086 (-1.2)	.001 (1.0)	-.311 (-.4)

expectations while Taylor's results do.

The coefficient of the expected inflation rate is positive and very significant in all the modified models as we expected, that is, a higher expected future price of goods relative to current goods should stimulate production. This could allow existence of short run Phillips curve. These positive signs could show that substitution effect of a higher expected future price level dominate income effect. While Taylor's estimates show that the coefficient b_5 is negative and has small t value so that this allow existence of long run vertical Phillips curve.

In the inflation equation, the coefficient of expected output variable show negative signs but have small t ratios in the modified models except yearly modified model 2 under REH.1. These results could say existence of long run vertical Phllips curve. However, Taylor's result is matched with the assumption of accelerationist regardless sticky or flexible prices, that is output can be increased permanently above its secular trend growth rate with accelerating rates of inflation. The intercept term in the inflation equation has an economic meaning. Other words, the zero change of inflation rate may not occur where output equals its estimated secular trend. Most results of the modified models show that estimated coefficients of intercept term in inflation equation are not significant and some of them are positive and some are negative. But Taylor's estimate is positive and significantly different from zero which means that inflation will be stimulated when the economy is operating at the estimated secular trend.

C. Optimal Money Supply Rules

For comparison of the syntheses of REH and QEP, this study focuses on different assumptions about predictions by the private sector of the endogenized policy variables, in alternatives A1 and A2, and inclusion or exclusion of the policy variables in the preference function, in alternatives B1 and B2. Taylor's synthesis of the QEP and the REH is the combination of A1-B1-C1-D1-E1. This study investigate other combination of assumptions with special attention to A2 and B2. From the numerical comparison of the syntheses, it is expected that we could find numerical differences resulting from differences in underlying assumptions and conclusions. As mentioned earlier, solutions for Y_t at any single time period, C2, might not be the same as optimal solutions for multi-period, under C1. Since this study employs Taylor's simple macroeconomic model, there is no difference between E1 and E2. However, we recognize that some underlying assumptions of the QEP and the REH are irrelevant in some syntheses. For example, assumption D2 may not be applied to quarterly analysis and assumption B1, excluding endogenized policy instruments in the objective function may result in a nonunique solution. Therefore the total number of possible synthesis varies according to situations.

Like estimation procedure for the reduced form equation system, the optimal money supply rules depend also on the basic assumptions and the policy decision making term. To derive optimal policy rules for the single period, rewrite Taylor's equation system (6.1) through (6.4) to match the notation of (4.1) as follows:

$$BY_t + A\hat{Y}_t + P_1X_{1t} + P_2X_{2t} + P_3X_{3t} = U_t \tag{6.23}$$

where

$$Y_t = [y_t, \pi_t]', \qquad \hat{Y}_t = [\hat{y}_t, \hat{\pi}_t]',$$

$$X_{1t} = [y_{t-1}, y_{t-2}, m_{t-1}-p_{t-1}, \pi_{t-1}, e_{t-1}]' \text{ for model 1,}$$

$$= [y_{t-1}, y_{t-2}, m_{t-1}-p_{t-1}, \pi_{t-1}]' \text{ for model 2,}$$

$$X_{2t} = [t, 1]', \qquad X_{3t} = [m_t-p_t], \qquad U_t = [n_t, e_t]',$$

$$B = -\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}, \qquad A = -\begin{bmatrix} 0 & b_5 \\ r_1 & 0 \end{bmatrix},$$

$$P_1 = -\begin{bmatrix} b_1 & b_2 & b_4 & 0 & q_1 \\ 0 & 0 & 0 & 1 & q_2 \end{bmatrix}, \qquad P_2 = -\begin{bmatrix} b_0 & b_6 \\ 0 & r_0 \end{bmatrix}, \qquad P_3 = -[b_3 \;\; 0]'$$

To derive optimal money supply rules it is necessary to specify the desired target values of Y_t and X_{3t} and the weight matrixes G and H. The desired goal for y_t is assumed to be $(y_{t-1})(1+\pi_{t-1})$, that is government's goal on y_t is to at least maintain same level of y_t in real terms. For example, y_t^* for 1986-I and 1986 turn out to be 4,123 billion dollars and 4,211.8 billion dollars, respectively. The π_t^* is assumed to be the lowest inflation rate in any quarter during the previous calendar year and its value, for example, is 1.48 for 1986-I and 5.92 for 1986. The goal value for money supply, m_t^*, is replaced with the predicted value by equation (6.21) for the quarterly analysis and by equation (6.22) for the annual analysis with the corresponding values for 1986-I being 634.0 billion dollars and for 1986 being 631.0 billion dollars, respectively. The weight matrixes G and H are assumed to be G = [.5 0 / 0 .5] and H = [1], where symbol / represent separation of rows in the matrix.

1. Quarterly policy rules

For the quarterly optimal money supply rules, the D2 is unrealistic assumption, so the possible combination of the underlying assumptions, the optimal money supply rules according to the assumptions, and intermediate calculating procedures of the models are summarized as follows, where $M = B^{-1}A[B+A]^{-1}$, $Q = [P_3'B^{-1'}GB^{-1}P_3]^{-1}$, $D = [H + P_3'B^{-1'}GB^{-1}P_3]^{-1}$, $K = [P_3'(M-B^{-1})'G(M-B^{-1})P_3]^{-1}$, and $F = [H + P_3'(M-B^{-1})'G(M-B^{-1})P_3]^{-1}$.

(1) A1-B1-C2-D1-E1;

$$X^S_{3t} = KP_3'(M-B^{-1})'GY^*_t - KP_3'(M-B^{-1})'G(M-B^{-1})(P_1X_{1t} + P_2X_{2t}) \quad (6.24)$$

$$= [26.229, -.797][Y^*_t] - [.000135, -.0914][X_{2t}] - [29.084, -3.167, -1.178, 16.831, -16.83][X_{1t}] \quad \text{(model 1)}$$

$$= [28.92, -.173][Y^*_t] - [-.00007, -.00568][X_{2t}] - [36.05, -7.406, -.836, 16.974][X_{1t}] \quad \text{(model 2)}$$

(2) A1-B2-C2-D1-E1;

$$X^S_{3t} = FP_3'(M-B^{-1})'GY^*_t + FHX^*_{3t} - FP_3'(M-B^{-1})'G(M-B^{-1})(P_1X_{1t} + P_2X_{2t}) \quad (6.25)$$

$$= [.999][X^*_{3t}] + [.019, -5.8(10^{-4})][Y^*_t] - [9.77(10^{-8}), 6.64(10^{-4})][X_{2t}] - [.0211, -.0023, -.000856, .0122, -.0132][X_{1t}] \quad \text{(model 1)}$$

$$= [.999][X^*_{3t}] + [.0173, -.000104][Y^*_t] - [-4.2(10^{-8}), -3.4(10^{-6})][X_{2t}]$$
$$- [.0215, -.00442, -.0005, .0101][X_{1t}] \qquad \text{(model 2)}$$

(3) A2-B1-C2-D1-E1;

$$X^s_{3t} = - QP_3\mathcal{B}^{-1\prime}GY^*_t + QP_3\mathcal{B}^{-1\prime}G(M-B^{-1})(P_1X_{1t} + P_2X_{2t})$$
$$+ QP_3\mathcal{B}^{-1\prime}GMP_3\hat{f}_3X_{3t-1} \qquad (6.26)$$

$$= - [-46.95, 0][Y^*_t] + [.00192][\hat{f}_3X_{3t-1}] + [2.26(10^{-4}), .214][X_{2t}]$$
$$+ [-51.779, 5.389, 1.265, -29.989, 32.379][X_{1t}] \qquad \text{(model 1)}$$

$$= - [369.0, 0][Y^*_t] + [.0032][\hat{f}_3X_{3t-1}] + [.000743\ 4.688][X_{2t}]$$
$$+ [-461.24, 95.264, -2.354, -205.24][X_{1t}] \qquad \text{(model 2)}$$

(4) A2-B2-C2-D1-E1;

$$X^s_{3t} = DHX^*_{3t} - DP_3\mathcal{B}^{-1\prime}GY^*_t + DP_3\mathcal{B}^{-1\prime}G(M-B^{-1})(P_1X_{1t} + P_2X_{2t})$$
$$+ DP_3\mathcal{B}^{-1\prime}GMP_3\hat{f}_3X_{3t-1} \qquad (6.27)$$

$$= [.999][X^*_{3t}] - [-.0106, 0][Y^*_t] + [4.346(10^{-7})][\hat{f}_3X_{3t-1}]$$
$$+ [-.0117, .00122, .000287, -.0068, .00734][X_{1t}]$$
$$+ [-5.12(10^{-9}), 4.86(10^{-4})][X_{1t}] \qquad \text{(model 1)}$$

$$= [.999][X^*_{3t}] - [.00136, 0][Y^*_t] + [1.185(10^{-8})][\hat{f}_3X_{3t-1}]$$
$$+ [-.00169, .00035, -8.6(10^{-5}), -.000754][X_{1t}]$$
$$+ [2.73(10^{-9}), 1.72(10^{-4})][X_{2t}] \qquad \text{(model 2)}$$

Table 2. Optimal money supplies for 1981-I to 1986-I (billion $ in real terms)
(Values in parentheses represent actual money supply in each quarter)

Synthesis	Model	1981-I (223.11)	1981-II (225.47)	1981-III (220.25)	1981-IV (220.9)
A1-B1-C2-D1-E1	model 1	3952.93	3098.83	3201.53	4068.23
	model 2	3756.74	2911.35	3039.82	3915.06
A1-B2-C2-D1-E1	model 1	224.84	227.5	215.67	217.63
	model 2	223.97	227.51	214.51	217.63
A2-B1-C2-D1-E1	model 1	7104.34	7777.02	5755.66	7305.76
	model 2	46659.1	52116.1	37409.3	48572.8
A2-B2-C2-D1-E1	model 1	223.13	226.55	214.18	216.72
	model 2	221.58	224.77	213.43	214.85

Model	1982-I (223.55)	1982-II (225.9)	1982-III (220.76)	1982-IV (228.95)	1983-I (236.1)	1983-II (240.52)
model 1	4220.99	2853.65	3245.88	2396.33	2469.8	3286.12
model 2	4092.5	2637.84	3102.96	2133.22	2273.12	3196.94
model 1	223.25	216.48	214.94	217.27	226.93	235.17
model 2	222.9	216.27	214.81	217.38	226.7	234.9
model 1	7542.54	5123.3	5824.07	4302.28	4427.02	5891.4
model 2	50812.7	32140.9	38079.8	25613.5	27389.5	39212.5
model 1	221.97	218.62	214.04	216.63	226.19	234.17
model 2	219.99	214.2	212.37	215.41	225.41	232.93

Synthesis	Model	1983-III (243.22)	1983-IV (245.58)	1984-I (244.41)	1984-II (246.53)
A1-B1-C2-D1-E1	model 1	2219.53	2477.68	3121.32	4347.68
	model 2	2002.49	2268.9	2932.72	4052.59
A1-B2-C2-D1-E1	model 1	227.32	234.21	236.81	241.48
	model 2	227.11	233.95	236.7	241.16
A2-B1-C2-D1-E1	model 1	3979.36	4443.38	5600.65	7818.39
	model 2	23878.3	27265.1	35734.3	50003.8
A2-B2-C2-D1-E1	model 1	226.66	233.44	235.89	240.24
	model 2	226.06	235.83	234.99	236.63

Model	1984-III (246.21)	1984-IV (247.12)	1985-I (249.8)	1985-II (257.04)	1985-III (263.75)	1985-IV (266.74)	1986-I
model 1	2939.73	3148.66	2561.48	4062.49	2591.34	3057.95	3101.15
model 2	2961.11	2969.87	2345.67	780.41	3048.53	2905.52	2937.57
model 1	248.34	237.44	236.37	240.24	246.55	259.3	274.13
model 2	248.38	237.37	236.21	238.07	246.79	259.15	273.96
model 1	5257.72	5648.04	4631.91	7316.99	4684.58	5518.96	5597.05
model 2	36080.6	36126.9	27799.4	7708.5	36779.4	34867.0	35245.3
model 1	247.54	236.61	235.62	238.97	245.77	258.5	273.2
model 2	246.45	235.62	233.39	237.56	245.41	258.16	272.98

The empirical results for the period of 1981-I to 1986-I are summarized in Table 2. To test theoretical synthesis of QEP and REH, this study derived twenty one quarterly optimal money supplies in real terms for 1981-I to 1986-I. The optimal money supplies for each quarter represent optimal decisions of the Federal Resreve Board at the beginning of each quarter based on economic performance in previous quarters. As can be seen, when the endogenized policy variables, X_{3t}, are excluded from the preference function under assumption B1, the derived quarterly money supply rules are optimal but not acceptable solutions because they are much too large compared to actually realized money supplies in real terms. Whereas, when the policy instruments are included in the objective function under B2, the optimal money supplies are quite acceptable because they are close to actual values. They are assumed to be a unique solution for 1981-I to 1986-I.

Let us consider only acceptable money supply rules, that is those from assumption B2. Deviations of actual money supplies from optimal supplies are relatively small during 1981-I to 1982-I with range of 0.02 to 6 billion dollars compare to deviations during 1982-III to 1985-IV which range from 0.2 to 18.3 billion dollars in real terms. Especially realized money supplies are very close to the optimal rules in 1981-I, 1981-II, 1982-I, and 1984-III. Quarterly optimal money supplies, generally, are smaller than actually realized money supplies during the whole period of 1981-I to 1985-IV except for 1981-I, 1981-II, and 1984-III. The results imply that if the government has exact preference function as (5.1) and faces constraints as (6.1) through (6.4), then the government, the Federal Resreve Board, over-supplied money by 5.44 billion dollars in 1985-IV under assumptions of A1-B2-C2-D1-E1 and of the model 1. This suggest that the Federal Reserve Board should have tightened money markets to achieve government's goals during 1981-I to 1985-IV. There are small differences in optimal money supplies between assumption A1 and A2 under the models 1 and 2, that is, there are only small differences between the results for REH.1 and REH.2. Also there exist small differences in optimal money supply rules between different assumptions of error structure, the models 1 and 2, if we consider only acceptable money supply rules. Assumption B1 shows large deviations of actual money supplies from optimal rules.

2. Annual policy rules

We recognize that the U.S. monetary policy rule is determined biweekly or monthly rather than quarterly or yearly. So deriving optimal annual money supply rules may have no attraction if we have interests only in short-term government behavior. However, if we analyze any economic behavior which is related to government money supply over on periods, we need information on quarterly or yearly money supply rules. Other words, we need average annual money supply rules as guideline for yearly decision making. For example, a firm owner who makes yearly wage contracts with employees may need information on annual money supply. Also, if we have interests in annual beef consumption, even though beef purchases occur daily or weekly, we need annual money supply rules if we believe that beef consumption is eventually related to money supply. Therefore, period of money supply rules depend on nature of economic behavior and purpose of economic analysis.

By employing the assumption (6.23), that is for the current term, policy maker could use partial information on the realized quarterly residuals from the quarterly policy rules, so U_t in (6.23) can be replaced with $\hat{U}_t = [\hat{n}_{tj}, \hat{e}_{tj}]'$. The eight optimal money supply rules for possible syntheses and intermediate calculating steps are summarized as follows:

(5) A1-B1-C2-D1-E1;

$$X^s_{3t} = KP_3'(M-B^{-1})'GY^*_t - KP_3'(M-B^{-1})'G(M-B^{-1})(P_1X_{1t} + P_2X_{2t}) \quad (6.28)$$

$$= [4.904, -.288][Y^*_t] - [.00579, -6.372][X_{2t}] - [5.536, -1.612, 2.349, 2.037, 4.484][X_{1t}] \quad \text{(model 1)}$$

$$= [10.357, .61][Y^*_t] - [.000546, -8.208][X_{2t}] - [11.992, -3.606, -3.825, 6.74][X_{1t}] \quad \text{(model 2)}$$

(6) A1-B2-C2-D1-E1;

$$X^s_{3t} = FP_3'(M-B^{-1})'GY^*_t + FHX^*_{3t} - FP_3'(M-B^{-1})'G(M-B^{-1})(P_1X_{1t} + P_2X_{2t}) \quad (6.29)$$

$$= [.98][X^*_{3t}] + [.0995, -.00585][Y^*_t] - [.000117, -.129][X_{2t}] - [.132, -.0327, .00476, .0414, .091][X_{1t}] \quad \text{(model 1)}$$

$$= [.936][X^*_{3t}] + [-.172, .0101][Y^*_t] - [-9.1(10^{-6}), .137][X_{2t}] - [-.259, .06, .0636, -.112][X_{1t}] \quad \text{(model 2)}$$

(7) A2-B1-C2-D1-E1;

$$X^s_{3t} = - QP_3\mathcal{B}^{-1}{}'GY^*_t + QP_3\mathcal{B}^{-1}{}'G(M-B^{-1})(P_1X_{1t} + P_2X_{2t}) + QP_3\mathcal{B}^{-1}{}'GMP_3\hat{f}_3X_{3t-1} \quad (6.30)$$

$$= - [.0002, -2.347][Y^*_t] + [.0084][\hat{f}_3X_{3t-1}] + [.0002, -2.374][X_{2t}]$$

$$+ [2.279, -.565, .698, 1.049, .172][X_{1t}] \qquad \text{(model 1)}$$

$$= - [2.315, 0][Y_t^*] + [.0382][\hat{f}_3 X_{3t-1}] + [.000356, -.32][X_{2t}]$$
$$+ [2.213, -.316, .376, 1.8][X_{1t}] \qquad \text{(model 2)}$$

(8) A2-B2-C2-D1-E1;

$$X_{3t}^S = DHX_{3t}^* - DP_3'B^{-1\prime}GY_t^* + DP_3'B^{-1\prime}G(M-B^{-1})(P_1X_{1t} + P_2X_{2t})$$
$$+ DP_3'B^{-1\prime}GMP_3\hat{f}_3X_{3t-1} \qquad (6.31)$$

$$= [.903][X_{3t}^*] - [.209, 0][Y_t^*] + [.000814][\hat{f}_3 X_{3t-1}]$$
$$+ [.296, -.0547, .0676, .102, .0167][X_{1t}]$$
$$+ [1.9(10^{-4}), -.23)][X_{1t}] \qquad \text{(model 1)}$$

$$= [.915][X_{3t}^*] - [.198, 0][Y_t^*] + [.00326][\hat{f}_3 X_{3t-1}]$$
$$+ [.257, -.027, .0321, .154][X_{1t}]$$
$$+ [3.04(10^{-6}), -.0273][X_{2t}] \qquad \text{(model 2)}$$

(9) A1-B1-C2-D2-E1;

$$X_{3t}^S = KP_3'(M-B^{-1})'GY_t^* - KP_3'(M-B^{-1})'G(M-B^{-1})(P_1X_{1t} + P_2X_{2t})$$
$$- KP_3'(M-B^{-1})'GB^{-1}\hat{U}_t \qquad (6.32)$$

$$= [4.904, -.288][Y_t^*] - [.00579, -6.372][X_{2t}]$$
$$- [5.536, -1.612, 2.349, 2.037, 4.484][X_{1t}]$$
$$- [4.904, -.288][\hat{U}_t] \qquad \text{(model 1)}$$

$$= [10.357, -.61][Y_t^*] - [.000546, -8.208][X_{2t}]$$
$$- [11.992, -3.606, -3.852, 6.741][X_{1t}]$$
$$- [10.357, -0.61][\hat{U}_t] \qquad \text{(model 2)}$$

(10) A1-B2-C2-D2-E1;

$$X_{3t}^s = FP_3'(M-B^{-1})'GY_t^* + FHX_{3t}^* - FP_3'(M-B^{-1})'G(M-B^{-1})(P_1X_{1t} + P_2X_{2t})$$
$$- FP_3'(M-B^{-1})'GB^{-1}\hat{U}_t \qquad (6.33)$$

$$= [.98][X_{3t}^*] + [.0995, -.00585][Y_t^*] - [.000117, -.129][X_{2t}]$$
$$- [.132, -.0327, .00476, .0414, .091][X_{1t}]$$
$$- [.0995, -.00585][\hat{U}_t] \qquad \text{(model 1)}$$

$$= [.936][X_{3t}^*] + [-.172, .0101][Y_t^*] - [-9.1(10^{-6}), .137][X_{2t}]$$
$$- [-.259, .06, .0636, -.112][X_{1t}]$$
$$- [.0479, -0.028][\hat{U}_t] \qquad \text{(model 2)}$$

(11) A2-B1-C2-D2-E1;

$$X_{3t}^s = - QP_3'B^{-1}'GY_t^* + QP_3'B^{-1}'G(M-B^{-1})(P_1X_{1t} + P_2X_{2t})$$
$$+ QP_3'B^{-1}'GMP_3\hat{f}_3X_{3t-1} + QP_3'B^{-1}'GB^{-1}\hat{U}_t \qquad (6.34)$$

$$= - [.0002, -2.374][Y_t^*] + [.0084][\hat{f}_3X_{3t-1}] + [.0002, -2.374][X_{2t}]$$
$$+ [2.279, -.565, .698, 1.049, .172][X_{1t}]$$
$$+ [.232, 0][\hat{U}_t] \qquad \text{(model 1)}$$

$$= - [2.315, 0][Y_t^*] + [.0382][\hat{f}_3X_{3t-1}] + [.000356, -.32][X_{2t}]$$

$$+ [2.213, -.316, .376, 1.801][X_{1t}]$$
$$+ [-.191, .0094][\hat{U}_t] \qquad \text{(model 2)}$$

(12) A2-B2-C2-D2-E1;

$$X^s_{3t} = DHX^*_{3t} - DP_3\mathcal{B}^{-1\prime}GY^*_t + DP_3\mathcal{B}^{-1\prime}G(M-B^{-1})(P_1X_{1t} + P_2X_{2t})$$
$$+ DP_3\mathcal{B}^{-1\prime}GMP_3\hat{f}_3X_{3t-1} + DP_3\mathcal{B}^{-1\prime}GB^{-1}\hat{U}_t \qquad (6.35)$$

$$= [.903][X^*_{3t}] - [.209, 0][Y^*_t] + [.000814][\hat{f}_3X_{3t-1}]$$
$$+ [.296, -.0547, .0676, .102, .0167][X_{1t}]$$
$$+ [1.9(10^{-4}), -.23)][X_{1t}] + [.209, 0][\hat{U}_t] \qquad \text{(model 1)}$$

$$= [.915][X^*_{3t}] - [.198, 0][Y^*_t] + [.00326][\hat{f}_3X_{3t-1}]$$
$$+ [.257, -.027, .0321, .154][X_{1t}]$$
$$+ [3.04(10^{-6}), -.0273][X_{2t}] + [.198, 0][\hat{U}_t] \qquad \text{(model 2)}$$

The optimal annual money supplies in real terms for 1981-1986 in Table 3 show again that excluding policy variables from the government objective function resulted in unacceptable rules because money supplies are either negative or too large compared to actually realized money supplies. The empirical results show no differences between results for D1 and D2 assumptions for both models under assumptions B1 and B2. Actually, the average error component of the model 2 for previous four quarters in 1985, for example, under A1-B2-C2-D2-E1 and model 1 is -0.0003635 which can be disregarded. The combination of A1 and B2 yields nearly the same optimal money supplies as combination A2 and B2 under both models 1 and 2.

Deviations of actual money supplies from optimal supplies in annual analysis of

Table 3. Optimal money supplies for 1981-1986[a] (billion $ in real terms)

Synthesis	Model	1981 (241.6)	1982 (235.1)	1983 (246.3)	1984 (253.5)	1985 (269.9)	1986
A1-B1-C2-D1-E1	model 1	1852.9	3401.4	3948.1	5299.0	4309.4	4799.0
	model 2	3602.1	6049.6	7974.9	10809.1	8704.5	9729.9
A1-B2-C2-D1-E1	model 1	198.0	207.8	207.5	273.2	241.8	294.8
	model 2	299.3	269.6	239.7	243.4	285.0	318.3
A2-B1-C2-D1-E1	model 1	4890.1	5509.0	5913.0	6204.0	6638.4	6934.6
	model 2	-862.9	-1422.2	-2486.6	-2616.3	-2109.0	-2125.6
A2-B2-C2-D1-E1	model 1	304.3	268.0	234.7	231.3	281.9	318.4
	model 2	297.1	261.1	231.7	232.5	280.0	318.8
A1-B1-C2-D2-E1	model 1	1852.9	3401.4	3948.1	5299.0	4309.4	4799.0
	model 2	3602.1	6049.6	7974.9	10809.1	8704.5	9729.9
A1-B2-C2-D2-E1	model 1	198.0	207.8	207.5	273.2	241.8	294.8
	model 2	299.3	269.6	239.7	243.4	285.0	318.3
A2-B1-C2-D2-E1	model 1	4890.1	5509.0	5913.0	6204.0	6638.4	6934.6
	model 2	-862.9	-1422.2	-2486.6	-2616.3	-2109.0	-2125.6
A2-B2-C2-D2-E1	model 1	304.3	268.0	234.7	231.3	281.9	318.4
	model 2	297.1	261.1	231.7	232.5	280.0	318.8

[a]Values in parentheses represent actual money supply in each year.

the government's monetary policy behavior are relatively large during 1981-1985 with range of 5.44 to 57.64 billion dollars in real term compare to those in quarterly analysis. This fact implies that quarterly analysis of government behavior of monetary policy produces realistic money supply rules than do annual analyses under the assumption of B2. This also implies that errors of predicting government behavior are greater in annual analyses than in quarterly analyses. However, this does not necessary mean that the prediction errors of government behavior in the long run are larger than prediction errors in the short run, because each set of money supply rules is based on different data and estimated coefficients for the same model. From the empirical results we can justify including endogenized policy instruments in the preference function. Of course, optimal money supply rules we derived depend upon the assumption about values of H and G matrices and also desired target values of Y_t and X_{3t}.

D. Specification Errors

This section investigates numerical specification errors according to Theil's definition discussed in previous chapter. The first specification error is due to difference between the reduced form equations (4.4) and (5.7) where (4.4) excludes relevant variables Y_t^* and X_{3t}^* while (5.7) includes them. This difference stems from the fundamentally different assumption about policy instruments: exogenous policy variables vs endogenized policy variables. Since (5.7) was derived by substituting optimal solution of X_{3t}, (5.6), into (5.2), we replace X_{3t} with X_{3t}^S in (5.2). Thus the difference of (5.7) from (4.4) becomes

$$B^{-1}P_3(X_{3t}^s - X_{3t}) \tag{6.36}$$

for both REH.1 and REH.2. This difference represent the specification errors of reduced form equation and these errors are equivalent to the differences between the predicted value of Y_t in (4.4) and in (5.7).

The other specification error is the difference between rational expectations errors in (4.5) and in (5.8). Subtracting (5.8) from (4.5) results in (6.36). So we find that the specification errors of reduced form equations are just the same as the specification errors of the rational expectations and this fact comes from the definition of the rational expectations errors.

The specification errors are summarized in Table 4 based on the possible syntheses and the modified models. The assumption B1 is excluded in procedures of deriving the specification errors because B1 assumption results in unacceptable solutions for optimal money supplies. As can be seen, there are no specification errors of inflation because this equation, (6.2), does not contain the m_t variable. The specification errors are much smaller in quarterly analysis than in yearly analysis. This fact may come from suggested inflationary annual monetary policy rules. There is no difference between specification errors under assumptions D1 and D2. This also come from fact that error components are close to zero.

Table 4. Specification errors: exogenous X_{3t} vs endogenized X_{3t}

Synthesis	Model	Specification errors on Y_t y_t (billion \$ in real terms)	π_t (index)
Quarterly analysis (1985-IV)			
A1-B2-C2-D1-E1	model 1	.284	0.0
	model 2	.263	0.0
A2-B2-C2-D1-E1	model 1	.176	0.0
	model 2	.024	0.0
Annual analysis (1985)			
A1-B2-C2-D1-E1	model 1	5.883	0.0
	model 2	-1.511	0.0
A2-B2-C2-D1-E1	model 1	5.579	0.0
	model 2	4.342	0.0
A1-B2-C2-D2-E1	model 1	5.883	0.0
	model 2	-1.511	0.0
A2-B2-C2-D2-E1	model 1	5.579	0.0
	model 2	4.342	0.0

VII. SUMMARY AND CONCLUSIONS

This study had paid attention to endogenization of government policy instruments in contrast to treating them as exogenous. Modern governments, regardless of economic system and of stage of economic development, have the ability and the motivation to make major and detailed interventions, through economic policies, into the whole economy, from production to consumption. Every individual and/or group responds to the government policy choices.

From the view point of political macroeconomics, we derive general conclusion that there is an interdependent relation between public sector and private sector. Government authorities achieve their purpose, say, maximizing popularity in order to be re-elected by manipulating policy variables. This claim justifies existence of political business cycle. In this context, government policy variables are no longer exogenous, rather they are endogenous variables.

From the view point of political microeconomics, it is possible for us to assume that government regulates our economic life, and our feedback responses to the regulations could be revealed through election process. Various empirical studies try to estimate policy instrumental behavior equations and preference functions. Given the constructed preference functions and appropriate constraints, policy instruments or choice equations can be derived endogenously. Therefore, meaningful policy analysis allow a high degree of interdependence of microeconomic performance and microeconomic policy and justifies endogenizing government behavior.

The flexible target model, in theory of the QEP, includes a social welfare function and reduced form equations as constraints policy makers face. The optimal policy rules can be expressed as a function of disturbance term so that variation in an error in a constraint may cause optimal policy choice also to vary. Thus the policy instruments is not exogenous under specific assumptions.

The theory of the REH verify relationship between public and private sectors. When policy makers choose policy rules, they form expectations on responses of the private sector to their choices and the private sector also form expectations on government's policy choices for economic decision.

The synthesis of QEP and REH can be expressed as an optimal decision problem by assuming government authorities try to maximize their preference function with desired targets of economic variables under a certain decision environment which describes private sector's economic behavior. In the behavioral equations that describe the decision environment, private sector's expectations on policy choices can be included. When we focus on the government's optimal decision rules, this optimization process is a one-side policy game because as the policy makers formulate policies, they may take account properly of influences of the policy choices on the private sector's expectations. The one-side game we discussed is a nonrepeated game because we assumed government has a single period objective function and government wants to derive optimal policy rules for the one period.

Recognition of the "policy filter" which assume a hierarchical information structure allows us to extend the one-side policy game to two-sided policy game. This policy game will be a dominant player policy game because the private sector can not recognize what goes on inside of the policy filter. This dissertation focused on single period policy rules. If we extend single period policy rules to multi-period policy rules, then the policy game will be repeated game. This two-sided repeated policy game might be a further research issue.

The synthesis also allows us to revisit well known Lucas' critique of econometric policy evaluation. When the private sector can not form proper expectations about policy choices (REH.1), in other words, when the private sector does not fully understand what goes on inside the policy filter, then Lucas' critique is not applicable because the private sector can not take proper account of changes in coefficients caused by changes in public policy. However, if the private sector forms proper expectations (REH.2), then Lucas' critique is valid.

Generally, Taylor's empirical results of Taylor's economic model show more high t values than do results for the models 1 and 2. These differences mainly come from the different assumption about error structure, different sample periods, and different estimation methods. One important feature of the estimators in this study is opposite signs of coefficients of predicted inflation rate (b_5) and output (r_1). But these opposite signs can be explained on reasonable economic grounds. For example, the positive and highly significant b_5 in this study shows existence of short run Phillips curve, that is higher expected future price results in higher production (or consumption). While negative and nonsignificant b_5 in Taylor's study implies existence of long run vertical Phillips curve. A negative and nonsignificant r_1 in this study represents a long run vertical Phillips curve while positive and significant r_1 in Taylor's study support the accelerationist assumption that output can be increased with accelerating rate of inflation.

In numerical comparisons of various syntheses of REH and QEP, it was found that exclusion of endogenized policy variables from the government's preference function resulted in solutions which are optimal and unique but not acceptable because money supplies are either negative or too large compared to actual money supplies. Thus it is claimed that the endogenous policy instruments should be included in government objective function. The combination of A1 and B2 yields nearly the same optimal money supplies as combination A2 and B2 under both models 1 and 2. In contrast, optimal annual money supplies differed little between models 1 and 2 under combination A2 and B2, but they differed greatly between models 1 and 2 under combination A1 and B2. Deviations of actual money supplies in real term from optimal supplies in annual analysis are large compare to those in quarterly anlysis.

We recognize that the optimal money supply rules depend on the assumption of desired target values of GNP and money supply and of weight matrixes G and H. As the values of goals and weight matrixes vary, the optimal policy rules also vary. This fact supports existence of politically motivated business cycle.

According to Theil's definition, specification errors show what are the differences between assumption of exogenous policy choices and endogenous choices. We find that the rational expectations errors are same as the specification errors of exogeniety of endogenous policy variables.

Possible syntheses of the QEP and the REH give us different money supply rules according to the underlying assumptions. As economists, we may find gaps between optimal policy rules suggested by economists and economic policies implemented by policy makers. Traditionally, the relation between economists and policy makers is considered as a one-way channel of communication. Economists send a menu of choice to the policy makers and policy makers then impose value judgments and make choices from the economists menu. However most people agree that economic policy is very far from a state of perfection. Behind this recognition of reality, there may be an unrealistic degree of certainty in the economists' economic knowledge. Also economists so often misunderstand the political process and the part the policy makers play in it. In fact, all text books of macro and microeconomics deal with an extremely naive view of the state. There may also be an unrealistic willingness on the part of policy makers to leave technical judgement about the menu of choice to professional economists. Policy makers tend to be practical men and so often reject theorizing either on the grounds that all theories are unnecessary or irrelevant theories (Lipsey, 1979). Implicitly, the government authorities may be disinterested in maximizing economic welfare as defined by economists. Therefore, relationship between policy makers and economists as economic advisers can be a further research issue if we have an interest in endogenized optimal policy decisions.

VIII. APPENDIX A: NONLINEAR REGRESSION

A. Nonlinear Model and Parameter Estimation

Let's assume we have a correct nonlinear model to be estimated for parameters,

$$y_t = f(x_t, \theta^*) + e_t, \quad t = 1, 2, ..., T \tag{A.1}$$

and this set of equations can be written as a vector form

$$Y = F(\theta) + e \tag{A.2}$$

where

$$Y' = (y_1, y_2, ..., y_T)$$

$$F(\theta)' = [f(x_1, \theta^*), f(x_2, \theta^*), ..., f(x_T, \theta^*)]$$

$$e' = (e_1, e_2, ..., e_T)$$

and where y_t represents T observed dependent variables corresponding to nonstochastic k-dimentional exogenous variables x_t, θ^* is a p-dimentionalvector of unknown true parameters, and $f(x_t, \theta^*)$ denotes response function which is nonlinear in parameters, and e_t is an unobservable disturbance term, assumed to be independently and identically distributed with mean zero and unknown true variance σ^{*2}. The symbol * in θ^* represents true unknown parameter vector in the parameter space and θ denotes any trial value of the parameter vector.

The sum of squared deviations of the observed y_t from the predicted value $f(x_t, \theta)$ corresponding to a trial value of the parameter θ is

$$SSE(\theta) = \sum_{t=1}^{T} [y_t - f(x_t, \theta)]^2 \tag{A.3}$$

and as a vector form

$$SSE(\theta) = [Y - f(\theta)]'[Y - f(\theta)] \tag{A.4}$$

The estimation procedure for the nonlinear model is to choose the vector θ that minimizes (A.4). The least squares estimator, θ_{LS}, as an estimate for θ^*, is a solution to the normal equations

$$[\partial SSE(\theta)/\partial\theta_1 \mid \theta_{LS}] = -2 \sum_{t=1}^{T} [\partial f/\partial\theta_1 \mid \theta_{LS}][y_t - f(x_t, \theta_{LS})] = 0$$

$$\vdots \qquad\qquad \vdots \qquad\qquad \vdots$$

$$[\partial SSE(\theta)/\partial\theta_p \mid \theta_{LS}] = -2 \sum_{t=1}^{T} [\partial f/\partial\theta_p \mid \theta_{LS}][y_t - f(x_t, \theta_{LS})] = 0 \qquad (A.5)$$

where $[\partial SSE(\theta)/\partial\theta_p \mid \theta]$ is the derivative of $SSE(\theta)$, with respect to θ_p, evaluated at θ and similarly for $[\partial f/\partial\theta_p \mid \theta]$.

The nonlinear least squares (LS) estimator is, in general, not best linear unbiased estimator (BLUE). However, even if the error distribution is nonnormal, the nonlinear LS estimator, θ_{LS}, of θ^* is consistent and asymptotically normally distributed if following three conditions are satisfied: (i) e_t is independently and identically distributed with mean zero and varince σ^{*2}. (ii) $f(x_t, \theta)$ is continuous in both x_t and θ and is at least twice continuously differentiable with respect to θ. (iii) The sequence of x_t is such that it is bounded and well behaved in a certain sense as T approaches to infinity to guarantee the invertibility $[Z(\theta^*)'Z(\theta^*)]$, which will be discussed later.

The consistency of the LS estimator implies that, given a large sample, the estimates is likely to be close to the true parameter θ^*. The LS nonlinear estimation procedure approximates $f(x_t, \theta)$ in θ^* by the linear term of the Taylor series expansion, which is the best linear approximation.

Let us take a Taylor series expansion for (A.1),

$$f(x_t, \theta) \approx f(x_t, \theta^*) + \sum_{i=1}^{p} [\partial f(x_t, \theta)/\partial\theta_i \mid \theta^*][\theta - \theta^*] \qquad (A.6)$$

Note that

$$[\partial f(x_t, \theta)/\partial\theta_1 \mid \theta^*], \ldots, [\partial f(x_t, \theta)/\partial\theta_p \mid \theta^*]$$

is the t-th row of $Z(\theta^*)$ where $Z(\theta^*)$ is the (Txp) Hessian matrix of $f(x_t, \theta)$, that is

$$Z(\theta^*) = \begin{bmatrix} [\partial f(x_t, \theta)/\partial\theta_1 \mid \theta^*], \ldots, [\partial f(x_t, \theta)/\partial\theta_p \mid \theta^*] \\ \vdots \qquad\qquad \vdots \\ [\partial f(x_T, \theta)/\partial\theta_1 \mid \theta^*], \ldots, [\partial f(x_T, \theta)/\partial\theta_p \mid \theta^*] \end{bmatrix} \qquad (A.7)$$

Thus (A.6) can be written as

$$f(x, \theta) \approx f(x, \theta^*) + Z(\theta^*)(\theta - \theta^*) \qquad (A.8)$$

Substituting the RHS of (A.8) for $f(x, \theta)$ into

$$y = f(x, \theta) + e$$

gives

$$y = f(x, \theta^*) + Z(\theta^*)(\theta - \theta^*) + e \qquad (A.9)$$

or

$$\bar{y}(\theta^*) = Z(\theta^*) + e \qquad (A.10)$$

where[30]

$$\bar{y}(\theta) = y - f(x, \theta) + Z(\theta) \qquad (A.11)$$

---

[30]By the assumptions, mean of y_t is determined by θ, or, in other words, the random variable y_t depends on the unknown parameter vector. So we may write $y(\theta)$ instead of y.

Malinvaud (1980) calls (A.10) as the linear pseudomodel. Since θ^* is unknown, of course, the linear pseudomodel can not be directly used for parameter estimation. However, suppose that we knew $Z(\theta^*)$ and $\bar{y}(\theta^*)$, then the linear LS estimator for θ^* in (A.10) is

$$\theta_{LS} = [Z(\theta^*)'Z(\theta^*)]^{-1}Z(\theta^*)\bar{y}(\theta^*) \tag{A.12}$$

with variance-covariance matrix

$$M_{LS} = \sigma^{*2}[Z(\theta^*)'Z(\theta^*)]^{-1} \tag{A.13}$$

Since the model is only approximately correct, (A.13) holds only approximately. But if θ_{LS} is sufficiently close to θ^*, we can use

$$M_{LS} = \sigma^2_{LS}[Z(\theta_{LS})'Z(\theta_{LS})]^{-1} \tag{A.14}$$

The nonlinear estimators which are minimize the sum of square errors, (A.3) or (A.4), are consistent and asymptotically efficient estimators and asymptotically and normally distributed. In this study, proof for these properties of the estimates is omitted (for the proof, see Malinvuad, 1980, pp. 347-355).

B. Computing Estimates: Gauss-Newton Algorithm

To compute the LS estimates, it is necessary to minimize the sum of square errors, (A.3). However, for the nonlinear model, there may be multiple solutions not all of which correspond to the global minimum of the sum of squares function. In general, nonlinear estimation problems are solved by iterative techniques until this iterative process converges to the global minimum. So with different starting point and iterative process, it is possible to obtain global minimum of sum of squares function.

Discussed linear pseudomodel is one possible way to find the roots of the nonlinear normal equations, (A.5). In general, such a linear approximation to the nonlinear model will only be good close to the point where the derivative is evaluated. Since we do not know the true parameter vector, θ^*, and hence can not approximate the nonlinear model by a linear model close to θ^*, we use other vector, say, θ_1, as a starting point. Substituting this into (A.9), we obtain as linear pseudomodel

$$\bar{y}(\theta_1) = Z(\theta_1) + e \tag{A.15}$$

The algorithm for deriving global minimum of the sum of square errors, (A.3) or (A.4), by the least square estimation method proceeds as follows (Gallant, 1975):

First, choose a starting estimate θ_1, compute $D_1 = [Z(\theta_1)'Z(\theta_1)]^{-1}Z(\theta_1)'\bar{y}(\theta_1)$ and find a r_1 between 0 and 1 such that $SSE(\theta_1 + r_1D_1) \leq SSE(\theta_1)$

Second, let $\theta_2 = \theta_1 + r_1D_1$, compute $D_2 = [Z(\theta_2)'Z(\theta_2)]^{-1}Z(\theta_2)'\bar{y}(\theta_2)$ and find a r_2 between 0 and 1 such that $SSE(\theta_2 + r_2D_2) \leq SSE(\theta_2)$

Third, let $\theta_3 = \theta_2 + r_2D_2$, ...

There are several methods for choosing the step length r_i at each iteration (see Hartley, 1961 and Gallant and Fuller, 1973). One way is to choose r_i in i-th iteration to be the largest number in the sequence $r_s = (0.8)^s$, s = 0, 1, ..., for which

$$SSE(\theta_i + r_iD_i) \leq SSE(\theta_i) \tag{A.16}$$

It is imperative that the computer program verify (A.16) before taking next iterative step. The iterations are continued until terminated by a stopping rule such as

$$\| \theta_i - \theta_{i+1} \| < h(\| \theta_i \| + d) \tag{A.17}$$

and simultaneously

$$| SSE(\theta_i) - SSE(\theta_{i+1}) | < h[SSE(\theta_i) + d] \tag{A.18}$$

where h > 0 and d > 0 are preset tolerances. Reasonable values are $h = 10^{-5}$ and $d = 10^{-3}$ (Marquardt, 1963).

If the model is truly nonlinear, successful convergence and the rate of convergence may depend heavily on the choice of starting values for the estimates. Choosing starting values, θ_1, for the Gauss-Newton algorithm is an arbitrary process. As a normal practice, they may be obtained from prior knowledge of the situation, inspection of the data, grid search, or trial and errors. Hartley and Booker (1965) developed a general approach to finding the starting values. However, unfortunately no computer routines are available for the general approach of Hartley and Booker. Therefore, in practice, the algorithm is started at a few different points in the parameter space, which is reasonable if there is a rough idea of where the global minimum of SSE is located. In this study, we use Taylor's estimates of the parameters for Taylor model as starting values.

IX. APPENDIX B: SEEMINGLY UNRELATED REGRESSION (SUR)

In the case of the true variance-covariance matrix, M, is unknown, we can not use θ_{LS}. However, we can utilize the estimated generalized least squares (EGLS) estimator by modifying (A.12) as

$$\hat{\theta}_{LS} = [Z(\theta^*)'\hat{M}_{LS} \text{ x } I)Z(\theta^*)]^{-1}Z(\theta^*)(\hat{M}_{LS} \text{ x } I)\bar{y}(\theta^*) \quad \text{(B.1)}$$

where x represent the Kronecker product and the estimator $\hat{M}_{LS}$ is based on LS residuals

$$\hat{e}_i = \bar{y}_i(\theta_i^*) - \dot{Z}_i(\theta_i^*)\theta_i \quad \text{(B.3)}$$

and has elements given by

$$\hat{\sigma}_{ij} = T^{-1}\hat{e}_i'\hat{e}_j, \quad i, j = 1, 2, ..., p \quad \text{(B.3)}$$

The estimator $\hat{\theta}_{LS}$, defined by (B.1) and (B.3) is frequently referred as Zellner's SUR estimator.

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