

Different Macroclosures of the Original Johansen Model and Their Impact on Policy Evaluation

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It seems necessary to get a better understanding of the economics involved in the rather large and complicated computable general equilibrium models now being implemented in several countries. This paper contributes to the discussion on how the results from such models depend on the choice of closure rule. Within a very general setup, the original Johansen model, the different behaviors of the model are discussed under different closure rules, and the effects of fiscal policy under the alternative closures are quantified by numerical experiments.

1. BACKGROUND ON THE DISCUSSION OF MACROCLOSURE

The use of applied general equilibrium models for economic planning purposes is a growing business. These models are based mostly on the study of Leif Johansen (1960, 1974) and still do not differ very much from the original setup. This paper discusses the consequences of different ways of determining the original Johansen model, also called the Multi-Sectoral Growth model (MSG). We want to elaborate the very different behaviors of the model under different closure rules. In the first part of the paper, the different closure rules are presented analytically. In the second part of the paper, we show the importance of the different closure rules for comparative statics policy experiments with a numerical example.

The present discussion on macroclosures comes from two sources; both relate the issue to classical macroeconomic controversies. The first one is rather theoretical and is concentrating on possible "overdeterminations" of macromodels. There is not a very wide literature on the subject, however. Amartya Sen's discussion in *Economic Record* (1963) was not

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followed up until recently. In this early contribution, Sen discussed the differences between neoclassical, neo-Keynesian, Johansen, and general theory approaches to macrotheories of income distribution. He views the four different theories as four ways of handling a basic overdetermination in the macrosystem.

The second source of this debate has a more empirical basis. A number of Johansen-type applied general-equilibrium planning models appeared in the late 1970s. The most comprehensive and widely known studies are by Adelman and Robinson (1978) and Taylor et al. (1980). The studies include evaluation of policies following intensive policy experimenting with these computable general equilibrium models. Since some of the results from the studies were pretty surprising, Taylor and Lysy (1979) investigated the background more closely. They found that one aspect not frequently discussed by model builders, the closing of the model, to a great extent determined the model's qualitative characteristics. They put the problem the following way: after having established the "normal" accounting identities, functional relationships, and exogenous variables of a model, the author finds that this is not enough to close it. Additional assumptions have to be made to close the model; how should that be decided?

We present here further results following the approach put forward by Taylor and Lysy, applying this to a model with a more general formulation of the demand behaviors and price system. We start out by discussing the positions of Sen and Taylor/Lysy.

2. A CLOSER LOOK AT THE MACROTHEORY APPROACH AND THE PLANNING-MODEL APPROACH

Amartya Sen's article should be seen in relation to the extensive debate in the 1960s on theories of income distribution following Nicholas Kaldor's review (Kaldor 1955-56). We do not go into this debate here, but briefly discuss the very neat and compact presentation of the closure problem presented by Sen. Later we compare this to the planning-model experiences of the late 1970s.

The setting is as follows: one good is produced by constant return to scale technology. Labor and capital are the only factors of production and are given by fixed supply. We assume away problems related to depreciation and accumulation of the capital stock. Saving behaviors are different for profits income and labor income.

¹Symbols are given in the Appendix.

The model equations are¹

$$X = F(N, K), \quad (1)$$

$$PF_N = W, \quad (2)$$

$$PX = rK + WN, \quad (3)$$

$$PI = s_z rK + s_w WN, \quad (4)$$

$$I = \bar{I}, \quad (5)$$

$$N = \bar{N}, \quad (6)$$

$$K = \bar{K}. \quad (7)$$

This gives seven independent equations for the six variables: X , N , K , I , W/P , r/P . Consequently, the system is "overdetermined." It seems impossible to have full employment, given investments and real wages determined by marginal product at the same time.

This problem of "overdetermination" can be solved in different ways, and the working of the model will vary in accordance with choice of closure. Sen relates this to different "schools of thought" and discusses four alternatives.

The neoclassical closure assumes that eq. (5) be dropped, i.e., investment is not given autonomously. Investment is endogenous and consequently brought to be equal to the planned saving. We can think of an interest-rate adjustment mechanism outside the model clearing this investment-savings-market. The General Theory model assumes that eq. (6) is dropped, therefore allowing for unemployment. Variations in the level of output and employment will make the saving and investment market clear. The "Johansen-closure" assumes that eq. (4) is dropped. We must then think of a fiscal policy outside the model that makes the planned savings equal to the autonomously given investments. We return to a closer study of the Johansen model in the Section 3. Finally, in the neo-Keynesian system eq. (2) is dropped, not accepting the rule that real wage equals marginal product of labor. Here, an income-distribution mechanism gives the savings-investment balance.

Both in the neoclassical and the Johansen closure, the model's causal links are easy to follow. In both versions, output is given by the production side alone, since full utilization of resources is assumed. The real wage and the real rate of return on capital are then determined by the first-order condition for labor-input (2) and as a residual income by (3), respectively. From this point on the two determinations differ, however. In the Johansen-setup, the investments are exogenous, so that consumption must adjust endogenously. In the neoclassical model, the investments will adjust to the given savings decisions.

The General Theory and neo-Keynesian closures give more complicated interactions in the model. In the former, both supply and demand side represented by eqs. (1)–(4) interact to determine employment, output and the relative prices. In the latter, the situation is a bit simpler. The full-employment assumption gives output determined from the production side. The income distribution is determined by eqs. (3) and (4) to create the necessary savings.

Certainly this setup does not exhaust the debate between different income-distribution theories. I feel a bit uncomfortable about putting too much orthodoxy into the debate; nevertheless I think Sen's contribution is a very nice presentation of some basic differences in macromodeling.

The same sort of problems and choices have faced several model builders in more empirically oriented planning exercises. They are, however, not always handled in a very conscious way, and there is still disagreement on how this should be interpreted. For instance, while Taylor and Lysy stress the political and economic considerations involved in choosing the closure rule, De Melo, Dervis, and Robinson (1982) still argue for a "neutral" closing of the model.

To understand the macroeconomics involved in these large-scale computable general equilibrium models, it is convenient to construct an aggregated representation of the model. In fact, in 1960 Johansen cleared up some of the economic controversies by building a one-sector version of the model. Nowadays this seems once more to be a necessary task.

We here present once again the problems discussed by Taylor and Lysy (1979) and try to get a grasp of the main questions in the debate. The analytical setup is closely related to Sen's. We include the foreign sector, however, giving some new restrictions on the price system and some new adjustment mechanisms. In addition, we explicitly model the public sector, because it is an important part of the savings creation in the model.

The model is

$$V = F(N, K), \quad (8)$$

$$P_v F_N = W, \quad (9)$$

$$P_v F_K = r, \quad (10)$$

$$PI = s_z(1 - t_z)rK + s_w(1 - t_1)WN + F - D, \quad (11)$$

$$V = vX, \quad (12)$$

$$X = C + I + G + E, \quad (13)$$

$$P = vP + mP_0, \quad (14)$$

$$D = P_e E - P_0 mX, \quad (15)$$

$$F = t_1WN + t_2rK - PG - (P - P_e)E, \quad (16)$$

$$I = \bar{I}, \quad (17)$$

$$N = \bar{N}, \quad (18)$$

$$K = \bar{K}, \quad (19)$$

$$P = P_e. \quad (20)$$

This model has 13 independent equations and the following 18 variables: $X, V, N, K, I, C, G, E, F, D, P, P_v, P_0, P_e, W, r, t_1, t_2$. The small-country assumption implies that P_0 and P_e are exogenously given. Public policy determines t_1, t_2 , and G . Finally, since we have not specified any determining mechanism for export, we must assume D or E given. Here we choose to fix D . The overall specification gives the same problem as Sen's: the model is overdetermined. The model equations are self-explanatory. Note that the possibility of arbitrage is included in relation (16).

As mentioned above, there is some disagreement on how different closures of this model should be interpreted. Taylor and Lysy proposes three ways. The neoclassical closure drops eq. (17), the fixed investment assumption. At the same time they also delete eq. (18), the full employment, and assume the nominal wage fixed. This approach helps to focus on the problem they want to discuss—income-distribution responses to factor price changes. This adds a new dimension to the closure debate. Not only political and economic considerations are of importance when the closure is chosen, but also the nature of the problem to be discussed. I return to this later. A critical observer may think that the deletion of the full-employment assumption is not very neoclassical. The counter-argument could be that in this model “full employment would be easy to achieve by appropriate manipulation of the *real* wage.”

In the Keynesian closures, Taylor and Lysy no longer assume arbitrage involved by (20). They allow for the possibility that “the overall price level moves closely in response to money wage changes.” Hence the investment is fixed. Consequently, the full-employment assumption is unmoved and the nominal wage is set. In fact they present two Keynesian closures, one with nominal government purchases, PG , fixed. When some payment flows are fixed in nominal terms, they induce contractionary effects when prices in the economy rises. This is important for the relationship between wages and output in the model.

Constantino Lluich (1979), in a paper on the same model, presents an alternative and simpler interpretation of the neoclassical and Keynesian

closures. I do not here argue which is the "correct" representation of old classics. He assumes that dropping eq. (17), $I = \bar{I}$, gives the "neoclassical" version and that dropping eq. (18), $N = \bar{N}$, gives the Keynesian. He keeps the small-country assumption with full arbitrage, eq. (20), in both closures. The adjustment mechanism then very much follows Sen's setup. The production and consumption side are "separated" in the neoclassical alternative, while a Keynesian version allows for interaction.

Also the Johansen closure can be interpreted in this aggregated planning model setup. We then break the relation between income and production by assuming that one of the direct taxes, for instance t_1 , is endogenously determined so that full employment is satisfied by sufficient consumption, given investments.

The planning model discussed so far has not allowed for much autonomy of the domestic price system. I think that the original Johansen model is a better representative for the sort of consumption system and price system most commonly used in applied models. Let us therefore study this model more closely.

3. THREE CLOSURE RULES FOR THE ORIGINAL MSG MODEL

As mentioned above, Johansen (1960) presented a one-sector version of his general equilibrium model when it was first published. The version presented here includes the same economic mechanisms, but the consumption system is more elaborate than that in the models discussed in Section 2. We specify here a Linear Expenditure System in consumption, since that is used in the numerical experiments in Section 4. Johansen used a Frisch-type complete scheme consumption system in his version. In relation to the Taylor-Lysy model, MSG allows for a much more autonomous domestic price system by treating the foreign sector differently.

The model can be summarized as follows:

$$X = F(N, K), \quad (21)$$

$$(P_x - bP_0)F_N = W, \quad (22)$$

$$(P_x - bP_0)F_K = P_x R, \quad (23)$$

$$Y^* = (WN + RP_x K - P_0 bX)(1 - t)(1 - s), \quad (24)$$

$$F = t(WN + RP_x K - P_0 bK) - P_x G, \quad (25)$$

$$C = \theta_0 + (c_0/P_0)[Y^* - (P_0\theta_0 + P_x\theta_1)], \quad (26)$$

$$C_1 = \theta_1 + (c_1/P_x)[Y^* - (P_0\theta_0 + P_x\theta_1)], \quad (27)$$

$$X = C_1 + I + G + E, \quad (28)$$

$$D = P_x E - P_0 C_0 - P_0 b X, \quad (29)$$

$$I = \bar{I}, \quad (30)$$

$$N = \bar{N}, \quad (31)$$

$$K = \bar{K}, \quad (32)$$

The assumptions made in Section 2 still apply, including constant return technology. The parameters of the consumption-system (26) and (27) are assumed to be set so that the identity condition $P_0 C_0 + P_x C_1 = Y^*$ is satisfied. We assume that G , E , P_0 , and W are given exogenously. The model above then include 12 independent equations and 11 free variables: X , N , K , I , C_0 , C_1 , D , F , P_x , R , and Y^* . We have arrived at the same problem as discussed by Sen and Taylor-Lysy: the model is over-determined.

In discussing the determination of the model Johansen (1974, p. 32) states “. . . we have assumed that the chain between Y and the economic result of the production is broken by net direct taxes (taxes minus subsidies to consumers), which are not explicit in the model. It would, however, be easy to formally introduce one more equation which would yield the amount of net taxes on consumers implied by the model.” That is exactly what we have done by using eq. (24), and consequently the Johansen closure of this model is to assume the tax parameter t endogenous. With this determination, output will be fully determined on the production side of the economy with full use of the available resources N and K . The tax will then adjust so that the private disposable income Y is large enough to create the consumption C_1 necessary to exhaust production. An increase in investments, for instance, will only have effect on private disposable income through an increase in the tax so that the private consumption C_1 is reduced to give equilibrium in the output market. Both government surplus and balance-of-payment will be endogenous in this model. This closure is probably as close as you can come a “neutral” solution, in the sense that forced savings are left out altogether.

A neoclassical closure of this model would result if eq. (30), concerning exogenously given investments, is dropped. The output will now still be determined on the production side of the economy. Investments will be savings determined. We can see from (24) that private disposable income also will be given from the production side alone, given the tax t , and that the output price will be given by (22). Together, they will give consumption demand by (27) and consequently the investments will be given by (28) as a savings residual.

The Keynesian closure in the sense discussed in Section 2 is obtained by dropping eq. (31), the full employment-assumption. Then we lose the nice dichotomy between the production and the consumption side: the two will interact. An increase in investments will here create the traditional multiplier-effects, but will also influence the price system. An analytical solution of this Keynesian setup is messy, and we will therefore postpone the discussion to Section 4, which deals with the model's numerical solution.

4. NUMERICAL EXPERIMENTS ON THE IMPORTANCE OF THE DIFFERENT CLOSURE RULES IN POLICY MODELS

So far, we have compared the different closure rules analytically. To gain a better feeling for the importance of alternative setups, we will complete some numerical experiments. On the one hand, we want to study the effects of a Johansen closure in the Taylor-Lysy model. The neoclassical and Keynesian closures as interpreted by Lluch (1979) will be the reference points. On the other hand, we want to study the effects of alternative determinations of the original Johansen model, MSG.

We have not based the analysis on empirical data, but have chosen to run numerical experiments on an "archtype economy." To stay within the tradition, we use the same representative underdeveloped economy as studied by Taylor and Lysy (1979). The following numerical values are enumerated: total output, $X = 100$, is distributed to consumption, $C = 55$, investments, $I = 15$, exports, $E = 15$, and public expenditures, $G = 15$. All prices are initially set to 1. Factor incomes for labor, $N = 48$, and real capital, $K = 32$, add up to value added, $V = 80$. The savings ratios are assumed to be $s_1 = 0.05$ and $s_2 = 0.51333$, and the tax parameters are $t_1 = 0.05$ and $t_2 = 0.25$. The export surplus is $D = -5$. To make things simple, we have used a Cobb-Douglas production function. We are interested in the channels and the magnitudes of the effects in these models, and have studied the consequences of a 10% increase in real public expenditures. The results are shown in Tables 1 and 2.²

We start out by comparing the neoclassical and Johansen closures. Both results can be obtained by direct inspection of the model, without even using a hand calculator. The reason is, of course, that they do not allow for responses on the production side of the economy. In the neoclassical setup, an increase in public expenditures will give the exact same contraction in investments. And the channel is easy to follow: increased public expenditure reduces government savings by the same

²The experiments in the Keynesian cases are solved with the statistical package TROLL at the Computer Center, MIT.

Table 1: Fiscal-Policy Response in the Taylor-Lysy model

Elasticities with Respect to a Change in Real Public Expenditures			
Endogenous variables	Neoclassical ^a	Keynesian ^a	Johansen
<i>X</i>	0.0	+0.6	0.0
<i>V</i>	0.0	+0.6	0.0
<i>N</i>	0.0	+1.0	0.0
<i>K</i>	0.0	0.0	0.0
<i>I</i>	-1.0	0.0	0.0
<i>C</i>	0.0	+0.6	-0.3
<i>E</i>	0.0	+0.8	0.0
<i>F</i>	-3.2	-2.0	+3.5
<i>P</i>	0.0	0.0	0.0
<i>P_v</i>	0.0	0.0	0.0
<i>W</i>	0.0	-0.4	0.0
<i>r</i>	0.0	+0.6	0.0
<i>t_z</i>			+3.8

^aLluch (1979)**Table 2: Fiscal-Policy Response in the Original Johansen model**

Elasticities with Respect to a Change in Real Public Expenditures			
Endogenous variables	Neoclassical	Keynesian	Johansen
<i>X</i>	0.0	+0.2	0.0
<i>N</i>	0.0	+0.4	0.0
<i>K</i>	0.0	0.0	0.0
<i>I</i>	-1.0	0.0	0.0
<i>C₀</i>	0.0	+0.2	-0.4
<i>C₁</i>	0.0	+0.2	-0.3
<i>D</i>	0.0	-0.8	+0.8
<i>F</i>	-5.0	-4.3	+2.0
<i>P_x</i>	0.0	+0.1	0.0
<i>R</i>	0.0	+0.4	0.0
<i>Y</i>	0.0	+0.2	-0.3
<i>t</i>			+1.2

amount, thereby reducing the savings-determined investments, as can be seen from Table 1.

The Johansen closure is also very simple in this model. The increased public expenditure, given total output and investments, must replace consumption. The private consumption can only be reduced by compressing private disposable incomes, inducing here an upward shift of the

profit tax, t_z . (We could alternatively have assumed the labor-wage tax t_1 to be endogenous.) The decreased private saving following the tax increase is exactly compensated by increased government savings because of increased tax incomes excess of the increase in expenditures. The neoclassical and Johansen alternatives do not allow for large repercussions of increased public expenditures. They will result in a redistribution of existing output, first at the cost of investments and then by contracting consumption.

The Keynesian effect here is provided by the multiplier responses, which expand output, employment, and consumption. The output price is not allowed to vary. Relative prices will change, however. The relative price between the factors of production, W/r , will have to change in favor of real capital to have the increased employment "accepted." The decreased government savings are compensated by increased private savings due to increased private incomes.

We now proceed to the aggregated static version of the well-known Johansen planning model. The main difference from the model discussed above is the inclusion of a consumption system, able to capture in principle substitution and income effects occurring in the private consumption of both domestic and imported goods. The present version, however, does not allow much price effects. If prices are not given from abroad, they will be cost determined domestically with constant return to scale. Since both factors of production and wages are given in the neoclassical and "Johansen" closures, there will be no price effects. The Keynesian case will give some price effects by changing employment and thereby costs. The multisector Johansen model will have some more price effects, as is seen later.

We have to add some parameters for our "archetype economy" to represent it in a Johansen framework. In the LES-consumption system we have assumed that the marginal budget shares are $c_0 = 0.2$ and $c_1 = 0.8$, and that the floor-level consumptions are equal to $\theta_0 = 3$ and $\theta_1 = 29$. The tax rate $t = 0.2$, the overall saving rate $s = 0.0972$ and the import coefficient $b = 0.1$. We have also here used Cobb-Douglas production function. The results are given in Table 2.

The neoclassical closure of the Johansen model works as nicely as in the Taylor-Lysy model. An increase in public expenditure just reduces investment by exactly the same amount, and that's it. A truly stable world. The Johansen alternative, however, now gives some different results. We still have a necessary reduction in private consumption of the home good, taken care of by an increased tax levied on private income. This reduction in private disposable income will now also reduce consumption of the noncompetitive imported goods. In effect, the increased government

savings must compensate both reduction in private and foreign savings. Still, there will be no effects on the production side.

It should be pointed out that these aggregated models cannot fully represent the intricacies of real-life multisectoral planning models. Even with constant return to scale in all production sectors, prices will not be cost determined in the sense discussed above. A change in the composition of demand will generally influence the relative factor prices and this will induce a change in the relative prices of goods too. Then with respect to the exercise described above, in a multisector setup we will have to expect a change in the composition of production. It is also important to mention that the original Johansen model assumes decreasing returns to scale in some sectors, giving a more traditional simultaneous price determination.

In the Keynesian case, we basically have a multiplier effect, with increased output, employment, and incomes. The changed costs will now induce an increase in the output price, and we will have both income and substitution effects in consumption. The total effect is an increase in both consumption categories. Also here the relative price of real-capital to labor will have to shift in favor of real capital, to give factor substitution on the production side. The increased imports both of consumption goods and intermediate goods mean a reduction in export surplus and thereby increased foreign savings. The government savings will on the other hand decrease.

The "Keynesian" and "Johansen" closures give very different effects on balance-of-payments and the fiscal balance. The Johansen version has a positive impact on the balance of payments because imported consumption goods are reduced. The Keynesian alternative gives a larger negative balance of payments, because of increased imports of intermediate and consumption goods. The Johansen closure gives a positive effect on the fiscal balance, because of increased tax incomes excess of the increase in public expenditures. The Keynesian version has a negative effect on the fiscal balance because (1) the increased intermediate imports reduce the tax-incomes by reducing the tax base, namely the private incomes, (2) the increase in real public expenditure has an impact itself, and (3) the nominal public expenditure increases due to the increased price on output. The increased income from increased employment cannot by far outweigh these three effects.

5. CONCLUDING REMARKS

I think that the literature on closing rules is very helpful in understanding the economics involved in rather large and complicated general

equilibrium models now being implemented in several countries. The interactions and repercussion effects built into the models are clarified. The importance of the choice of closing rule is obvious when we see the very different effects of fiscal policy explored in Section 4.

It is hard to believe that the discussion about these closure rules in relation to old macrotheoretical controversies gives much guidelines for modelers. The basic problem with the planning models is whether they indeed offer the possibility of testing the models as such. It should obviously not be only a choice between schools of thought if the Norwegian, Mexican, or Indian economy is closed in a neoclassical, Keynesian, or Johansen way. Both historical and institutional information of the economy under study will give modelers some restrictions on the choice of closure. Partly, therefore, the problems discussed here boil down to an empirical investigation problem.

This, however, will not necessarily provide sufficient guidance about how to close a model. The reason is related to another basic problem with this model-type: Their analytical limitation due to their generality. It seems very popular these days to build very general models for one country, and apply the model to all sorts of policy-experiments. The results can easily generate much information on a variety of different issues, but of small interest. The particular economic problems under study should influence both model-formulation and model-closure. Simply the fact that modelers need to have control variables exogenous set places a restriction on the model's specification. I predict, that we will soon again return to more specific models made to study more narrowly defined problems. The closure choice will then probably be much less problematic. And the usefulness of the models will be more widely acknowledged.

APPENDIX

- X —output
- N —employment
- K —real capital
- I —net investment
- V —value added
- C —private consumption
- C_0 —consumption of noncompetitive imports
- C_1 —consumption of home goods
- G —public expenditures (real)
- E —exports
- D —export surplus

- F —government surplus
 P —output price
 P_v —price of value added
 P_x —price of home goods
 P_0 —price of noncompetitive imports
 P_e —price of exports
 W —wage
 r —return on capital
 R —interest rate
 Y —private disposable income
 t —direct tax
 t_1 —labor wage tax
 t_z —profits tax
 s_z —savings ratio for profits
 s_w —savings ratio for labor wage
 I —exogenously given investments
 \bar{N} —available labor force
 \bar{K} —stock of real capital
 m —import coefficient for intermediate imports
 v —($= 1 - m$)—value-added share in total output
 b —import coefficient of noncompetitive goods
 s —savings ratio
 Y^* —private consumption expenditures
 θ_0 —floor-level consumption (real) of noncompetitive imports
 θ_1 —floor-level consumption (real) of home goods
 c_0 —marginal propensity to consume noncompetitive consumer imports
 c_1 —marginal propensity to consume home goods

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