CONSUMPTION AND SAVING BEHAVIOR
UNDER STRICT AND PARTIAL RATIONING

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ABSTRACT: This study examines the effect of strictly rationed housing and partially rationed food grains on consumption and saving behavior for urban households in the People's Republic of China during 1981-1987. Complete demand system models with strict rationing are extended by incorporating compensated income, savings, and parallel markets for partially rationed goods. The econometric analysis shows that strictly rationed housing has a positive spillover effect on household savings. The estimated expenditure and price elasticities show that partially rationed food grains have become an inferior good. Policy simulation results further demonstrate that removing food grain rationing will have no important influence on the demand for other goods in urban China; however, increasing the level of rationed housing will induce more forced savings. A gradual reduction of rationing in China and other planned economies is an important step towards facilitating market oriented economic reform. JEL Classification Numbers: D12, O12, P50.

INTRODUCTION

Rationing and dual pricing are common policy instruments in many developing countries and in centrally planned economies under reform. Consumers in such economies commonly face parallel markets as a result of public distribution systems. These markets offer a limited quantity of necessities, such as food grains, at subsidized prices, along with an open market where extra quantities can be purchased at higher prices. Strictly rationed goods are available in limited quantities, at a set of controlled prices, with no possibility of satisfying excess demand. As market oriented reforms are initiated in formerly centrally planned economies, strict and partial rationing is relaxed; and the mix of consumer goods and savings changes. Households, as independent economic agents, begin to play a more important role in resource allocation and macroeconomic performance.

Market oriented economic reforms that started in China in 1979 provide particularly good examples of changes in consumer behavior under strict and partial rationing and during their gradual relaxation. China has practiced rationing longer than most other countries in the world. Strict rationing was the dominant method of distributing food and other necessities in urban areas before the economic reform. A mixed economy has evolved during recent years, involving a free consumer goods market, partial rationing of food grains and some nonstaple foods, and strict rationing of housing. Two seemingly contradictory phenomena have been observed: expansion of surpluses in some consumer goods markets and a sizable increase in household savings.
Considerable academic effort has been expended to model and study such stylized facts. Classical theoretical results relating to strict rationing were presented by Tobin and Houthakker (1951). They identified the relationships between the derivatives of the rationed and unrationed demand functions, proving that rationing of a good will reduce the price elasticity and increase the income elasticity of demand for unrationed goods.

Neary and Roberts (1980) used a dual approach to generalize Tobin-Houthakker's work. Using "virtual prices," they showed that all the properties of the demand for the rationed good may be expressed in terms of the demand for the unrationed good. Virtual prices were defined as the computed prices for rationed goods. This would induce consumers to voluntarily demand exactly the rationed amount if it were sold in a free market, provided they were compensated for the loss in utility caused by the removal of rationing. They also demonstrated that all the derivatives of the demand functions for rationed and unrationed goods can be decomposed into income and substitution effects in a manner identical to the familiar Slutsky equation.

Deaton (1981) extended Tobin-Houthakker's work from the empirical perspective. He derived a "matched pair" of demand functions, one rationed and one unrationed, using a theoretical construction similar to Neary and Roberts' (1980). Using British data to estimate a modified version of the Almost Ideal Demand System (AIDS) (Deaton & Muellbauer, 1980), he demonstrated a methodology for generating a flexible functional form for rationed and unrationed demand. His approach integrates rationing effects into a complete demand system in a simple, theoretically satisfactory, and econometrically tractable manner. Wang and Chern (1992) applied Deaton's framework to estimate demand for rationed and unrationed goods by Chinese urban households. They found that rationed housing and grain had significant impacts on the demand for unrationed food, especially nonstaple food. Strict rationing of all the rationed commodities was assumed, so the dual pricing was not explicitly reflected in their models.

Chetty and Jha (1986) treated dual pricing as two goods with a quantity restriction on the purchase of the good with a lower price. With this approach, they showed that the utility maximization problem is equivalent to maximizing utility. There is a single price obtained as a weighted average of the free market price and the ration price along with an appropriate compensation for the withdrawal of the rationing system. Chetty and Haliburn (1986) estimated price and income elasticities of demand for major food commodities in India using this framework with a single equation model. They found that using total demand, instead of free market demand, as the dependent variable can lead to overestimates of price elasticities and underestimates of income elasticities in the presence of a dual market. They suggested that when using aggregate demand as the dependent variable, it is necessary to include the rationed quantity and compensated income as additional explanatory variables.

Rationing systems may have induced repressed inflation and forced savings in China (Feltenstein and Ha, 1989). Many economists have argued that the high marginal propensity to save in China is not the result of voluntary behavior. Based on a utility maximization model with parallel markets, Byrd (1987) deduced that if households expect any future relaxation of a rationing system to be fully compensated through an increase in nominal income, household saving decisions would be voluntary, not forced. The choice to save rather than to purchase consumer goods in the parallel market is based on the market price, as well as on the consumer's ration quota. Yi (1991) also asserts that if there are surpluses in the consumer goods market, it is safe to say that savings are voluntary.
Ellis and Naughton (1990) analyzed the microeconomics of household saving behavior under rationing by using Neary and Roberts' "virtual prices" in a two period utility maximization model. Their analysis found no general relationship between individual household saving and rationing. Indeed, the effect of a change in the level of rationing on household saving is ambiguous and complicated. Ellis and Naughton (1990) showed that the relationships between saving and changes in ration levels or rationed good prices may be decomposed into expenditure displacement, income, and substitution effects. The signs of these effects may be determined, as in neoclassical demand theory; and the conditions to increase saving, by a change in the level of rationing or the price of a rationed good, may be expressed in terms of whether goods are substitutes or complements, normal or inferior.

From a macroeconomic perspective, Chang (1993) examined spillover effects and the relationship among disequilibrium aggregates; namely, general shortages, forced saving, and repressed inflation. He showed that it is quite possible for forced saving to be induced by a surplus in some of the consumer goods markets and that a general shortage is not a necessary condition for forced saving. He pointed out that common surpluses in centrally planned economies are not caused by soft demand, but by consumers' dissatisfaction with available products. "While the physical form of this surplus is a buildup of inventories of unwanted goods, the financial counterpart of these inventories must be the forced holding of money." (Chang, 1993 p. 82).

This study combines microeconomic theory and real data to explain consumer behavior under rationing. It extends the work of Wang and Chern (1992) and Deaton (1981) by incorporating a mixed economy with free market goods and partially and strictly rationed goods into a complete demand system. Spillover effects between rationed and unrationed markets are estimated, with special attention to household saving. The hypothesis is that the observed dramatic increase in household saving is partially caused by the spillover effects of rationing. This hypothesis is tested with econometric methods, in order to provide some empirical evidence on the controversies over forced versus voluntary saving behavior among Chinese urban households. The result will provide insight into the effectiveness of public policy during economic reform. Various policy options are simulated to analyze the expected changes in consumer demand as rationing changes.

This article is organized as follows. The second section contains a brief description of market structure, urban household consumption, and saving behavior in China since 1979. The third section provides a framework for analyzing consumer choice in economies with rationing. An Almost Ideal Demand System, with both strict rationing and dual pricing, is specified in terms of compensated income. Related formulas for expenditure and price elasticities of unrationed goods and comparative statistics for changing the ration level and price are also derived. In the fourth section, the model is estimated with pooled, cross-sectional, and time-series survey data from Chinese urban households, 1981 to 1987. The estimated results, expenditure and price elasticities, and relevant comparative statistics are presented and analyzed. In the fifth section, four potential policy changes are simulated using the estimated model. Then the policy implications of these experiments are discussed.

MARKET STRUCTURE AND OBSERVED BEHAVIOR
OF CHINESE HOUSEHOLDS

Since 1979, free market trade of consumer goods expanded rapidly in China. Most commodities in the urban consumer market are no longer subject to formal rationing. Even when
some commodities, such as food grains, were still under formal rationing, there usually existed a parallel free market along side the state ration store. Only housing in urban areas was allocated through strict rationing during the period of this study.

There were also notable changes in urban household consumption patterns. For example, Table 1 illustrates that the per capita consumption of beef and poultry increased about 80 percent between 1981 and 1987, while the free market share went from 28 percent to 76 percent for poultry and from 37 to 57 percent for beef. Similar increases occurred in most food items during that time. Another notable change was the surge in demand for consumer durables such as color TVs, washing machines, refrigerators, and other appliances (Table 2). The household budget share for these articles increased to nearly 17 percent, which is much higher than in countries where per capita GDP was more than three times that of China in 1987.

During the same period, private household saving increased more than 10 times. As shown in Table 3, bank deposits increased significantly for both urban and rural households.
Table 3
Saving Deposits of Urban and Rural Households
(Unit: Billion Chinese Yuan)

<table>
<thead>
<tr>
<th>Year</th>
<th>Urban Deposits</th>
<th>Urban Growth Rate</th>
<th>Rural Deposits</th>
<th>Rural Growth Rate</th>
<th>Total Deposits</th>
<th>Total Growth Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1979</td>
<td>20.26</td>
<td>30.8</td>
<td>7.84</td>
<td>40.8</td>
<td>28.10</td>
<td>33.4</td>
</tr>
<tr>
<td>1980</td>
<td>28.25</td>
<td>39.4</td>
<td>11.70</td>
<td>49.2</td>
<td>39.95</td>
<td>42.2</td>
</tr>
<tr>
<td>1981</td>
<td>35.41</td>
<td>25.3</td>
<td>16.96</td>
<td>45.0</td>
<td>52.37</td>
<td>31.1</td>
</tr>
<tr>
<td>1982</td>
<td>44.73</td>
<td>26.3</td>
<td>22.81</td>
<td>34.5</td>
<td>67.54</td>
<td>29.0</td>
</tr>
<tr>
<td>1983</td>
<td>57.26</td>
<td>28.0</td>
<td>31.99</td>
<td>40.2</td>
<td>89.25</td>
<td>32.1</td>
</tr>
<tr>
<td>1984</td>
<td>77.66</td>
<td>35.6</td>
<td>43.81</td>
<td>36.9</td>
<td>121.47</td>
<td>36.1</td>
</tr>
<tr>
<td>1985</td>
<td>105.78</td>
<td>36.2</td>
<td>56.48</td>
<td>28.9</td>
<td>162.26</td>
<td>33.6</td>
</tr>
<tr>
<td>1986</td>
<td>147.15</td>
<td>39.1</td>
<td>76.61</td>
<td>35.6</td>
<td>223.76</td>
<td>37.9</td>
</tr>
<tr>
<td>1987</td>
<td>206.76</td>
<td>40.5</td>
<td>100.57</td>
<td>31.3</td>
<td>307.33</td>
<td>37.3</td>
</tr>
</tbody>
</table>


Table 4
Per Capita Average Saving Ratio and Housing Expenditure Share for Chinese Rural Households

<table>
<thead>
<tr>
<th>Year</th>
<th>Income</th>
<th>Saving</th>
<th>Ratio</th>
<th>Expenditure</th>
<th>Rent</th>
<th>Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>1981</td>
<td>223.00</td>
<td>32.00</td>
<td>14.35</td>
<td>191.00</td>
<td>18.67</td>
<td>9.77</td>
</tr>
<tr>
<td>1982</td>
<td>270.00</td>
<td>50.00</td>
<td>18.52</td>
<td>220.00</td>
<td>23.00</td>
<td>10.45</td>
</tr>
<tr>
<td>1983</td>
<td>309.77</td>
<td>61.77</td>
<td>19.94</td>
<td>248.00</td>
<td>27.56</td>
<td>11.11</td>
</tr>
<tr>
<td>1984</td>
<td>355.33</td>
<td>81.53</td>
<td>22.94</td>
<td>273.80</td>
<td>32.12</td>
<td>11.73</td>
</tr>
<tr>
<td>1985</td>
<td>397.60</td>
<td>80.18</td>
<td>20.17</td>
<td>317.42</td>
<td>39.46</td>
<td>12.43</td>
</tr>
<tr>
<td>1986</td>
<td>423.76</td>
<td>66.81</td>
<td>15.77</td>
<td>356.95</td>
<td>51.23</td>
<td>14.35</td>
</tr>
<tr>
<td>1987</td>
<td>462.55</td>
<td>64.26</td>
<td>13.89</td>
<td>398.29</td>
<td>57.76</td>
<td>14.50</td>
</tr>
</tbody>
</table>

Note: The saving expenditure comes from household budget surveys. It is equal to the difference between net income and expenditure.


between 1981 and 1987. The growth rate of rural household saving was higher than urban household saving before 1984 and lower thereafter. There are a number of reasons for this pattern of savings and strict rationing of housing in the urban areas is believed to be one of the factors.

Partial rationing of selected food commodities and strict rationing of housing for urban people working in the state sector existed throughout the period of this study. This type of in-kind subsidy resulted in a very low percent of urban household budgets being allocated to housing, 1.4 percent in 1981, declining to 0.88 percent by 1987. In contrast, Table 4 shows that housing expenditures in rural household budgets increased from 9.8 percent to 14.5 percent during the same time period. Also, the saving ratio of rural households declined from 23 percent in 1984 to 14 percent in 1987. The reason for these trends seems quite obvious. Historically, the Chinese people have been categorized into urban and rural
residents, and migration from rural to urban areas has been restricted by the government. In rural areas, cash, bank deposits, and investment in rural housing were almost the only forms of private financial assets available to households. In the past, residential housing was also the only fixed private asset the government did not confiscate from peasants on a large scale. Hence, it was considered to be a relatively safe asset for rural households. Meanwhile, in the urban areas, housing supply was short and subject to strict rationing with heavy government subsidies. There was no private market for urban housing during this period. Compared with their rural counterparts, it seems reasonable to attribute at least part of the dramatic increase of urban household saving to rationed housing.

**ANALYTICAL FRAMEWORK AND EMPIRICAL DEMAND MODEL SPECIFICATION**

Approaches used in empirical modeling of consumer behavior in market economies follow the standard approach where consumers maximize utility, subject to their budget constraints and available supply. The Lagrangian of the utility maximization problem can be formally described as follows:

$$\text{Max } L = U(X) - \lambda (I - PX) - \lambda_q (Q - X)$$  \hspace{1cm} (1)

where $U(.)$ is the utility mapping of the consumer's preferences, $X$ is the vector of the consumer's choice bundle, $P$ is the price vector corresponding to the commodity set, $I$ is the consumer’s disposable income or total expenditure, and $Q$ is total supply. The last term in (1) does not typically appear since there is an implicit assumption that $X \leq Q$. That is, the quantities demanded are less than or equal to the goods supplied. It is reasonable to omit this pure quantity constraint in developed countries where excess production capacities and aggregate supply are virtually universal, and the individual's demand is seldom affected directly by the supply constraint. In mathematical terms, it implies that $PX = I$ with $\lambda_1 > 0$, and $X < Q$ with $\lambda_q = 0$ (complementary slackness condition). The $\lambda$'s are the Lagrangian multipliers or shadow prices, which can be interpreted as indexes of the degree of scarcity in resources and products at hand. A demand system with income and prices as independent variables, which is the solution to the above utility maximization problem, can then be fitted with observed data; and estimates of consumer behavioral response can be obtained.

Shortage makes the supply constraint effective in a controlled economy. This implies that $X = Q$ and $\lambda_q$ is positive (at least for some goods). Consequently, the observed market sales data no longer reflect the actual demand. If the solution of the consumer utility maximization problem, without a supply constraint, is denoted as $X(P, I)$, and with a supply constraint as $X^0(P, I, Q)$, the vector

$$S = \{X^0(P, I, Q) - X(P, I)\}$$  \hspace{1cm} (2)

will represent measures of disequilibrium for consumer demand in quantity terms. The positive coordinates of vector $S$ represent the so-called "spillover effect", which is the increase in consumption of the unrationed goods caused by the impossibility of spending income on more desirable goods that are rationed or in short supply (Podkaminer, 1982).

There are different degrees of supply shortage and rationing in the real world. They can be represented by different sets of quantity constraints in the consumer utility maximiza-
tion problem. The key problem in specifying an empirical model is to identify the special type of quantity constraints based on the stylized facts in the economy under study.

As described earlier, China has evolved into a mixed economy where free market goods, partially rationed food grains, and strictly rationed housing co-exist. A model of consumer choice in such an economy with dual markets and possible spillover effects can be formulated as consumers choose commodity bundles to maximize their utility subject to the budget and different types of ration constraints:

\[
\text{Max } U(X) \text{ s.t. } p_u x_u + p_{nr} x_d - (p_m - p_r)z + p_{sr} x_{sr} \leq I \text{ and } x_d \geq z, \text{ and } x_{sr} = q_{sr} \tag{3}
\]

where \( X = (x_u, x_d, x_{sr}) \), \( x_u \) represents the quantity of free market goods demanded, \( x_d \) is the quantity of partially rationed goods demanded in the dual market, and \( x_{sr} \) is the demand for the strictly rationed good. The supply and price of the strictly rationed good are \( q_{sr} \) and \( p_{sr} \) respectively; \( p_u \) is the market price for \( x_u \), \( p_m \) is the free market price; and \( p_r \) is the rationing price for the commodities which have a parallel market; \( z \) is the ration level; and \( x_d \) is the total demand for the partially rationed commodities. The quantity of the partially rationed commodity that is purchased in the free market equals \( (x_d - z) \). This means there will be two prices for partially rationed commodities, since they are available in the free market as well as in the ration stores. The free market price of a commodity is at least as high as its ration price. Consumers can only buy limited amounts at \( p_r \), but can purchase all they want at \( p_m \) in the free market, as long as it is within their budget constraint.

Define the compensated income as \( F = I + (p_m - p_r)z \). The last term can be thought of as a lump sum transfer from the government to consumers (Sicular, 1988). This transfer increases their disposable income such that they will be able to buy the same bundle \( x_d \) at a single market price \( p_m \) as they could under dual pricing. Given that \( x_d \geq z \), the following utility maximization problem has the same solution as equation (3):

\[
\text{Max } U(x_u, x_d, x_{sr}) \text{ s.t. } p_u x_u + p_{nr} x_d + p_{sr} x_{sr} \leq F, \text{ and } x_{sr} = q_{sr} \tag{4}
\]

Therefore, the necessary change in the specification of the demand functions due to the presence of partial rationing is the use of compensated income instead of the actual income.

Based on the duality theorem, the utility maximization problem equation (4) can be solved by minimizing the following constrained expenditure function:

\[
E'(U, p_u, p_m, p_{sr}, q_{sr}) = \min_{x_u, x_d, x_{sr}} \{p_u x_u + p_{nr} x_d; V(q_{sr}, x_u, x_d) \geq U\} = p_{sr} q_{sr} + C(U, q_{sr}, p_u, p_m) \tag{5}
\]

assuming that the consumer buys exactly the rationed levels \( q_{sr} \) and \( z \). Where \( V(q_{sr}, x_u, x_d) = \text{Max } U(x_u, x_d, x_{sr}) \), \( E'(\cdot) \) gives the minimum expenditure of reaching \( U \) at \( p_u, p_m, p_r \) and \( p_{sr} \) in the presence of quantity constraints \( x_{sr} = q_{sr} \) and \( x_d > z \). The expenditure for strictly rationed goods, \( p_{sr} q_{sr} \) is constant and can be subtracted from equation (5) without affecting the optimal \( x_u \) and \( x_d \). All the conventional properties and derivations of the cost function \( C(\cdot) \) apply to \( U, p_u, \) and \( p_m \). For empirical estimation, a suitable functional form of \( C(\cdot) \) needs to be specified. Deaton (1981) suggested a flexible functional form known as the PIGLOG class used for the Almost Ideal Demand System (AIDS). Using this form, the expenditure share equation can be expressed as:
where $W_i$'s are the budget shares as a proportion of the total compensated expenditure, minus strictly rationed expenditure. To simplify the notation, subscripts $i$ and $j$ refer to non-rationed goods ($x_i$) and the goods that have a parallel market ($x_j$); $k$ refers to the strictly rationed goods ($x_k$); $n > m$; $q_k$'s are the quantities of strictly rationed goods; $p_j^m$ is the market price for the $j$-th good, including the unrationed goods and the goods that have a parallel market; $p_k$ is the price for the $k$-th strictly rationed good; $F$ is the general market price index. The parameters $\alpha_i$'s, $n_{jk}$'s, $r_{ij}$'s, and $\beta_i$'s can be required to satisfy the theoretical properties of utility maximization by imposing the restrictions of adding up, homogeneity, and symmetry given in Deaton (1981).

This model can be appropriately called AIDSRD (AIDS with rationing and dual pricing). Saving can be introduced into this model as an additional commodity by assuming inter-temporally separable preferences. In this model, the effects of rationing on consumer behavior are captured by two terms. One is the income effect \( I + \sum \frac{r_{ij}}{p_j} (p_{ji} - p_{ji}) \); the other is the strict ration level $q_k$ as an explanatory variable. The coefficients of $q_k$ provide a quantitative measure of the effect of the $k$th strictly rationed good on the compensated budget share of the $i$th unrationed or partially rationed commodity.

This complete demand system is consistent with the utility maximization hypothesis. It is a flexible form that can be tested for all the theoretical properties of demand functions. It is also empirically tractable since equation (6) can be estimated as a nonlinear system of equations by a maximum likelihood method. Thus, the model provides a useful means to analyze consumer behavior in an economy with both strict rationing and dual pricing.

Consistent with many empirical applications, this study uses Stone’s price index as a proxy for the “true” general market price index given in equation (7). Stone’s price index is defined as

$$\ln P^* = \sum W_i \ln p_j^m$$

Substituting $P^*$ in equation (9) for $P$ in equation (6), adding a subscript $t$ for each observation, and assuming an additive and normally distributed error term $\mu_{it}$, the following estimating equation is derived.
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\[ W_{it} = \alpha_i + m \sum_{k=1}^{m} n_{ik} q_{kt} + \sum_{j=m+1}^{n} r_{ij} \ln p^m_{ij} + \beta_i \ln \left( \frac{F - \sum_{k=1}^{m} p_k q_{kt}}{P^*} \right) + \mu_{it} \]  

(10)

It is a linear approximation of the original AIDSRD. Total expenditure elasticities can be derived from equation (10) by calculating the partial derivative of \( W_{it} \) with respect to \( I \). The result is straightforward:

\[ \eta_i = (1 + \beta_i/W_i) \{ F - \sum_{k=1}^{m} p_k q_{kt} \} i = m+1, ..., n \]  

(11)

The price elasticities for the goods with a market price are derived under the assumption that all other prices and total compensated market expenditure are held constant, except \( W_{it} \) and the overall market price level, \( P^* \), are allowed to change (Green & Alston, 1990). The market price elasticities can then be computed as:

\[ e_{ij} = -\delta_{ij} + \frac{r_{ij}}{W_i} - \frac{\beta_i}{W_i} \{ W_j + \sum W_j \ln p_j^m (e_{ij} + \delta_{ij}) \} + D \left \{ (1 + \beta_i/W_i + \beta_i \{ \sum W_j \ln p_j^m \} (p_j^m z_j / (F - \sum_{k=1}^{m} p_k q_{kt})) \right \} \]

\[ i, j = m+1, ..., n \]  

(12)

where \( \delta_{ij} = 1 \) for \( i=j \) and 0 for \( i \neq j \), \( D=0 \) for the unrationed goods and \( D=1 \) for commodities with a parallel market.3

The effects of changes in the price of rationed goods, \( p_k \) or \( p_j^f \), and ration level, \( q_k \) or \( z_j \), can be analyzed by elasticities below:

a) When rationed price \( p_k \) or \( p_j^f \) changes, the rationed price elasticity of the demand for other goods can be computed as

\[ e_{ik} = -\{(1 + \beta_i/W_i + \beta_i \{ \sum W_j \ln p_j \}) \{ (p_k q_{ik} / (F - \sum_{k=1}^{m} p_k q_{kt})) \} \}

\[ e_{ij} = -\{(1 + \beta_i/W_i + \beta_i \{ \sum W_j \ln p_j \}) \{ (p_j^f z_j / (F - \sum_{k=1}^{m} p_k q_{kt})) \} \}

i = m+1, ..., n; k = 1, ..., m; j \in \text{the goods with dual prices.} \]

(13)

These elasticities should be negative for normal goods, since the compensated expenditure on other goods \( (F - \sum p_k z_k) \) is always positive, and a change in \( p_k \) or \( p_j^f \) has only an income effect. An increase in \( p_k \) or \( p_j^f \) would force consumers to pay more for the given ration level \( q_k \) or \( z_j \) and reduce the demand for other goods.

b) When the quantity of the strictly rationed commodities \( q_k \) changes, the impact can be evaluated by the following elasticity:

\[ \frac{\partial \ln x}{\partial \ln q_k} = \left( n_{ik} q_k / (W_i + \beta_i \sum W_j \ln p_j) \right) - \beta_i / (W_i + \beta_i \sum W_j \ln p_j) - 1 \{ (p_k q_{ik} / (F - \sum p_k q_{kt})) \}

i = m+1, ..., n; k = 1, ..., m \]  

(14)
A change in the ration level, \( q_k \), has a substitution effect and an income effect. An increase in \( q_k \) would reduce the demand for substitutes and increase the demand for complements of the rationed good. The sign of this elasticity will be ambiguous in general, because the income and substitution effects work in opposite directions when the unrationed goods are normal and net substitutes for the rationed goods.

c) When \( z_j \), the ration quantity of commodities with a parallel market, changes, its effects can be evaluated by the following elasticity:

\[
\frac{\partial \ln x_i}{\partial \ln z_j} = \left\{ \frac{1 + \beta_i(W_i + \beta_i \sum W_j \ln p_j)}{1 + \beta_i \sum W_j \ln p_j} \right\} \frac{(p^n_j - p'_j)z_j}{(r - \sum p_i q_i)}
\]

\[ i = m+1, \ldots, n; j \in \text{the goods with dual prices} \] (15)

where \( p'_j \) is the ration price of good \( j \) with a parallel market. Just like the change of prices for rationed goods, it has an income effect only. But in contrast to changes in ration prices, increased levels of rationing imply an increase in compensated income, so the elasticity should be positive for normal goods and negative for inferior goods.

**DATA, ESTIMATION PROCEDURES, AND MAJOR RESULTS**

The data used in estimation were obtained from city household budget surveys which were conducted by the State Statistical Bureau of the PRC from 1981 to 1987. Average per capita annual expenditures by income groups were available for 14 categories of goods and services plus savings. Some closely related expenditure categories were aggregated into eight broad categories for empirical estimation:

1) food grains;
2) nonstaple and other food;
3) tobacco, liquor, and tea;
4) clothing;
5) articles for cultural life and daily use (mostly durable goods);
6) services;
7) saving; and
8) housing rent.

Among these categories, housing was under strict rationing during the sample period. Food grains were subject to formal rationing, but urban households could purchase additional grain in a free market at market prices. Therefore, housing was treated as a strictly rationed good, food grains as a partially rationed good with dual prices, and all other categories as unrationed goods in the empirical model.

The price data were retail price indexes for 11 categories of goods and services sold in state commercial stores in cities and towns from 1981 to 1987, with 1978 as the base year. Only one price series was available for all income groups. The free market price for food grains was the price index at urban trade markets. Considering the static setting of the model, the lagged general index of the cost of living for staff and workers was used as an approximation of the price of saving. It represents the opportunity cost of giving up current consumption in exchange for future consumption. This assumes households form their inflationary expectations on last year's general price change. By such assumptions, household saving was treated as another unrationed good in the empirical model.
Table 5
Weighted Linear Seemingly Unrelated Regression Results of LA/AIDSRD Model

<table>
<thead>
<tr>
<th>Expenditure i</th>
<th>$\alpha_i$</th>
<th>$\beta_i$</th>
<th>$n_i$</th>
<th>$r_{i1}$</th>
<th>$r_{i2}$</th>
<th>$r_{i3}$</th>
<th>$r_{i4}$</th>
<th>$r_{i5}$</th>
<th>$r_{i6}$</th>
<th>$r_{i7}$</th>
<th>$R^2$</th>
<th>D.W.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Grains</td>
<td>1.1045</td>
<td>-0.1889</td>
<td>0.0175</td>
<td>0.1695</td>
<td>-0.1251</td>
<td>-0.0204</td>
<td>-0.1312</td>
<td>0.1118</td>
<td>0.0332</td>
<td>-0.0378</td>
<td>0.805</td>
<td>1.36</td>
</tr>
<tr>
<td></td>
<td>(8.19)</td>
<td>(-7.72)</td>
<td>(6.94)</td>
<td>(-3.91)</td>
<td>(-3.80)</td>
<td>(-10.96)</td>
<td>(5.67)</td>
<td>(2.18)</td>
<td>(-5.10)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Nonstaple Food</td>
<td>0.5055</td>
<td>0.0042</td>
<td>-0.0136</td>
<td>0.1221</td>
<td>0.0082</td>
<td>-0.1288</td>
<td>0.2318</td>
<td>-0.1979</td>
<td>0.0897</td>
<td>0.978</td>
<td></td>
<td>1.56</td>
</tr>
<tr>
<td></td>
<td>(2.73)</td>
<td>(0.12)</td>
<td>(-2.34)</td>
<td>(2.77)</td>
<td>(1.22)</td>
<td>(-8.57)</td>
<td>(9.81)</td>
<td>(-9.84)</td>
<td>(8.17)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Tea,Tobacco and Liquor</td>
<td>0.0363</td>
<td>0.0060</td>
<td>-0.0020</td>
<td>-0.0003</td>
<td>0.0439</td>
<td>-0.0427</td>
<td>0.0210</td>
<td>-0.0096</td>
<td>0.985</td>
<td>1.98</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1.78)</td>
<td>(1.60)</td>
<td>(-3.14)</td>
<td>(0.06)</td>
<td>(5.25)</td>
<td>(-3.29)</td>
<td>(3.73)</td>
<td>(-1.90)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Clothing</td>
<td>-0.0007</td>
<td>0.0514</td>
<td>-0.0078</td>
<td>0.082</td>
<td>0.0758</td>
<td>-0.0263</td>
<td>0.0847</td>
<td>0.995</td>
<td>2.24</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.20)</td>
<td>(7.72)</td>
<td>(7.11)</td>
<td>(1.82)</td>
<td>(1.16)</td>
<td>(-1.09)</td>
<td>(4.40)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Articles &amp; Durables</td>
<td>-0.4732</td>
<td>0.081</td>
<td>-0.0052</td>
<td>-0.1897</td>
<td>-0.0755</td>
<td>-0.1114</td>
<td>0.995</td>
<td>2.12</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(-9.89)</td>
<td>(8.88)</td>
<td>(-3.44)</td>
<td>(-1.89)</td>
<td>(-2.25)</td>
<td>(-3.92)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Saving</td>
<td>-0.2806</td>
<td>0.0491</td>
<td>0.0136</td>
<td>0.0861</td>
<td>0.1593</td>
<td>0.986</td>
<td>1.44</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(-3.63)</td>
<td>(3.46)</td>
<td>(5.53)</td>
<td>(4.10)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Service</td>
<td>0.1081</td>
<td>-0.0028</td>
<td>-0.0025</td>
<td>-0.1749</td>
<td>0.989</td>
<td>1.32</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(4.15)</td>
<td>(-0.58)</td>
<td>(-3.02)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: 
* The figures in parentheses are asymptotic t-ratios. Those over two are significant at the 95 percent level. The model was estimated two times, once the service share equation was dropped, once the saving expenditure share equation was dropped. The iterative SUR guarantees the same solution convergence no matter which equation is dropped.

b The t-ratio was not estimated because the coefficients were derived from the homogeneity and symmetry conditions.
Compensated income ($F$) was computed as follows: $F = I + (p_m - p_r)z$, where $I$ is the actual expenditure, $p_m$ and $p_r$ are the free market price for grain and the grain price in the state ration store respectively, and $z$ is the grain ration level.

Interactive Linear Seemingly Unrelated Regression procedures were used to simultaneously estimate the system of seven expenditure share equations. Since the number of households in each income group increased considerably year by year during the sample period, all regressors were weighted by group size in order to minimize the heteroscedasticity problem. The theoretical constraints of adding up, homogeneity, and symmetry were imposed; and one equation was dropped from the system. Its parameters were obtained from the adding up conditions. The estimation results are reported in Table 5.

The models fit the data very well, and the computed $R^2$s are as high as 0.98-0.99 for most of the expenditure share equations (Table 5). In addition, most regression coefficients are statistically significant. The coefficients of real compensated expenditure ($\beta_j$) are negative for grains and services, indicating that they are necessary goods. This means their budget shares decline as real compensated incomes rise. The estimated coefficients ($n_i$) of housing ration level $q_i$ can be interpreted as a proxy of the spillover effect due to the strict rationing on housing. Since the adding up condition requires that the sum of the coefficients of the strictly rationed good equals zero ($\sum n_i = 0$) across all expenditure share equations, the estimated $n_i$'s can be positive or negative. The positive and highly significant coefficient $n_i$ on the saving share equation indicates that when the housing ration level increases one unit, the budget share for saving increases 1.36 percent. This is a strong indicator of forced savings and a spillover effect of rationed housing. These statistical results imply that rationing was an important factor affecting consumption and saving behavior of Chinese urban households during the period being analyzed. Own and cross price effects ($r_{ij}$) show that the budget shares of grains, nonstaple food, and saving increase significantly with their own prices. Since inflation was used to measure the opportunity cost of saving, one would expect to find that the saving share would decrease as its cost rises. However, in an economy with both inflation and a shortage of a most important consumer good (housing), increases in the saving share may indicate that money has no other desirable place to go.

Table 6 presents the estimated expenditure and own price elasticities. The expenditure elasticity of food grains has a negative sign, indicating that it is not only a nutritional necessity, but also has become an inferior good for Chinese urban households as their living standard has been enhanced during the economic reform. This is also consistent with observations on per capita consumption of food grains, which has declined since 1983 (Table 1). The pattern of the expenditure elasticities of unrationed goods shows that durable goods (articles for daily use) have the highest expenditure elasticity (1.53), clothing ranks second (1.36), and savings is third (1.26), followed by tea, tobacco, and liquor (1.08). Nonstaple food and services have relatively low expenditure elasticities (less than one). The estimated price elasticities indicate that food grains were the least price elastic consumer good ($-0.1$) for Chinese urban households during the sample period. Because they could obtain enough grain from the state ration store at the constant subsidized price, a change in its market price had little effect on its demand. It is the rationed quota that makes the demand for grain so inelastic. Among the unrationed goods, durables were very responsive to changes in their own prices (with $-2.11$). Nonstaple food and clothing had a price elasticity of about $-0.65$, and addictive products such as tobacco had a price elasticity near unity. This is consistent with observations on the Chinese urban consumer goods market.
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Table 6
Estimated Price and Expenditure Elasticitiesa

<table>
<thead>
<tr>
<th>Elasticity</th>
<th>Grain</th>
<th>Nonstaple Food</th>
<th>Tea, Tobacco and Liquor</th>
<th>Clothing</th>
<th>Articles for Daily Use</th>
<th>Saving</th>
<th>Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expenditure</td>
<td>-0.074</td>
<td>0.955</td>
<td>1.075</td>
<td>1.356</td>
<td>1.534</td>
<td>1.255</td>
<td>0.90</td>
</tr>
<tr>
<td>Own Prices</td>
<td>-0.104</td>
<td>-0.632</td>
<td>-1.015</td>
<td>-0.656</td>
<td>-2.113</td>
<td>-0.70</td>
<td>-3.867</td>
</tr>
</tbody>
</table>

Note: a All elasticities are calculated at sample means.

Table 7
Cross Price Elasticity of Housing and Grain, and Elasticity of Ration Levela

<table>
<thead>
<tr>
<th>Elasticity</th>
<th>Grain</th>
<th>Nonstaple Food</th>
<th>Tea, Tobacco and Liquor</th>
<th>Clothing</th>
<th>Articles for Daily Use</th>
<th>Saving</th>
<th>Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>e_{ir}</td>
<td>0.0057</td>
<td>-0.0095</td>
<td>-0.0107</td>
<td>-0.013</td>
<td>-0.0143</td>
<td>-0.0122</td>
<td>-0.009</td>
</tr>
<tr>
<td>e_{ig}</td>
<td>0.0434</td>
<td>-0.0721</td>
<td>-0.809</td>
<td>-0.0988</td>
<td>-0.1087</td>
<td>-0.0927</td>
<td>-0.0679</td>
</tr>
<tr>
<td>\partial \ln x_1 / \partial \ln q_r</td>
<td>1.1047</td>
<td>-0.3156</td>
<td>-0.3441</td>
<td>-0.4450</td>
<td>-0.2611</td>
<td>0.6007</td>
<td>-0.3103</td>
</tr>
<tr>
<td>\partial \ln x_1 / \partial \ln z_g</td>
<td>-0.0407</td>
<td>0.0677</td>
<td>0.0759</td>
<td>0.0927</td>
<td>0.1021</td>
<td>0.087</td>
<td>0.0638</td>
</tr>
</tbody>
</table>

Note: a All elasticities are calculated at sample means.

The effects of housing and grain rationing can also be evaluated by computing the cross price elasticity of an unrationed good with respect to the ration price of housing (e_{ir}) and grain (e_{ig}), and the elasticity for demand with respect to the rationed quantity of housing and grain (\partial \ln x_1 / \partial \ln q_r and \partial \ln x_1 / \partial \ln z_g). Those elasticities were calculated based on the estimates in Table 5, by using equations (13), (14), and (15), and are reported in Table 7.

The cross-price elasticities of unrationed goods, in relation to the prices of rationed goods, are negative for all goods categories except grain, indicating that when the prices of rationed goods increase, the demand for unrationed goods will decrease. This is because the income effect reduces the amount of expenditure available for unrationed goods; consequently, compensated income is reduced. The positive sign on grain means that it became an inferior good in the sample period.

The absolute value of the cross price elasticities with respect to the price of the partially rationed food grains (e_{ig}) and the elasticity with respect to the quantity of grain rationing (Rows 2 and 4 in Table 7) are similar. This is because both the rationed quantity and the cross price elasticity have only an income effect for a partially rationed good. The grain ration level elasticity is positive for all goods categories, except grain itself, which is consistent with the estimated cross-price elasticities (signs opposite each other). It implies that when the quantity of the partially rationed good increases, its market demand decreases, and the demand for unrationed goods increases. A high level of grain rationing will increase government's subsidy and increase consumers' compensated income.

The rationed quantity elasticities with respect to strictly rationed housing are larger than their rationed price elasticities (Row 3 verses Row 1 in Table 7), implying that the demand for unrationed goods is more sensitive to the quantity of the strictly rationed good than to its ration price. This is because the income effect of a change in the housing quota is usually much greater than a change in housing rent. In addition, for strictly rationed goods, a price
change has only an income effect. But a change in the rationed quantity also has a substitution effect, which may be much greater than the income effect. The elasticity of demand for unrationed goods, with respect to the quantity of a strictly rationed good, can be, and is, both positive and negative. It is interesting to note it is positive for saving. This indicates that when the level of housing rations increased, Chinese urban households increased the portion of their budget allocated to savings. This empirical evidence supports the hypothesis that housing rationing contributed to forced savings in urban China.

**IMPLICATIONS OF POLICY SIMULATION**

In order to evaluate the consequences of possible policy changes, four policy simulations were conducted using the model estimated in the last section and altering the rationing levels or prices. The four scenarios for change were:

1) Remove the government grain rationing, keeping the market price of grains as before;
2) Remove the government grain rationing and allow the new market equilibrium price to decline to the average of the state ration price and the old market price;
3) Increase the housing ration level by 50 percent when per capita real expenditure of urban households increases by 50 percent; and
4) Eliminate grain rationing but increase the housing ration level by 50 percent and also allow per capita real expenditures (real income) to increase 50 percent. That is, scenarios (2) and (3) are combined.

Clearly, many policy changes could be simulated. These four were chosen because they represent plausible reactions to an increased need for housing space, a phasing out of grain rationing, and a rise in income levels as China develops.

The results from the policy simulations reported in Table 8 show that the removal of grain rationing has a very small effect on the pattern of urban household consumption, especially for the highest income groups. Since removing the grain quota (Simulation 1, Table 8) has only an income effect, household real income decreases, causing the expenditure share of grain and services to increase; the share of other categories decreases. The percentage change in the budget share is very small, less than one percent, except for food grains (Column 4). The induced change in demand for other goods is also relatively small, with all goods declining less than 10.5 percent (Column 5). Confining this simulation to high and low income groups showed that in the highest income group, the demand for other commodities decreased only about three percent, while the demand in the lowest income group decreased more than 10 percent along with a two percent decline of food grain consumption. If the market price for grain is unchanged after removing state rationing, urban households are worse off because of the income effect. In reality, the new market price would likely reach a lower equilibrium as the grain demand curve shifts backward in the absence of the state's subsidy through rationing. The new market price would be somewhere between the old market price and the state ration price, depending on the original proportions of rationed and market purchased grain. If the original market share was large and the old free market price decreases, consumers' real income could increase and households may actually be better off.
Table 8
Results of Policy Change Simulation
(Over all average)

<table>
<thead>
<tr>
<th>Expenditure Group</th>
<th>Simulation 1&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Simulation 2&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Simulation 3&lt;sup&gt;c&lt;/sup&gt;</th>
<th>Simulation 4&lt;sup&gt;d&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Base Share</td>
<td>New Share</td>
<td>% of Share Change</td>
<td>% Change of Demand</td>
</tr>
<tr>
<td>Grains</td>
<td>0.1511</td>
<td>0.1642</td>
<td>1.3079</td>
<td>1.39</td>
</tr>
<tr>
<td>Nonstaple Food</td>
<td>0.3326</td>
<td>0.3323</td>
<td>-0.0288</td>
<td>-0.77</td>
</tr>
<tr>
<td>Tea, tobacco and</td>
<td>0.0439</td>
<td>0.0435</td>
<td>-0.0416</td>
<td>-7.57</td>
</tr>
<tr>
<td>Liquor</td>
<td>0.1215</td>
<td>0.1180</td>
<td>-0.3558</td>
<td>-9.42</td>
</tr>
<tr>
<td>Clothing</td>
<td>0.1382</td>
<td>0.1326</td>
<td>-0.0612</td>
<td>-10.48</td>
</tr>
<tr>
<td>Articles for</td>
<td>0.1503</td>
<td>0.1469</td>
<td>-0.3398</td>
<td>-7.57</td>
</tr>
<tr>
<td>Daily Use</td>
<td>0.0624</td>
<td>0.0626</td>
<td>0.0193</td>
<td>-6.40</td>
</tr>
</tbody>
</table>

Notes:
<sup>a</sup> Remove the partial rationing on grain.
<sup>b</sup> Remove the partial rationing on grain and allow a new equilibrium price.
<sup>c</sup> Increase the strict housing ration level and per capita expenditures by 50 percent.
<sup>d</sup> Combine <sup>b</sup> and <sup>c</sup>.
Suppose that, after removing state grain rationing, the new market equilibrium price declined to equal the average of the old market price and the state ration price. The results of Simulation 2 show that, on the average, the food grain demand would decrease considerably (36.65 percent), but the demand for nonstaple food, tea and liquor, clothing and services would increase. Durable goods and saving would decrease. Considering the dramatic increase in durable goods possessed by Chinese urban households in recent years, a little slowdown in this sector may not be a problem. Meanwhile, removing state grain subsidies would relieve a huge burden from the government budget and, in turn, might reduce the burdens of urban households as taxpayers. This may partially explain why the Chinese government eliminated all grain price subsidies in all urban areas in May 1993. There was, in fact, little social or market shock, and the daily life of Chinese urban households proceeded as usual. It represents a policy of "gradualism," which is less painful than "shock therapy" in reforming centrally planned economies.

As economic growth and per capita income increase, Chinese urban households will need more housing. To solve the excess demand for housing in urban areas, the rationed level of housing per household could be increased. Simulation 3 increased the housing ration level by 50 percent, assuming per capita real expenditure on unrationed goods also increased by 50 percent; other things were unchanged. The results show that this type of policy will induce more forced savings and larger expenditures on durable goods. The elasticity of saving, with respect to the level strictly rationed housing, was positive in Table 7 (0.60); and the results reflect this elasticity plus an increased budget allocation (real income) of 50 percent. The per capita share of household expenditures going into savings increased 7.1 percent on average, with a 5.3 percent increase in the lowest income group and more than a 10 percent increase in the highest income group. This caused the share of real expenditures on most other consumption goods to decline, except for the budget share spent on durables. With a 50 percent increase in real income and an income elasticity of greater than one, one would expect expenditures on durable goods to rise more than 50 percent. In addition, durable goods expenditures typically increase with increases in housing. Overall demand for other goods increased, but less than it would have if there were no forced saving effect.

Results of Simulation 4 reinforce the point made by Simulation 2. Removing grain rationing in urban areas could make households better off because of a decline in market prices and a potential decrease in the tax burden. The results show that removing the state grain subsidy could reduce the negative effects of increased housing ration levels. Forced saving increased less than in Simulation 3; and demand increased more for all other categories of commodities, except grains and durables, compared to Simulation 3. Therefore, a strategy for housing reform could follow the path of food grain reform: introduce the free market into urban housing allocation by gradually reducing the state housing ration level until a full housing market could be established in China.

CONCLUSION

This study represents the first major attempt to estimate both strict and partial rationing effects in a complete demand system framework. An Almost Ideal Demand System with both strict rationing and dual pricing (AIDSRD) was extended from Deaton (1981) by using the concept of compensated income. The model was estimated with urban household budget data from China. The objectives of the econometric analysis were to investigate and quan
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tify the impacts of rationing on household saving and consumption behavior. This study does not attempt to explain other saving such as business accumulations or changes in government budget deficits. Linking the results herein to macroeconomic policy would require a general equilibrium framework and was beyond the scope of this study.

For reasons mentioned earlier, estimations and simulations were conducted with a linear version of AIDSRD and, therefore, the numerical results need to be interpreted as approximations. Still, the econometric results obtained provide convincing evidence that rationing of housing has had a positive spillover effect on Chinese urban household savings. It constitutes one of the basic institutional reasons for the dramatic increase in household saving and distortion of consumer behavior in China in recent years. The estimated expenditure and price elasticities show that food grains have become an inferior good and inelastic with respect to price and income. This is related to the rising standard of living in urban China and to the government’s grain price subsidy.

The policy simulations further demonstrate that eliminating grain rationing would not have much influence on Chinese urban consumers because of the significant development of a parallel free market, and because food grains have become less important in the everyday diet. An increase in the ration quantity of housing cannot solve the excess demand for housing as the economy and the population grow, but will only further distort the market and induce more forced saving.

NOTES

1. For convenience, it is assumed that the utility function $U(.)$ has all the regular properties; that is, it is a strictly quasiconcave, twice-differentiable and an increasing function of its arguments, throughout the analysis.

2. When $p_m$ changes, the lump sum transfer $(p_m - p_r)z$ also changes. This fact is very important in the derivation of the formulas for various elasticities and comparative statics.

3. Here Green and Alston’s formula is extended to the case of rationing and dual pricing; that is, there is an additional term $D(.)$ for the goods with a parallel market.

4. Expenditure data were obtained from Chinese Urban Household Budget Surveys (1985, 1986, and 1987), all the price data were obtained from China Statistical Year Book and China Price Statistical Year Book; both are published by the State Statistical Bureau in Chinese. The data were used as is, except for necessary aggregation of commodities. There were six income groups for the period 1981-1984 and seven income groups for the period 1985-1987. Only group means were available for each income group. The original data will be made available upon request to the authors.

5. Data on $P_m$ and $P_r$ are the same across all households, but data was available on household expenditures for rationed grain and market grain by income group. This allowed the ration level $(z)$ to be calculated by income group as the portion of expenditure for rationed grain divided by $P_r$.

6. Maximum likelihood procedures may be used taking the starting values from the linear model presented here. Considering the small sample size (45 observations) and because there is no guarantee that a global maximum will be reached with this expensive estimating technique, only the linear estimation results are reported here as an approximation of the nonlinear model.

7. Simulation results for high and low income households are available from the authors.

REFERENCES


