A SIMULATION STUDY
OF A DISEQUILIBRIUM MACRO MODEL
WITH SPECIAL REFERENCE
TO THE THEORY OF CREDIT RATIONING

By

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I alone am responsible for any remaining deficiencies.

ABSTRACT

The purpose of this study is to explore the implications for various government stabilization policies of explicit consideration of market disequilibrium, especially credit rationing in the commercial bank loan market. The analysis centers in each case on the value of the government expenditure multiplier.

First, a control or equilibrium version of the model is developed which is consistent with standard macrotheory and which contains a well-described banking sector. The results of the simulations with this version of the model confirm that the impact multiplier is larger when the deficit is financed by printing money than when bonds are issued to meet the requirement for funds. However, it is shown that in the long run the bond-financed multiplier is greater than the money-financed multiplier. This version of the model also confirms the possibility raised in the current literature that the bond-financed case may be unstable.

Since the current model has a well developed banking sector, the theory of the government finance restraint is extended to consider the case in which the deficit is financed by transferring the ownership of government bank deposits to the private sector. This case closely resembles the bond-financed case in the short run but it is statically stable. The deposit-financed case is limited, of course, by the initial size of the government deposits. Therefore, the restoration of the level of government deposits by one of the other means of financing is considered.

Next, a disequilibrium version of the control model is developed consistent with current literature on disequilibrium phenomena. This version of the model contains a feedback mechanism by which a disequilibrium in one market will affect the decisions in all other markets.

The results of the simulations with the disequilibrium model show that the government expenditure impact multiplier may be increased by the presence of credit rationing. In fact the bond-financed case which is unstable in the control version becomes stable under "equilibrium" credit rationing, where the loan rate does not adjust at all.

Since the model used in this study is <u>ad hoc</u>, sensitivity analysis is used to investigate the importance of the exact values of the key parameters of the system. The policy implications of the study do appear to hing on the values of the feedback coefficients. If the force of credit rationing is mainly felt in the real sector, the government expenditure impact multiplier will be smaller in the disequilibrium version than in the control model. On the other hand, if the impact of credit rationing is mainly felt in the financial sector, the opposite result will occur. However, the range of values that the multiplier may take on, depending on the impact of the credit rationing, is quite small.

Thus, given the size of the error of prediction of standard models, this study concludes that it is unlikely that the inclusion of credit rationing will allow a better evaluation of government stabilization policies. This is especially true if the impact of credit rationing is believed to be in roughly the same proportion as normal expenditures in the various markets.

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INTRODUCTION

The study of market disequilibrium has become an increasingly popular topic in current economic literature. This follows a re-interpretation of the writing of Keynes as suggested by Clower[1] and Leijonhufvud[2]. This development has been motivated, as Barro and Grossman have stated, by the fact that:

> conventional analysis has chronically attempted to coax Keynesian results out of a framework of general market equilibrium. The result has been to leave conventional macroeconomics with an embarrassingly weak choice-theoretic basis, and to associate with it important implications that are difficult to reconcile with observed phenomena.[3]

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[1] Clower, R.; "The Keynesian Counterrevolution: A Theoretical Appraisal" in Hahn, F.H. and Brechling, F.P.R.; The Theory of Interest Rates; MacMillan; Toronto, 1966.

[2] Leijonhufvud, A.; On Keynesian Economics and the Economics of Keynes; Oxford University Press; New York, 1968.

[3] Barro, R.J. and Grossman, H.I.; "A General Disequilibrium Model of Income and Employment"; American Economic Review; March, 1971, p. 82.

The existence of markets that fail to clear each period will impose additional constraints on the system, and hence the explicit inclusion of these disequilibrium phenomena could substantially alter the predictions of the system. Several economists[4] have argued that credit rationing in the commercial bank loan market is likely to exist and to have important implications for the operation of government stabilization policies.

This theory of disequilibrium is becoming well-developed at the microeconomic level, but it has not as yet been adequately adapted to macroeconomic models to allow a proper evaluation of the importance of considering such phenomena when studying general government stabilization policy actions. At the present time some policy makers[5] are attempting

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[4]For example see Jaffee, D.M. and Modigliani, F.; "A Theory and Test of Credit Rationing"; American Economic Review; December, 1969, and Tucker, D.P.; "Credit Rationing, Interest Rate Lags and Monetary Policy Speed"; Quarterly Journal of Economics; February, 1968.

[5]For example, the Bank of Canada is currently undertaking a research project to attempt to build a credit rationing system into RDX2.

to construct models which will incorporate this feature. However, as has been pointed out by Tucker,[6] there are many econometric problems that must be overcome before such a model can be estimated. Such a development will involve a high cost in terms of research facilities while the benefits in terms of improved predictions are uncertain.

The main objective of this study is to examine the size of the impact that non-market-clearing situations, particularly credit rationing, will have on the predictions of government stabilization policy effects.

Analytical solutions of such disequilibrium systems tend to be extremely complex because of the size of the model required and the mathematics involved in describing the possible structural changes as the markets move between positions of excess demand and excess supply. This complexity makes interpretation of the results difficult. To overcome this

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[6] Tucker, D.P.; "Macroeconomic Models and the Demand for Money under Market Disequilibrium"; Journal of Money Credit and Banking; February, 1971.

problem the present study uses the technique of computer simulation.

The model that is used is based, where possible, on existing empirical studies. In the specification of the disequilibrium system, however, this is not always possible. As suggested above, the theory of disequilibrium estimation is still at a rather naive stage, although some progress has recently been made.[7] For this reason use is made of the standard[8] economic procedure of assuming a hypothetical model and changing only the elements to be studied.

The parameters of the model are not precise and therefore, the predictions of the model must be considered to be suggestive rather than definitive. However, the key parameters are subjected to sensitivity

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[7]For example see Fair, R.C. and Jaffee, D.M.; "Methods of Estimation for Markets in Disequilibrium"; Econometrica; May, 1972 and Fair, R.C. and Kelejian, H.H.; "Methods of Estimation for Markets in Disequilibrium; A Further Study"; Econometrica; January, 1974.

[8]This technique has been used by Brainard, W.C. and Tobin, J.; "Pitfalls in Financial Model Building"; American Economic Review; papers and proceedings; May, 1968; and Christ, C.F.; "A Model of Monetary and Fiscal Policy Effects on the Money Stock Price Level and Real Output"; Journal of Money, Credit and Banking; November, 1969.

analysis so that the size of possible errors may be recognized. The sensitivity analysis also points out which parameters require the most precise estimation in order to obtain reliable results from such a model.

As a by-product of the main study, this thesis will be able to extend the theory of the government finance restraint to consider the case in which the budget deficit is financed by transferring the ownership of government bank deposits to the private sector.

Also, in a recent paper by Blinder and Solow,[9] it has been shown that when the interest on government debt is taken into account, the standard model may be unstable if the budget deficit is financed by issuing bonds. They conclude that, given the likely values of the parameters, the model is probably in the stable range. However, an extension of this work by Scarth[10] has shown that, due to an error in their

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[9] Blinder, A.S. and Solow, R.M.; "Does Fiscal Policy Matter?"; Journal of Public Economics; November, 1973.

[10] Scarth, W.M.; " A Note on the 'Crowding Out' of Private Expenditures by Bond-Financed Increases in Government Spending"; Journal of Public Economics, (forthcoming).

interpretation of the parameters, the model may still be in the unstable range.

Although the model used in this study is not well suited to a detailed investigation of this issue due to its limited supply side, Christ[11] and Turnovsky[12] have shown that the long-run position of such systems is largely determined by the parameters of the tax function, independently of the behavioural relationships of either the supply or the demand side. In this context we are able to comment on the relative magnitudes and on necessary conditions for stability in the long-run cases for both the equilibrium and the disequilibrium versions of the model.

In chapter two an equilibrium or market-clearing version of the model used in the study is set forth. It is shown that this model is representative of standard macrotheory. In addition, the second chapter contains the extension of the current theory of the government finance restraint to include the case in which the

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[11] Christ, op. cit.; pp 696-701.

[12] Turnovsky, S.J.; "Monetary Policy, Fiscal Policy and the Government Budget Constraint"; Australian Economic Papers; (forthcoming).

government budget deficit is financed by drawing from the government's deposits with the commercial banking sector. The results of the simulation experiments on this equilibrium version of the model are also contained in chapter two.

Chapter three contains a survey of some of the more important papers in the literature on disequilibrium systems. The model developed in chapter two is then modified in chapter three to incorporate the key elements of disequilibrium theory, especially with regard to the theory of credit rationing.

The fourth chapter reports the results of the various simulation experiments that have been run using this disequilibrium version of the model. The sensitivity analysis of the key parameters of the model is also given in this chapter.

Finally, chapter five presents a general summary of the study and organizes the major conclusions of the thesis. Also, the limitations of the study and some suggestions for future research are discussed in this last chapter.

II

A CONSTRAINED MARKET CLEARING MACRO MODEL WITH A BANKING SECTOR.

2.1 Introduction

If the results of an experiment are to be of any value they must be compared to those of a control experiment. Thus, if the results of the present study, a simulation experiment to determine the effects of market disequilibrium constraints, are to have any meaning a market clearing or control version of the model must first be developed. It is the purpose of this chapter to develop such a model and to investigate its properties.

The model set out below is a modified form of Carl Christ's simulation model.[1] Since it includes a banking sector it facilitates examination of market disequilibria that arise from credit rationing, which is one of the main objectives of the study.

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[1]Christ, C.F.; "A Model of Monetary and Fiscal Policy Effects on the Money Supply, Price Level and Real Output"; Journal of Money, Credit and Banking; November, 1969, pp 683-704.

Section 2.2 describes the nature of Christ's original model and the modifications that have been made in it to reach the final form of the control model. Section 2.3 explains the implications of the macroeconomic constraints that affect the model. This section also reconciles the continuous time theoretical models with the discrete time simulation model that is used throughout this study. Section 2.4 describes the simulation results obtained from the control version of the model, comparing them with the results of Christ's model. Finally, Section 2.5 will sum up the results of this section and point out some of the central hypotheses to be tested using the disequilibrium or non-market clearing version of the model that is developed in chapter 3.

2.2 The Control Model

The Christ model provides a particularly useful framework in which to study alternative forms of financing various stabilization policies, for it has well developed financial markets including a banking sector. As well, care has been taken to ensure that the model is consistent with the standard macroeconomic constraints, both of the financing type and of the kind stressed by

Brainard and Tobin.[2]

The model is a three sector aggregate demand model with two versions, fixed price or fixed output. The fixed output version represents a situation of capacity output and hence may be valuable for considering policy effects in inflationary situations, while the fixed price case corresponds to the conventional models for dealing with the case of less than full employment levels of aggregate demand.

The three sectors of the model are the government, the private nonbanking sector and the private banking sector. The behaviour of the government is assumed to be exogenous, while the behaviour of the other two sectors is fully explained within the system. Care has been taken to ensure that the balance sheet conditions of each sector hold, including the government financing restraint.

The first twelve equations of the model are the restraints and identities that describe the balance sheet equalities and the exogenous behaviour of the

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[2]Brainard, W.C. and Tobin, J.; "Pitfalls in Financial Model Building"; American Economic Review; Papers and Proceedings; May, 1968, pp 99-122.

government sector. The model starts with the definition of real net national product:[3]

$$x = c + i + g \qquad (1)$$

proceeds to the definition of real disposable income:

$$y = x - t \qquad (2)$$

followed by the tax-transfer schedule:

$$t = \frac{V}{\bar{P}} + ux + \frac{uB}{\bar{P}} \qquad (3)$$

followed by the definition of real capital gains on bonds (assumed to be consols) and high-powered money:[4]

$$z = H\Delta\left\{\frac{1}{\bar{P}}\right\} + B\Delta\left\{\frac{1}{\bar{r}bP}\right\} \qquad (4)$$

the real physical capital stock equation:

$$k = k_{-1} + i \qquad (5)$$

the definition of private nonbank liquid wealth, assuming that capital stock does not affect liquid wealth because of the absence of markets for used capital goods:[5]

$$Pwp = Hp + \frac{Bp}{\bar{r}b} + D - L + Pwb \qquad (6)$$

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[3]Capital letters denote money terms, small letters denote real terms. The definition of the notation and the assumed initial values of the variables are given in appendix A.

[4]The symbol Δ is the first difference operator.

[5]The private nonbank sector is assumed to own the banking sector.

the definition of bank net worth or the balance sheet constraint on the banking sector:[6]

$$Pwb = Hb + \frac{Bb}{rb} + L - D \qquad (7)$$

the definition of total bank assets:

$$Pa = D + Pwb \qquad (8)$$

the definition of the money stock:

$$M = Hp + D \qquad (9)$$

the high-powered money identity:

$$H = Hp + Hb \qquad (10)$$

the government bonds identity:

$$B = Bp + Bb \qquad (11)$$

and the government finance restraint:

$$g + \frac{B}{P} = t + \frac{\Delta H}{P} + \frac{\Delta B}{rbP} \qquad (12)$$

The next five equations explain the behaviour of the private nonbanking sector. Explicitly considered here is the demand for consumption and investment and the allocation of financial wealth between the holdings of deposits, bonds, and loans. Private holdings of high powered money are determined residually with the above behavioural equations and the total wealth definition described above. Thus the equations of this section

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[6] For simplicity, the level of bank net worth is assumed to be constant.

of the model are, real consumption:

$$c = \Phi(y,z,rb,rd,rl,wp_{-1}) \qquad (13)$$

real net investment:

$$i = \theta(x,rb,rd,rl,k_{-1}) \qquad (14)$$

real private nonbank bond demand:

$$\frac{Bp}{rbP} = Bp(wp,x,rb,rd,rl) \qquad (15)$$

real deposit demand:

$$\frac{D}{P} = d(wp,x,rb,rd,rl) \qquad (16)$$

and real private nonbank borrowers' loan demand:

$$\frac{L}{P} = \lambda p(wp,x,rb,rd,rl) \qquad (17)$$

The final three equations explain the behaviour of the banking sector. The banks are assumed to set the deposit rate in relation to the rates on bonds and on loans and to have a perfectly elastic supply of deposits at the rate set. The remainder of the sector explains the banks' portfolio allocation between bonds and loans, with the banks' demand for reserves of high-powered money being determined residually by the other equations and the bank balance sheet equation. The equations of this sector are,

real bank bond demand:

$$\frac{Bb}{rbP} = Bb(a,rb,rl) \qquad (18)$$

real bank lenders' loan supply:

$$\frac{L}{P} = \lambda b(a,rb,rl) \qquad (19)$$

and the deposit yield:

$$rd = d(rb,rl) \qquad (20)$$

The behavioural relationships of the model are assumed to be linear in first difference form and hence the simulation experiments are performed on this version of the model.[7]

The above model has been modified in several ways to arrive at the control model used in the present study. The first change resulted from two inconsistencies present in the original model. Although Christ included interest payments on the government debt in the finance restraint, he omitted them from the definition of disposable income. Thus, while he recognized that the government must make these payments, he neglected the fact that someone must receive them. Here the interest payments are entered in the tax minus transfer function which, in turn, enters both the disposable income equation and the government finance restraint.

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[7]Note that the model is not completely linear because of the effects of the price level and yield on bonds via capital gains.

Thus, Christ's tax-transfer schedule[8]

$$t = \frac{V}{P} + ux + u\frac{B}{P} \qquad (3)$$

is changed to become

$$t = \frac{V}{P} + ux + (u-1)\frac{B}{P} \qquad (3')$$

and Christ's government finance restraint

$$g + \frac{B}{P} = t + \frac{\Delta H}{P} + \frac{\Delta B}{rbP} \qquad (12)$$

becomes simply

$$g = t + \frac{\Delta H}{P} + \frac{\Delta B}{rbP} \qquad (12')$$

The other inconsistency in Christ's model is that he assumes, in equilibrium, that capital stock lagged equals its current level, but he also assumes that the initial value of net investment is seventy-two billion instead of zero. Thus, for this study, we set the initial value of net investment to zero and in order to keep the results comparable with the original, we assume that the initial level of national income is unchanged at 800 billion and that the initial level of consumption is 632 billion instead of 560 billion.

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[8]Christ's schedule can not include the interest payment transfer in the intercept term as it would cancel out of the finance restraint upon substitution. In any event, such an inclusion would clearly be inadmissible for the case when the supply of bonds was the endogenous policy variable.

The banking sector is modified to include a minimum required reserve ratio against deposits of 14.25%,[9] a level which is not binding at the initial conditions but one which could come into play for any large shocks.

To better evaluate the impact of the required reserve ratio, the demand for reserves equation is included in the model, and the supply of loans equation is suppressed. Thus, if the reserve requirement is not binding, the demand for reserves is given by the behavioural relationship and the supply of loans is determined residually by the balance sheet equation. On the other hand, if the minimum reserve requirement is effective, bank holdings of high-powered money are determined by this equation. While the supply of loans is still residually determined from the definition of total bank wealth equation, in this case, the exact form of the suppressed equation will not be the same.[10] The behavioural interpretation of this change is that if the banks are constrained to hold a different level

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[9]This value is chosen as a rough approximation of the average of actual reserve requirements in the U.S. banking system.

[10]The difference is caused by the fact that the bank's demand equation for high-powered money is different in this case.

of reserves than that which they would normally choose, they are assumed to change the value of their loan portfolio to make up the difference. Clearly this is only one of an infinite number of behavioural assumptions that could have been made and in general a 'feedback' mechanism of the type developed in the next chapter could well be used here.[11]

Finally, government deposits with the banking sector are added. This allows direct analysis of another important form of monetary policy; that is, the ability of the government sector to control total bank assets by varying the level of the government deposits held in the banking sector. It also allows the extension of the theory of the government finance restraint to the case in which the government finances an increase in expenditure simply by letting its bank deposits run down. Clearly there is a limit to this type of financing set by the initial level of such government deposits. However, it is quite conceivable that this method of financing could be used in connection

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[11] The fact that we have not employed such a feedback mechanism here will not affect the results since the bond market is assumed always to clear rapidly and the market for deposits must always clear since the bank's supply is assumed to be perfectly elastic. Thus, it is only in the loan market that any disequilibrium could result from the effects of the minimum reserve requirement.

with some other type. We shall further discuss the rationale for such policy in the next section and in section 2.4 the results of some of the simulation experiments will show that the issue is of some considerable importance.

The exact form of the control model used in the simulation experiments is given in Appendix B.

2.3 Constraints in a Discrete Time Model

The control model has to be constructed to incorporate explicitly the major constraints on the system. In this section we shall expand on the importance of these constraints.

Once we have admitted the importance of including explicit recognition of the government budget constraint, we can ask whether it is necessary to add an equation to represent the private need to finance expenditures. This question is of particular importance, since all of the behavioural functions of the private sector are derived from implicit maximization of individual preference functions subject to the individual budget constraint. Thus, the exact form of the private financing restraint will have a direct impact on the variables to be found in the demand relationships of the model.

It can be demonstrated that no such addition is required because the other constraints of the system already imply that such a private financing constraint must hold. This may be shown by combining the national income identity and the government budget restraint. The national income identity is

$$x = c + i + g \qquad (1)$$

and the government budget constraint may be rewritten as

$$g - t = \Delta wp - z \qquad (12")$$[12]

Solving (12") in terms of g and substituting into (1) we get

$$x - t = c + i + \Delta wp - z \qquad (I).$$

Since the change in wealth is simply the wealth at the end of the period minus the wealth at the start of the period, we can substitute $wp - wp_{-1}$ for Δwp. Thus, after substituting and rearranging terms we get the expression

$$y + z + wp_{-1} = c + i + wp \qquad (II).$$

Equation (II) is the private finance constraint, where the left hand side denotes the sources of funds and the

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[12]Actually the government deficit is equal to the issue of new elements of liquid total wealth, that is, high-powered money and bonds. However, we assume that bank wealth is constant. The capital gains term in this equation represents the fact that the change in wealth equals the additional elements of wealth plus the capital gains on the existing wealth at the beginning of the period.

right hand side gives the allocation of the funds. Therefore, it is clearly not necessary to add such an equation to the system.

Steven Turnovsky[13] claims that the above demonstration requires that all behavioural demand functions, that is, the equations explaining the variables on the right hand side of (II), must be formed only in terms of the variables on the left hand side, if they are to be consistent with the private budget constraint. Specifically, he claims that it would be incorrect to include current wealth in the consumption function as the budget constraint requires that wealth in the beginning of the period, or lagged wealth, be used.

While there is some element of truth in this statement, Turnovsky's strong conclusion is without foundation. The important point is that the variables on the left hand side of (II) must enter the behavioural relationships with coefficients that sum to unity across the set, while any other variables that affect the behavioural set must have coefficients that sum to zero. Presumably, these variables

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[13] Turnovsky, S.J.; "Monetary Policy, Fiscal Policy and the Government Budget Constraint"; Australian Economic Papers; (forthcoming).

must come from the individuals' utility functions. Thus, while Turnovsky is correct that lagged wealth must enter the demand functions, we can not reject the possibility of current wealth also entering, not as a source of funds which must be consistent with the individual budget constraint, but as an allocative force resulting from the preference functions of the individuals.

The above argument is an application of the basic principles of the constraints on model building developed by Brainard and Tobin[14] and then extended by Mark Ladenson[15] and Kevin Clinton[16]. This literature deals only with the financial sector and stems from the assumption that the savings decision is separable from the portfolio allocation decision. This is appropriate for continuous time models, but it is necessary to decide whether such an approach is valid for a discrete time model.[17]

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[14]Brainard, W.C., and Tobin, J.; "Pitfalls in Financial Model Building"; American Economic Review; Papers and Proceedings; May, 1968, pp 99-122.

[15]Ladenson, M.L.; "Pitfalls in Financial Model Building: Some Extensions"; American Economic Review; March, 1971, pp 179-186.

[16]Clinton, K.; "Pitfalls in Financial Model Building: Comment"; American Economic Review; December, 1973.

[17]This question is of particular importance because Christ does assume this separability in constructing his model.

The present simulation model works in discrete time. Individuals make their decisions at fixed intervals and the system reacts until the next decision time is reached. In some markets choices seem to be revised almost continuously. However, wage income for many individuals is set by yearly contracts, and loans and investments in certain assets are often for fixed periods and decisions in these areas can be changed only at high cost during the period.

The point at issue here, whether the portfolio allocation decision is separable from the savings decisions, becomes a question of whether the Brainard-Tobin type constraints hold across the entire model or across the two subsectors separately. The control model, based on the model developed by Christ, makes the second assumption, whereas, the normal assumption in discrete time is the first.

Although this point has important theoretical implications, mathematically there is no difference if the constraints are properly imposed. This result holds because the same sort of constraints hold on the sums of the coefficients of individual demands for consumption, investment, and holdings of liquid wealth. Again with this set, one equation may be omitted as it is implied by the balance sheet equation. In the control model this becomes the demand equation for liquid wealth. To be consistent with the model its form must be,

$$\Delta wp = .3\Delta y + .72\Delta z - .1\Delta x + .05\Delta k_{-1} + .85\Delta wp_{-1}$$
$$+ 740\Delta rb + 617\Delta rl + 1850\Delta rd \qquad \text{(III)}$$

If this expression is then substituted for the liquid wealth term in the allocation equations for the financial assets, the following set of equations is obtained:

$$\frac{-\Delta L}{P_{-1}} = -.12\Delta y - .288\Delta z - .11\Delta x - .020\Delta k_{-1}$$
$$- .340\Delta wp_{-1} - 5096\Delta rb + 9753.2\Delta rl$$
$$- 2558\Delta rd - \frac{L\Delta P}{PP_{-1}} \qquad \text{(IV)}$$

$$\frac{\Delta Hp}{P_{-1}} = .0435\Delta y + .1044\Delta z + .009\Delta x$$
$$+ .0725\Delta k_{-1} + .12325\Delta wp_{-1} - 692.7\Delta rb$$
$$- 577.535\Delta rl - 1731.75\Delta rd + \frac{Hp\Delta P}{PP_{-1}} \qquad \text{(V)}$$

$$\frac{\Delta D}{P_{-1}} = .1506\Delta y + .36144\Delta z + .0036\Delta x + .0251\Delta k_{-1}$$
$$+ .42670\Delta wp_{-1} - 2428.52\Delta rb - 2023.266\Delta rl$$
$$+ 7928.7\Delta rd + \frac{D\Delta P}{PP_{-1}} \qquad \text{(VI)}$$

$$\frac{\Delta Bp}{P_{-1}rb} = .2259\Delta y + .54216\Delta z + .055\Delta x$$
$$+ .03765\Delta k_{-1} + .64005\Delta wp_{-1} + (8957.22 + \frac{Bp}{rb^2})\Delta rb$$
$$- 6535.399\Delta rl - 1788.95\Delta rd + \frac{Bp\Delta P}{rb_{-1}PP_{-1}} \qquad \text{(VII)}$$

The sums of the coefficients across these equations plus the consumption and investment functions satisfy the Brainard-Tobin type constraints and thus this system is consistent with the individual financing restraint. It should also be noted that, after this substitution has been made, the demand for asset equations do depend on the lagged value of wealth rather than on its current level.

If the demand for loans function, given as (V) above, is solved in terms of the rate on bank loans and then substituted into the set (13, 14, IV, VI, VII), the result is a series of demand equations which depend upon the quantity of loans present in the system. The coefficients on the quantity of loans in this system, where the price adjusts to clear the market, represent the proportion of loans that are expended in each particular market, whether real or financial.

The discrete nature of the present model also has implications for the variables that are perceived to enter the behavioural relationships. For instance, if the household sector believes that the income level in the current period will be unchanged from the level of the previous period, lagged income should enter the behavioural functions. Since the current level must still be represented in the accounting identities or balance sheet equations, this lack of knowledge on the part of the individuals may lead to a non-market clearing situation because of the asymmetry of variables in the two sets of equations.[18] In chapter three of this study we expand on this concept and incorporate it into one version of the disequilibrium simulation model.

The discrete nature of the model presented here is one of the most important reasons for including government bank deposits in the system, particularly in the way

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[18] The basic point here is that the individuals attempt to allocate a different quantity than that which they are constrained to allocate. The result of this constraint must either be distributed to all markets by a 'feed back' mechanism or will be felt entirely in the suppressed market. This latter case is clearly a special case of the former.

that they may affect the financing constraint. In this discrete framework the government must make its financing decision at the start of the period. However, problems may arise as the amount of financing that is actually required depends on the stochastic behavioural relationships. Specifically, since changes in the tax levels and entry into the bond market are discrete actions, their usefulness as the endogenous financing variables is reduced. This does not mean that these policies cannot be used, but it does mean that if the stochastic element is large and if government forecasts are not perfect, they must be combined with other measures. Changing the supply of high-powered money does not give rise to the same problem as currency may be printed as expenditures rise and retired when the revenues are received. This option is not available for the junior levels of government and the recent growth in these sectors makes this issue of potential importance.

In a continuous time model, this problem would not arise as all of the policy parameters may be constantly altered to meet the financing constraint. In the present context, we assume that this issue may be overcome by assuming that the deficit is financed by running down the level of government bank deposits. This policy has the added advantage, for inflationary periods, that the rate of expansion is less rapid than for the case of financing by printing money.[19]

The use of this form of financing is, of course, limited by the original size of the government deposits. However, this does not reduce the usefulness of studying the effects of such a policy since, if the government deposits are too small but the policy seems desirable, the recommendations must be for the government to increase the level of their deposits.[20] The most likely use for this method of financing is to meet first period requirements. In the next period other methods may be used to build the deposits back to their original level, with the deposits thus financing only the current period deficits. Although this may still require large levels of deposits, this problem can be reduced by shortening the length of the period of analysis.[21]

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[19]See the simulation results reported in section 2.4.

[20]Such an increase would require an increase in the required reserve ratio on the banking sector so as not to affect the financial markets too greatly.

[21]that is, changing the number of times that decisions are made from once a year, to once a quarter or once a month.

2.4 Results of the Simulation Experiments on the Control Model.

The first simulation runs that were done for this study involved the use of Christ's original model. Christ reports only the first period or impact results and is, therefore, unable to comment on the stability of the cases or on the time paths of adjustment. In fact, because of the misspecification of his model that we have already mentioned above, Christ's analysis of the long run results for some cases is in error.

The brief analysis of the long run case that he does present centers on the fact that in the long run, the budget must be balanced if the model is to be in a state of equilibrium. Accordingly, in his model Christ states that long run equilibrium is obtained when

$$\Delta^* t = \Delta^* g$$

where Δ^* refers to changes between equilibrium points.

In his model the tax-transfer function is:

$$\Delta t = u\Delta x + \Delta V/P \qquad (3)$$

Hence, since in equilibrium $\Delta^* g = \Delta^* t$, the long run multiplier must be $\Delta x/\Delta g = 1/u$, unless the deficits are financed by changing the intercept of the tax-transfer function.[22]

However, Christ neglected the fact that under the bond-financed case, the interest on the debt becomes an endogenous transfer which should be included in the tax-transfer function. Thus, the proper equation should be of the form:

$$\Delta t = u\Delta x + \Delta V/p + (u-1)\Delta B/P$$

It is still true that for long run equilibrium, $\Delta^* t$ must equal $\Delta^* g$, but this now implies that

$$\Delta g = u\Delta x + (u-1)\Delta B/P + \Delta V/P.$$

In this case,

$$\Delta x/\Delta g = 1/u - ((u-1)/u)(\Delta B/P)/\Delta g - 1/u(\Delta V/P)/\Delta g$$[23]

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[22] If the deficits are financed by changing the intercept of this function, the long run multiplier will depend on all the behavioural coefficients since the exact time path of adjustment will be important in determining how much of the tax change is due to the changed intercept and how much is due to the changed level of income.

[23] In this case, $\Delta V = 0$ for bond-financing and $\Delta B = 0$ for tax financing, both $\Delta V = 0$ and $\Delta B = 0$ for financing by printing money or running down government bank deposits.

where $(\Delta B/P)/\Delta g$ represents the interest payments on the new bonds that are required to finance the deficits in the sum of the periods until the new long run equilibrium is reached.

This means that, if the bond-financed case is stable, the long run increase in income will be larger under bond-financing than if the deficit resulted in the printing of more high-powered money.[24] This is caused by the fact that the term

$$-((u-1)/u)(\Delta B/P)/\Delta g$$

must be positive for all values of u, the marginal tax rate, positive but less than one. The size of this term will depend on all the parameters of the system and thus, in general, the long run multiplier for this case is not determined by the size of the marginal tax rate alone.

Likewise, for the case of financing by means of the level of taxation, the long run multiplier will be less than $1/u$ because the term $-1/u(\Delta V/P)/\Delta g$ will be negative. Again the exact value in this case will depend on all of the parameters of the system.

The stability of the system may be analyzed by looking at the tax-transfer function. For the bond-

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[24] Assuming $\Delta B/\Delta g$ is positive.

financed case, assuming that an increase in government spending leads initially to a deficit position, that is, assuming that income does not increase to or beyond its new equilibrium level in the first period, a necessary condition for the model to be stable is Δt positive. Therefore, the expression

$$u\Delta x + (u-1)\Delta B/P$$

must be greater than zero. However, the term

$$(u-1)\Delta B/P$$

is negative and thus, if the model is to be stable, $u\Delta x$ must be positive and greater than $(u-1)\Delta B/P$. This is equivalent to the stability condition developed by Blinder and Solow[25] for their study of the effects of fiscal policy.

Another way of looking at this adjustment process may be seen by considering the standard textbook IS-LM model shown in Figure 2-1. In the first period, the IS curve is shifted to the right from IS to IS' by the increase in government expenditures. When the deficit is financed by borrowing, the IS curve, in the first period, is shifted further to the right from IS' to IS'' as the interest payments that the government must make are

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[25]Blinder, A.S. and Solow, R.M.; "Does Fiscal Policy Matter?"; Journal of Public Economics; November, 1973, pp 318-336.

Figure 2-1: Adjustment of the Standard Textbook IS - LM Model Under Bond Financing.

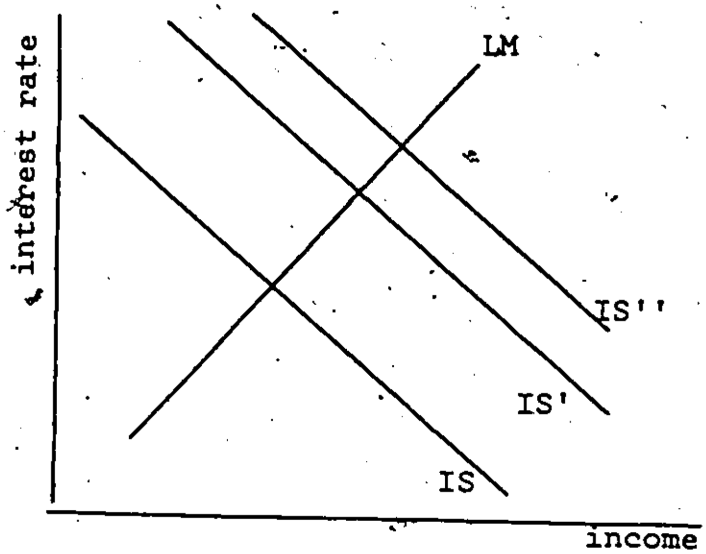
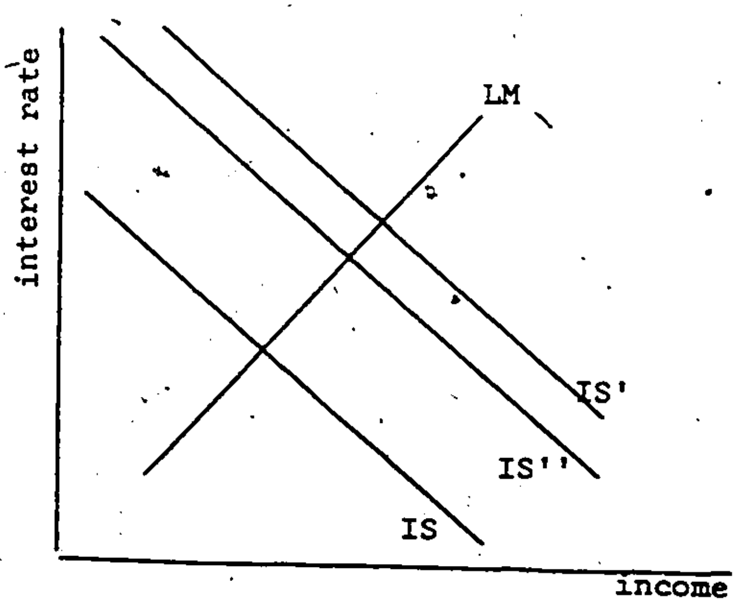


Figure 2-2: Adjustment of IS - LM Model With Exogenous Tax Financing.



increased. In each subsequent period that the budget is not balanced, the IS curve will be shifted further to the right as the interest payments are increased by additional debt issues. The stability condition for this case is that each subsequent shift of the IS curve be smaller than the last so that the system may approach a new equilibrium position. This condition is, of course, equivalent to that given above, namely that the size of the budget deficit must decline over time.

If the deficit is financed by increased taxation, the situation for the textbook model is given in Figure 2-2. In the impact period the increase in government spending again causes the IS curve to shift rightward to IS'. However, the increase in exogenous taxes required to finance the deficit, will then cause the IS curve to shift back to the left to a position IS''. In this case the IS curve will shift left each period until the deficit is removed. Thus the long run multiplier must be smaller than the impact multiplier.

The model used in this study, like the textbook model, is not well suited to answering growth questions as it has a very limited supply side. However, the long run case is presented here so that questions of stability and relative magnitudes of long run effects may be considered in relation to the debate[26] on these issues that has been carried on in recent economic literature.

The length of the time period as Christ[27] claims is somewhat arbitrary because of the *ad hoc* nature of the model. However, since most of the studies he refers to in support of the coefficients chosen are annual studies, a period is best viewed as a year. Thus a four or five period horizon is probably appropriate for most policy questions.

The simulation experiments that are reported here involve setting the values of all the exogenous variables and allowing the model to trace out the time paths of all the endogenous variables as the system adjusts to its new equilibrium position. Since the model used is in first differenced form, the only exogenous variables that need be considered are the government policy variables.

The results of the simulation runs of the control

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[26]For example see, Blinder, A.S. and Solow, R.M.; "Does Fiscal Policy Matter?"; *Journal of Public Economics*; November, 1973 and Turnovsky, S.J.; "Monetary Policy, Fiscal Policy and the Government Budget Constraint"; *Australian Economic Papers*; (forthcoming).

[27]Christ, C.F.; "A Model of Monetary and Fiscal Policy Effects on the Money Stock, Price Level, and Real Output"; *Journal of Money Credit and Banking*; November, 1969, p.690.

Table 2-1 Government Expenditure Multiplier for the Control Model. (Fixed Price Version)

	Impact	Long run
financed by		
i) printing money	3.00	4.00
ii) borrowing	2.39	unstable
iii) increased taxes	1.39	0.975
iiii) government deposits	2.49	4.00

Table 2-2 Change in price level per unit increase in government expenditure in the Control Model. (Fixed Output Version)

	$\Delta P/\Delta g$ Impact	$\Delta P/\Delta g$ Long run
financed by		
i) printing money	.0143	.03125
ii) borrowing	.009	unstable
iii) increased taxes	.004	.011
iiii) government deposits	.010	.03125

model are summarized in Table 2-1 for the fixed price version and Table 2-2 for the fixed output version. The results for the case of printing money to finance the increase in government expenditures are identical with those obtained by Christ. Thus, the long run multiplier for the fixed price version equals the reciprocal of the marginal tax rate and in the fixed output case, a once and for all increase in government expenditure of 0.6% leads to a long run increase of 3 1/8% in the price level. These results confirm that the behavioural parameters affect only the time paths of adjustment and not the position of the new equilibrium for this type of financing. However, the full model must be used if either bond financing or tax financing the increased government expenditure is to be used.[28]

When the government expenditures were financed by changing the tax-transfer intercept, the impact multipliers again were the same as for Christ's original model. However, the long run fixed output case spotlighted the

[28] Frank Steindl (1971) has been led into error by missing this point. He states that, for a model of this type, an increase in government expenditures financed by an equal increase in taxes must have a multiplier of zero. This result is obtained by using only the tax-transfer function and the government finance restraint and by assuming that the change in the high-powered money stock is the dependent policy variable. However, if an increase in taxes is to be the method of financing, then clearly, it is the level of taxation that should be the dependent variable.

importance of not generalizing from the impact results when deciding which type of financing to use. Here, the long run equilibrium multiplier turned out to be positive but less than one. Accordingly, while printing money was approximately twice as expansionary as financing by taxation, in the first period, it led to an increase in output more than four times as great in the long run.

Still, it was the case of bond financing that showed the most striking evidence of the importance of considering the dynamic nature of the adjustment to policy changes. Again, the impact results were approximately equal to those obtained by Christ.[29] However, in the long run, this version of the model proved to be unstable for both the fixed output and the fixed price cases. For stability, the absolute magnitude of the first differences must decline over time as all variables approach new constant levels. In this case, on the other hand, the level of net borrowing and the price level (level of output) increased through time without limit. However, although this version of the model was 'explosive', the rate of increase was not great and thus, the values of the various

[29]The minor differences are due to the way that the interest on the government debt enters the model.

variables did not shoot off rapidly to infinity but instead rose gradually at an increasing rate. This accelerating rate of increase might be viewed as advantageous in periods of high unemployment but would clearly be considered disastrous as the economy approached the full capacity output position.

The case of financing by allowing the government bank deposits to run down resembles the bond-financing case in the short run but approaches the same stable long run position as the money-financed case does. This case seems to be more suitable for the full capacity version of the model. However, the size of government deposits required to finance the deficits is quite large.[30] Thus, this method of financing should be combined with another method to rebuild the level of deposits in the next period.

There are two important conclusions that may be drawn from the results of this simulation experiment. The first is that, in general, looking only at the first period results of policy action is misleading and, therefore, a dynamic study of the paths of adjustment is necesary to get a clear picture of the true effects of the

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[30]The loss of deposits in this case will be .378 billion dollars in the first period and approximately 5 billion dollars in the long run.

Figure 2-3. Time path of the government expenditure multiplier for various methods of financing the budget deficit in the control model.

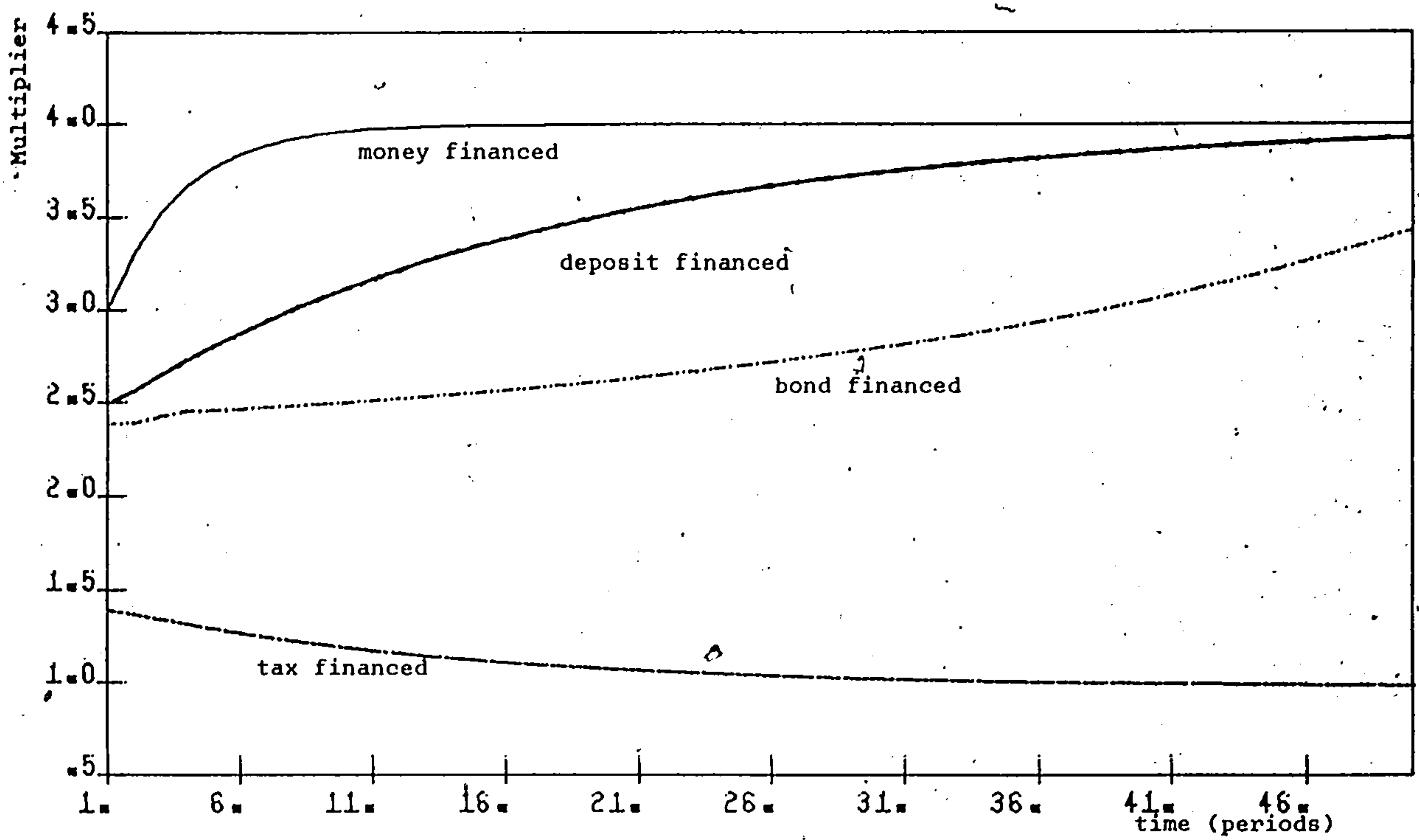
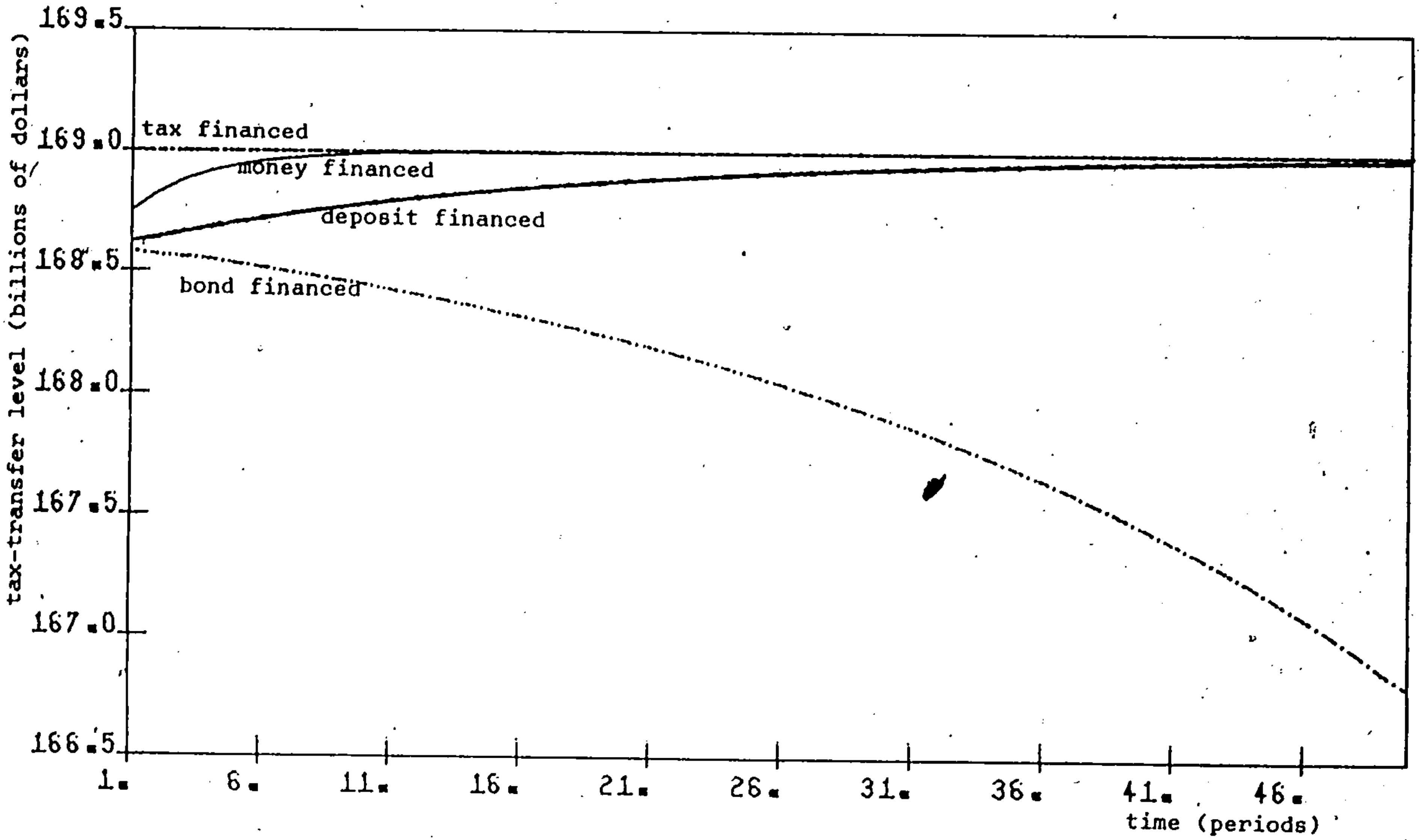


Figure 2-4. Time path of the tax-transfer level for various methods of financing the budget deficit in the control model.



policy action. These time paths for the income levels and the level of taxes-transfers are given in Figure 2-3 and Figure 2-4 respect~~ively~~.

The second main point developed by ~~this~~ study is that if this model may be viewed as a good approximation of the real world, one must seriously question the wisdom of financing increasing levels of government spending by borrowing from the public. This is especially true for periods of near capacity output (the fixed output version of the model) as the result is a moderate but ever increasing rate of inflation.

The effects of letting the current period deficit be financed by running down government bank deposits are explored in the next set of simulations. In this version of the model, the drop in deposits is offset by one of the other means of financing with a one period lag. The results obtained from these runs are summarized in Table 2-3.

As can be seen from Table 2-3, the model is stable for all means of secondary financing. When the reduction in government bank deposits is replaced, in the next period, by printing more high-powered money, the system

Table 2-3 Government Expenditure Multiplier with Deposit Financing in the Control Model.

	Impact	Long Run
secondary financing by		
i) printing money	2.49	4.0
ii) borrowing	2.49	4.8
iii) taxation	2.49	1.607

has the same long run multiplier as the earlier money-financed case. However, the process of adjustment is less rapid in the early periods.

When increased taxation is used as the method of secondary financing, the system proves to be stable and adjustment is more rapid than for the case of primary-tax-financing. This results from the fact that the impact multiplier for the deposit-financing case is much larger than the impact multiplier for the tax-financing case. Indeed, the long run multiplier for the secondary-tax-financing case is greater than unity, while the long run multiplier for the primary-tax-financing is less than one.

As Figure 2-4 clearly shows, the earlier mentioned bond financed case is unstable. In the present situation, however, the addition of government deposits makes secondary bond financing stable. This result is intuitively pleasing as the amount of the government budget deficit that must be financed by issuing bonds is less than in the case of primary bond financing. Thus, it is more likely that the stability condition derived above will be met. Also, as expected, the long run multiplier is larger than if the deficit was financed by printing money.

The simulation results of this system, for all three cases, are summarized in Figure 2-5 for the adjustment in the level of income and in Figure 2-6 for the adjustment in the level of taxes-transfers. These graphs when compared with Figure 2-3 and Figure 2-4 show that deposit financing has a good deal of merit.

In the original article[31] which presented the model upon which this control version of the current model is based, Christ conducted a sensitivity analysis on the first period effects. He concluded that results of the system were most sensitive to the slopes of the behavioural functions with respect to disposable income, capital gains,

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[31] Christ; *op. cit.* p 702.

Figure 2-5. Time path of the government expenditure multiplier for deposit financing and various methods of secondary financing in the control model.

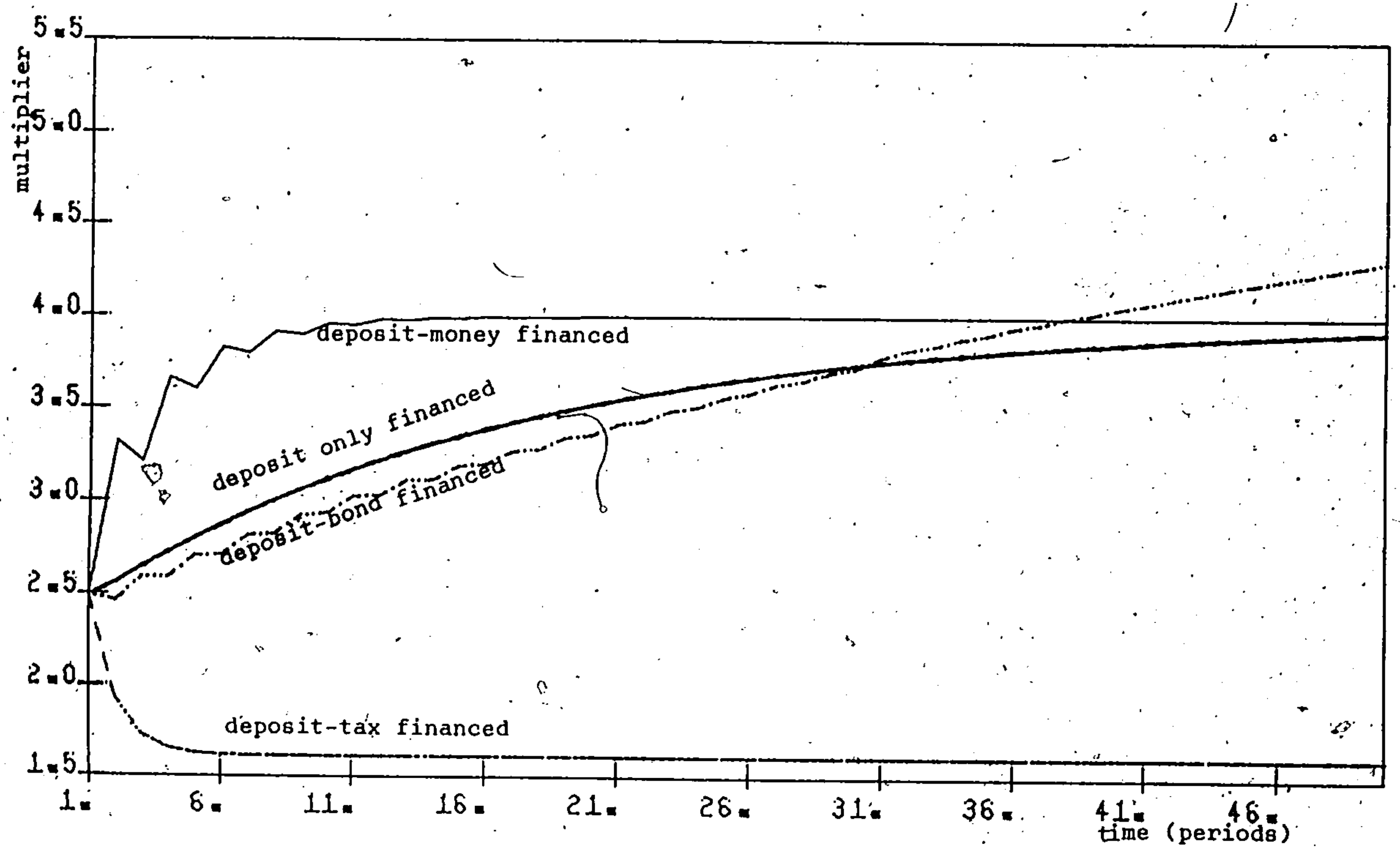
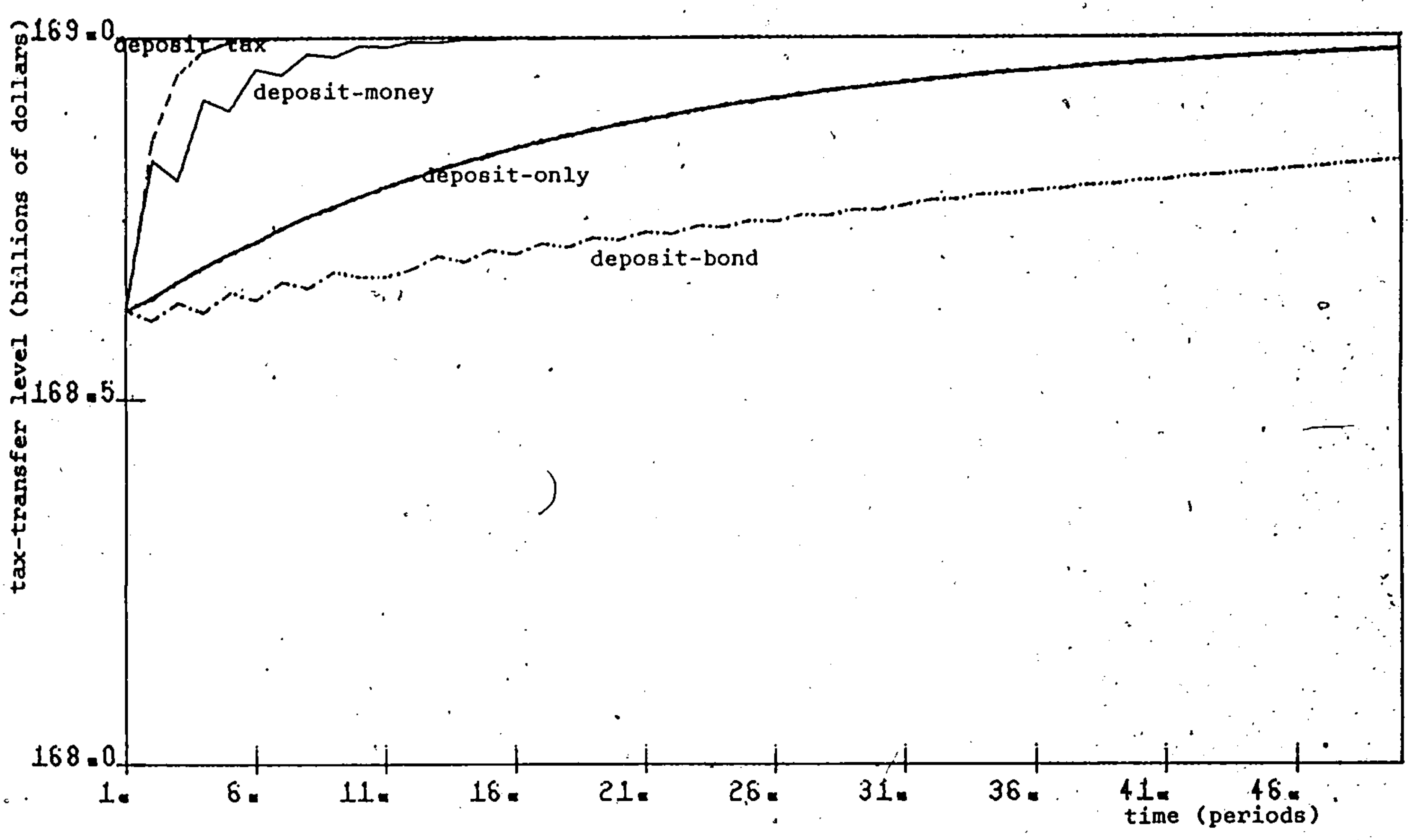


Figure 2-6. Time path of the tax-transfer level for deposit financing and various methods of secondary financing in the control model.



private nonbank liquid wealth, and bank assets. As well, the model appeared to be very sensitive to change in the marginal tax rate. Christ claims that these are the areas in which the best estimates are available and hence the results of the model can be given added weight. However, as the present study shows, this is not necessarily the case. The present study shows that even very small changes may have great impact because the model appears to be very close to the critical values separating the stable and unstable ranges. Also, although the marginal tax rate is easy to estimate, the important parameter is the marginal tax-transfer rate and it is not as clear how the level of transfers will react to a change in income.

In their paper on the effects of fiscal policy Blinder and Solow[32] conclude that the stability of the method of financing government expenditures by issuing government debt, depends on much the same set of critical parameters as is mentioned above. In particular, they single out the importance of the marginal tax rate and the coefficient on wealth in the consumption function.

The system does, in fact, appear to be extremely sensitive to the effect of wealth on the consumption

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[32] Blinder and Solow; op. cit.; p 335.

decision. For example, the control model assumes that the coefficient on lagged private liquid wealth in the consumption function is 0.15. In this case, the model proves to be unstable and expansionary, that is, a unit increase in government expenditure will cause the level of income to increase without limit. If the value of this parameter is decreased to 0.12, the system is unstable but contractionary for several periods following the impact increase.

These features of both the control version and the disequilibrium version of the model are tested at greater length in the sensitivity analysis carried out in chapter four of this study.

2.5 Summary

This chapter has developed a control model to which the results of the disequilibrium model of chapter three may be compared. This version of the model is based on an extended version of a model developed by Carl Christ. The model is consistent with the model building constraints suggested by Brainard and Tobin. Since the model is fully constrained, the amount of loans expended in each market is implied by the coefficients on the loan rate in each of the demand equations.

The simulation runs of the control model are interesting for the case of bond-financing. This case of the model is shown to be unstable. This is especially important for the case of near capacity output. In this case, the recommendation often has been to use bond-financing rather than printing money in order to reduce the inflationary pressure of increased government spending which may be required for welfare considerations. This model suggests that this may be the wrong policy to follow.

This chapter has also expanded the theory of the government finance restraint to include the case in which financing is by transferring government deposits to the private sector. This case proves to be less expansionary than financing by printing money, in the short run.

III

A DISEQUILIBRIUM SIMULATION MODEL.

3:1 Introduction

Although economists have long recognized the relevance of studying individual markets in disequilibrium a 'general disequilibrium theory' is a recent idea. To date, most work on disequilibrium models seems to have taken place at the micro level. Accordingly, we cannot yet evaluate the importance of considering such features when undertaking overall government stabilization policy actions. Such an evaluation must await the formation of an aggregate macroeconomic model which includes disequilibrium feedbacks, along with the standard features so that the results may be compared.

It is the purpose of the present chapter to develop such a system. This is done by modifying the model presented in chapter two to allow analysis of the situation which arises when prices do not adjust in such a way as to clear every market each period. This process imposes additional quantity constraints on the system which are not required in the equilibrium version. The implications of this system for government policy action are described in chapter four.

The outline of the rest of the current chapter is as follows: Section 3.2 surveys some of the most important contributions to the current theory of disequilibrium systems. Some of the possible sources of disequilibrium are discussed and the underlying assumptions which give rise to them are evaluated in section 3.3. The basic structure of this version of the model is then described in section 3.4. Finally, a summary of the features of the disequilibrium model developed in this chapter is found in section 3.5.

3.2 A Survey of Disequilibrium Theory

The fundamental issue involved in the examination of a disequilibrium system arises because the existence of one market that does not clear means that all other markets will be affected. This results from what Clower[1] has called the 'Dual Decision Hypothesis'. To see this, consider the maximization of a utility function,

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[1] Clower, R.; "The Keynesian Counterrevolution: A Theoretical Appraisal"; In Haln and Brechling, ed.; <u>The Theory of Interest Rates</u>; MacMillan; Toronto; 1968.

$U(d_1,\ldots,d_m;s_{m+1},\ldots,s_n)$ subject to the budget constraint, $\Sigma_i^m p_i d_i - \Sigma_j^n p_j s_j - r = 0$, in order to find 'notional demand' functions. The d_i's represent goods, the s_j's factors, the p_i's prices, and r the profit factor. The notional demand functions $d_i(p_i,\ldots,p_n,r)$ depend only on all prices but on no quantities. Now, if the individual encounters a constraint in either a factor market, or a goods market, a second round of decision making is indicated. Assume he is constrained in the factor markets such that $\bar{s}_j$ is the constrained amount in each. Hence the function $U(d_i,\ldots,d_m;\bar{s}_{m+1},\ldots,\bar{s}_n)$ is maximized subject to $\Sigma_i^m p_i d_i - \Sigma_j^n p_j \bar{s}_j - r = 0$. In this case, the 'constrained demand' functions are $d_i'(p_i,\ldots,p_n,Y)$ where by definition $Y = \Sigma_j^n p_j \bar{s}_j + r$.

There are two important points to note here. First, while the notional demand functions depend only on prices, the constrained demand functions also include the quantity of every factor (good) where a constraint was encountered. Second, in general, for every market, d_i' will not equal d_i and hence, even if only one market is not cleared, the demands for all commodities will be different from what they would have been if full equilibrium had occurred.

Barro and Grossman[2] use this technique to analyze the feedbacks between the output and employment markets when there is disequilibrium in either. They criticize conventional theory for allowing disequilibrium only in the labour market. "Because of this perculiar asymmetry, previous analyses of unemployment have had to rely on such contrived devices as a countercyclical pattern of real wages or fixed proportion production functions.[3]

Grossman[4] has extended and modified Clower's Dual Decision process. His system treats all goods and services, including labour services, as a single homogeneous commodity, y, with a single money price, P. He also has a single form of debt, b, with an interest rate, r, and money, n. All variables are measured in money terms. In general equilibrium, under this system, prices and interest rates are consistent with zero excess demands for commodities, debt, and money balances. In disequilibrium there may be three different excess demands but only two relative prices, the rate of interest

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[2]Barro, R.J. and Grossman, H.I.; "A General Disequilibrium Model of Income and Employment"; American Economic Review; March, 1971.

[3]Ibid, p 93

[4]Grossman, H.I.; Money, Interest, and Prices in Market Disequilibrium"; Journal of Political Economy; September/October, 1971.

and the general price level. The excess demands for each asset are found by maximizing the individual's objective function subject to his budget constraint

$$y_i + b_i + n_i = 0.$$

To find the relationship between the notional demands and the 'effective' or constrained demands for commodities (y') and for money (n') assuming a constraint in the debt market ($\bar{b}$), the maximization problem is repeated subject to the effective financing constraint

$$y_i' + \bar{b}_i + n_i' = 0.$$

The result is of the form

$$y_i' = y_i + \alpha_i\ (b_i - \bar{b}_i)$$

where $$n_i'(y_i', \bar{b}_i) = n_i + (1-\alpha_i)(b_i - \bar{b}_i)$$

and $$\alpha_i = \alpha_i(r, P, \bar{b}_i).$$

That is, the effective excess demands have the same functioned form as the desired excess demands, with the addition of the feedback effect from the constrained market. If debt, commodities and money balances are all net substitutes, all markets will be affected by the presence of a constraint and thus α_i will be between zero and unity.

If the individual is also constrained in the commodity market, the desired decisions in the other markets will be modified by a similar feedback mechanism of the form

$$b_i' = b_i + \beta_i(y_i - \bar{y}_i)$$

where $n_i'(\bar{y}_i, b_i') = n_i + (1-\beta_i)(y_i - \bar{y}_i)$

and $\beta_i = \beta_i(r, P, \bar{y}_i)$.

Again the feedback coefficient, β_i, will be within the range

$$0 < \beta_i < 1.$$

Upon aggregation, Grossman's spillover coefficients depend on the number of markets in which each individual considers himself to be constrained, on the individuals position in the rationing queue, (that is, what proportion of the total market constraint the individual faces), as well as on the variables coming from the utility function and the budget constraint.

Changes in the general price level and the rate of interest are governed by a partial adjustment mechanism of the form

$$DP = \lambda y' \text{ and}$$
$$Dr = ub',$$

that is, a partial adjustment mechanism based on the constrained excess demands rather than on the desired excess demands.

Although this theory is fairly well established at the micro level, it has not yet been adequately applied in macro models. One model that has attempted this process has been developed by Tucker.[5] Disequilibrium in this model is caused by lagged adjustment in the loan market and in the output market. In the loan market, the interest rate partially adjusts in response to the gap between desired lending and desired borrowing, including government activity in the lending market. In the output market, the level of output partially adjusts to the gap between aggregate demand and current supply. The exact forms of the adjustment equations are

$$\frac{dR}{dt} = k(B^{**} - L^{*} - \frac{dM}{dt})$$

and

$$\frac{dY}{dt} = n(C^{**} + I^{**} - Y).$$ [6]

The rest of the model is divided into two sectors, an investor-borrower sector and a consumer-lender sector. There is no banking sector and the only allowable government activity is entry in the lending-borrowing market. There is no government debt, save money and for analytical simplicity, the only case that Tucker investigates is the

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[5]Tucker, D.P.; "Credit Rationing, Interest Rate Lags, and Monetary Policy Speed"; Quarterly Journal of Economics; February, 1968

[6]Where B^{**} is constrained borrowing, L^{*} is constrained lending, C^{**} is effective consumption and I^{**} is effective investment.

one in which the rate of expansion of the money supply equals the rate at which the flow demands for money, in both sectors, remove the gap between desired and actual stocks.

The lack of a banking sector forces firms, in their investment spending, to face the full effects of rationing as consumers never borrow. The feedback relationship is:

$$I^{**} = I^{*} - h(B^{*} - B).$$

Here, effective investment demand equals desired investment minus a fraction, h, of the amount of rationing (desired minus actual borrowing). The remaining fraction (1-h) of the rationed amount is assumed to be financed from other means; thus the model is inconsistent as investors are assumed to borrow to finance everything.[7]

Desired borrowing equals desired investment plus the desired flow demand for money by investors. Desired private lending equals income minus the sum of desired consumption and consumer flow money demand.

The rest of the model is consistent with a linear

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[7] Consistency here requires a feedback into the demand for money by investors as this is the only other possible source of funds in this model.

form of the standard IS - LM model with no government sector.

Tucker solves this system analytically under the assumption that the supply is reduced according to

$$M = M_0 - (1 - e^{-mt})$$

where m is the rate of money demand adjustment in the private sectors. All stability conditions are assumed to hold and, indeed, the possibly destabilizing element of interest bearing government debt is absent from the model. The solution shows that the time path of adjustment may be either monotonic or cyclical depending on the values of the partial adjustment coefficients and the values of the feedback coefficient.

The analytical solution to this model is very complex; in fact, the model appears to be about the most complicated for which such a solution is feasible. At the same time, it is much too simple to be of much use in the present study which involves an evaluation of the impact of allowing for disequilibrium feedbacks when considering a broad range of government policy actions. Accordingly, the more complex model given in chapter two is modified to reflect the disequilibrium conditions and simulations are carried out with it. An analytical solution which is bound to be extremely difficult to interpret, is not attempted.

3.3 Possible Sources of Disequilibrium

The main source of disequilibrium in this study results from credit rationing in the bank loan market. This occurs in the model whenever the yield on bank loans does not fully adjust to the demand and supply in the market.

Recent work by Jaffee and Modigliani[8] has already provided a theoretical justification and an empirical test of the existence of credit rationing in the commercial loan market. In their model, because of institutional constraints in the loan market, disequilibrium may occur even in a steady-state position. This results from the fact that the bank will regard each borrower as having a different risk of default. Therefore, in general, a different rate of interest should be charged to each borrower even for the same size of loan. Thus, they state that if the bank acts as a "discriminating monopolist", each individual borrower will face a different loan rate, the loan rate will adjust to clear the lending market, and credit rationing will not exist. However, in practice, either for fear of usury laws,

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[8] Jaffee, D.M. and Modigliani, F.; "A Theory and Test of Credit Rationing"; <u>American Economic Review</u>; December, 1969.

social pressure, competition, or simply because of a conservative tradition, bankers tend to charge the same rate of interest to broad classes of borrowers. Thus, if an individual borrower wishes a larger loan than the bank is willing to lend, at the going rate for his group, the result will generally be a smaller than desired loan rather than an increase in the interest rate to clear the market. Jaffee and Modigliani call this result 'equilibrium credit rationing'.

This theory is consistent with the view that the desire to have good customer relations influences a bank's behaviour. Such a desire would affect the banks subjective view of the likelihood of default. Accordingly, the theory suggests that rationing would be greater to individuals who desired the loan for consumption as opposed to the case for individuals (firms) who desired the loan for investment purposes.[9] The incidence of the rationing would of course be least for individuals who used the loan to acquire assets, particularly bonds. This does not mean that such individuals actually use the loans to purchase new bonds, but instead, they may use new loans

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[9] This assumes that banks will in general place a higher subjective default risk on individual consumers relative to large corporate investors.

rather than selling existing bonds to finance their current expenditures.

Jaffee and Modigliani also consider the possibility that the interest rate charged to a whole group or class of borrowers may not be at the optimal position from the bank's point of view. If there is any lag in the adjustment of the rate to this optimal position, the concept of 'dynamic rationing' will also be present.

There are some important differences between these concepts of rationing and they affect how the disequilibrium assumption is introduced to the model. The most fundamental difference occurs because dynamic rationing implies some upward pressure on the loan rate, while equilibrium rationing does not. In fact, an increase in the loan rate may reduce or increase the level of equilibrium rationing. The possible reduction in the level of equilibrium rationing in this case is caused by the effect of the loan rate reducing demand for loans and possibly increasing supply. However, the larger the loan rate, the greater will be the probability of partial default in repayment as the total to be repaid will be larger. This risk effect may well cause the level of rationing to increase, especially if the new optimal loan rate is much higher than the old.

The discrete nature of the model also results in additional possibilities of disequilibrium. Still, in the banking sector, it is possible that loan and deposit rates may be adjusted only by discrete amounts, for example by the amount of .25%. This may be caused by large costs (advertising or accounting) involved with small changes in the optimal rates. While this concept may not appear significant because of the magnitudes, it is to be remembered that in the present model this means that a change in the loan rate must be at least 4.16% of the total level[10] and clearly a change of less than this amount could have a large impact on desired quantities. While this discrete nature of the system can cause disequilibrium in the loan market similar to that caused by other actions as described above, this is not the case for the deposit market. The deposit market must always clear as the supply of these assets is assumed to be perfectly elastic at all rates of interest.

As mentioned in chapter two, the discrete nature of the system may cause disequilibrium in markets other than the loan market as well. This can occur if the desired demand equations depend on lagged values as the

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[10] that is, .25/6.0.

individuals look at last period's position when making decisions for the current period. This will force the system into disequilibrium as the individuals attempt to equate their demand to a supply that is different from the actual amount offered, or plan to expand a different quantity of funds than is actually available. Although this disequilibrium might also cause a second or feed-back round of maximization to occur, the fact that this type of disequilibrium is caused by lack of information suggests that its impact should be restricted to the suppressed or residual equation. For example, if the individual thinks that income change will be the same as last period, while in fact it will not be, the difference is assumed to be allocated through the suppressed demand for liquid wealth into the residual demand for currency.

This system may cause quantities demanded in the real sector to be different than they would have been in full equilibrium. In the asset markets the rates will still adjust to clear the markets because of the actions of the banking sector.

3.4 The Model

The control version of the model is contained as a subset of the disequilibrium version of the model. When all markets are being cleared, the desired and the constrained quantities are identical and thus the feedback effects will disappear.

In setting up the disequilibrium form of the model, the first change that must be made involves the determination of the loan rate. In the control version of the model, quantity demanded always equalled quantity supplied. Thus, the loan rate adjusted to force this equality. In the present context, however, there is no reason to believe that this will be the case. Equations (17) and (8) will continue to give the quantity of loans demanded and the quantity of loans supplied respectively. In this case, however, a third equation must be added to the loan market. This extra equation will set the loan rate and its exact form will depend on just how the disequilibrium is created.

The basic assumption behind all of the disequilibrium theory is that the bank sets both the quantity supplied and the price or interest rate level. If the system is to be in equilibrium the bank must set the rate that will clear the market at the level that the bank wishes to supply. This rate may be calculated by solving the demand for deposits equation (17) in terms of the loan rate. Thus if the banks are to set both the quantity and the price for an equilibrium system, the equation that sets the loan rate must be:

$$\Delta rl^* = (.4\Delta wp + .15\Delta x = \frac{L\Delta P}{PP_{-1}} + 4800\Delta rb + 1818\Delta rd - \Delta L^D)/10000$$

where rl* is defined as the equilibrium or desired loan rate.

If the disequilibrium is caused by dynamic credit rationing, the process will resemble the normal partial adjustment procedure.[11] Here the loan rate will adjust from one optimal level to the next according to the following equation:

$$rl - rl_{-1} = \lambda(rl^* - rl_{-1})$$

where λ is the lagged adjustment coefficient. Taking first differences of both sides and re-arranging terms yields the final form of the equation used in this version of the model.

$$\Delta rl = \lambda\Delta rl^* + (1-\lambda)\Delta rl_{-1} \qquad (22).$$

In this version of the model, adjustment will depend upon the value of the adjustment coefficient λ. If λ equals unity, the system will adjust instantaneously to the market clearing position. If on the other hand, λ equals zero, there will be no adjustment as the

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[11]that is, the normal partial adjustment procedure is the same as a disequilibrium model except that it omits the feedback effects.

initial value of Δrl_{-1} is also zero. This would be an example of equilibrium credit rationing.

Once the loan rate equation has been added the model requires only the addition of the feedback mechanism to be complete. Specification of this mechanism involves a series of equations explaining the difference between the desired demands and the constrained demands. This is equivalent to showing how the reduction in funds due to credit rationing is allocated to reductions of the various types of expenditures.

Thus the following equations are added to the model:

$$\Delta C = \Delta C^* + \alpha_c(\Delta L^D - \Delta L^S) \qquad (23)$$

$$\Delta I = \Delta I^* + \alpha_i(\Delta L^D - \Delta L^S) \qquad (24)$$

$$\Delta D = \Delta D^* + \alpha_d(\Delta L^D - \Delta L^S) \qquad (25)$$

$$\frac{\Delta Bp}{rb} = \frac{\Delta B^*p}{rb} + \alpha_b(\Delta L^D - \Delta L^S) \qquad (26)$$

$$\Delta H = \Delta H^* + \alpha_h(\Delta L^D - \Delta L^S).$$

However, since the feedback coefficients must add to minus one, as the total reduction in loans must equal the total reduction in private spending on both goods and assets, only equations (23-26) are added. The remaining equation is implied by the balance sheet equation.

This feedback mechanism is a binding constraint on the system only if the amount of credit rationing is positive, ~~that~~ is, a borrower cannot be forced to take a loan that is larger than the one that he desired. Thus, the system (23-26) is effective only for cases where

$$\Delta L^D > \Delta L^S.$$

The exact values of the feedback coefficients depend partly on the individual's utility function (will rationed consumer spend less or will he consume the same amount by drawing from his holdings of deposits, bonds, and currency?) and partly on the bank's rationing preference (the bank may prefer to ration the individual consumer rather than the corporate investor). This last concept is analogous to the position of the individual in the rationing queue, that is, it is a question of how much of the total rationing the individual is subject to.

The α's used in the initial simulations have been estimated by Ordinary Least Squares using residuals from the structural equations of the model. The procedure is not strictly valid for two reasons. First, it is well-known that unless the omitted variable is orthogonal in the sample, to the other independent variables in the equation, regression of the residual on the omitted variable will produce a biased estimate of the coefficient of the omitted variable. Secondly, this particular model is a simultaneous model and the treatment of the problem of omitted variables in a simultaneous system is not well documented.

Nevertheless, this approach provides us with an initial set of estimates for use in the simulations and a detailed sensitivity analysis of the responses of this model to a whole range of parameter values is carried out in chapter four.

Considering the consumption function as an example, the equation to be estimated is

$$\Delta C' = \Delta C^{*} + \alpha(\Delta L^{D} - \Delta L^{S})$$

where C' is effective consumption, C* is notional or desired consumption, α is the feedback coefficient, L^D is the amount of loans desired and L^S is the amount of loans offered. Since data on the desired variables is not available, actual data[12] was substituted into the desired equation of the model, thereby predicting the desired levels. The effective or constrained values were assumed to be the same as the actual data series. The equations were then estimated in the form:

$$(\Delta C' - \Delta C^{*}) = \alpha(\Delta L^{D} - \Delta L^{S})$$

The results of this process are given in Table 3-1. Except where specifically stated otherwise, these are the

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[12] Annual U.S. data from Survey on Current Business for period 1952-1969.

Table 3-1 The Feedback Coefficients

	α	t ratio
consumption	-.318	4.92
investment	-.076	4.10
bonds	-.248	2.36
deposit	-.179	3.09
currency	-.201	6.55

values of the α's in equations (23-26) that are assumed throughout this study.

The only remaining change in the basic model is that the private demand equations now become the desired demand equations. Thus equations (13-16) are modified to become:

$$\Delta c^* = .7\Delta y + .278\Delta z - 500\Delta rb - 417\Delta rl - 1250\Delta rd + .5\Delta wp_{-1} \qquad (13')$$

$$\Delta i^* = .1\Delta x - 240\Delta rb - 200\Delta rl - 600\Delta rd - .05\Delta k_{-1} \qquad (14')$$

$$\frac{\Delta B^*_p}{rb_{-1}P_{-1}} = .753\Delta wp + .0809\Delta x + \frac{Bp\Delta P}{rb_{-1}PP_{-1}} + \left(8400 + \frac{Bp}{rb_{-1}rbP_{-1}}\right)\Delta rb - 7000\Delta rl - 3182\Delta rd \qquad (15')$$

$$\frac{\Delta D^*}{P_{-1}} = .502\Delta wp + .0538\Delta x + \frac{D\Delta P}{PP_{-1}} - 2800\Delta rb$$

$$- 2333\Delta rI + 7000\Delta rd \qquad (16')$$

The full model used in the simulation study of the disequilibrium version of the model consists of twenty-six equations. Equations (1 - 11 and 12') represent the definition of the government sector, and the identities facing the private sector. Equations (13' - 16' and 17) represent the desired demand equations for the private sector. Equations (18 - 22) describe the behaviour of the banking sector. Finally, equations (23 - 26) represent the disequilibrium feedback mechanism. The full disequilibrium version of the model is given in Appendix C.

Although the main focus of the study is on the effects of credit rationing, that is, on the results of the model described above, the possibility of disequilibrium caused by the discrete nature of the model is also examined. In this case, the independent variables of the desired demand equations of the private sector become lagged one period as these are the values known when the individual decisions are made at the beginning of the period. The banking sector and the identities still involve only current variables as before.

3.5 Summary

We have now surveyed the current literature on disequilibrium systems and then extended the basic or control version of the model, which was developed in chapter two, in such a way as to be consistent with a disequilibrium system.

In chapter four this model is used to show how disequilibrium of the type discussed here affects the results of various kinds of government policy actions. Thus the major objective of this chapter has been to incorporate the existing theory on disequilibrium systems into a moderately complex macroeconomic model. This will facilitate study of the comparative effects of stabilization policy actions under the different systems and will lead to an evaluation of the importance of considering the disequilibrium phenomenon.

IV

THE SIMULATION EXPERIMENTS

4.1 Introduction

This chapter reports and interprets the results of the simulation study of government stabilization policies within the framework of the disequilibrium model developed in the previous chapter. A simulation experiment involves setting the values of the exogenous variables and allowing the model to trace out the time paths of the endogenous variables. Since the model used here is in first differenced form, the only exogenous variables are the government policy variables. For the most part, the simulation experiments involve a once and for all increase in government expenditures of one billion dollars.[1] This increase in expenditure is partly financed by endogenous tax changes and partly by other government actions[2] as required by the government finance constraint. The analysis concentrates on the time path

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[1]This represents an increase of approximately 0.6% from the initial equilibrium value.

[2]Such actions include exogenous tax increases, printing money, selling bonds and running down government deposits in the private banking sector.

of the government expenditure multiplier as it adjusts from its impact value to its long run position. Of particular interest are the relative magnitudes of the multiplier under various means of financing the government's deficit during the process of adjustment.

The model used for these experiments is subject to the same asymmetry that current writers[3] have blamed for making the procedures unwieldy under analytical analysis. The reaction of the model to credit contraction differs from its reaction to credit expansion. As credit is tightened, desired loan demand will exceed loan supply in the early stages of adjustment and, therefore, a constraint is imposed on the private sector as individuals find that they cannot finance their desired expenditures. If credit conditions are being eased, however, desired loan supply will exceed loan demand. In this case, there is no additional constraint on the private sector as individuals cannot be forced to accept larger loans than they wish at the going rate.

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[3]See Tucker, D.P.; "Credit Rationing, Interest Rate Lags, and Monetary Policy Speed"; Quarterly Journal of Economics; February, 1968, p 67-68, and Korliras, P.G.; "A Disequilibrium Macro Model"; Quarterly Journal of Economics; February, 1975, p 56-57.

While this asymmetrical nature of the model makes analytical solution difficult, especially when the adjustment path is cyclical, no such problem exists for the simulation process as the program is easily able to separate periods of effective constraints from those periods where no such restrictions are felt.

However this asymmetry must be remembered when trying to explain the different results obtained under alternative means of financing the government deficit. When an increase in government spending is financed by printing money, the disequilibrium model predicts that if the loan market does not clear, desired loan supply will exceed desired loan demand. Thus there is no constraint on the behaviour of the private nonbanking sector.[4] The results in this case will not be the same as those obtained with the control model for, with a different value of the loan rate, the individuals' desired actions will be changed.

When an increase in government expenditure is financed by issuing bonds, increasing exogenous taxation

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[4]There will of course be a reallocation of bank assets.

or running down government deposits, the disequilibrium model predicts that credit rationing will occur and thus the disequilibrium feedback mechanism will constrain the decisions of the private sector.

The results of the simulation experiments are discussed in section 4.2. Sensitivity analysis of some key parameters of the system is presented in section 4.3 as a test of the results of the model. Section 4.4 summarizes the chapter and draws some conclusions.

4.2 The Simulation Results

The first set of simulation experiments performed on the disequilibrium version of the model simply repeated the runs reported in chapter two for the control version, with the added assumption that the loan rate does not fully adjust each period to clear the lending market. Thus the results obtained in chapter two represent the case when the partial adjustment coefficient, λ in equation (22), is equal to unity. The first experiment with the disequilibrium model makes the other extreme assumption, that λ equals zero. Subsequently, intermediate values of the loan rate adjustment coefficient are tried.

The results of these simulations, depending on how the government budget deficit is financed, are

Table 4-1 The Government Expenditure Multiplier for the Disequilibrium Model with $\lambda = 0$

	Impact	Long Run
financed by		
printing money	3.00	4.0
borrowing	2.58	7.5
increased taxes	1.46	1.39
government deposits	2.70	4.0

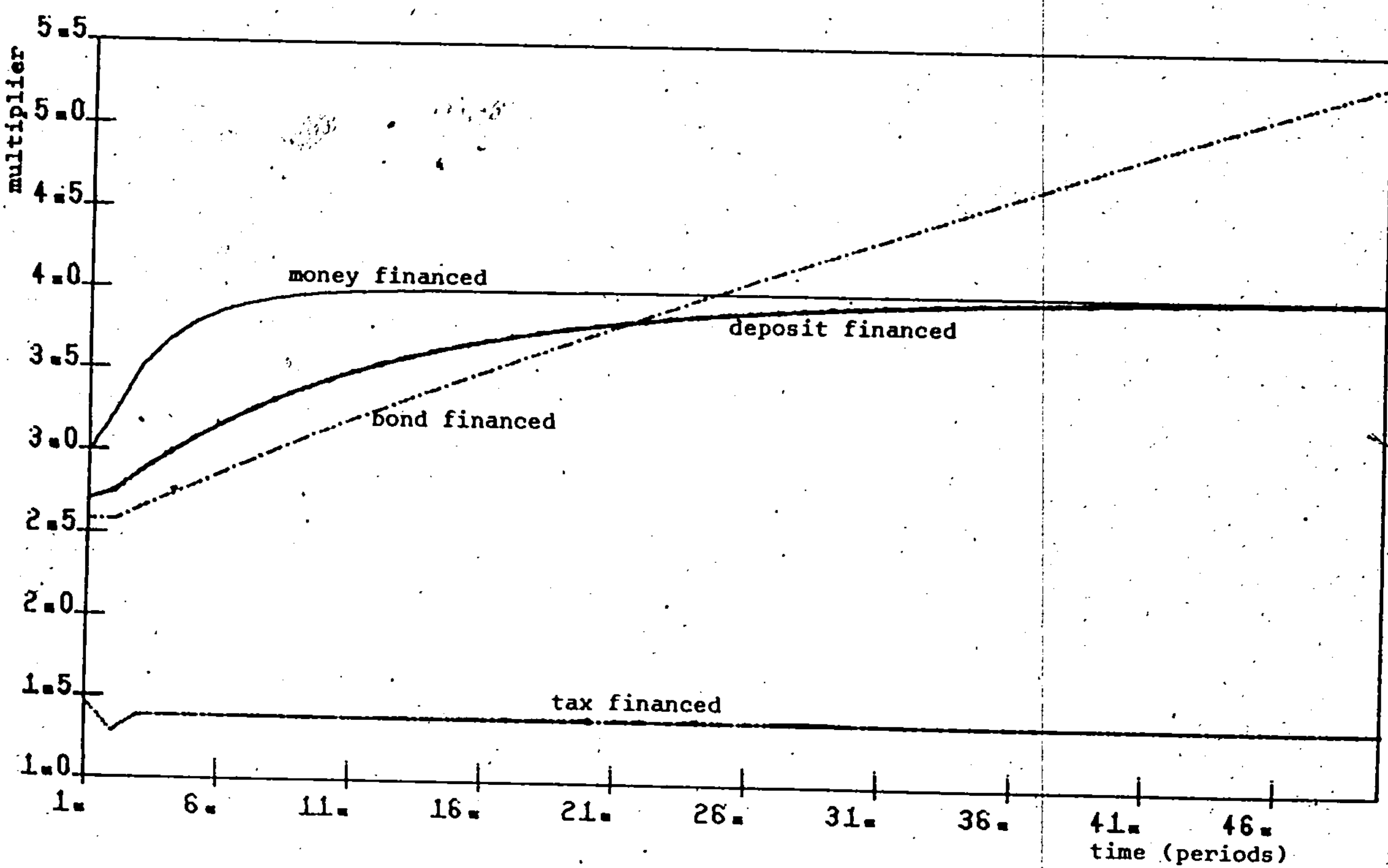
summarized in Table 4-1.[5] The money-financed case appears to be identical to what it was in the control model. However, by comparing Figure 4-1, which gives the time path of the multipliers for the disequilibrium model, with Figure 2-1 which shows the same paths for the control model, it may be seen that the adjustment is slightly faster[6] in the disequilibrium version of the model.

The tax-financed case is also slightly more expansionary in the disequilibrium model. The impact

[5]The ratio of credit rationing to the stock of loans is quite small, but as a percentage of the flow demand for loans, it varies from 55% for deposit-financing to 5% for money-financing.

[6]The difference is really insignificant.

Figure 4-1. Time path of the government expenditure multiplier for various methods of financing the budget deficit in the disequilibrium model.



multiplier is 1.46 when the loan rate does not adjust as opposed to 1.39 when it does clear the market. As in the control model, this impact multiplier is larger than the long run multiplier. However, in the present case, the long run tax-financed multiplier is greater than unity while in the control experiments it proved to be less than one. As developed in chapter two, the long run multiplier for the case of exogenous tax increases to maintain a balanced budget position will be

$$\Delta x/\Delta g = 1/u - (1/u)(\Delta V/P)/\Delta g.$$

The size of the term $(1/u)(\Delta V/P)/\Delta g$ will depend on the size of the deficit[7] and on the length of time until the new equilibrium position is reached. In the disequilibrium version, since the impact multiplier is larger, the initial deficit is smaller and the adjustment process is faster. Both of these effects tend to reduce the size of the term $(1/u)(\Delta V/P)\Delta g$ and hence increase the size of the long run multiplier as compared to the value in the equilibrium model shown in chapter two.

In the rationing model it is the bond-financed case that is the most interesting. As in the control model, the impact multiplier under bond financing is

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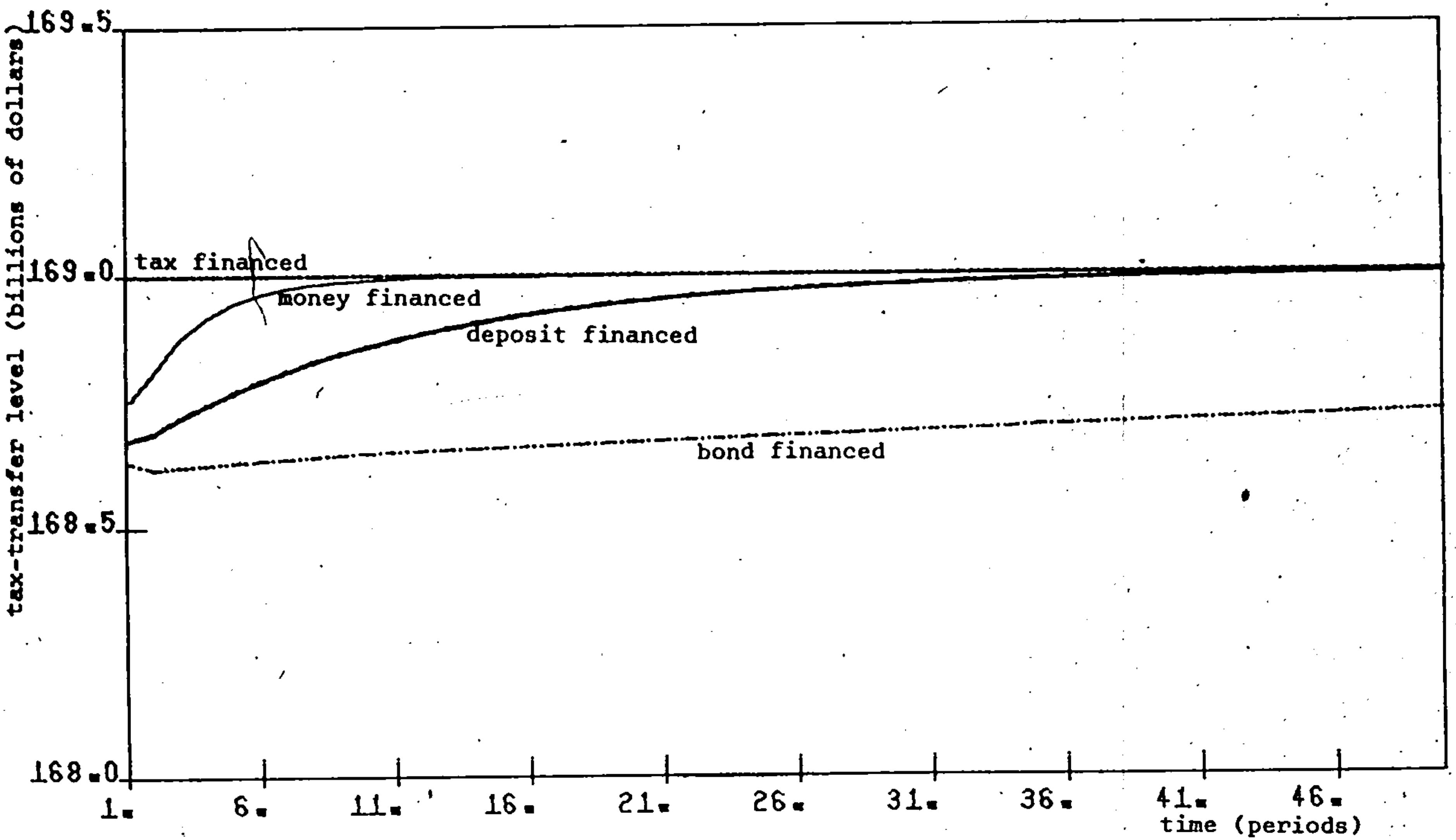
[7]The term 'deficit' here refers to the amount by which the change in endogenous taxes fall short of the change in government expenditures.

less than when the deficit is financed by printing money. In the long run, however, the two versions of the model yield dramatically different results. In the equilibrium version, bond-financing proves to be unstable. In the disequilibrium version on the other hand, bond-financing is stable but the long run multiplier is almost twice as large as that obtained when the deficit is financed by printing money.

The difference in the stability of the two cases may best be seen by comparing the time paths of the tax-transfer levels shown in Figure 2-2 for the control model and in Figure 4-2 for the disequilibrium model. In the control model, the level of the tax-transfer function moves away from its long run equilibrium level of 169 billion. In the disequilibrium version, the time path moves towards this same long run equilibrium value. However, the rate of adjustment is very slow suggesting that this case is not very far inside the stable range.

As was the case for the tax-financed cases, the differences are caused by the size of the initial deficit and speed of adjustment. In chapter two it is shown that a necessary condition for stability of the bond-financed case is that the expression $u\Delta x + (u-1)\Delta B/P$ must be positive. The second term of this expression is negative

Figure 4-2. Time path of the tax-transfer level for various methods of financing the budget deficit in the disequilibrium model.



and depends on the size of the deficit to be financed by borrowing. The smaller the deficit, the smaller will be the absolute value of the term. The magnitude of the long run multiplier in this case will be

$$\Delta x/\Delta g = 1/u-((u-1)/u)(\Delta B/P)/\Delta g.$$ [8]

Again this value depends on the size of the government deficit and on the time path of adjustment. Since the second term on the right hand side must be positive for all marginal tax rates less than unity, this expression must be greater than 1/u, the value of the long run multiplier, when the deficit is financed by printing money or running down government deposits in the private banking sector.

The case of financing the deficit by drawing down government bank deposits again resembles bond-financing in the short run and printing money in the long run. As in the control model, the major problem with these types of financing is the possibility that the government might run out of deposits. Since the deficits are smaller and the adjustment process is faster in the disequilibrium model, the loss of deposits is less in this case than is true in the equilibrium version. Here the loss of deposits is .325 billion in the first period and 3.6 billion in the

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[8] See chapter two page 27.

Table 4-2. Government Expenditure Multiplier for Deposit Financing in the Disequilibrium Model with $\lambda=0$

	Impact	Long Run
secondary financing by		
printing money	2.70	4.0
borrowing	2.70	4.5
increased taxation	2.70	1.81

long run.[9] However this problem can be alleviated by using one of the other means of financing to offset the drop in deposits. The results of such a procedure are summarized in Table 4-2.

Here, the impact results are the same as for the deposit-financed case.[10] In the long run, secondary financing by printing money approaches the same position but adjustment is more rapid than under deposit financing above. The time paths for this type of policy are shown in Figure 4-3 and Figure 4-4 for the government expenditure multiplier and the level of the tax-transfer function respectively.

[9] Since the long run here is at least sixty periods, this is probably beyond the point of interest as it is unlikely that the ceteris paribus assumptions would still hold, expecially if a period is assumed to be a year.

[10] This occurs since the secondary financing does not begin until the second period.

Figure 4-3. Time path of the government expenditure multiplier for deposit financing and various methods of secondary financing in the disequilibrium model.

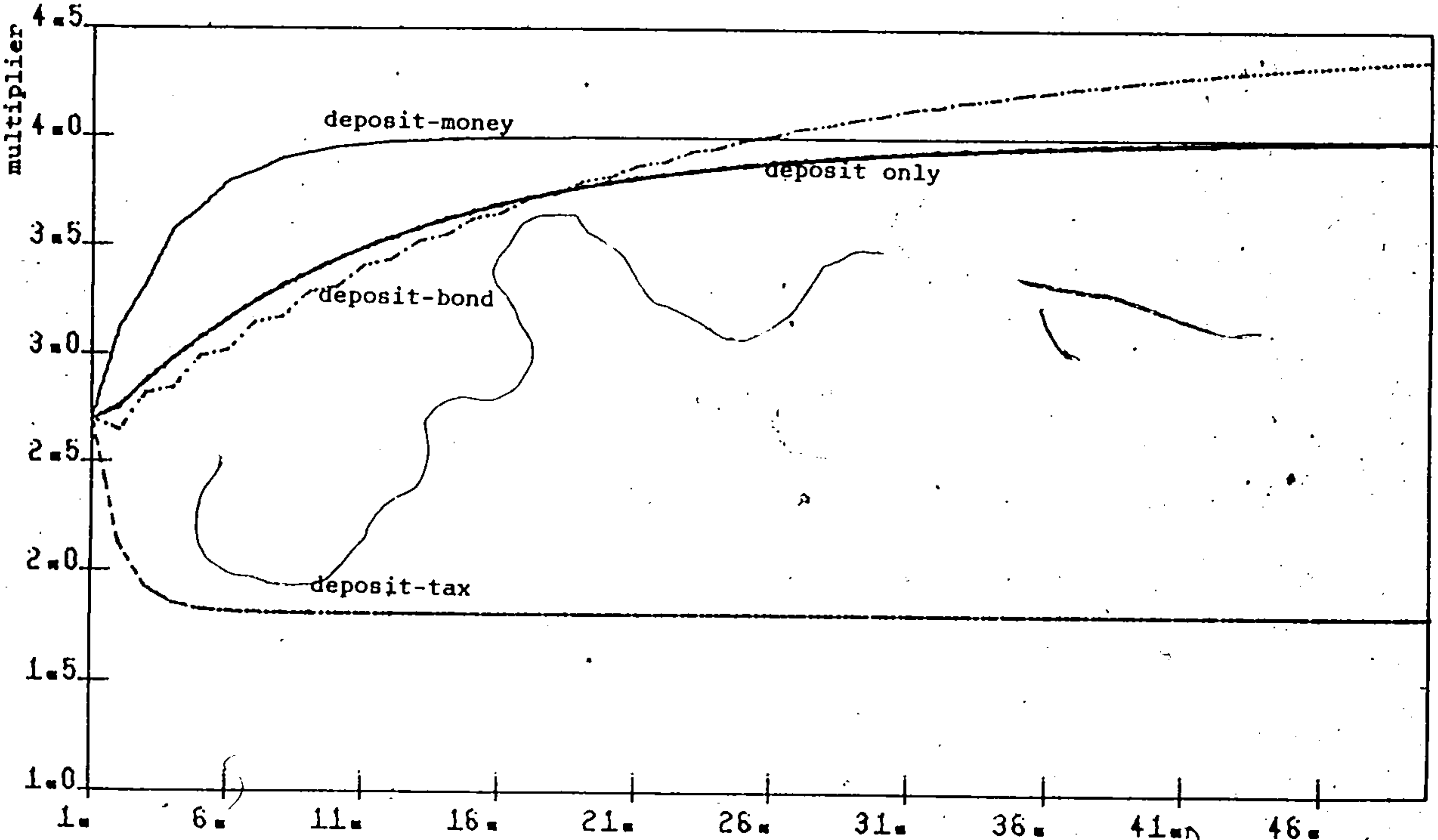
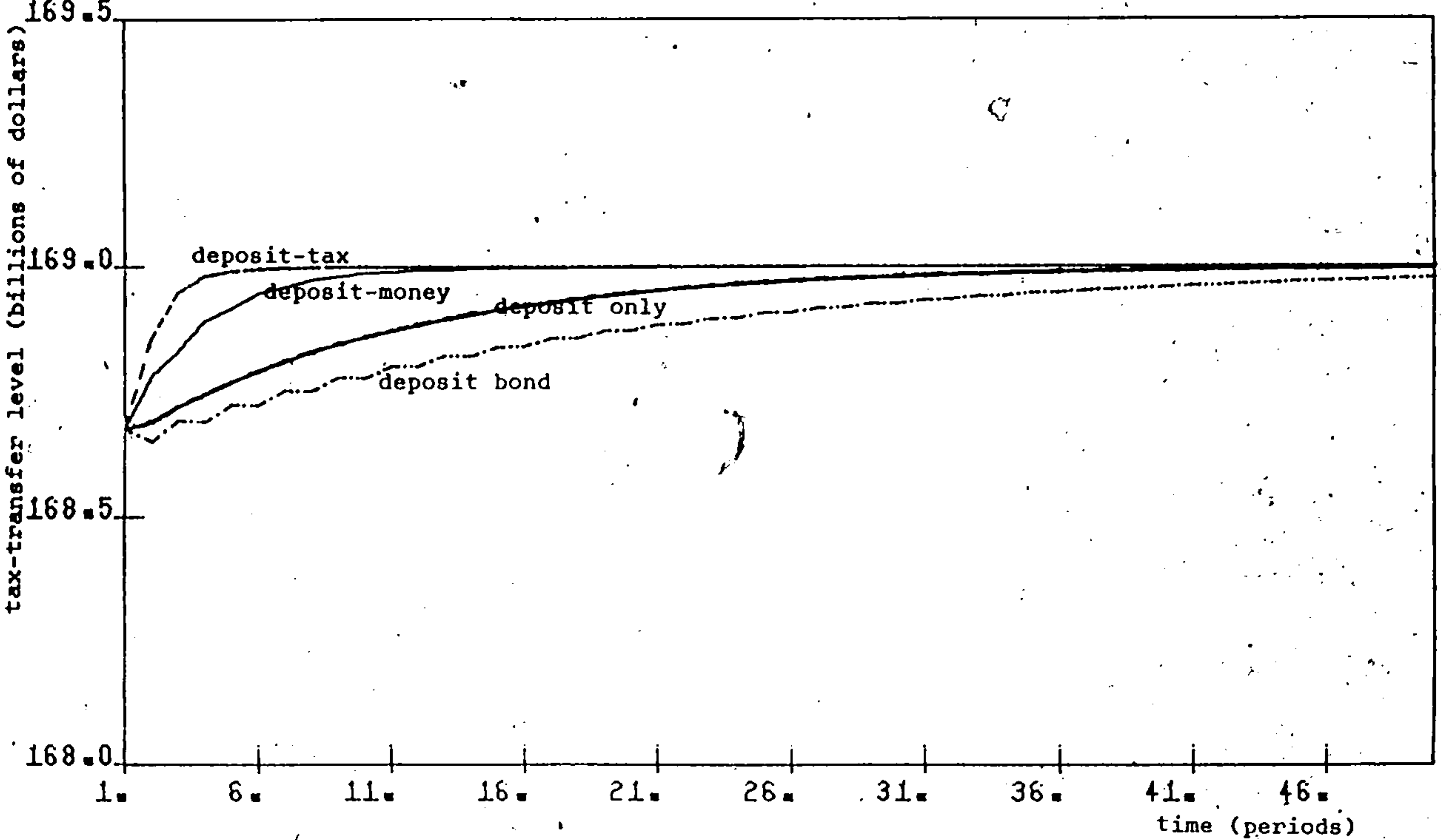


Figure 4-4. Time path of the tax-transfer level for deposit financing and various methods of secondary financing in the disequilibrium model.



When taxes are increased as the means of secondary financing, the long run multiplier is less than the impact value but again in this case it is greater than unity. The adjustment process in this case is very rapid.

If the secondary financing is carried out by borrowing from the public, the adjustment process is stable[11] and the long run multiplier is greater than that for the case of financing by deposits alone. However, this long run government expenditure multiplier is much less than when the issue of new bonds is used as the primary method of financing the government deficit. Again this results from the fact that the amount of the government deficit that must be financed by borrowing is less than in the earlier case. Also, the adjustment process is faster here because of the influence of the deposit-financing.

The simulation experiments that have been discussed thus far have been performed on the fixed price version of the model. When the fixed output version of the model is run the results are somewhat different.

The most dramatic difference occurs in the bond-financed case. For this version of the model, bond

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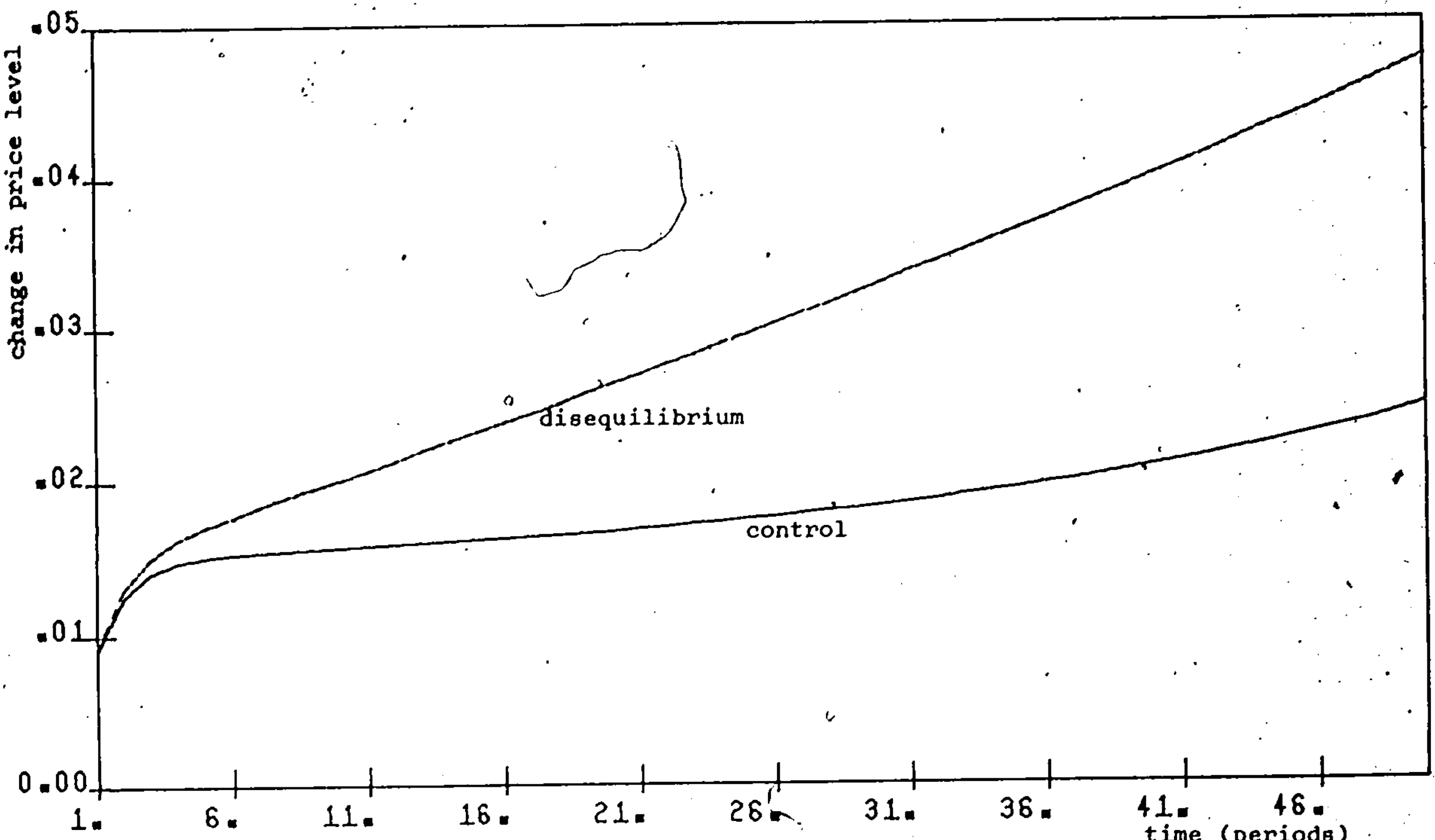
[11]By comparing Figure 4-4 with Figure 4-2 it may be seen that the deposit-bond financing method appears to be further into the stable range than the straight bond financing case.

Figure 4-5. Time path of change in the price level for the fixed output versions of the control and disequilibrium models for bond financing of the deficit.

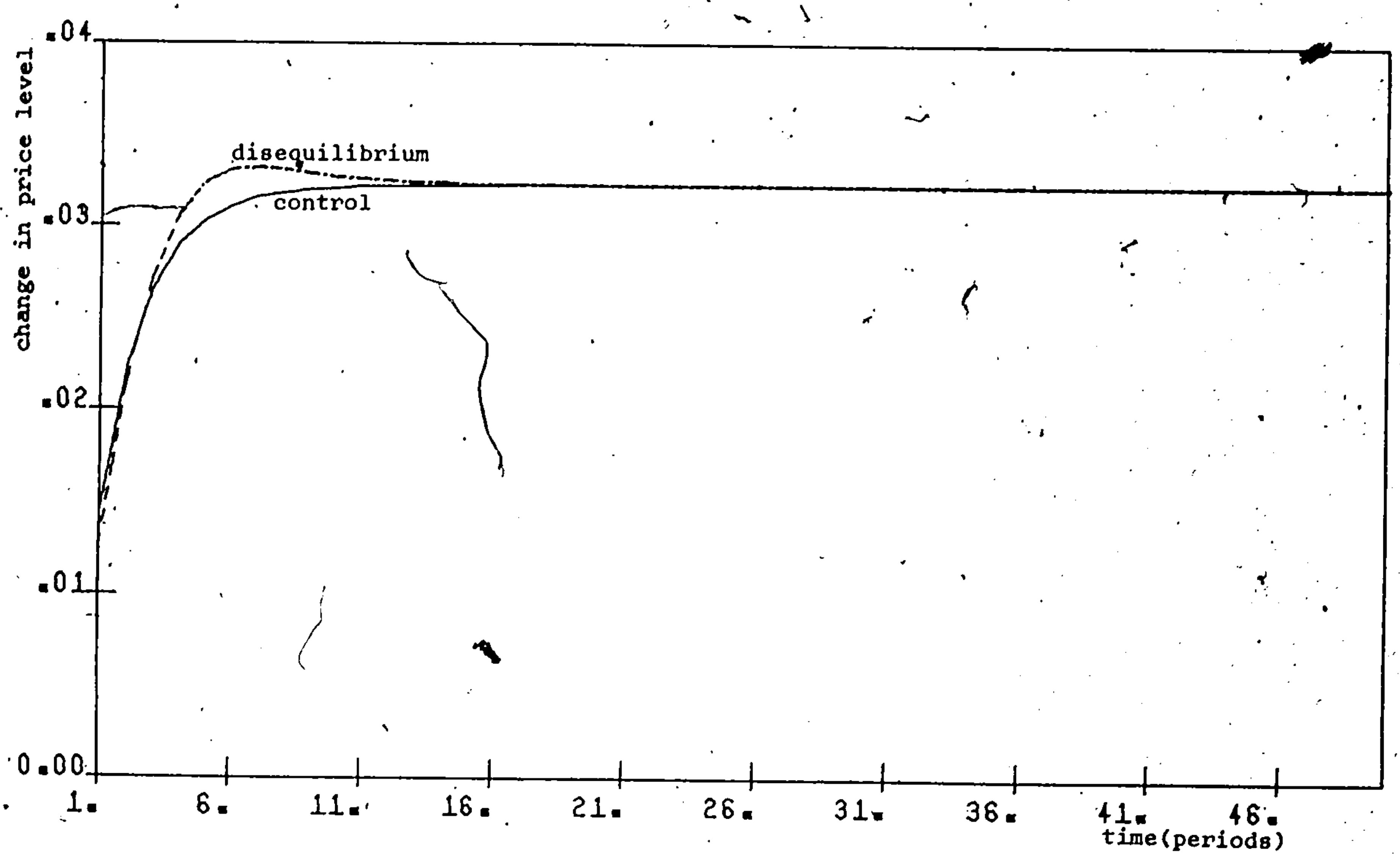


financing still proves to be unstable as may be seen by examining Figure 4-5. In this case, the rate of adjustment is more rapid in the disequilibrium model than it was in the control experiment. However, it is not rapid enough to allow the increase in tax receipts to offset the increased interest payments as is required if the budget deficit is to be eliminated. The difference between the fixed output and fixed price versions is intuitively pleasing as the increased output in the earlier simulation adds an extra expansionary influence while the increased price level present in the fixed output situation adds a contractionary force via the real balance effect.

The money-financed case of the fixed output model, as shown in Figure 4-6 also shows that the disequilibrium model adjusts more quickly than the equilibrium model does. In fact, the price level actually overshoots its long run equilibrium position during the adjustment process.

All of the results of the simulation experiments discussed here suggest the mildly surprising conclusion that the introduction of credit rationing in the bank loan market will make the government expenditure impact multiplier larger than if full equilibrium had

Figure 4-6. Time path of change in the price level for the fixed output versions of the control and disequilibrium models for money financing of the deficit.



occurred for all means of financing the deficit.[12] This means that the savings versus expenditure decision of the private sector has been changed by the rationing in such a way as to increase real spending. There are two effects interacting to bring about this result. One is the lagged adjustment of the loan rate and the other is the feedback effect as expenditures are reduced to match the reduction in available funds caused by the rationing.

The disequilibrium feedback can increase effective expenditure on consumption and investment relative to effective expenditure on assets as the constraint is binding on both the real and financial expenditures of the private sector. Therefore, the larger the constraint on the financial decisions of the private sector, the larger will be the impact multiplier in the disequilibrium model. The extent to which the results reported above depend upon these feedback coefficients is examined in section 4.3.

The fact that a lag in the adjustment process of the rate of interest may accelerate the adjustment of the

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[12] In the case of financing by printing money, the credit rationing constraint is not present but the disequilibrium impact of the lagged adjustment in the loan rate and the lagged adjustment of bank assets have a similar effect.

level of income has been shown by Tucker.[13] The main point in this argument is that the lags in adjustment of the various sectors may tend to cancel out and hence increase the rate of adjustment. This is caused by certain variables overshooting their long run equilibrium values in the short run because other variables are adjusting with a lag. Of particular interest to the present study, is the fact that lags in demand for assets may cause interest rates to overshoot their long run values. These interest rate changes may then cause variables in the real sector to expand more rapidly.

Since the rate of lagged adjustment is very important to the speed of adjustment,[14] intermediate values of the partial adjustment coefficient are used to see the importance of this feature of the model. Figure 4-7 shows the time path of the government expenditure multiplier for the money-financed case with various values of λ. If the value of λ is between zero and unity, there is a slight overshoot and although the adjustment is faster if λ is less than unity, the exact value makes

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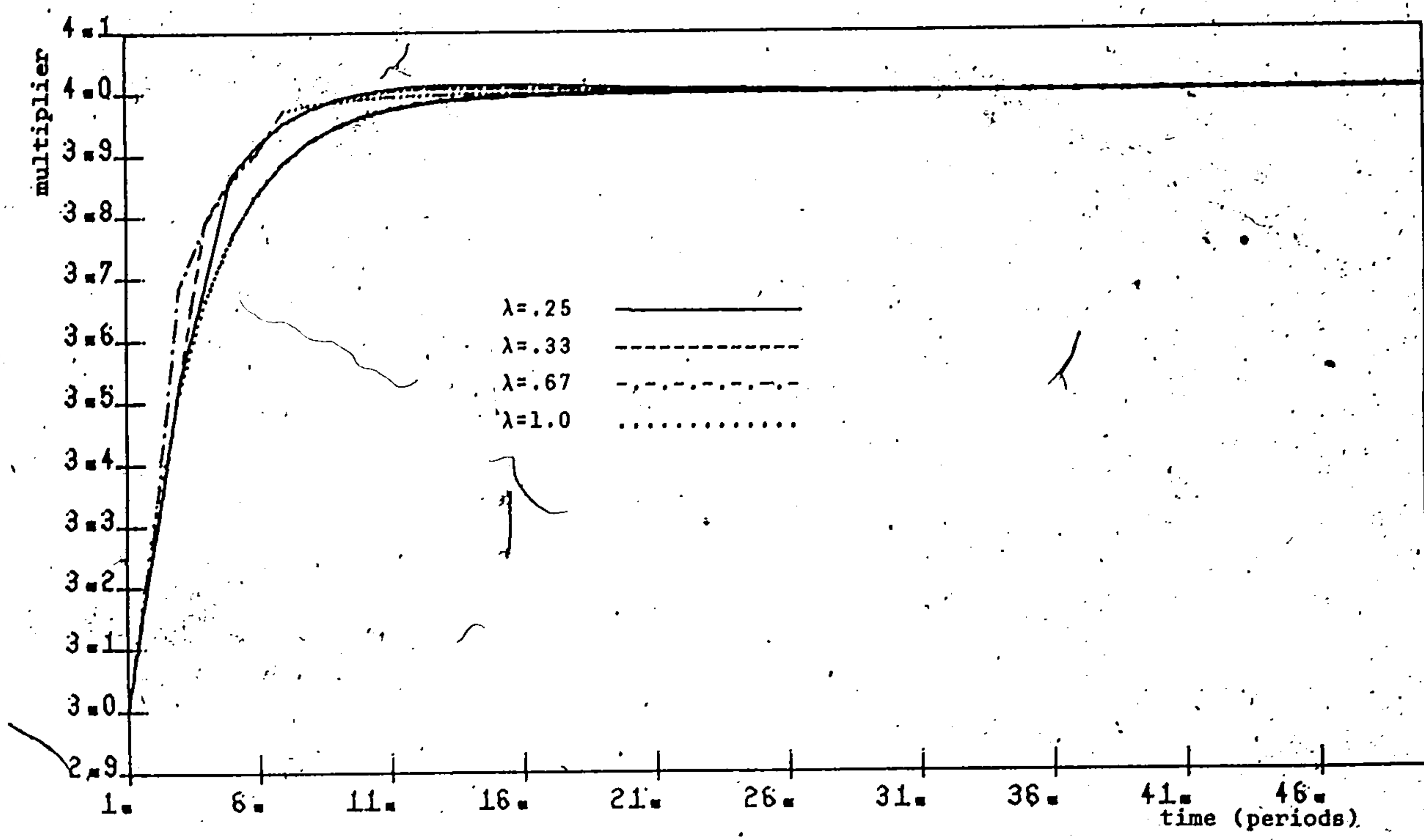
[13]Tucker, D.P.;. "Dynamic Income Adjustment to Money Supply Changes"; American Economic Review; June, 1966, p 433-449.

[14]The partial adjustment coefficient will determine the speed of adjustment via the possible overshoot effect and as well, it will determine the amount of credit rationing that will be present.

Figure 4-7. Time path of the government expenditure multiplier for money financing in the disequilibrium model with different interest rate adjustment speeds.



little difference[15] in this version of the model.[16]

The bond-financed case however, depends critically on the value of λ. If the partial adjustment coefficient is larger than 0.1, the model is unstable. This result is not unexpected as the larger λ is, the quicker the loan rate adjusts to clear the lending market and thus the smaller will be the amount of credit rationing present in the model. This will slow the adjustment process and as was already noted the disequilibrium model with λ equal to zero is only barely in the stable range under bond-financing.

Thus far, all the analysis of disequilibrium effects on stabilization policy has centered on credit rationing. The discrete nature of the model makes consideration of lagged adjustment in the desired demand equations a natural extension. In this lagged demand version of the model, it is assumed that the individual demand

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[15] The different rates of adjustment of the loan rate changes the value of the multiplier in the second through sixth periods as the adjustment between the same impact and long run levels occurs at different speeds.

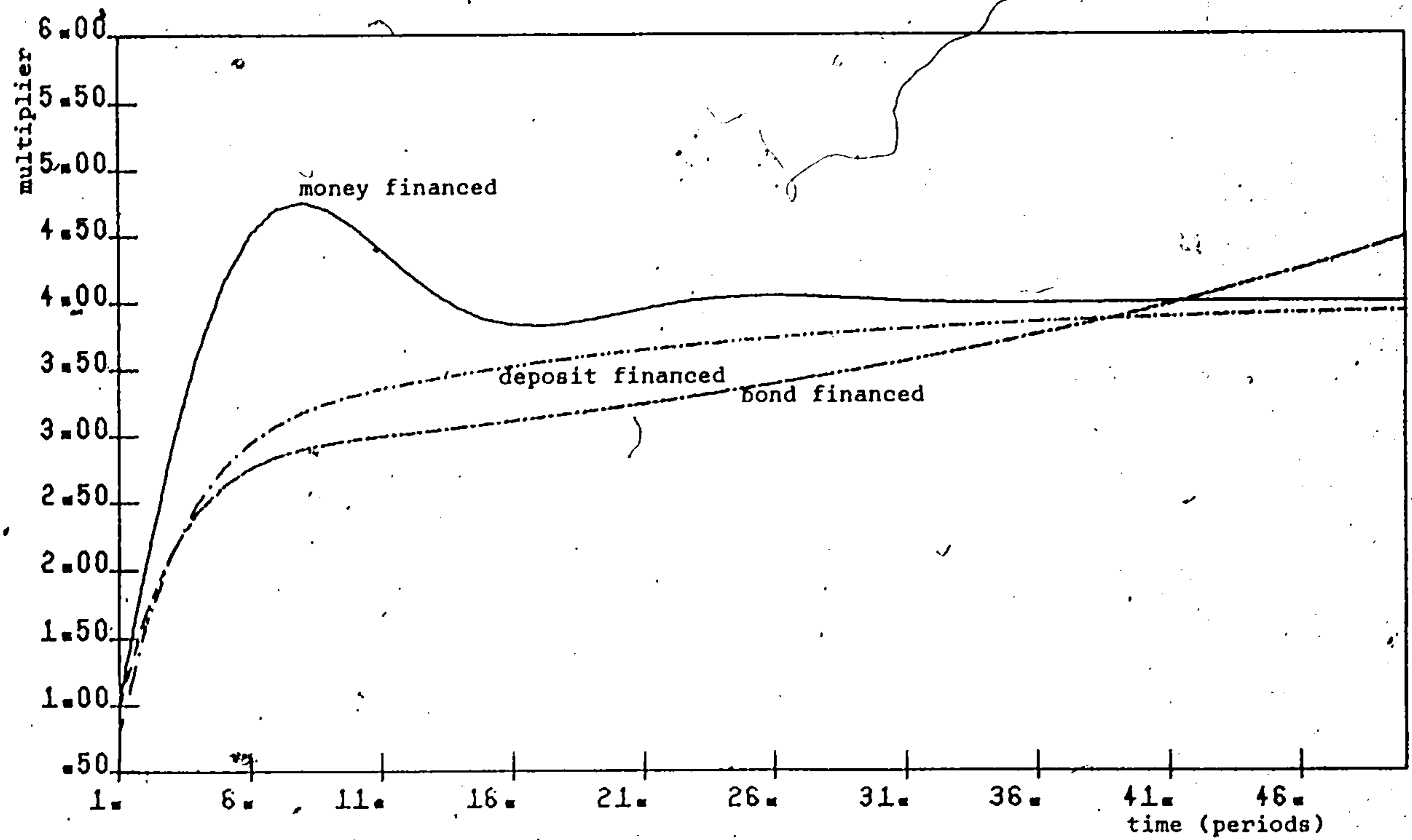
[16] Credit rationing is not effective here as credit conditions are being eased in this version. If government spending is reduced the multiplier's adjustment is faster with a slightly larger overshoot for the intermediate values of λ.

decisions are based on the assumption that conditions in the previous period will remain unchanged. Figure 4-8 shows the time path of the government expenditure multiplier under the assumption of instantaneous loan rate adjustment.

When the deficit is financed by running down the government bank deposits, the impact multiplier is 0.8. In the long run, the multiplier is the same, 4.0, as for the other versions of the model. As may be seen in Figure 4-8, the rate of adjustment in this case is rapid in early periods but then becomes quite slow with full adjustment requiring some sixty periods.

If the deficit is instead financed by issuing bonds, the impact multiplier is .99 and in the long run, the model is unstable. The adjustment process in this case is faster than it is in the control model but it is not rapid enough to be within the stable range.

While the lagged demand model does not yield results different from those of the control model, except for the lower impact multiplier, when the deficit is financed by bonds or deposits, the money-financed version does. The money-financed situation has an impact multiplier of 1.02 and although the long run multiplier figure 4-8. Time path of the government expenditure multiplier for the lagged demand version of the model with instantaneous loan rate adjustment and various methods of financing the deficit.



is still 4.0 as in the early versions, the time path of adjustment is cyclical. The multiplier reaches a peak of 4.75 in the eighth period and full equilibrium is not restored for about sixty periods.[17]

When the lagged loan rate adjustment assumption is added to the lagged demand model, the results are similar to those discussed earlier. The results are summarized in Figure 4-9. For all cases, there is very little change in the impact multiplier. However, the time paths of adjustment are considerably altered. For the money financed situation, the path is still cyclical but only the first overshoot is of any significant size. The peak is reached in the sixth period[18] at a value of 4.5. Effective full adjustment is achieved after fourteen periods in this case.

If the deficit is financed by deposits, adjustment is also much more rapid when the credit market is not cleared. There is, in fact, a slight overshoot in

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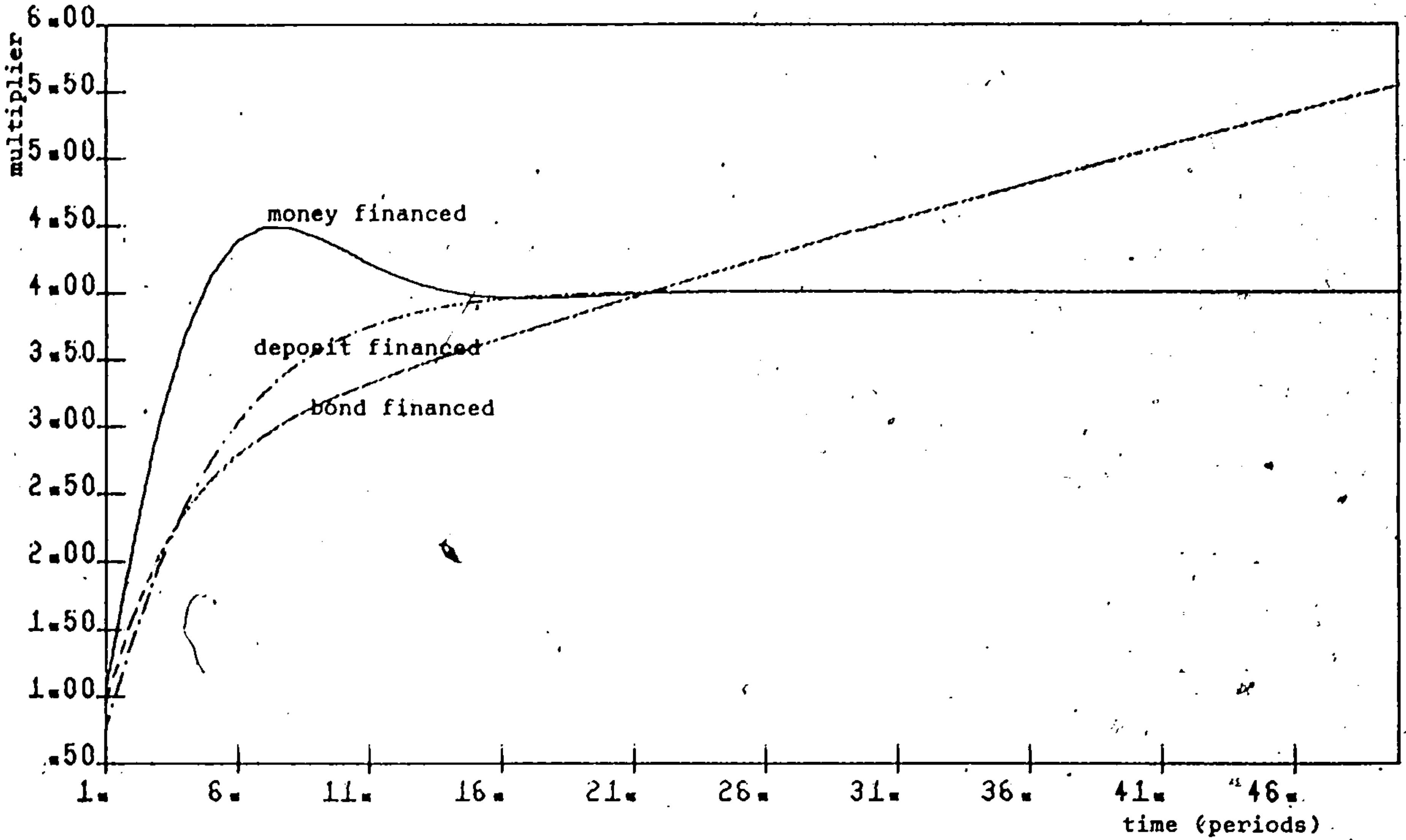
[17]Again because of the length of the adjustment process the long run value is of little meaning. Accordingly this policy may be viewed as more expansionary than the other stable measures.

[18]two periods earlier than when the loan rate adjusted instantaneously.

Figure 4-9. Time path of the government expenditure multiplier for the lagged demand version of the model with lagged loan rate adjustment and various methods of financing the deficit.



this case. Full adjustment in this version of the model is also effectively completed after fourteen periods.

If the deficit is financed by borrowing, the added assumption of lagged adjustment in the loan rate leading to credit rationing again moves the model into the stable range. As in the earlier version of the disequilibrium model, the long run value of the multiplier in this case is much larger[19] than for either the deposit or money-financed cases. When compared to the disequilibrium model without lagged demand, the present case may be seen to be further into the stable range.[20]

It has been shown that in the long run the bond-financed case will have a larger government expenditure multiplier than would occur if the deficit had been financed by printing money. Since this is the opposite to the situation that results in the impact period the policy maker must ask which method is the least expansionary means of increasing government expenditure.

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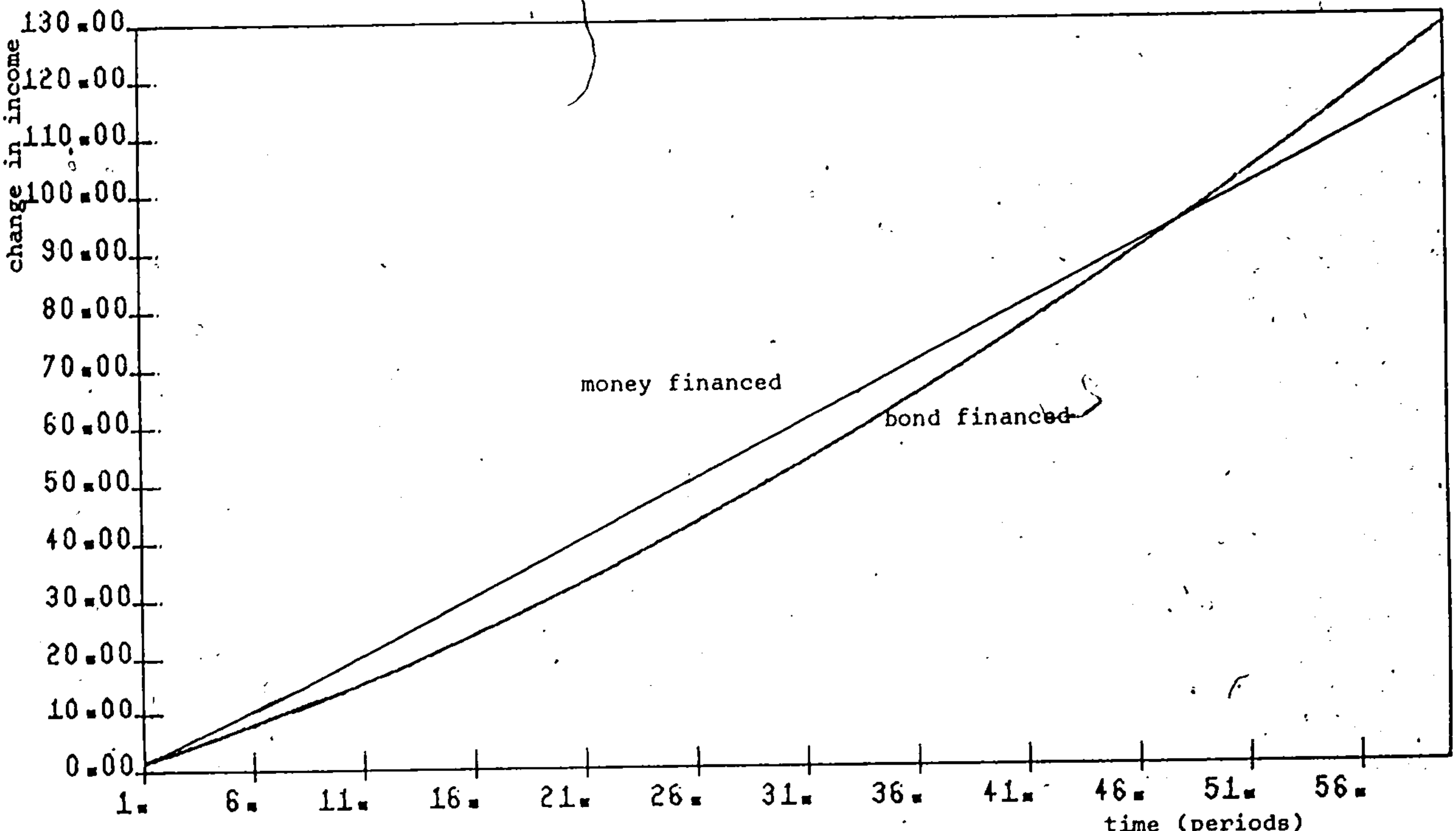
[19]The long run multiplier value in this case is approximately six.

[20]That is, the case more rapidly approaches a stationary long run position.

Figure 4-10. Time path of change in income for a continuous increase in government expenditure of 0.5 billion per period with money and bond financing of deficit.



In the case of a once and for all increase, as has been considered previously in this chapter, the choice seems clear. Bond-financing will be preferred by the policy maker who wishes a less expansionary policy as the time period involved in reaching the long run position is too long, and thus, other exogenous factors would likely swamp out the long run effects.

If on the other hand the increase in government expenditure is continuous, the question of whether the more expansionary impact effect of the money financed case will dominate the more expansionary long run effect of borrowing becomes relevant. In order to answer this question a simulation experiment was run in which government expenditures were increased continuously by 0.5 billion dollars per period and the results of financing by printing money compared to the case where the deficit was financed by borrowing. In both cases, the model used was the one with lagged adjustment only in the loan market. The results are shown in Figure 4-10. While the impact effect of money-financing does dominate for a considerable period of time, in the long run and bond-financing version of the model will be more expansionary.

4.3 Sensitivity Analysis

Since the model used in the present study is rather ad hoc, some of the key parameters[21] are tested in this section in order to determine to what extent the results depend on the arbitrary choice of these values.

Clearly the most important set of parameters in the present model is the feedback coefficients that determine how much the credit rationing affects each of the other markets in the system. As there is no good estimate of these values, a systematic study across all likely values of these parameters is carried out. The set of possible values is reduced by the constraint that the sum of the coefficients must be minus one. This set is further reduced by making the plausible assumption that credit rationing will not cause an individual to expend more in a given market than he would have desired to expend if equilibrium had occurred in each market. Thus the value of the coefficients as tested here must be between zero and minus one. The sensitivity analysis

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[21] Other parameters have already been tested in the article which formed the basis for the control model. Christ, C.F.; "A Model of Monetary and Fiscal Policy Effects on the Money Stock, Price Level and Real Output"; Journal of Money, Credit and Banking; November, 1969, p 701-702.

tests all possible combinations of the feedback coefficients with values of -.25 or multiples thereof which satisfy the two constraints given above. The seventy cases are given in Appendix D.

The model is simulated in such a way as to make credit rationing effective for each method of financing the government deficit. Thus in the cases of bond-financing, deposit-financing and tax-financing the relative effects of increasing government expenditures by one billion dollars are studied. In the case of money-financing, on the other hand, the effect of decreasing government expenditures by one billion dollars is studied.

The results of this analysis turn out not to depend on the individual values of the feedback coefficients, but instead, on whether the relative impact is greater on the real sector (that is, on consumption and investment) or on the financial sector (that is, on bonds, deposits, and currency). The distribution of the multiplier values depending on this relative impact is given in Table 4-3 for the case of bond-financing, in Table 4-4 for the case of deposit-financing, in Table 4-5 for the case of exogenous tax-financing, and in Table 4-6 for the case of financing by printing money.

Table 4-3: Distribution of multiplier values for a given percentage impact of rationing on the real sector under bond financing.

percentage of rationing impact on real sector	multiplier 2.3	2.4	2.5	2.6	2.7	2.8
100%	5	0	0	0	0	0
75%	4	8	0	0	0	0
50%	0	3	12	3	0	0
25%	0	2	0	10	8	0
0%	0	0	0	0	3	12

Table 4-4: Distribution of multiplier values for a given percentage impact of rationing on the real sector under deposit financing

percentage of rationing impact on real sector	multiplier 2.4	2.5	2.6	2.7	2.8	2.9
100%	5	0	0	0	0	0
75%	3	5	4	0	0	0
50%	0	3	6	9	0	0
25%	0	0	2	5	13	0
0%	0	0	0	0	1	14

Table 4-5: Distribution of multiplier values for a given percentage impact of rationing on the real sector under tax financing

percentage of rationing impact on real sector	multiplier 1.3	1.4	1.5	1.6	1.7
100%	5	0	0	0	0
75%	0	12	0	0	0
50%	0	5	11	2	0
25%	0	2	8	10	0
0%	0	0	0	7	8

Table 4-6: Distribution of multiplier values for a given percentage impact of rationing on the real sector under money financing

percentage of rationing impact on real sector	multiplier 2.9	3.0
100%	0	5
75%	0	12
50%	0	18
25%	0	20
0%	5	10

A diagonal relationship is clearly evident in the tabulated results. As the percentage of rationing impact on the real sector declines, the government expenditure multiplier increases.[22] The individual observations not corresponding to a diagonal position generally tend to be cases with a high percentage of rationing impact in the deposit market. This occurs as bank assets are reduced when rationing causes a reduction in deposits, therefore causing the total level of rationing to increase as bank loans are reduced further.

This sensitivity analysis suggests that credit rationing will not affect the government expenditure multiplier if approximately seventy-five percent of the impact of rationing is on the real sector. If a higher percentage of rationing impact is felt in the real sector, the government impact multiplier in the disequilibrium model is smaller than it is in the control model. However, even if the whole impact of rationing is in the real sector, the government expenditure multiplier will only be reduced by five percent.

Similarly, if less than seventy-five percent of

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[22]The opposite result holds for the money financed case as this represents a contractionary policy while the other three cases are expansionary.

the impact of rationing is felt in the real sector, the disequilibrium government expenditure impact multiplier will be larger than is the case in the control model. Since the percentage impact of rationing in the real sector, in the disequilibrium model used in section 4.2, is approximately forty percent, the multiplier for this version of the model is larger than in the control version.

Again, the range of values that the multiplier may take on appears to be rather limited. Even in the unlikely situation in which credit rationing has no impact on the real sector, the impact multiplier would be increased only about fifteen percent above the value predicted by the equilibrium model.

In the long run, however, the question of the stability of the bond-financed case may make consideration of the feedback mechanism more important. As explained in section 4.2, the stability question here is related to the size of the budget deficit which is, in turn, related to the size of the impact multiplier. Thus, this case is more likely to be stable when the impact of rationing is relatively high on the financial sector of the model.

Similar, although less dramatic results are obtained in the long run for other methods of financing the government deficit. In all versions, the adjustment process is faster the higher the incidence of rationing on the financial sector. The long run multiplier value is not altered in the case of deposit or money financing. However, when the deficit is financed by increasing exogenous taxation, the long run multiplier is larger[23] in cases where rationing is more heavily felt in the financial markets.

The value of the coefficient on lagged wealth in the consumption function is one of the least certain of the parameters of the control model. However, this variable has been cited in recent literature[24] as being of great importance in determining the speed of adjustment and stability of the bond-financed case. Figure 4-11 shows the effect of reducing this coefficient by twenty percent. This experiment is undertaken in the context of the control model and both cases turn out to be unstable.

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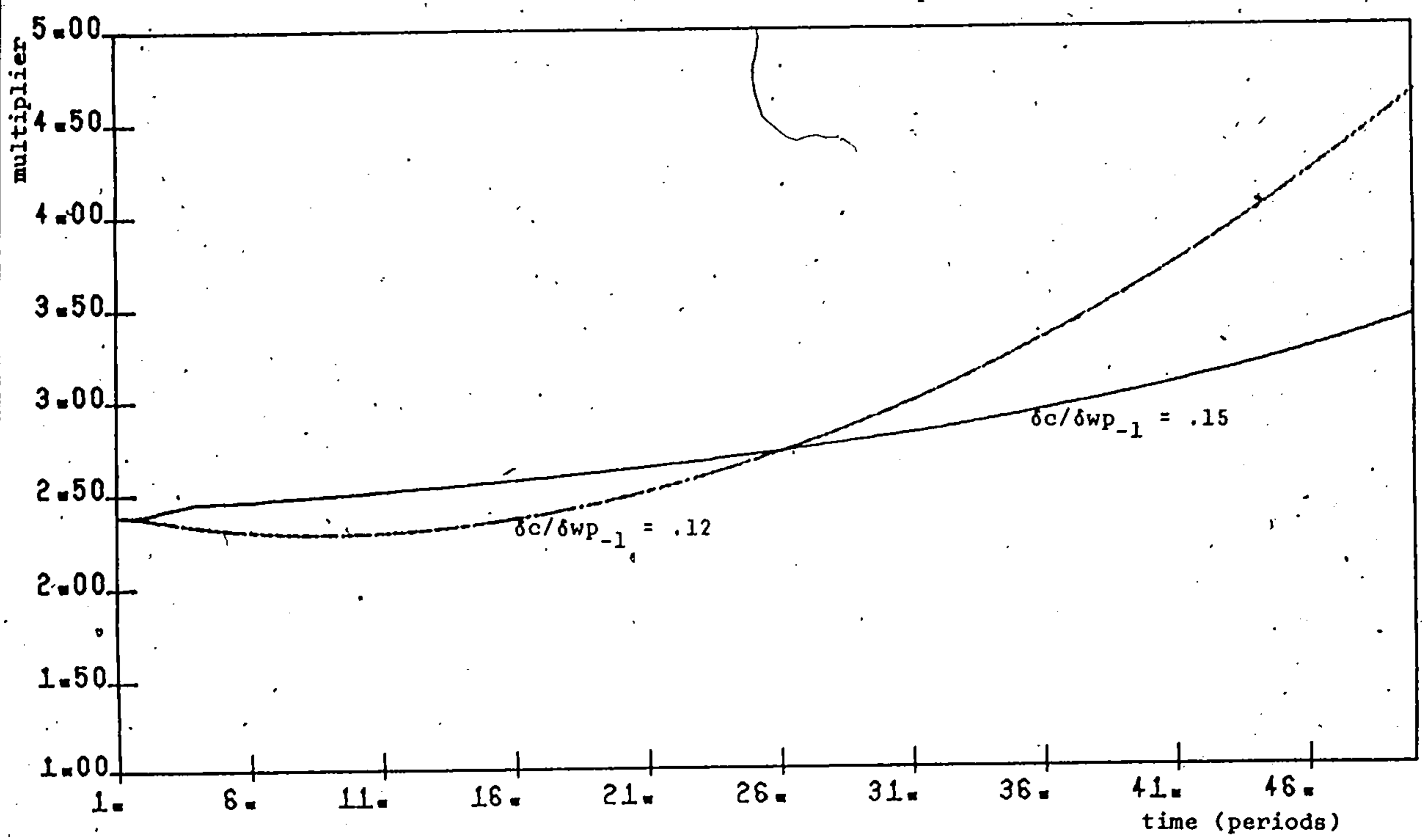
[23] The long run multiplier is still smaller than the impact multiplier for this method of deficit financing.

[24] See, Blinder, A.S. and Solow, R.M.; "Does Fiscal Policy Matter?"; Journal of Public Economics; November, 1973, p 328 and Scarth, W.M.; "A Note on the 'Crowding Out' of Private Expenditures by Bond Financed Increases in Government Spending"; Journal of Public Economics, (forthcoming).

Figure 4-11. Time path of the government expenditure multiplier with bond financing of the deficit and various values of the coefficient on wealth in the consumption function.

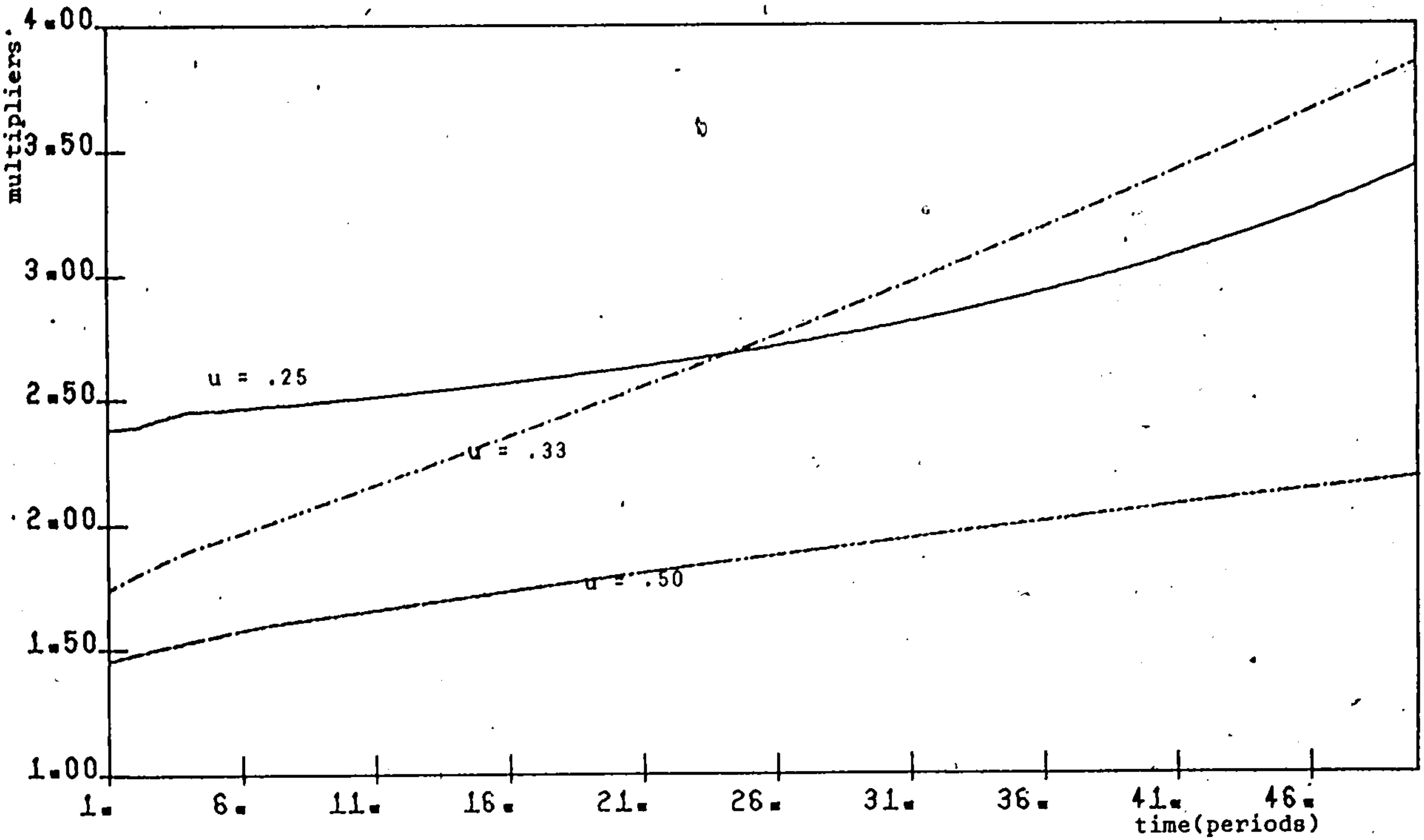


The impact multipliers are of course the same, as this coefficient acts on the system with a one period lag. The time paths of adjustment are quite different however. When the lower value of this coefficient is used, the multiplier declines from its impact value for about ten periods and then begins to move off rapidly towards its long run position at infinity. In fact, by this change the system has been moved far enough into the unstable range that even the disequilibrium version of the model is unstable.

Again, the other methods of financing yield similar but less dramatic results. For both money-financing and deposit-financing the process of adjustment is much slower when the wealth effect on consumption is reduced. Here neither the impact nor the long run values of the multiplier are affected. For the case of financing via increased taxation, the smaller the coefficient on wealth, the smaller the long run multiplier.

The sensitivity analysis reported above suggests that the speed of adjustment of the present model, and therefore the probability of the bond-financed version being stable, is increased by parameter changes that tend to favour real expenditure over saving. The control model

Figure 4-12. Time path of the government expenditure multiplier with bond financing of the deficit and various values of the marginal tax-transfer rate.



may be influenced in this way by changing many of the parameters. Carl Christ[25] has tested the sensitivity of a similar model to most of these parameters and thus this experiment is not repeated here.

However, since Blinder and Solow[26] claim that the stability of the bond-financed case rests with having a large enough marginal tax-transfer rate, the parameter will be tested. Figure 4-12 shows the time path of the government expenditure multiplier for the control model with various values of u, the marginal tax-transfer rate. As u is increased, the impact multiplier is reduced and the speed of adjustment is increased. If u equals 0.5 this version of the model does appear to be stable with a long run multiplier larger than the value 2.0 that is obtained under money-financing. It should be noted that if the coefficient on wealth in the consumption function is .12 instead of .15 as assumed in the model, the bond-financed case is still unstable even for a marginal tax-transfer rate of one half.

4.4 Summary

The results of the simulation experiments reported

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[25]Blinder and Solow; op. cit.; p 335.

[26]Christ; op. cit.; p 702.

in this chapter show that the inclusion of disequilibrium phenomena can alter the answers the model will give to policy questions. This result will occur whenever the disequilibrium alters the saving-expenditure decision and thus changes the speed of adjustment of the entire system.

The disequilibrium model used in the present study adjusts towards its equilibrium level at a faster rate than the control model. Thus bond-financing moves in the direction of stability and to a lower value of the long run government expenditure multiplier. For the same reason, the long run multiplier for the tax-financed case is larger in the disequilibrium model.

The results of the simulations using the lagged demand version of the model confirm that lagged adjustment in several sectors of the model may interact in such a manner as to increase the speed of adjustment.

While the actual version of the disequilibrium model that is used in the present model has a faster speed of adjustment than the control model, a model typical of conventional macrotheory, the sensitivity analysis carried out here shows that this need not be the case. If rationing did not affect the desired asset transactions, the speed of adjustment would be much slower and thus, the bond-financed case would more likely be unstable.

V

SUMMARY AND CONCLUSIONS

The purpose of this study has been to explore the effects of market disequilibrium, especially credit rationing in the commercial bank loan market, on the results of government stabilization policies under various methods of financing the budget deficit.

In order to accomplish this goal, an equilibrium or market clearing version of the model was first developed. This version of the model has been shown to be consistent with all the constraints binding on discrete time models in standard macroeconomic theory. Also, the model has well-developed financial markets including a commercial banking sector.

The simulations with this version of the model confirm that the impact multiplier is larger when the deficit is financed by printing money than when the financing is done by issuing bonds. If the budget deficit is financed by increasing exogenous taxation, the value of the impact multiplier is still smaller.

Simulations with the control or equilibrium version of the model also suggest that the bond-financed case may be unstable in the long run. This result cannot be confirmed by the present model because of its limited supply sector.

The model developed here describes only the aggregate demand sector of the economy. If the fixed price version of the model is used, the aggregate supply curve is assumed to be horizontal. This means that the level of aggregate supply will adjust instantaneously to match the amount of aggregate demand. If the fixed output version of the model is used, the aggregate supply will not change and the price level will adjust to force aggregate demand to the level at which aggregate supply is fixed.

While these assumptions may be valid for the short run, with the fixed output version representing the full employment case and the fixed price version representing the unemployment situation, neither can adequately describe the long run growth of the economy.

However, there are certain long run questions that this model can answer. Since the budget must be balanced for long run equilibrium, the government expenditure multiplier in the long run must equal the reciprocal of the marginal tax-transfer rate in the money-financed case. This study also shows that the long run government expenditure multiplier is less than the reciprocal of the marginal tax-transfer rate if the budget deficit is financed by an exogenous shift in the intercept of the tax-transfer schedule. Moreover, while the stability question surrounding the bond-financed case cannot be settled by this model, it does show that in the long run the government expenditure multiplier for this method of financing is larger than the multiplier obtained when the deficit is financed by printing money.

Thus, even for continuous policy action, the fact that the bond-financed case is more expansionary in the long run will eventually outweigh the more expansionary short run financing by printing money. However, as this process takes fifty periods, it is not likely to be of interest to policy makers since later policy actions or other exogenous changes would certainly swamp the effects of such a lengthy adjustment.

Since the control model has a well developed banking sector, the theory of the government finance restraint has been extended to consider the case in which the deficit is financed by transferring the ownership of government deposits with the commercial banking sector to the private sector. The simulation experiments suggest that this version of the model resembles the bond-financed case in the short run and the money-financed case in the long run.

The deposit-financed case is subject, of course, to the obvious limitations imposed by the initial size of the government's deposits with the commercial banks. However, this method of financing the deficit may be combined with another method of secondary financing to restore the level of the government's deposits in later periods. An interesting result of this case is that deposit-bond-financing is more likely to be stable and to have a smaller long run multiplier than the primary bond-financed case.

The disequilibrium version of the model has been developed in a manner consistent with current literature on disequilibrium phenomena. This version of the model contains a feedback mechanism by which disequilibrium in one market will affect the results in all other markets. Since the supply sector is limited, as mentioned above, disequilibrium in the present model is restricted to credit rationing in the commercial bank loan market.

The simulation experiments with the disequilibrium version of the model study the cases of "dynamic" credit rationing and "equilibrium" credit rationing. In the case of "equilibrium" credit rationing the loan rate does not adjust at all and, hence, all adjustment in the loan market takes the form of credit rationing. In the case of "dynamic" credit rationing the loan rate partially adjusts with the remaining portion of the market "cleared" by rationing.

The results of the simulation with the disequilibrium model show that the government expenditure multiplier may be slightly increased by the presence of credit rationing. However, one of the most dramatic results of the simulation experiments is that the introduction of credit rationing seems to make little difference in the value of the impact multiplier. In fact, in the money-financed case no change is observed at all.

In the long run the speed of adjustment appears to be affected to a greater degree than are the impact results. Although this may be of theoretical interest, the time period involved is so long as to make the issue of little practical importance to the policy maker.

The lagged demand version of the model shows that interaction of lagged or partial adjustment in several sectors may intensify the effects each would have separately. Thus, a system with lagged adjustment in several sectors may adjust more rapidly than a system with no lag at all in its adjustment process.

Since the parameters of the model are not precise, sensitivity analysis has been used to evaluate the importance of the exact values of the coefficients as assumed in the present system. Of particular importance to the results of the current study are the values of the feedback coefficients. If the impact of credit rationing is mainly felt in the real sector, the government expenditure impact multiplier will be smaller in the disequilibrium version than in the control model. On the other hand, if the impact of credit rationing is mainly felt in the financial sector the opposite result will occur.

However, the system appears to be rather insensitive to the values of the feedback coefficients. Even if all of the rationing affected the real sector, the government expenditure impact multiplier would be reduced by no more than five percent. If all of the impact of rationing were in the financial sector, the value of the impact multiplier would be no more than fifteen percent larger than in the control model. In the case of financing by printing money, the multiplier would never change by more than three percent. Considering the size of the exogenous factors which the model assumes not to change, these differences are not significant from a policy maker's point of view.

The feedback coefficients that are assumed in this study imply that approximately sixty percent of the impact of credit rationing will be on the financial sector and forty percent on the real sector. Thus, it is concluded that the likely effect of considering credit rationing would be to increase the predicted value of the impact multiplier, but by no more than five percent. Indeed, since the most common method of financing the budget deficit is by printing money, consideration of credit rationing is not likely to significantly affect the evaluation of government stabilization policy actions.

However, other forms of disequilibrium, alone or in combination with credit rationing, may have important implications for stabilization theory. In fact, the present study suggests that disequilibrium may be more important as a long run phenomenon. However, a full evaluation of this issue must await a further study using a model with a supply sector more suited to the long run case.

A further limitation to this study is the fact that it uses a closed economy model and, therefore, policy recommendations may not be relevant to the Canadian economy. Thus, an extension of this theory to the open economy case, especially one with a high degree of capital mobility, would be useful.

APPENDIX A

The definition of notation and assumed initial conditions for the control model. All initial conditions, except for the interest rates, are measured in billions of dollars.

a	=	170	=	total real bank assets
B	=	12	=	annual interest on government consols in private hands
Bb	=	1.5	=	annual interest on consols held by bank sector
Bp	=	10.5	=	annual interest on consols held by private nonbank sector
c	=	632	=	real consumption
D	=	140	=	total bank deposits
Dg	=	10	=	government bank deposits
Dp	=	130	=	private bank deposits
g	=	168	=	real government purchases
H	=	60	=	stock of high-powered money
Hb	=	20	=	stock of high-powered money held by banks
Hp	=	40	=	private nonbank holdings of high-powered money
i	=	0	=	real net private investment
k	=	2400	=	real private physical capital stock
L	=	120	=	stock of bank loans
M	=	180	=	stock of money
P	=	1.0	=	price level
rb	=	.05	=	yield on bonds

APPENDIX A (continued)

rd	=	.02	= yield on bank deposits
rl	=	.06	= yield on bank loans
t	=	168	= real tax revenue less real government transfer payments
u	=	.25	= marginal tax-transfer rate
v	=	-23	= intercept of tax-transfer schedule
wb	=	30	= real net worth of the banking sector
wp	=	290	= real private nonbank liquid wealth, net of bank loans
x	=	800	= real net national product
y	=	632	= real disposable income
z	=	0	= real private capital gains.

APPENDIX B

The Control Model

$$\Delta x = \Delta c + \Delta i + \Delta g \tag{1}$$

$$\Delta y = \Delta x - \Delta t \tag{2}$$

$$P\Delta t = \Delta V + .25P\Delta x + .25(x-t)\Delta P - .75\Delta B \tag{3'}$$

$$\Delta z = \frac{H\Delta P_{-1}}{P_{-1}P_{-2}} - \frac{\Delta P_{-1}\Delta H}{P_{-1}P_{-2}} + \frac{B(P_{-1}\Delta rb_{-1} + rb_{-1}\Delta P_{-1})}{rb_{-1}rb_{-2}P_{-1}P_{-2}}$$

$$- \frac{B\Delta rb}{rbrb_{-1}P_{-1}} - \frac{B + rb_{-1}H\Delta P}{rb_{-1}PP_{-1}} + \frac{rb_{-2}P_{-2} - rb_{-1}P_{-1}\Delta B}{rb_{-1}rb_{-2}P_{-1}P_{-2}} \tag{4}$$

$$\Delta k = \Delta k_{-1} + \Delta i \tag{5}$$

$$\Delta M = \Delta Hp + \Delta D \tag{6}$$

$$P\Delta wp = \Delta Hp + \frac{\Delta Bp}{rb_{-1}} - \frac{Bp\Delta rb}{rbrb_{-1}} + \Delta Dp - \Delta L - (wp-wb)\Delta P \tag{7}$$

$$0 = \Delta Hb + \frac{\Delta Bb}{rb_{-1}} - \frac{Bb\Delta rb}{rbrb_{-1}} + \Delta L - \Delta Dp - \Delta Dg - wb\Delta P \tag{8}$$

$$P\Delta a = \Delta Dp + \Delta Dg - (a-wb)\Delta P \tag{9}$$

$$\Delta H = \Delta Hp + \Delta Hb \tag{10}$$

$$\Delta B = \Delta Bp + \Delta Bb \tag{11}$$

$$P\Delta g = P\Delta t + (t-g)\Delta P + \Delta H - \Delta H_{-1} + \frac{\Delta B}{rb_{-1}} - \frac{\Delta B_{-1}}{rb_{-1}}$$

$$- \frac{B-B_{-1}}{rbrb_{-1}}\Delta rb + \Delta Dg - \Delta Dg_{-1} \tag{12'}$$

$$\Delta c = .7\Delta y + .28\Delta z - 500\,\Delta rb - 417\Delta rl - 1250\Delta rd$$
$$+ .15\Delta wp_{-1} \tag{13}$$

APPENDIX B (continued)

$$\Delta i = .1\Delta x - 240\Delta rb - 200\Delta rl - 600\Delta rd - .05\Delta k_{-1} \tag{14}$$

$$\frac{\Delta Bp}{rb_{-1}P_{-1}} = .753\Delta wp + .0809\Delta x + \frac{Bp\Delta P}{rb_{-1}PP_{-1}}$$

$$+ \left(8400 + \frac{Bp}{rb_{-1}rbP_{-1}}\right)\Delta rb - 7000\Delta rl - 3182\Delta rd \tag{15}$$

$$\frac{\Delta D}{P_{-1}} = .502\Delta wp + .0538\Delta x + \frac{D\Delta P}{PP_{-1}} - 2800\Delta rb - 2333\Delta rl$$

$$+ 7000\Delta rd \tag{16}$$

$$\frac{\Delta L}{P_{-1}} = .4\Delta wp + .15\Delta x + \frac{L\Delta P}{PP_{-1}} + 4800\Delta rb$$

$$- 10000\Delta rl + 1818\Delta rd \tag{17}$$

$$\frac{\Delta Bb}{rb_{-1}P_{-1}} = .1765\Delta a + \frac{Bb\Delta P}{rb_{-1}PP_{-1}} + \left(2600 + \frac{Bb}{rbrb_{-1}P_{-1}}\right)\Delta rb$$

$$- 1833\Delta rl \tag{18}$$

$$\Delta Hb = .1176\Delta a + \frac{Hb\Delta P}{PP_{-1}} - 200\Delta rb - 167\Delta rl \tag{19}$$

$$\Delta rd = .2\Delta rb + .1667\Delta rl \tag{20}$$

$$\Delta HB \quad .1425(\Delta Dp + \Delta Dg + Dp_{-1} + Dg_{-1}) - Hb_{-1} \tag{21}$$

APPENDIX C

The Disequilibrium Model

$$\Delta x = \Delta c + \Delta i + \Delta g \qquad (1)$$

$$\Delta y = \Delta x - \Delta t \qquad (2)$$

$$P\Delta t = \Delta V + .25P\Delta x + .25(x-t)\Delta P - .75\Delta B \qquad (3')$$

$$\Delta g = \frac{H\Delta P_{-1}}{P_{-1}P_{-2}} - \frac{\Delta P_{-1}\Delta H}{P_{-1}P_{-2}} + \frac{B(P_{-1}\Delta rb_{-1} + rb_{-1}\Delta P_{-1})}{rb_{-1}rb_{-2}P_{-1}P_{-2}}$$

$$- \frac{B\Delta rb}{rbrb_{-1}P_{-1}} - \frac{B+rb_{-1}H}{rb_{-1}PP_{-1}}\Delta P + \frac{rb_{-2}P_{-2}-rb_{-1}P_{-1}}{rb_{-1}rb_{-2}P_{-1}P_{-2}}\Delta B \qquad (4)$$

$$\Delta k = \Delta k\text{-}1 + \Delta i \qquad (5)$$

$$\Delta m = \Delta Hp + \Delta D \qquad (6)$$

$$P\Delta wp = \Delta Hp + \frac{\Delta Bp}{rb_{-1}} - \frac{Bp\Delta rb}{rbrb_{-1}} + \Delta Dp - \Delta L - (wp-wb)\Delta P \qquad (7)$$

$$0 = \Delta Hb + \frac{\Delta Bb}{rb_{-1}} - \frac{Bb\Delta rb}{rbrb_{-1}} + \Delta L - \Delta Dp - \Delta Dg - wb\Delta P \qquad (8)$$

$$P\Delta a = \Delta Dp + \Delta Dg - (a-wb)\Delta P \qquad (9)$$

$$\Delta H = \Delta Hp + \Delta Hb \qquad (10)$$

$$\Delta B = \Delta Bp + \Delta Bb \qquad (11)$$

$$P\Delta g = P\Delta t + (t-g)\Delta P + \Delta H - \Delta H_{-1} + \frac{\Delta B}{rb_{-1}} - \frac{\Delta B_{-1}}{rb_{-1}}$$

$$- \frac{B-B_{-1}}{rbrb_{-1}}\Delta rb + \Delta Dg - \Delta Dg_{-1} \qquad (12')$$

$$\Delta c^* = .7\Delta y + .28\Delta z - 500\Delta rb - 417\Delta rl - 1250\Delta rd$$

$$+ .15\, wp_{-1} \qquad (13')$$

$$\Delta i^* = .1\Delta x - 240\Delta rb - 208\Delta rl - 600\Delta rd - .05\Delta k_{-1} \qquad (14')$$

APPENDIX C (continued)

$$\frac{\Delta B^*p}{rb_{-1}P_{-1}} = .753\Delta wp + .0809\Delta x + \frac{Bp\Delta P}{rb_{-1}PP_{-1}}$$

$$+ (8400 + \frac{Bp}{rb_{-1}rbP_{-1}})\ \Delta rb - 7000\Delta rl - 3182\Delta rd \quad (15')$$

$$\frac{\Delta D^*}{P_{-1}} = .502\Delta wp + .0538\Delta x + \frac{D\Delta P}{PP_{-1}} - 2800\Delta rb$$

$$- 2333\Delta rl + 7000\Delta rd \quad (16')$$

$$\frac{\Delta L}{P_{-1}} = .4\Delta wp + .15\Delta x + \frac{L\Delta P}{PP_{-1}} + 4800\Delta rb$$

$$- 10000\Delta rl + 1818\Delta rd \quad (17)$$

$$\frac{\Delta Bb}{rb_{-1}P_{-1}} = .1765\Delta a + \frac{Bb\Delta P}{rb_{-1}PP_{-1}} + (2600 + \frac{Bb}{rbrb_{-1}P_{-1}})\Delta rb$$

$$- 1833\Delta rl \quad (18)$$

$$\Delta Hb = .1176\Delta a + \frac{Hb\Delta P}{PP_{-1}} - 200\Delta rb - 167\Delta rl \quad (19)$$

$$\Delta rd = .2\Delta rb + .1667\Delta rl \quad (20)$$

$$\Delta Hb = .1425\ (\Delta Dp + \Delta Dg + Dp_{-1} + Dg_{-1}) - Hb_{-1} \quad (21)$$

$$\Delta rl = \lambda\Delta rl^* + (1-\lambda)\ \Delta rl_{-1} \quad (22)$$

$$\Delta C = \Delta C^* + .318\ (\Delta L^D - \Delta L^S) \quad (23)$$

$$\Delta I = \Delta I^* + .076\ (\Delta L^D - \Delta L^S) \quad (24)$$

$$\Delta D + \Delta D^* + .179\ (\Delta L^D - L^S) \quad (25)$$

$$\frac{\Delta B}{rb} = \frac{\Delta B^*}{rb} + .248\ (\Delta L^D - \Delta L^S) \quad (26)$$

APPENDIX D

The Combinations of Values of the α's Used in the Sensitivity Analysis.

There are $\frac{n!}{n_1!\, n_2! \ldots n_j!}$ permutations of n objects into j groups, where n_1 objects are alike and of one kind, n_2 objects are alike and of another kind, and so on, with $n_1 + n_2 + \ldots + n_j = n$.

Using intervals of .25, there are five distinct sets of points which satisfy the two constraints

$\alpha_1 + \alpha_2 + \alpha_3 + \alpha_4 + \alpha_5 = -1$ and

$-1 \leq \alpha_i \leq 0, \; i = 1,\ldots,5.$

These five sets, with associated permutations, are:

(1) {-1,0,0,0,0}, which has 5 permutations,

(2) {0,-.25,-.25,-.25,-.25}, which has 5 permutations,

(3) {0,0,0,-.5,-.5}, which has 10 permutations,

(4) {0,0,0,-.75,-.25}, which has 20 permutations,

(5) {0,0,-.5,-.25,-.25}, which has 30 permutations.

In all there are 70 permutations, and each of these was used as a set of coefficient values in the sensitivity analysis.

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