A MULTI-SECTOR SIMULATION MODEL OF SOVIET ECONOMICS DEVELOPMENT

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Abstract

This paper presents a multi-sector model of the Soviet economic for the period 1928-40. The purpose of the model is to simulate the effects of collectivization, investment strategy, and soft-budget constraints on Soviet economic development. Details of baseline national accounts and related databases used in the modelling are also presented.

I. Introduction

The purpose of this essay is to document the model of the Soviet economy that I have used in other papers. The aim of the model is to simulate the results of Soviet policies and institutions in order to determine their role in the economic development of the U.S.S.R.

My point of departure is Domar's (1957) version of Fel'dman's growth model. Fel'dman was a Soviet economist who developed a theoretical model of economic development during the 1920s. The Fel'dman model divides the economy into producer goods and consumer goods sectors. Output in each sector depends only on capital in that sector. Producer goods output can be invested in either the producer goods or consumer goods sectors. The more capital invested in the former, the faster the economy grows.

This model is an appropriate place to begin since capital accumulation was the main source of growth in the Soviet Union and since most investment was effected with domestically produced plant and equipment. (While the possibility of exporting farm products and light manufactures and importing capital equipment was considered and, indeed, tried briefly, the 1930s were not a propitious time for export led growth, so Soviet development quickly became autarchic.)

To assess Soviet policies, the model must be elaborated to

more accurately describe Soviet conditions. So I have elaborated his model in several ways. I divide the economy into four sectors--agriculture, manufactured consumer goods, producer goods, and services (including government). Administrative rules and markets define the relationships between these sectors. The important markets were the labour market (encompassing rural-urban migration and the allocation of labour between industries), consumer goods markets where the available supply was sold to consumers, and the collective farm market where peasants sold food to city dwellers. Other important decisions like the allocation of investment or the delivery of farm products to industry were handled by administrative fiat rather than by markets and are so treated in the model.

Indeed, to address issues like collectivization, it is necessary to develop several closely related models. The NEP and the Stalinist (collectivized) system differed in many ways, so comparing them is not a matter of changing the value of one or two parameters. I will explain the models in turn.

II. The Model of the Collectivized Economy

I begin with the model of the collectivized economy. Each year, a series of subprograms are executed in the same order. The following equations specify the collectivization model for 1930-39. For 1928 and 1929 (before forced collectivization), the

model incorporates elements of the NEP model (like its migration function), and many variables are set to their historical values since their simulation would be extremely difficult.

1. demography and employment

The rural (rurpop) and urban (urbpop) populations are updated by adding births, subtracting normal and "excess" deaths (exdeath) and accounting for migration (mig). The appendage (-1) indicates a lagged value, and the variables beginning with cdr and cdr are crude birth and death rates respectively. (Cdrrurok is the "normal" crude death rate in rural areas.)

(1) rurpop=rurpop(-1)+(((cbrrural(-1)-cdrrurok(-1))
*rurpop(-1))/1000)-mig(-1)-exdeath(-1)

(2) urbpop=urbpop(-1)+(((cbrurban(-1)-cdrurban(-1))
*urbpop(-1))/1000)+mig(-1)

An estimate of the farm population in 1928 is updated by the change in the rural population, and the nonfarm population equals the total population minus the farm population:

(3) farmpop=farmpop(-1)+rurpop-rurpop(-1)

(4) nonfarmpop=rurpop+urbpop-farmpop

The nonagricultural labour force (l) is computed as the urban population multiplied by the observed employment rate (emprate) plus the size of the armed forces (lmil):

(5) l=emprate*urbpop+lmil

2. investment

One third of the investment expenditures undertaken in any year (i) are presumed to come into productive use in each of the following three years, so the additions to productive capacity (efinvest) equal one third of the investment expenditures in the three preceding years:

(6) efinvest=(i(-1)+i(-2)+i(-3))/3

As in the Feld'man model, a fraction (e) of new investment is assigned to the producer goods sector increasing its capital stock by dkp, and the remainder is assigned to the consumer goods industry:

(7) dkp=e*efinvest

(8) dkc=(1-e)*efinvest

The fraction e was determined from the investment breakdowns for 1929-34 reported in the Soviet statistical abstract Socialist Construction in the U.S.S.R. (1936, pp. 346-51). This source subdivided investment for the "total socialist economy"--essentially the entire economy outside of agriculture--by commissariats and branches. The data were first reorganized by industry. Then investment in each industry was multiplied by the fractions shown in Table 1 that decompose each industry into a producer goods and a consumer goods component. Summing the investment in the producer goods components and dividing by the total gave an estimate of e for each year. The average value was .16, and

there was little variation from year to year. This may not seem like a high number in view of the rhetoric about heavy industrialization, but it is considerably larger than 7%, which was the share of the nonagricultural capital stock in the producer goods industry in 1928.

The capital stocks of the two sectors (kp and kc) are updated by adding new investment and subtracting depreciation:

(9) kp=dkp+(1-.015)*kp(-1)

(10) kc=dkc+(1-.015)*kc(-1)

Investment in these calculations is defined to be gross and inclusive of repair expenditures. With these conventions a depreciation rate of 1.5% rationalizes Moorsteen and Powell's (1966, pp. 315, 386) investment and capital stock series.

3. labour allocation

The nonagricultural labour force is allocated between the p-goods (producer goods) and c-goods (consumer goods, broadly conceived) industries by equating the value of the marginal product of labour (in 1937 prices) in the two sectors. P-goods include machinery, structures, military equipment, hospital equipment, and consumer durables. C-goods include manufactured consumer goods, housing, private services, and government activities other than the acquisition of military equipment. Equation 11 is the marginal product of labour in the c-goods

industry, equation 12 is the marginal product in the p-goods industry, and equation 13 is the labour constraint. The production functions are explained shortly.

```
(11) mpp=(((kc+kp)/136.3)**.25075733)*(83.2513/9.977)*(1-f-h)*
          ((lc/9.977)**(-p-1))*(f*(kc/126.540)**(-p)
          +h*(agmfsim(-1)/16006.26)**(-p)+(1-f-h)*(lc/9.977)
          **(-p))**((-1/p)-1)
(12) mpp = (((kc+kp)/136.3)**.25075733)*(12.0267/2.368)*(1-d)
           *(((lp)/2.368)**(-p-1))*(d*(kp/9.729)**(-p)
           +(1-d)*((lp)/2.368)**(-p))**((-1/p)-1)
(13) l=lc+lp
```

4. supply of goods

With the labour force and capital stock in each sector determined, output can be calculated from the production functions. The functions are CES functions. The output of p-goods depends on capital and labour in that sector, while the output of c-goods depends on capital, labour, and on the quantity of agricultural products processed (agmfsim). The latter is lagged one year--what was processed in 1930 was harvested in 1929. The intercepts are 1928 output levels as given in Table 2. Input indices are normalized by dividing by 1928 values from Table 2.

```
(14) yp=(((kc+kp)/136.3)**.25075733)*12.0267*(d*(kp/9.729)**(-p)
        +(1-d)*((lp)/2.368)**(-p))**(-1/p)
```

```
(15) yc=(((kc+kp)/136.3)**.25075733)*
          83.2513*(f*(kc/126.540)**(-p)
         +h*(agmfsim(-1)/16006.26)**(-p)+(1-f-h)*(lc/9.977)
         **(-p))**(-1/p)
```

The term ((kc+kp)/136.3)**.25075733 is these equations represents technical change by making it a function of capital accumulation. Output growth unexplained by input growth was first determined (about 2% per year) and then prorated over the actual increase in the capital stock to obtain the specification shown here. This specification captures the idea that new factories were responsible for the rise in efficiency.

In the simulations d is assumed to be .6 and the elasticity of substitution is taken as .4. This implies that p=1.5. These values were suggested by Weitzman's (1970) estimates of industry production functions for the Soviet Union in the 1950s and 1960s. The same value for the elasticity of substitution is used in the c-goods industry as in the p-goods. The coefficients of capital, labour, and processed agricultural goods are assumed to be .35, .35, and .30, respectively.

Since c-goods include services and since consumer durables are p-goods, consumer goods sold in shops (congoods), i.e. real retail sales, are defined as:

```
(16) congoods=yc-yhs-ygov-milps+condur
```

where yhs is housing and private services, ygov is goverment

services (education, health, administration, the secret police), milps is military pay and subsistence, and condur is consumer durables, which are part of p-goods. Yhs, ygov, milps, and condur are all set equal to their actual historical values. Consumer goods sold in shops are subdivided into nonfoods (shpmfsup) and foods (shpfdsup) according to value added weights in their production:

(17) shpmfsup=.55*congoods

(18) shpfdsup=.45*congoods

The output of the p-goods industry includes agricultural equipment (iag), consumer durables (condur), hospital equipment (healtheq), and military equipment (milequip). All of these deductions are set to equal their historical values.

(19) i=yp-iag-condur-healtheq-milequip

5. demand for consumer goods

Wage income (wagebill) is the main component of income driving the consumer goods market and equals nonagricultural employment multiplied by the average nonagricultural wage (wact):

(20) wagebill=l*wact

Consumer preferences in the nonfarm sector are assumed to be Cobb-Douglas, so spending on each commodity equals a constant fraction multiplied by income. Purchases on the collective farm market (kolkexp) and food goods purchased in shops (shpfdexp)

depended on wage income and transfer payments. The latter are set to their historical values:

(21) kolkexp=.13*(wagebill+trans)

(22) shpfdexp=.42*(wagebill+trans)

Expenditures on nonfood consumer goods (shpmnexp) are assumed to depended on lagged agricultural income as well--this year's purchases depend on the sales of last years crop.

(23) shpmnexp=.27*(wagebill+trans)+aginc(-1)

6. consumer good market clearing

In this model the prices of nonfood consumer goods (priceman) and processed food sold in shops (pricefd) are determined by equating supply and demand (equation 18 with 22 and 17 with 23):

(24) pricefd=1.77*(shpfdexp/shpfdsup)/.1932775

(25) priceman=2.42*(shpmnexp/shpmfsup)/.200383176

1.77 and 2.42 are the 1928 values of price indices with bases equal to 1.00 in 1913, and the divisors on the right normalize the indices with respect to those 1928 values.

7. government budget balance

Real government spending (govreal) includes investment (i), hospital (healtheq) and military equipment (milequip), military pay and subsistence (milps), and education, health, adminsitration, and the secret police (ygov):

(26) govreal=i+healtheq+milequip+milps+ygov

Real government expenditures are converted to current ruble expenditures by multiplying the real value by the historical ratio of nominal to real values (govnomrl):

(27) govnom=govreal*govnomrl

The government budget was balanced by adjusting the turnover tax. A regression equation indicates the required turnover tax receipts (in current rubles) as a function of government spending in current rubles:

(28) turntax=exp(-1.51876+1.240056*log(govnom))

8. agricultural prices and marketing

The supply of agricultural products is modelled as a consumption decision by peasants, as described in Allen (1997). Peasants can either consumer their production or sell it to obtain money to buy consumer goods at a price equal to priceman. Since the total supply is determined by the decision of how much to sell on the collective farm market, total supply is made a function of that price (pricekol). Consumer preferences are modelled with a ces function where utility depends on the consumption of agricultural products (fiiksim) and purchased manufactures. Parameter values are calculated to explain the decline in marketing that occurred between 1913 and 1928. The variable split is the ratio of farm income in kind (fiiksim) to

total marketings (agmarksm). Agnet is agricultural production net of seed and feed. Nonkolk is the actual level of centralized and decentralized procurements. These are treated as obligatory deliveries, and they are imposed on farmers in this model. The numbers in equation 33 link the index of prices on the collective farm market to a free market index of agricultural prices with a 1913 value of 1.00.

(29) split=1.5043*(pricekol/priceman)**(-.9298)

(30) fiiksim=agmarksm*split

(31) agmarksm=(agnet/1000)-fiiksim

(32) kolksim=agmarksm-nonkolk/1000

(33) pricekol=2.47*(kolkexp/kolksim)/.430723084

Equation 34 identifies centralized and decentralized procurements as the raw material supply to the c-goods industry (agmfsim):

(34) agmfsim=1000*(agmarksm-kolksim)

Equation 32, of course, implies that agmfsim equals the actual historical level of procurements.

9. value added in consumer goods

To determine farm income from government procurements, value added in producing consumer goods and the turnover tax receipts must be subtracted from retail sales in shops. Value added consists of the labour and capital costs of producing the c-goods. Labour costs in the production of c-goods are given by:

(35) wagescon=lc*wact

Following the Soviet practice of disregarding the interest cost of capital, capital costs in producing c-goods are defined to be depreciation charges as in equation 38. These charges are the product of three terms--kc (the quantity of capital in 1937 prices in the c-goods industry), ract (an index of the value of the capital stock in current prices relative to its value in 1937 prices), and dep (the depreciation rate). From the values of the 1928 nonagricultural capital stock in 1928 and 1937 prices (Moorsteen and Powell 1966, pp. 326-7) and the nonagricultural wage rate in 1928 and 1937, equation 36 was estimated to show how the price of capital varied with the wage. Equation 37 is intended to retrieve depreciation charges in 1937 prices from the capital stock series in 1937 prices. The depreciation rate increased with the nonagricultural capital stock since the share of equipment, which depreciated faster, was rising while the share of structures was falling.

(36) ract=(1000*wact/3330)**.46

(37) dep=.000356448*(kp+kc)-.0035839

(38) capcon=kc*ract*dep

Equations 35 and 38 sum to value added in the production of c-goods. However, that includes government and other services as well as consumer goods sold in shops. In 1937, multiplying wagescon plus capcon by .31 gives value added in the production

of consumer goods:

(39) vacon=.31*(wagescon+capcon)

10. agricultural incomes and prices

Agricultural income equals collective farm market sales plus the retail sales of consumer goods minus the labour and capital costs required to produce them less turnover tax receipts and agricultural tax collections:

(40) aginc=kolkexp+(shpfdexp+shpmnexp-vacon)-turntax-agtax

The average price received by farmers for agricultural goods equals aginc divided by agmarksm, the level of farm marketings:

(41) priceag=1.57*((aginc/(1000*agmarksm))/.00017264)

The various numbers in equation 41 set the 1928 value of the index to equal 1.57 so it links with an index of wholesale agricultural prices with a 1913 base value of 1.00.

11. standard of living

Equation 43 defines private consumption to be the sum of household purchases of consumer goods in shops (congoods), household purchases of food on the collective farm market (kolkreal), farm income in kind (fiiksim), housing and other privately purchases services (yhs), and military subsistence (milsub). Privsol is measured in 1937 retail prices. Equation 42 converts the kolksim series (the volume of collective farm

market sales measured average prices received by farmers across all marketings in 1937) to the collective farm market prices paid by consumers in 1937.

(42) kolkreal=16*kolksim/5.158936

(43) privsol=congoods+kolkreal+.8*kolkadj*fiiksim
+(26.3/11.143)*(yhs+milsub)

The coefficient of fiiksim is .8*kolkadj. kolkadj is the ratio of the value of farm income in kind measured in 1937 collective farm market prices to the value in 1937 average realized prices. This ratio varies slightly from year to year due to changes in the composition of farm income in kind. Multiplication by .8 follows Bergson (1961, p. 167) and eliminates marketing and home processing costs.

Multiplying yhs+milsub by 26.3/11.143 is also a Bergsonesque adjustment intended to revalue the services whose prices were controlled at "free market" prices.

To breakdown overall private consumption into farm and nonfarm components, it is necessary to define the transaction terms of trade (tofttran) since that defines the rate at which farmers could exchange farm products for nonfood manufactured goods:

(44) tofttran=priceman/priceag

Consequently, if farmers spent all of the proceeds from their sales on nonfood manufactures, their consumption (inclusive of

income in kind) equalled:

(45) farmsol=.8*kolkadj*fiiksim+agmarksm(-1)/tofttran

Nonfarm consumption was, therefore, total private consumption less farm consumption:

(46) urbansol=privsol-farmsol

Dividing farm and nonfarm consumption by the respective populations gives the following percapita values:

(47) solfmpc=farmsol/farmpop

(48) solnfpc=urbansol/nonfarmpop

12. migration

Rural-urban migration is modelled as a response to differences in average consumption on and off the farm. Equation 50 is the key relationship, for it shows how the rate of rural out-migration depends on relative per capita consumption.

(49) relsol=solnfpc/solfmpc

(50) migrate=+.01875*relsol-.018375

(51) mig=migrate*rurpop

Equation 50 is a very rough fit to the migration data for the 1930s (e.g. Lorimer 1946, p. 150). As relsol varies from 1.6 to 2.3, visual inspection of the data indicated that the migration rate varied from .012 to .025. Equation 50 captures that movement. There are certainly errors, however, the annual values generated are sometimes in error since nonmonetary factors

(dekulakization, international passports, etc.) are not modelled.

13. other equations

A variety of other variables--gross domestic product, for instance--can be computed in a straightforward way from the variables defined above.

II. The Model of the New Economic Policy

The model of the collectivized economy is fundamental to the study of Soviet development since that model is supposed to replicate what actually happened. By altering parameters like e, it is possible to investigate how the concentration of investment on heavy industry influenced the growth of output and consumption during the Soviet industrial revolution. However, to explore many issues--for instance, the impact of collectivization on growth--a model of the New Economic Policy is essential. The difference between the NEP and collectivization is not captured by varying one or two parameters in the collectivization model. The differences are more profound.

There are four areas of difference between my models of the 'collectivized' and 'NEP' economies:

First, agricultural output is higher under the NEP. I increase grain production from 1930 to 1934 to make up for the

shortfall during collectivization, and I assume that livestock herds (other than horses) increased at 2% per year from 1928 onwards. Livestock products increased commensurately, as did the consumption of farm produce as feed. In 1933, the trough of farm output under collectivization, the value for net agricultural output under the NEP is 51% greater than under collectivization. In 1939, after the restoration in grain output and the rebuilding of herds, my value for agricultural production under NEP style institutions is still 16% above the actual value under collectivization. Furthermore, since there is no fall in farm output under the NEP, I assume that there was no famine in the 1930s.

Second, both models include a migration function that indicates the fraction of the rural population that moved to the cities each year as a function of the ratio of nonfarm to farm consumption per capita. I posit a higher function under collectivization to reflect the impact of dekulakization, the anger at the imposition of collectivization, and the sense among the peasants that the future lay in the city. (Fitzpatrick 1993, 1994.)

Third, I assume that private trade would continue under the NEP, so that farmers would have received as income the value of retail sales minus any sales taxes and the labour and capital costs necessary to transport and convert farm products into consumer goods. Under collectivization, the turnover tax

absorbed much of the gap between the value of retail sales in state and cooperative shops and the labour and capital costs necessary to produce them. The burden of this tax fell mainly on the rural population since the supply of requisitioned produce was price inelastic. In the NEP model, I assume that the turnover tax (and the much smaller agricultural tax) were replaced with a uniform tax on all cash incomes including wages as well as farm sales. The cash income tax is set at a rate to bring in the same revenue as the turnover tax and agricultural tax combined. Under this scenario, some of the tax burden is shifted from peasants to workers.

Fourth, in my model of collectivization, about 80% of farm supply is requisitioned, but the remaining 20% is supplied voluntarily on the collective farm market. Hence, I model collective farm marketing as a function of the price on the collective farm market. In contrast, farm supply in the NEP model is fully voluntary, and I make it a function of the average price on all sales.

It should also be noted that there are important similarities between my modelling of the NEP and collectivization. In neither case is the focus on the organization of farming. Instead, the models concentrate on the relationship between agriculture and the rest of the economy. Moreover, I have modelled the NEP in the most "progrowth" way possible. In

particular, I presume that farm mechanization and the promotion of technical crops (e.g. cotton) would have been pursued as vigorously under the continued NEP as was the case historically.

With these considerations in mind, I have altered the model of the collectivized economy in three ways to model the NEP: Sections 5 and 7 are replaced with a section called 7A. It follows section 6. Sections 8 and 10 are replaced with a section called 8A, and equation 50 in section 12 is replaced with a new equation 50A. The details are as follows:

5A. demand for consumer goods and government budget balance

Changes in this section are required since the agricultural tax and turnover tax are replaced with a uniform tax on cash incomes. This tax is set to bring in the same income as the turnover tax would have collected. Since the tax is imposed of agricultural incomes and since they depend on consumer spending, the cash income tax rate (cashrate) must be determined simultaneously with consumer demand. Hence, the following four equations are solved simultaneously:

(5A-1) cashrate=(turntax+agtax)/(wagebill+trans+kolkexp
+shpfdexp+shpmnexp-vacon)

(5A-2) kolkexp=.13*(1-cashrate)*(wagebill+trans)

(5A-3) shpfdexp=.42*(1-cashrate)*(wagebill+trans)

(5A-4) shpmnexp=.27*((1-cashrate)*(wagebill+trans)+aginc(-1))

The solutions to these equations are values of the four left hand side variables.

8A. agricultural prices and marketing and agricultural income

The changes in this section are implied by the change in tax regimes and also by the elimination of obligatory deliveries. The definition of agricultural income is change to reflect the cash income tax:

(8A-1) aginc=(1-cashrate)*(kolkexp+shpfdexp+shpmnexp-vacon)

Agricultural prices, farm income in kind, split (the ratio of farm income in kind to marketings), and agricultural marketings and prices are determined by solving the following four equations simultaneously:

(8A-2) priceag=1.57*((aginc/(1000*agmarksm))/.00017264)

(8A-3) split=1.5043*(priceag/priceman)**(-.9298)

(8A-4) fiiksim=agmarksm*split

(8A-5) agmarksm=(agnet/1000)-fiiksim

A regression equation was estimated to separate agricultural marketings into sales on the collective farm market and shipments to industry for processing:

(8A-6) kolksim=(-.08892+.00000573*agnet)*agmarksm

(8A-7) agmfsim=1000*(agmarksm-kolksim)

12. migration

The only change in this section is replacing equation 50 with a new migration rate equation:

(50A) migrate=+.005*relsol-.001

This equation generates lower levels of migration than equation 50. Equation 50 overpredicts migration rates in the late 1920s, and equation 50A corrects that error. With a value of relsol equal to 1.6, the predicted migration rate is .007. These values are like those of the late 1920s. There is of course no data for migration under the NEP with higher values of relsol. In the 1930s, relsol actually rose from 1.6 to as high as 2.3. Equation 50A implies a 50% increase in the migration rate under such a circumstance while equation 50 implies an increase of 110%. The smaller response represents the judgement that farm life would have been more satisfying under the NEP.

III. Harris-Todaro Model

The Harris-Todaro model is a variant of the collectivization model. Equation 13 is eliminated and mpp is set equal to 3 in equations 11 and 12. They can then be solved independently for lc and lp.

IV. Data

The forgoing discussion of the model indicated how many of the parameters were determined. In addition, running and

validating the model required several subsidiary data bases, as follows:

A. agricultural data

Time series on agricultural output and marketings were required for the simulations. Except as noted, all series are constant price series in which the various quantities were aggregated with Karcz's (1979, p. 105) estimates of the average price across all marketings in 1937. (The grain price was calculated inclusive of payments to Machine Tractor Stations.) Quantities of thirteen crops--grain, vegetables (excluding mellons), potatoes, flax fiber, sunflower seeds, sugar beets, cotton, milk, meat, wool, big hides, little hides, eggs--were aggregated. These comprised most of the output of Soviet agriculture. The various series were derived as follows:

1. gross agricultural production

Priority was given to the values in Davies, Harrison, Wheatcroft (1994, pp. 286-8). Other values were taken from Wheatcroft (1983). I used the "low" estimate for grain, the Davies, Harrison, Wheatcroft estimate for potatoes, and the revised Soviet estimates for other crops. For hides, I estimated output in the late 1930s from regressions of hide output on meat regression in other years.

2. feed, seed, and losses on the farm

I estimated losses and the use of agricultural products as seed and feed following Bergson (1961, pp. 325-330) and Johnson and Kahan (1960) with the following emendations: For grain, seed equals the number of hectares (from Hunter and Szyrmer 1992, p. 107, Jasny 1949, p. 790, and Johnson and Kahan 1959, p. 229) times a seed rate from Wheatcroft (1983, p. 269). Feed equals rates per animal from Jasny (1949, p. 753) and Nimitz (1954, p. 78) times livestock numbers from Davies, Harrison, Wheatcroft (1994, p. 289) with some detail from Nimitz (1954, Table 4). For potatoes, seed equalled hectares from Jasny (1949, p. 790) and Johnson and Kahan (1959, p. 229) multiplied by a seed rate from Johnson and Kahan (1959, p. 236).

3. net agricultural production

gross production minus feed, seed, and losses on the farm.

4. agricultural marketings

Two marketing concepts were used in Soviet statistics--sales by farmers and sales by farmers net of repurchases by other farmers. Since I am concerned with the relationship between the agricultural and nonagricultural spheres, the second concept is the pertinent one. In Soviet parlance it was called the sal'do sela, the balance of the village. This two concepts diverge particularly for grain, meat, milk, and eggs.

Data are from Zaleski (1971, pp. 313,338-9, 1984, pp. 728-9, 782-5), Jasny (1949, pp. 78-9), Barsov (1969, table facing

p. 112), and Karcz (1977, pp. 102-3).

For grain, Barsov (1969, p. 103) gives the sal'do sela for 1928-32. For subsequent years, I estimated the sal'do sela as total collections (Davies, Harrison, Wheatcroft 1994, p. 290) less three million tons. This corresponds reasonably well with Barsov's figure for 1928-32.

For meat, milk, and eggs, marketings are from Karcz (1979, pp. 102-3). To compute the sal'do sela, the meat figure was divided by 1.3, the milk figure by 1.15, and the egg figure by 1.1 to allow for intrarural sales. See Karcz (1979, p. 98).

For some commodities, some missing values were interpolated, some with regressions.

5. farm income in kind

net agricultural production less agricultural marketings

6. farmers' market and collective farm market sales (constant prices)

The estimation proceeded in steps. First, Karcz's data (in Karcz 1957 but mainly 1979, pp. 105-8) were used to calculate the value of total sales and of collective farm market sales in 1937 using 1937 prices averaged across all marketings.

Second, this value for collective market sales was extrapolated to other years from 1932 to 1940 using an index of the quantity of goods transacted on collective farm markets. For 1932-40, the index is the official value of transactions deflated

by an index of their price. Zaleski (1971, 1984) reproduces the official returns as series 235. However, for 1940, the value shown by Zaleski is extremely large, and I use the smaller value shown in Sovietskaya Torgovlia, 1956, p. 19. In his first estimate of Soviet national income in 1940, Bergson apparently also used the "large" value for 1940 but revised it downward to the "small" value in his final work. Cf. Bergson and Heymann (1954, p. 21) and Bergson (1961, p. 46). The price index used as a deflator is based on the prices of commodities sold on the collective farm market and is pieced together from the returns given by Malafeyev (1964, p. 402) and Vyltsan (1966, p. 61) for 1932-9. The 1940 value is from Karcz (1979, p. 334).

Third, for 1928-32, I relied on Barsov's work. He published a constant price index of the volume of agricultural marketings through all channels and indices of procurement and farmers' market prices for 1929-32 and an overall price index which was weighted by the volumes of the two sorts of sales (Barsov 1969, p. 107n 11, 108, table facing p. 112). One can work backwards from his price indices and calculate relative volumes of procurements and farmers' market sales. When the total volume of sales is multiplied by the later fraction for each year, the result is an index of the volume of sales on farmers' markets. I assumed the fraction was the same in 1928, for which Barsov gave no information, as in 1929. I used this index to extend the index

of collective farm market sales back to 1928.

7. farmers' market and collective farm market sales (current prices)

For 1932-40, the official series on the value of transactions on the collective farm market was used, as just explained. For 1928-31, I calculated the value of transactions by reducing the 1932 figure by the product of the quantity index of sales described previously (but rebased to 1932) and Malafeyev's (1964, p. 401) index of the free market price of food--again with a 1932 base.

8. government procurements

agricultural marketings minus farmers' market and collective farm market sales (constant prices)

B. national income accounts

New estimates of real national income for 1928-39 have been prepared. The procedure follows that of Bergson's (1961) pioneering work in which gross national product is computed as the sum of the components of final demand. These are household purchases in shops, household purchases in farmers' markets, farm income in kind, housing and privately consumed services, communal services (education and health care), government administration, the NKVD, military subsistence, purchases of military equipment, and gross investment. Table 3 summarizes the results. All

figures are in millions of 1937 rubles.

The resulting series of real national income grows faster than Bergson's series because real consumption grows faster. However, this series grows at a similar rate to that of Moorsteen and Powell (1966, pp. 622-3) and Hunter and Szyrmer (1992, pp. 34-5).

The series were derived in the following manner:

1. household purchases in retail markets

Bergson's (1961, p. 46) 1937 figure was extrapolated to other years with an index of the volume of manufactured consumer goods produced. The construction of this index is described in detail in Allen (1995a).

2. household purchases in farmers' markets

Bergson's (1961, p. 46) 1937 figure was extrapolated to other years with an index of the volume of sales on the collective farm market (for 1932-39) and on farmers' markets for earlier years. This index is explained in the discussion of the agricultural data base.

3. farm income in kind

The construction of this index is explained in the discussion of the agricultural data base.

4. housing and privately consumed services

Interpolated from Bergson's (1961, p. 48) estimates for 1928, 1937, and 1940.

5. communal services (education and health care)

For education, labour costs were estimated by multiplying Moorsteen and Powell's (1966, p. 622) index of the number of education employees by Bergsons' (1961, p. 347) estimate of total wage and salary costs in education in 1937. Bergson (1961, p. 347) reported nonlabour expenses for 1928, 1937, and 1940. These were interpolated for intervening years. Health care was dealt with in the same manner with the data reported in Moorsteen and Powell (1966, p. 622) and Bergson (1961, p. 355).

6. government administration

Bergson's (1961, p. 359) estimate of total outlays in 1937 was extrapolated to other years using Moorsteen and Powell's (1966, p. 359) index of employment in government administration.

7. NKVD

Bergson (1966, p. 361) presents estimates of total outlays in 1928, 1937, and 1940. These were interpolated--roughly--to intervening years on the presumption that the series never went down and that increases were concentrated during the collectivization period and the party purges.

8. military subsistence

The number of military personnel from Moorsteen and Powell (1966, p. 628) multiplied by 1500 rubles per year from Bergson (1961, p. 60).

9. purchases of military equipment

Bergson's (1961, p. 364) estimate of munitions and other procurements in 1937 was extrapolated to other years using Moorsteen and Powell's (1966, p. 629) index of munitions procurements.

10. gross investment

I use Moorsteen and Powell's (1966, p. 386) series of gross investment in fixed capital including capital repairs. It should be noted that I do not include livestock or inventory changes in my investment or GDP series.

C. Demographic Model

The demographic model developed here is based on Lorimer's (1946, pp. 112-144) reconstruction of Soviet population history. This was an early effort. I have based my work on it (rather than later work) since Lorimer's estimate (5.5 million) of the number of "excess deaths" has been substantially vindicated by Wheatcroft (1990b). Moreover, Lorimer's calculations are well documented, so they can be readily extended.

At the time Lorimer composed his estimates, the firmest data for estimating the Soviet population were the censuses of 1926 and 1939, which indicate the population and allow estimates of the vital rates. Lorimer used a variety of other data to project the birth rate between 1926 and 1939. The crude birth rate followed a "U" shaped trajectory. The crude death rate was

linearly interpolated between the dates. With these estimates of "normal" ferility and mortality, Lorimer projected the 1926 population forward and the 1939 population backwards. When his projections met in 1934, the forecast from 1928 exceeded the backcast from 1939 by 5.5 million. This is Lorimer's estimate of "excess" mortality. Obviously, the estimate of "excess" mortality is only as good as the estimates of "normal" fertility and mortality. Lorimer believed that most of the excess deaths occurred in the period of collectivization, and allocated them to those years. He then formed annual estimates of the Soviet population between 1926 and 1939.

The question of births, deaths, and excesses deaths has been debated since Lorimer's work. (See Davies, Harrison and Wheatcroft 1994, pp. 64-77, for a survey.) Many scholars have proposed higher numbers of excess deaths, e.g. Andreev, Darski, and Kar'kova (1990). The increased number of excess deaths occur among infants and offset a posited rise in the fertility rate in 1933 (Davies, Harrison, and Wheatcroft, 1994, pp. 74-6). There is no point trying to incorporate this mortality into my models since it does not result in any change in the labour force.

My estimates of the rural and urban population begin with Lorimer's figures for the whole Soviet Union. First, I separate the "excess" deaths and calculate the crude birth and the crude "normal" death rates for the USSR as a whole. Second, I calcul-

ate series of urban and rural crude birth and "normal" death rates from 1926 to 1939. To calculate the urban crude birth rate series, for instance, I multiply the crude birth rate series for the Soviet Union as a whole by the ratio of the crude birth rate in urban areas of the European part of the Soviet Union in 1927 to the crude birth rate in the whole European part of the Soviet Union in 1927. (Lorimer 1946, p. 81). The other vital rates are formed analagously. Third, I assume that "excess" deaths affected the rural population only. This is surely wrong in detail since no allowance is made for deaths during and after the purges of the late 1930s, and those deaths were mainly urban. The number of purge deaths, however, was small compared to the number accompanying collectivization. Fourth, I accept Lorimer's (1946, p. 150) annual estimates (based on official data and a reconciliation of the 1926 and 1939 censuses) of rural-urban migration. Fifth, the rural and urban populations were then calculated year-by-year from the rural and urban populations in 1926 by cumulating births, deaths, and net migration. The sum of the urban and rural populations agrees closely with Lorimer's annual estimates of the total population, and the pojections of the rural and urban populations in 1939 agree with the census results of that year. Moreover, the pojected 1937 population is in accord with the results of the suppressed 1937 census.

In addition to the rural and urban populations, the farm and

nonfarm populations are needed for simulations. The urban population was very largely nonfarm (Lorimer 1946, p. 228), but the rural population included a fair number of nonagricultural workers in farm related activities (e.g. flour milling, proto-industry, construction) and other activities (government administration, education, health care). Many rural residents shifted between farming and other activities. I estimated the farm population c. 1928 and c. 1939 from Lorimer (1946, pp. 222-230) and Jasny (1949, pp. 710-14). The figures are meant to be the sum of people in households engaged in farming full and part time. To simulate the farm population from 1928 forwards, I updated the 1928 value by the change in the rural population. The nonfarm population equalled the total population minus the farm population.

D. Other Series

investment, 1925-7--1928 investment was extrapolated backwards using an index of construction materials (rolled steel, fire-clay bricks, and cement--weighted equally) from Nutter (1962, pp. 420, 427).

production function parameters--Attempts were made to fit production functions to interwar Soviet data with little success. Consequently, the parameters were derived from the results of other statistical studies. Weitzman (1970) fit a two factor

(capital and labour) CES production function to Soviet industrial data and estimated the elasticity of substitution at about .4 and the coefficient of capital at .6. I used these values for the p-goods production function. A three factor (capital, labour, and processed agricultural commodities) was necessary for the c-goods function. I used a CES function again with the elasticity of substitution of .4. I made the coefficients of the three inputs approximately equal.

V. Division of the Economy into Producer Goods and Consumer Goods Sectors

It was necessary to determine 1928 values for outputs and inputs in the c-goods and p-goods industries in order to begin the simulations. All valuation was in 1937 prices. In this analysis, the economy is conceptually divided into three sectors--c-goods, p-goods, and agriculture. GDP equals the sum of value added in the three sectors, and output in each sector equals value added in the sector plus purchases from other sectors.

Begin with p-goods. The output of p-goods is defined to be the sum of gross investment inclusive of repair expenditures,[1]

[1]Moorsteen and Powell (1966, p. 386).

consumer durables,[2] military equipment,[3] and hospital equipment.[4] I took the production of these items to have equalled the total output of the machinery and construction industries. The producer goods sector was presumed to have purchased no intermediate inputs from other sectors, so the output of p-goods equalled value added in the p-good sector.

Agriculture was also presumed to have purchased no current inputs from other sectors, so the value of agricultural output net of seed and feed equals value added in agriculture. The calculation of net agricultural output is explain in the discussion of the agricultural data base.

Since GDP equals the sum of value added in the three sectors, value added in c-goods equalled GDP less net agricultural output and producer goods output. Value added in the c-goods sector plus its purchases of agricultural produce equals the output of c-goods. As noted earlier, the c-goods industry

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[2]Nutter's (1962, p. 524) estimates of the value of output in 1928, 1932, 1937, and 1940 in 1928 prices were converted to 1937 prices using Moorsteen's (1962, p. 72) index of machinery prices. Values of intervening years were interpolated.

[3]Bergson's (1961, p. 364) value of "munitions and other procurements" in 1937 was extrapolated to other years with Moorsteen and Powell's (1966, p. 629) index of "munitions procurements in 1937 prices."

[4]Bergson (1961, p. 349) takes "small-valued equipment not in included in fixed capital" to have been 10% of nonlabour outlays in the health care system. Consequently, I estimated the real value of these acquisitions to have been 10% of the value of nonlabour outlays in 1937 prices (Bergson 1961, p. 347) in the health care system in 1928, 1937, and 1940. Intervening years were interpolated.

includes the production of consumer goods (except durables), housing, privately consumed services, health, educational, administrative, police, and military services.

To determine input use in the various sectors, input-output analysis was used. First, an input-output table was adapted from the provisional table of Kaplan et al. (1952) based on the Fourth Five Year Plan. Some elements in this table are well founded on late 1930s Soviet data, but other elements are not. I modified the table for industries like textiles where the input-output coefficients diverged markedly from those in Leontief's US tables for 1919 and 1929. (Leontief 1951). I aggregated the defence and machinery industries whose coefficients, in any event, were similar. The coefficients from this table apply to c. 1940, but I used them for 1928 calculations.

Second, to obtain 1928 starting values for the inputs, the components of final demand (household purchases, current government spending, investment) in 1928 were subdivided into purchases from the various industries distinguished in the input output table. A vector, each of whose elements was purchases from an industry, was thus established for each component of aggregate demand. These vectors were then used to specify vectors corresponding to the consumer goods (in this case agriculture plus c-goods) and producer goods (p-goods) industries, as defined in this study. The producer goods vector had

elements equalling the total final purchases from the machinery and construction industries; otherwise, its elements were zero. Conversely, the elements of the consumer goods industry vector were the total final purchases from all industries except machinery and construction, which were zero.

Third, the table of input-output coefficients was postmultiplied by the producer goods and consumer goods vectors. The gross output of each industry was thus split into investment goods and consumer goods. Table 1 shows the proportions of each industry allocated to each use. The division is much as one would expect. All, or virtually all, of the output of food processing, textiles, and light industry are consumer goods. The heavy industries--iron and steel, machinery, etc.--are mainly producer goods.

Fourth, total employment by industry in 1928 was pieced together from Nutter (1962, pp. 499-504), Kaplan (1969, pp. 208-212), Weitzman and Elias (1961), Moorsteen and Powell (1966, pp. 642-650), and Bergson (1961, pp. 442-7). Multiplying each industry total by the fraction of that industry's gross output classified as investment or consumption goods yielded employment by industry in investment and consumption goods. The sum for each sector gave total employment in 1928 in that sector.

Fifth, capital was dealt with similarly, although it was necessary to break down the capital stock in the industrial

sector. Moorsteen and Powell's (1966, pp. 408-418) reworking of Gosplan's estimates of the capital stock on 1 January, 1928, gave values by sector but not by the various industries making up the industrial sector. I estimated capital in those industry by using the employment figures and estimates of the capital-labour ratio derived from American data (taken principally from Creamer et al. 1960, pp. 248-251, 273, 318, 323, but also from US Census of Mines for 1929, p. 44, and the US Census of Manufactures for 1920, Vol. 8, p. 20, 146, and Vol. 10, p. 920, and Jorgenson et al. 1987, pp. 380 ff.). Soviet employment figures were multiplied by American capital-labour ratios and the industrial capital stock was divided among the industries in proportion to the products. This procedure assumes that the relative capital labour-ratios in the Soviet Union were the same as the relative ratios in the United States at about the same time, but the absolute levels are allowed to differ. Capital stocks in the p-goods and c-goods industries were the sums of the industry components.

Table 2 shows the results of this disaggregation of the Soviet economy in 1928. The economy was dedicated overwhelmingly to producing consumer goods. The producer goods sector comprised only 7% of the capital, 19% of the employment, and 15% of the value added of the nonagricultural economy.

Table 1

Division of Soviet Industries into
"Investment Goods" and "Consumer Goods" in 1928

fraction of the industry's gross output and inputs assigned to--

industry	investment goods industry	consumption goods industry
agriculture	0.00	1.00
food processing	0.00	1.00
textiles	0.00	1.00
light industry	0.00	1.00
iron & steel	0.76	0.24
nonferrous metals	0.22	0.78
machinery & metalwork	1.00	0.00
construction materials	0.59	0.41
chemicals	0.25	0.75
wood	0.51	0.49
paper	0.17	0.83
electric power	0.11	0.89
coal	0.19	0.81
peat	0.07	0.93
petroleum products	0.04	0.96
transportation	0.14	0.86
communications	0.04	0.96
trade	0.01	0.99
construction	1.00	0.00
other	0.00	1.00
other government	0.00	1.00

Table 2

The Division of the Soviet Economy into
Investment Good and Consumer Good Sectors in 1928

	capital stock	employ-ment	final sales	value added
investment goods	9729	2368	12.03	12.03
consumption goods except agriculture	126540	9977	81.65	65.65
agriculture	21162	35000	42.60	58.60
total	157431	47345	136.28	136.28

note:
Capital stock is in millions of 1937 rubles,and output is in billions of 1937 rubles.
Employment is in thousands of people.

Table 3
Soviet Household Consumption Expenditure, 1928-40
(billions of 1937 rubles)

	shops	farmers' m'k't	serv/ house	mil sub	FIIK food	rural mft'rs	total
1928	61.5	3.4	25.5	.8	78.2	8.9	178.4
29	63.9	3.8	27.2	.8	85.0	8.2	188.9
1930	65.5	12.8	28.8	.8	73.7	6.6	188.2
1	69.4	9.9	30.5	.8	61.4	4.5	176.4
2	68.6	4.2	32.1	.8	56.8	2.6	165.1
3	68.2	4.3	33.8	1.0	58.8	2.3	168.4
4	79.7	8.6	35.4	1.3	56.9	1.0	182.9
5	87.2	12.6	37.1	1.6	63.2	1.2	202.8
6	101.0	15.9	38.7	2.1	43.2	1.0	201.8
7	110.0	16.0	40.4	2.6	81.2	1.0	251.3
8	113.7	25.3	40.4	3.4	61.7	.8	245.2
9	114.3	21.6	40.4	4.4	58.1	1.5	240.3
1940	111.0	12.5	45.0	5.3	78.4	1.0	253.2

column headings--
shops=household purchases in retail shops
farmers' m'k't=household purchases on collective farm (or farmers') market
serv/house=household purchases of services and housing
mil sub=military subsistence
FIIK-food=farm income in kind
rural mft'rs=rural handicrafts and manufacturers

Note:
(1) Investment and GDP are defined exclusive of livestock and inventory investment. See Moorsteen and Powell (1966) for estimates of those components.

(2) The 1940 figures are supposed to represent economic activity on interwar Soviet territory. Where possible series have been adjusted to achieve that, but there is a greater likelihood of error in this figure than in others.

(3) Total may not equal sum of columns due to rounding.

Table 4
Soviet Gross National Expenditure, 1928-40
(billions of 1937 rubles)

	private consu	govt	milit	invest	GDP
1928	178.4	9.4	1.0	11.3	200.1
29	188.9	11.2	1.1	14.0	215.3
1930	188.2	14.8	1.4	19.4	223.9
1	176.4	18.4	1.4	21.6	217.8
2	165.1	21.7	1.4	22.4	210.7
3	168.4	23.0	1.4	20.5	213.2
4	182.9	24.5	4.7	23.5	235.6
5	202.8	26.7	7.5	29.4	266.4
6	201.8	29.4	13.2	39.9	284.2
7	251.3	32.3	14.8	36.6	334.9
8	245.2	34.9	19.9	38.1	338.1
9	240.3	37.6	29.1	37.9	344.9
1940	253.2	40.3	40.5	37.8	371.9

column headings--
private consu=household consumption (from Table 3)
govt=nonmilitary government expenditures (public administration, health care, education, NKVD)
milit=military pay and procurements of munitions
invest=investment in fixed capital
GDP=sum of spending in table

Note:
(1) Investment and GDP are defined exclusive of livestock and inventory investment. See Moorsteen and Powell (1966) for estimates of those components.

(2) The 1940 figures are supposed to represent economic activity on interwar Soviet territory. Where possible series have been adjusted to achieve that, but there is a greater likelihood of error in this figure than in others.

(3) Total may not equal sum of columns due to rounding.

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