An Intersectoral Perspective on the Relationship between the Agricultural and Industrial Sectors in Chinese Economic Development

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Abstract: In a developing economy characterized by economic dualism, the interrelationship between the growth of the agricultural sector and that of the industrial sector is crucial for overall development. Theoretically, the agricultural and industrial sectors are closely linked. Agricultural progress would depend increasingly on the growth of industrial development and vice versa. However, no mutual dependency occurred in the Chinese economic development process. A causality test between the agricultural and industrial sectors of the Chinese economy indicates no cause-effect relationship. Growth models for the agricultural and industrial sectors were estimated using two-stage least squares. Labour productivity was low in China's agricultural sector before 1979, and the marginal productivity of labour was negative. Labour productivity and capital productivity in the industrial sector were also low. China's industrial development was mainly capital intensive and took place at the expense of the traditional agricultural sector. Labour productivity in the agricultural sector increased significantly after 1979, while productivity in the industrial sector decreased. This indicates that economic reform positively affected the agricultural sector in terms of labour productivity but negatively affected the industrial sector. Rural peasants have supported market-oriented economic reform more enthusiastically than urban people.

Introduction

The interrelationship between the growth of the traditional indigenous agricultural and the modern industrial sectors of the economy are critical for overall development. Policy makers in most developing countries have realized its importance to industrialization and more recently the importance of the agricultural sector. However, economic analysis has largely neglected intersectoral links, concentrating instead on either macroeconomic or single-sector and subsector issues (Bacha, 1980). The primary objective of this paper is to evaluate the intersectoral perspective for China's agricultural and industrial economies.

Before 1949, the Chinese economy was very underdeveloped. The rural areas in China were destitute. From 1949, when the Communist party came to power, the Chinese leadership has promoted a nationwide industrialization programme. For a long time, priority in economic development was given to industry, especially heavy industry, and emphasis was placed on large-scale, state-owned industry, which was highly capital-intensive and concentrated mostly in urban areas. Although the Chinese leadership recognized agriculture's important contribution to economic growth and seemed to support a policy of concurrent growth, in practice they sought to achieve agricultural growth primarily through organizational changes and to accelerate industrial development through a high level of state investment financed largely through direct and indirect taxes on agricultural commodities. Consequently, great progress was made in China's industrial development, while agriculture was at a very low ebb. In terms of gross industrial and agricultural output value, the value of industrial output climbed from 30 percent of national income in the early 1950s to 74 percent in 1987, with agricultural output values falling from 70 percent to 25 percent. However, no corresponding changes took place in the employment structure. About 76 percent of the total labour force is still engaged in agriculture.

A series of reform programmes was launched on a large scale. The contract "responsibility system," with remuneration linked to output based on publicly owned land, was introduced and eventually gave way to individual household farming. Rural markets were free, and agricultural procurement prices rose significantly. The government switched from the take-grain-as-the-foundation policy to promoting a diversified development policy. Consequently, agricultural production grew rapidly. During 1978–88, agricultural output value increased at an average annual growth rate of 6.2 percent, and rural per capita incomes increased from 134 to 545 yuan, an average annual growth rate of 7.6 percent. Urban per-capita income rose from

316 yuan in 1978 to 1,119 yuan in 1987, an average annual increase rate of 5.9 percent (Zhong, 1989).

According to the World Bank (1985), Chinese agriculture will remain one of the largest and most important sectors of China's economy for the next two or three decades. By the year 2000, food will account for about 50 percent of the household budget and more than 50 percent of the total labour force still will work in agricultural activities. This implies that the Chinese agricultural sector will play an important role in the Chinese economy. It is therefore both interesting and challenging to study the agricultural and industrial economies in intersectoral terms, including patterns of sectoral development of the past four decades.

Development of the Growth Model

Growth-promoting interactions between the agricultural and industrial sectors have been reviewed in the literature and accepted by many policy makers. The "theology" of development has emphasized that agricultural progress contributes to the support of great productivity throughout the economy. Agricultural progress will increasingly depend on growth of the industrial demand for agricultural commodities. In a dual economy, the ultimate question for future development of the economy is how the modern exchange sector can expand while the indigenous agricultural sector contracts. This requires an analysis of the interrelationship between the two sectors.

Using the methodology of Ranis and Fei (1964) to evaluate the interrelationship between the Chinese industrial and agricultural sectors, a growth model can be expressed as follows:

$$(1)\quad AY_t = \alpha_0 AL_t^{\alpha 1} AB_t^{\alpha 2} IY_t^{\alpha 3}$$

$$(2)\quad IY_t = \beta_0 IK_t^{\beta 1} IB_t^{\beta 2} AY_t^{\beta 3}$$

where AY_t = gross national income in the agricultural sector, AL_t = acres of arable land, AB_t = the quantity of labour in the agricultural sector, IY_t = gross national income in the industrial sector, IK_t = the total amount of capital in the industrial sector, and IB_t = the quantity of labour in the industrial sector.

In this model, AY_t and IY_t are treated as endogenous variables under an assumption that the two sectors of the economy help each other in the process of economic development and that the other variables (AL_t, AB_t, IK_t and IB_t) are treated as exogenous. Equations (1) and (2) are a static model in which changes in the value of independent variables (i.e., AL and AB in Equation (1)) affect gross national income at the same time. There is, however, some evidence that indicates that changes in the value of independent variables in time t affect gross income in t and several periods in the future. Assuming that the dynamics take place under the partial adjustment hypothesis (Nerlove, 1958), Equation (1) can be rewritten as:

$$(3)\quad AY_t^* = \alpha_0 AL_t^{\alpha 1} AB_t^{\alpha 2} IY_t^{\alpha 3}$$

$$(4)\quad \left(\frac{AY_t}{AY_{t-1}}\right) = \alpha \left(\frac{AY_t^*}{AY_{t-1}}\right)$$

where AY_t^* is desired or optimal gross income in the agricultural sector, and α is a dynamic adjustment coefficient. Combining Equations (3) and (4) yields:

$$(5)\quad AY_t = \lambda\, \alpha_o AL_t^{\lambda\alpha 1} AB_t^{\lambda\alpha 2} IY_t^{\lambda\alpha 3} AY_{t-1}$$

Similarly, Equation (2) is rewritten, using the partial adjustment hypothesis, as follows:

$$(6)\quad IY_t^* = \beta_0 IK_t^{\beta 1} IB_t^{\beta 2} AY_t^{\beta 3}$$

$$(7)\quad \left(\frac{IY_t}{IY_{t-1}}\right) = \lambda \left(\frac{IY_t^*}{IY_{t-1}}\right)$$

Combining Equations (6) and (7) yields:

$$(8)\quad IY_t = \lambda\beta_0 IK_t^{\lambda\beta 1} IB_t^{\lambda\beta 2} AY_t^{\lambda\beta 3} IY_{t-1}$$

where IY^* is desired or optimal growth income in the industrial sector and λ is the dynamic adjustment coefficient. Equation (5) is a dynamic growth model for the agricultural sector and Equation (8) for the industrial sector.

Equations (5) and (8) are derived under an assumption that one sector of the Chinese economy influences the growth of the other sector. The causal direction between the agricultural and industrial sectors of the Chinese economy is tested using the procedure of Nelson and Schinert (Granger and Newbold, 1986). To test the null hypothesis that the growth of the industrial sector (IY_t) does not cause the growth of the agricultural sector, the following equation is specified (Nelson and Schinert):

$$(9)\quad AY_t = \sum_{j=1}^{k} d_{ij} AY_{t-j} + \sum_{i=1}^{n} d_{2t} IY_{t-i} + e_t$$

$$(10)\quad AY_t = \sum_{j=1}^{k} d_j AY_{t-j} + e_2 t$$

Let us assume that $\hat{\sigma}_1^2$ and $\hat{\sigma}^2$denote the residual estimates from Equations (9) and (10), respectively. The test statistic is:

$$(11)\quad T = n(\hat{\sigma}^2 - \hat{\sigma}_1^2)/\hat{\sigma}_1^2$$

which has an asymptotic χ^2 distribution with k degrees of freedom under the null hypothesis that the economic growth of IY_t does not cause that of AY_t.

To test the null hypothesis that AY_t does not cause IY_t, Equations (9) and (10) are respecified as:

$$(12)\quad IY_t = \sum_{j=1}^{k} h_{ij} IY_{t-j} + \sum_{i=1}^{n} h_{2j} AY_{t-i} + e_{1t}$$

$$(13)\quad AY_t = \sum_{j=1}^{k} h_j IY_{t-j} + e_2 t$$

The test statistics in Equation (11) are calculated from estimated residuals from Equations (12) and (13) and are used to test the null hypothesis.

Empirical Results

Time-series data for 1952–88 were used to estimate the models. Most of the data used in this study were obtained from the 1988 *Almanac of China's Economy*. Chinese official economic statistics (except for 1958–60) are generally reliable. Other data such as those on the agricultural labour force and land came from Crook (1988). Land index data were adjusted based on Tang's index (Tang, 1981). National income is the value added to the country's

material wealth from industry, agriculture, construction, transport, and trade. Industrial income in the model includes net material product from productive sectors other than agriculture. As an indicator of capital in the industrial sector, accumulated capital is the part of national income used to increase fixed capital assets, working capital, and material reserves.

Relationship between the Agricultural and Industrial Sectors

Equations (12) and (13) are estimated as follows:

$$(14)\quad IY_t = \underset{(2.480)}{-2.661} + \underset{(4.918)}{0.895}\, IY_{t-1} - \underset{(0.882)}{0.127}\, IY_{t-2} + \underset{(3.046)}{0.921}\, AY_{t-1} - \underset{(0.915)}{0.344}\, AY_{t-2} + e_{1t}$$

$R^2 = 0.9755$, *s.e.* = 0.117

$$(15)\quad IY_t = \underset{(0.572)}{0.182} + \underset{(7.402)}{1.257}\, IY_{t-1} - \underset{(1.603)}{0.270}\, IY_{t-2} + e_{2t} \qquad R^2 = 0.9629,\ s.e. = 0.144$$

Equations (9) and (10) are estimated as follows:

$$(16)\quad AY_t = \underset{(1.213)}{0.637} + \underset{(10.444)}{1.545}\, AY_{t-1} - \underset{(3.679)}{0.677}\, AY_{t-2} - \underset{(0.404)}{0.036}\, IY_{t-1} + \underset{(1.263)}{0.089}\, IY_{t-2} + e_{1t}$$

$R^2 = 0.9685$, *s.e.* = 0.057

$$(17)\quad AY_t = \underset{(0.405)}{0.123} - \underset{(9.952)}{1.531}\, AY_{t-1} - \underset{(3.354)}{0.544}\, AY_{t-2} + e_{2t} \qquad R^2 = 0.9685,\ s.e. = 0.060$$

where numbers in parentheses are the *t*-values for the corresponding parameters and *s.e.* represents standard error.

The value of the χ^2 statistic calculated from Equations (14) and (15) is larger than the critical value of the statistics at the 5-percent significance level, rejecting the null hypothesis that growth of the agricultural sector has not caused the growth of the industrial sector in the Chinese economy.

The χ^2 test with Equations (16) and (17) accepts the null hypothesis that growth of the industrial sector has not caused growth in the agricultural sector in the Chinese economy.

The causality test indicates that growth of the agricultural sector has contributed to growth of the industrial sector, but that the industrial sector has not contributed to the growth of the agricultural sector. The following factors may explain this result.

Industry has developed at the expense of an "agricultural squeeze." In the 1950s, the Chinese leadership adopted many aspects of the Soviet model of economic development. The agricultural sector was a resource base to be "exploited" to serve development strategies. To accumulate capital to serve the development of the country's weak and underdeveloped industry, the government adopted the practice of monopolized state procurement and marketed farm and "sideline" products at low prices. The state purchased these commodities at extremely low prices in rural areas and marketed them at similar or slightly higher prices to urban residents and enterprises. This policy kept wage expenditure and cost of raw materials for its major industries low and created exceptional profits in the industrial sector and the necessary contribution of funds for its industrial development. Relevant statistics show that during 1949–78 the differentials between industrial and farm and "sideline" product prices have meant a "gratis contribution" of 600,000 million yuan from the peasants or 45 percent of their total income for this period (Jiang and Luo, 1989).

An "urban bias" discriminated against agriculture. The Chinese leadership, particularly Mao, recognized the distinct forms that agriculture's contribution could take.

The rural areas became isolated from the urban areas. A strict system of resident registration divided the country's urban and rural residents. The peasants had to work on limited arable land and perceived no possibility of improving their circumstances in this closed or semi-closed economy. Agricultural development lost vigour and vitality. Egalitarian distribution practices reduced the peasants' enthusiasm for production and productivity.

Growth Model for Agricultural and Industrial Sectors

Growth models for the agricultural and industrial sectors (Equations (5) and (8)) were estimated using two-stage least squares. Following the causality test described in the previous section, the growth model for the agricultural sector does not include the growth measures in the industrial sector as an independent variable, but the industrial growth model contains growth measures for the agricultural sector. A dummy variable (D_t) representing economic reform since 1978 and a variable interacting with the labour variables are included to investigate the impacts of the policy on labour productivities. The agricultural growth model also includes a trend variable to capture effects of improvements in farming technology. The estimated equations are as follows:

$$\begin{array}{l} \text{Log } AY_t = -1.854 + 1.292 \text{ Log } AL_t - 0.149 \text{ Log } AB_t + 0.709 \text{ Log } AY_{t-1} - 21.33\, D_t \\ \qquad\qquad (0.419)\ (1.613) \qquad\quad (0.339) \qquad\quad (6.329) \qquad\quad (1.950) \\ \qquad + 1.694\, (D_t \text{ Log } AB_t) + 0.0046\, TR \qquad R^2 = 0.9622 \\ \qquad\qquad (1.955) \qquad\quad (0.618) \end{array} \tag{18}$$

$$\begin{array}{l} \text{Log } IY_t = -1.885 + 0.361 \text{ Log } IK_t + 0.381 \text{ Log } IB_t - 1.174 \text{ Log } AY_{t-1} + 0.381 \text{ Log } IY_{t-1} \\ \qquad\qquad (1.263)\ (4.878) \qquad\quad (2.894) \qquad\quad (2.897) \qquad\quad (5.314) \\ \qquad + 1.308 \text{ Log } AY_t + 4.379\, D_t - 0.380\, (D_t \text{ Log } IB_t) \qquad R^2 = 0.9880 \\ \qquad\qquad (3.957) \qquad\quad (2.488) \quad (2.494) \end{array} \tag{19}$$

where D_t is a dummy variable representing the 1979–88 period in which the Chinese government used a semi-market-oriented economic policy. This dummy variable is used to evaluate the effects of economic policy on growth of gross national income in the agricultural and industrial sectors. The dummy variable interacting with the labour variable is used to evaluate changes in labour productivity in the agricultural and industrial sectors during 1979–88 compared to 1953–78.

The values of R^2 are 0.96 for the growth model of the agricultural sector and 0.99 for the growth model of the industrial sector, indicating that economic growth in both the agricultural and industrial sectors can be explained very well by the variables used in the models. In the growth model for the agricultural sector, the estimated coefficients are not highly significant except for the lagged dependent variables, although the model has a high R^2. This is due mainly to the high multicollinearity among the independent variables. The estimated coefficients in the growth model for the industrial sector all differ significantly from zero at the 5-percent significance level.

The dummy variable and the variable interacting with the labour variables can be adjusted to the intercept term and to the estimated coefficients for the labour variable for the models for 1979–88, while the coefficients are the same as those of Equations (18) and (19) for the models for 1952–77. The coefficients of labour for 1952–78 are –0.149 for the agricultural sector and 0.381 for the industrial sector and 1.545 and 0.001 for 1979–88. These coefficients are interpreted as marginal products of labour.

Three implications can be drawn from comparing these coefficients of the industrial and agricultural sectors models between these two time periods.

1. The marginal productivity of labour was negative and increased substantially in 1979–88. The economic institutions and strategy developed in China since the 1950s repeated the major features of the traditional Soviet model with only minor variations. Planners

attempted to extract the maximum level of surplus agricultural product to meet the demands of planned growth in the industrial sectors. During the period of collectivization of agricultural production, all the agricultural labour was kept on the farmland. Peasants could not work in non-agricultural lines of production, nor in forestry, animal husbandry, or fisheries.

The steady natural growth of the agricultural labour force and the sharp decline in the available arable land per capita produced an army of surplus agricultural workers. In 1978, the number of people of working age totalled 528 million, of which 298 million were employed, leaving labour resources of 230 million available (Yeh, 1984).

The situation regarding the rural labour surplus seems to have been more severe. A detailed study of 30 population teams in Nantong County, Jiangsu Province, concluded that this county had surplus labour with only 1.6 mu (about 0.107 ha) per head of the agricultural labour force. The study reports that about 4 mu (about 0.267 ha) per worker would be needed to avoid surplus labour (Song, 1982). This is a substantially higher estimate of labour requirements than many others have used. The Ministry of Agriculture, Animal Husbandry, and Fisheries uses an estimated average cropping intensity of 9 mu (about 0.6 ha) per worker in crop production to forecast labour requirements. An estimated one-third of the agricultural labour force is superfluous (World Bank, 1985). Although 1,000 million person-days of labour input were mobilized in China's agriculture, particularly in rural labour-intensive construction work campaigns since the 1950s, agricultural production per person-day fell. Consequently, China's success in absorbing rural surplus labour through collectivization brought with it a substantial decline in the average and marginal productivity of labour.

Since 1978, the new system of production responsibility in rural areas and the higher prices for state purchases of major farm products have encouraged peasants to engage in "sideline" production, revived free markets so that peasants can sell their privately produced products, and increased their incentive to work for the collective and for themselves. In 1979, the first year the new agricultural policies were put into effect, total output value from agriculture rose 8.6 percent over the 1978 level. Grain production increased by 6.1 percent, reaching 333.12 Mt, a record high. Cotton production rose by 1.8 percent, and the three oil-bearing crops (groundnuts, sesame, and rape) increased by 23.5 percent. Each peasant's average income rose from 117 yuan in 1977 to 170 yuan in 1980. Peasants' savings deposits in banks increased from 4,650 million yuan in 1977 to 12,660 million yuan in 1980 (Lin and Chao, 1982).

2. Both labour and capital productivity in the industrial sector are low, indicating that China's industrial development is based mainly on capital intensity with low efficiency of workers.

3. Unlike labour productivity in the agricultural sector, that in the industrial sector decreased in the 1979–80 period, indicating that economic reform since 1978 has affected the agricultural sector positively in terms of labour productivity but the industrial sector negatively.

Summary and Conclusion

In a developing economy characterized by dualism, the interrelationship between growth of the agricultural and industrial sectors is crucial for overall development. Theoretically, the agricultural and industrial sectors are closely linked. Agricultural progress depends increasingly on the growth of industrial development and vice versa. However, this did not happen in the Chinese economic development process. Empirical testing of a dual growth model indicates that growth of the agricultural sector increased growth of the industrial sector, but growth in the industrial sector did not increase growth in the agricultural sector. Chinese planners followed Soviet economic development strategies of developing the industrial sector by an "agricultural squeeze." The government monopolized state procurement and marketed farm and "sideline" produce at low prices to accumulate enough capital to develop modern

industry. Agriculture has been discriminated against by an "urban bias." A strict resident registration system, which divided the country's urban and rural residents into two parts and forced peasants to remain on limited arable land, also contributed to the interrelationship between agricultural and industrial development.

Growth models for the agricultural and industrial sectors were estimated using two-stage least squares. Labour productivity was low in the agricultural sector before 1979, and the marginal productivity of labour was negative. Since both labour productivity and capital productivity in the industrial sector were low, China's industrial development was based mainly on intensity of resource use. While labour productivity in the agricultural sector increased significantly after 1979, that in the industrial sector decreased, indicating that economic reform positively affected the agricultural sector in terms of labour productivity but affected the industrial sector negatively. Rural peasants have supported market-oriented economic reform more enthusiastically than urban dwellers.

Note

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Discussion Opening—*Petri Ollila* (University of Helsinki)

In the real world, the effects of any sector of economic activity cannot be isolated from other sectors. Koo and Lin have made a contribution to agricultural economic research in widening the view of analysis beyond agriculture. The complex process of interaction between the agricultural and industrial sectors has been captured in a relatively simple form of analysis.

Because my personal experience of Chinese circumstances is extremely limited, it is very difficult to evaluate how well the researchers have succeeded in their task. The evaluation is probably also hard for some other readers, because many things obviously well known to China experts are not defined in the paper. Knowledge of the exact contents of "industry" and "agriculture" would have helped in understanding exactly what has been analysed. The borders between these two and their relationship to other sectors are undefined. For instance, how is the income from self-sufficiency agriculture evaluated in the gross national income of agriculture? What is the unit of income, and has it remained comparable during the period discussed? How is the description of the state buying agricultural commodities at extremely low prices included into the model? What does it tell about the volume?

How stable have the categories "agriculture" and "industry" been during 1952–88, the period of analysis? In many countries, the following reasoning would be possible: The development of agriculture has had some technical and income effects. Adoption of the mattock, the steel plough, a better variety of rice, or an improved irrigation system actually shifts tasks from agriculture both downstream and upstream. This means that the development of agriculture has actually become visible in other economic sectors, which is also the finding of the present analysis. The limited population migration may be among the reasons for the finding that development of industry does not contribute to agriculture. Even if these categories had been stable and the data usable, some further clarification other than simply "Chinese official economic statistics (except for 1958–60) are generally reliable" should have been presented.

The authors make many choices about data and factors in the model, its shape, and the method of estimation, without much explanation of their choices. Would consumption have been a relevant factor? Although it is perhaps obvious, why was a Cobb-Douglas type model with two-stage least squares estimation chosen?

The implications of the results seem to me quite strong. If the null hypothesis that agricultural growth has not caused the growth of industrial sector is rejected, the opposite may not necessarily be true. The link between results and the explanation also remain to some extent unclear.

The description leads well into the problem area under analysis. The key finding that the development of agriculture has supported the development of the industrial sector but not vice versa is an interesting one. Some discussion about the data, estimation techniques, and the meaning of the results could have been expected.

[Other discussion of this paper appears on page 166.]