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Dynamic Modelling of a Three-Sector Transitional Economy

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Abstract

Rural industry provides inputs and markets for agriculture, which in turn provides inputs and markets for rural industry. As the mutually supportive linkages between rural industry and agriculture develop, the size of both sectors increases. Under certain conditions rural industry grows more rapidly than agriculture, resulting in the structural transformation of the rural sector. But the growth of rural industry may hurt the state-owned industrial sector if both sectors compete for similar resources and product markets. To protect their state enterprises, transitional economies have at times suppressed the growth of non-state rural industries. This can hurt the economy overall. We show how the growth rates of agriculture and rural industry may decline, and, surprisingly, how the growth of state industry might fall if rural industry is suppressed. This is especially so if agriculture supports state industry. By suppressing rural industry, agriculture is hurt. The decline in agriculture then hurts state industry, undermining the objective of protecting state industry. Depending on the magnitude of the relevant impacts, intervention to protect state industry may or may not be optimal, leaving governments with difficult policy decisions.

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1 Introduction

In mediating the interactions between agriculture, rural industry and state industry to achieve multiple objectives, the Chinese economy has encountered serious distortions and structural dislocations. When the social and economic objective of protecting state industry conflicts with the desire for economic growth in rural industry, China has shown itself at times willing to intervene in favor of state industry. The result has been an uneven pattern of growth within the rural sector since the mid-1980s.

The objective of this paper is to examine the sectoral interactions that generate such tensions and relate them to the structural transformation of China's rural economy. We outline the phases of sectoral linkage in an economy undergoing structural transformation and develop one-, two- and three-sector models of the Chinese economy. The models include an integrated two-sector development process in which rural industry and agriculture support one another to provide positive feedback. In this scenario market linkages transcend competition to establish complementary intersectoral growth.

The growth in rural industry can adversely affect state industry, however. Our three-sector model highlights the beneficial and competitive interactions between agriculture, rural industry and state industry. Given the prospect of state industry succumbing to competitive pressures from rural industry, one response by the Chinese leadership has been to protect state industry by restricting rural industry. But direct suppression of rural industry may indirectly harm state industry. This stems from the positive interaction between rural industry and agriculture: when rural industry declines, so does agriculture. Since agriculture helps to support state industry by providing inputs and establishing market linkages, state industry is potentially disadvantaged by the restrictions imposed on rural industry.

The severity of the choice facing the leadership becomes clear: either allow rural industry to prosper and compete with state industry, or, in suppressing rural industry to release resources for state industry, suffer the adverse economic consequences of indirectly harming agriculture (and possibly even state industry itself). We conclude with policy options, including reform of the state industrial sector as an alternative to suppressing rural industry.

2 Phases of sectoral interaction

Economic development over time involves the interaction of various sectors. Sectoral articulation has been studied extensively in the development economics literature (eg., Chowdhury and Chowdhury (1993), Ranis and Stewart (1993), Anderson (1992), Timmer (1989), Mellor (1986), Ghatak and Ingersent (1984), Mellor (1984), Asian Development Bank (1977), Jorgenson (1970), Johnston (1970), Ruttan (1970), Hirschman (1958)) and also in the Chinese economy literature (eg., B. Lin (1995a), Findlay, Watson and Wu (1994a), Ratha, Singh and Xiao (1994), Islam and Jin (1994), Woo, Hsueh, Shi and Zhang (1993), Zweig (1992), Sicular (1992), Wu (1992), Findlay and Watson (1992), Islam (1991), and Byrd and Lin (1990)). The novelty of our contribution concerns the application of sectoral linkage theories to the structural transformation of the Chinese rural economy, and the way in which the maintenance of opposing objectives generates distortions that inhibit the structural transformation. (We use the term structural transformation to mean a temporal increase in the ratio of the number of rural industrial firms to agricultural firms. Firms within a given sector are assumed to be identical, and their size is assumed to be invariant with time.)

It is useful to distinguish three phases of sectoral linkage between agriculture, rural industry and state industry. *Phase I* relates to the resource transfers from agriculture to the growing sectors. Agriculture is initially the largest sector in GDP share and is required to make a net resource contribution to the growth of emerging sectors. The resource transfers are competitive in the sense that agriculture loses from the growth of the other sectors, such as rural industry. *Phase II* emphasizes the development of sectoral linkages. Intersectoral competition eventually gives way to positive growth linkages between sectors. This is discussed in a later section, which considers the positive feedback between agriculture and rural industry; the two sectors provide markets and resources for one another's growth. In *Phase III* the sectors grow independently of each other.

Phases I and II have been evident in China, although the temporal demarcation between them is not clear due to phase overlap. The rapid flow of labor from agriculture to rural industry in the mid-1980s is an example of Phase I. Phase II corresponds to the Central Committee and State Council's March 1984 view of the role of rural enterprises in an integrated rural economy, an economy in which agricultural and rural industrial growth would be mutually supportive (eg., see Findlay and Watson 1992:64). The transition to Phase II includes greater reliance on market forces and a reduction in the bias against agriculture to facilitate its development on an equal basis with rural industry.

3 The basic models

We now develop models of sectoral growth and interaction, beginning with a one-sector model. Consider a sector in which all firms are identical. Let $C(q,X)$ be the cost per unit of the firm's output, q, when the number of firms in the industry is X. Let $R(q,X)$ be the revenue per unit of output. Total profit is $\pi(q,X) = (R-C)q$. If profits facilitate growth in the number of firms, the average growth rate of X is:

$$\frac{1}{X}\frac{dX}{dt} = \beta\pi(q,X)\,, \tag{1}$$

where $\beta>0$ is a constant. Let:

$$C(q,X) = \gamma(q-q^*)^2 + \phi X\,, \tag{2}$$

where γ is a positive constant. The term q^* represents the output level corresponding to the minimum average cost for the firm, with:

$$\phi = \frac{\partial C(q, X)}{\partial X} . \qquad (3)$$

Assume that firms are competitive. Each firm takes price, *p*, as given: $R(q,X) = p$. Since firms produce at minimum average cost, from (1):

$$\frac{dX}{dt} = q^* \gamma X (p - \phi X) . \qquad (4)$$

Defining the constants $r=q^*\gamma p$ and $K=p/\phi$ we have:

$$\frac{dX}{dt} = (r - (r / K)X)X . \qquad (5)$$

Equation (5) represents a simple logistic model describing the growth of a single sector, such as agriculture or rural industry, in the absence of interactions with other sectors. Let the sector grow at an intrinsic rate *r*, which reflects the rate at which the sector would grow without the inhibiting effects of resource scarcity. This rate may depend on factors such as the macro- or microeconomic environment and is assumed to be constant.

As economic activity consumes available resources, a physical limit to the number of firms that may exist and compete in this sector is approached. Refer to this physical limit as the *carrying capacity, K* (defined as the number of firms that resources may support indefinitely). Defined in this way, the carrying capacity has useful economic interpretations: property rights and governance, hard or soft budget constraints, operational autonomy and intersectoral competitive pressures, for example, may influence the efficiency with which resources are used and determine the carrying capacity of a given sector.

Equation (5) models growth as depending on the intrinsic growth rate, *r*, and on intrasectoral competition, ie., the competition for resources between firms in the same sector. The effect of this density-dependent competition is given by the term $-r / K$. As the number of incumbent firms, *X*, approaches the carrying capacity, *K*, the logistic growth rate falls.

As time continues, the number of firms tends to the carrying capacity. From (5) we have:

$$\dot{X}_i = (r_i - \frac{r_i}{K_i} X_i) X_i ,$$

$$\Rightarrow \frac{dX_i}{X_i(1 - X_i / K_i)} = r_i dt.$$

To integrate the LHS, obtain the partial fractions:

$$\frac{1}{X_i(1 - X_i / K_i)} = \frac{1}{X_i(1 - 1/K_i)} + \frac{1}{K_i(1 - X_i / K_i)}.$$

Thus:

$$\int \left\{ \frac{1}{X_i} + \frac{1}{K_i - X_i} \right\} dX_i = \int r_i dt$$

$\Rightarrow \ln|X_i| - \ln|K_i - X_i| = r_i t + C$, where C is a constant of integration.

Setting $C = \ln|c|$, with c having the same sign as $X_i / (K_i - X_i)$ yields:

$$\ln\left\{ \frac{X_i}{c(K_i - X_i)} \right\} = r_i t$$

$$\Rightarrow \frac{X_i}{K_i - X_i} = c\exp(r_i t)$$

$\Rightarrow X_i(t) = \dfrac{K_i}{[K_i / X_i(0) - 1]\exp(-r_i t) + 1}$, by setting $X_i = X_i(0)$ for $t = 0$.

As $t \rightarrow \infty$, $X_i \rightarrow K_i$.

Now suppose that another sector exists as well, and that this sector partially competes for resources. The growth of each sector will be inhibited by the competitive presence of the other - this is intersectoral competition (or negative interaction). Competition for resources may be either exploitative or interfering. Exploitative resource competition occurs when at least two sectors exploit the same limiting resources, such as state and rural industry competing for labor. Interfering resource competition refers to actions undertaken by one sector to inhibit another sector's ability to survive or exploit resources. An example is the request by state industry for the state to close down rural industries. Note that in this expository section competition is confined to exploitative competition.

A model of competition between the two sectors is given by:

$$\begin{aligned} \dot{X}_1 &= (r_1 - (r_1 / K_1)X_1 - (r_1 / K_1)b_{12}X_2)X_1 \\ \dot{X}_2 &= (r_2 - (r_2 / K_2)X_2 - (r_2 / K_2)b_{21}X_1)X_2. \end{aligned} \tag{6}$$

The difference between (5) and the first equation in (6), for example, is the addition of the term $-(r_1 / K_1)b_{12}X_2$. This represents the effect on sector one of competition for resources by firms in sector two; ie., the effect of intersectoral competition. The way in which this is denoted allows a comparison of the relative effects of inter- and intrasectoral competition. If $b_{12} = 1$, then the dampening effect on sector one of firms in sector two is the same as if they were in sector one. If $b_{12} > 1$, then firms in sector two inhibit growth in sector one more than they would if they belonged to sector one (conversely for $b_{12} < 1$).

In the model for *n* sectors, the system becomes:

$$\dot{X}_i = r_i \frac{(K_i - \sum_{j=1}^{n} b_{ij} X_j)}{K_i} X_i . \tag{7}$$

b_{ij} is the competition coefficient, with b_{ij}=1 for all *i=j*. This term reflects the competitive effect of sector *j* on sector *i* relative to the competition in sector *i* itself.

Let there be three sectors in our model: agriculture (X_1), rural industry (X_2) and state industry (X_3). (Three sector models of the Chinese economy have been used elsewhere; eg., see Shi and others 1993, Putterman 1992.) This model highlights intersectoral competition for resources whose supply is fixed. The resources are assumed to be potentially mobile within China, but not internationally (with the implications of an open economy discussed later). In particular, assume that all three sectors draw upon a fixed quantity of labor as a prime resource in their production. The emphasis on labor is important, given that China's post-reform transfer of labor from traditional agriculture to rural industry has been described as the largest in recent world history (Kalirajan and Wang 1994:66).

4 The growth of rural industry

The intersectoral competition model can be used to investigate the conditions under which rural industry will emerge. This emergence has been spectacular, with non-state industrial output rising from 26.7 percent of total output in 1983 to 58.6 percent in 1993 (Wong 1995:19). The mid-1980s boom in rural industrialisation shall be treated as a distinct new phenomenon (see Chang 1993:241), with only agriculture (X_1) and state industry (X_3) assumed to exist before this period. Again, the sectors are sustained on a one-dimensional continuum of labor quality. The focus on labor links the emergence of this new phase of rural industrialisation to one of its intended goals (namely, the absorption of underemployed or displaced farm labor) and facilitates discussion of rural structural transformation, a process in which labor transfer is a major component.

Let agriculture and state industry initially be at their equilibrium sizes in the approximate absence of rural industry. As rural industry just begins to be established in very low numbers, $X_1 = X_1^{(2)}$, $X_3 = X_3^{(2)}$ and $X_2 \approx 0$, where $X_1^{(2)}$ and $X_3^{(2)}$ are the equilibrium values of the sectors when rural enterprises are rare. Growth in rural industry (X_2) at these points requires that $dX_2 / dt > 0$.

Assume that the intersectoral competition coefficients are identical and that the interactions of rural industry with agriculture and with state industry are the same. For the purposes of this section, let the intersectoral competition coefficients between adjacent sectors on the resource axis be $b(d)$ and that between agriculture and state industry be $b(2d)$, where d is the average difference between the sectors in terms of the type of resource used.

A result from Roughgarden (1974:165) forms the basis of the following proposition.

PROPOSITION 1. *The condition for the successful entry of rural industry into the two-sector economy is*:

$$b(2d) - \frac{b(d)(K_1 + K_3)}{K_2} + 1 > 0 \,. \tag{8}$$

Proof. The condition for X_2 to be able to grow when rare is provided by Roughgarden (1979:543):

$$K_2 - b(d)X_1^{(2)} - b(d)X_3^{(2)} > 0 \,.$$

Rural industry can only emerge if sufficient resources allow it to grow; ie., if and only if the carrying capacity of rural industry exceeds the combined inhibitory effects of the incumbent sectors.

$X_i^{(j)}$ represents the equilibrium size of sector X_i in the absence of sector X_j. That is:

$$X_1^{(2)} = \frac{K_1 - b(2d)K_3}{1 - b(2d)^2} \,, \qquad X_3^{(2)} = \frac{K_3 - b(2d)K_1}{1 - b(2d)^2} \,.$$

Substituting these equilibrium values into the growth expression above gives Proposition 1.

Competition against rural industry by the incumbent sectors is reflected in $-b(d)$. It is difficult to determine how strong these competition effects are. Distinct resource niches appear to exist for each sector, with agricultural workers being of lower quality than those in rural enterprises, who in turn are less skilled than state industrial workers. The presence of these niches tends to reduce the strength of intersectoral competition for labor resources.

An important factor in the growth of rural industry relates to the expression $(K_1 + K_3) / K_2$. The greater the amount of resources available to rural industry relative to the other sectors, the more likely is a successful entry into the economy. This was the case in the mid-1980s, when farm labor displacement due to agricultural productivity gains, together with unfavorable relative prices for agriculture and restrictions on rural-urban migration, left a large pool of surplus labor in the countryside. State industry did not step in to absorb the labor because of rigidities in central planning; thus, the carrying capacity of rural industry rose. (Other important resource continua besides labor would include financial and physical inputs. Financial resources for rural enterprises became more readily available as a result of fiscal contracting (Findlay, Watson and Wu 1993:9), the unwillingness of peasants to invest their savings in urban enterprises (Findlay and Watson 1992:66) and the mandating of rural credit cooperatives to provide credit for rural enterprises (Sicular 1992:360), while declining state control over the allocation of producer goods meant that rural enterprises could expand. These results have been treated elsewhere; for example, see Anderson (1992)).

5 Linkages between rural industry and agriculture

The growth of rural industry described in the previous section relates to Phase I of structural transformation, with a one-way flow of resources from agriculture to rural industry. As structural transformation proceeds, some intersectoral resource competition eventually makes way for mutually beneficial interaction. This leads to Phase II, where the two sectors support one another in net terms. Phase I overlaps with Phase II as agriculture and rural industry begin their economic integration. Rural industries have been important in helping agriculture to grow (Islam and Jin (1994:1644). A mutualistic relationship develops as rural industry grows, generates more employment and raises off-farm incomes. Part of the rising incomes are spent on or remitted to the agricultural sector (eg., see Islam and Jin (1994:1651-1655) for a discussion of financial flows from rural industry in support of agriculture). Farm incomes rise and farmers are able to increase their expenditures on inputs, such as transport services and farm equipment, and on consumer goods, such as electrical appliances and housing, much of which is provided by rural industry. The increased availability of consumer goods, for example, in turn provides more incentives for farmers to produce more in order to buy consumer goods. (This is represented in the previous figure by the dotted line linking rural industrial output with agricultural supply.) A virtuous circle emerges in which rural industry and agriculture expand in tandem. Recent changes such as the greater freeing of agricultural prices contribute to these developments.

The beneficial intersectoral relations are readily modelled. Consider the mutually supportive agriculture-rural industry articulation:

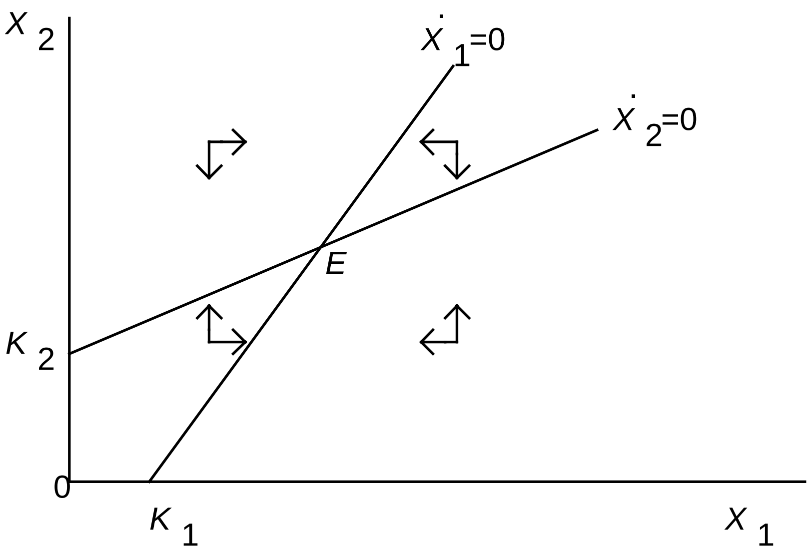
$$\dot{X}_i = (r_i - a_{ii} X_i + a_{ij} X_j) X_i . \qquad (9)$$

The notation has been simplified, with the intrasectoral competition coefficient denoted by $a_{ii} = r_i / K_i$ and the a_{ij} terms representing the intersectoral interaction coefficients, such that $a_{ij} > 0$, $i = 1, 2$, $i \neq j$. In the case at hand the interactions are beneficial, so that a_{ij} shows the positive effect of a production unit from sector *j* on a unit from sector *i*. The equilibria are given by:

$$X_i^* = \frac{K_i + \alpha_{ij} K_j}{1 - \alpha_{ij} \alpha_{ji}}, \tag{10}$$

where $\alpha_{ij} = a_{ij} / a_{ii}$. It is easy to show that the X_i^* are strictly positive if $r_i a_{ji} > -r_j a_{ii}$. Assuming both sectors can persist in the absence of interaction, the phase diagram for the stable mutualistic system is presented in Figure 1.

Figure 1 *Phase diagram*



The equilibrium point is $E = (X_1^*, X_2^*)$. The slope of the $\dot{X}_1 = 0$ isocline is a_{11} / a_{12} and that of $\dot{X}_2 = 0$ is a_{21} / a_{22}. The larger the beneficial interaction and the weaker the intrasectoral competition, the larger is the equilibrium size of the benefiting sector. Note that $X_i^* > r_i / a_{ii} = K_i$; ie., both sectors are larger than they would be in the absence of mutually beneficial interactions.

The equilibrium *E* is stable if $a_{11} a_{22} > a_{12} a_{21}$. To determine the stability of *E*, let $X_1 = X_1^* + x_1$ and $X_2 = X_2^* + x_2$, where x_1 and x_2 are small. Linearise the system (1) in the neighbourhood of the fixed point, taking the first two terms of a Taylor series:

$$\dot{x}_1 = ax_1 + bx_2$$
$$\dot{x}_2 = cx_1 + dx_2.$$

The coefficients are the partial derivatives evaluated at the fixed point. For example, $\partial \dot{X}_1 / \partial X_1 = r_1 - 2a_{11}X_1 + a_{12}X_2$. When evaluated at the fixed point, and recalling that $r_1 = a_{11}X_1 - a_{12}X_2$ in equilibrium:

$$\left(\frac{\partial \dot{X}_1}{\partial X_1}\right)^* = -a_{11}X_1^*.$$

Thus:

$$\begin{pmatrix} \dot{x}_1 \\ \dot{x}_2 \end{pmatrix} = \begin{pmatrix} -a_{11}X_1^* & a_{12}X_1^* \\ a_{21}X_2^* & -a_{22}X_2^* \end{pmatrix} \begin{pmatrix} x_1 \\ x_2 \end{pmatrix}.$$

It is necessary to find eigenvalues λ satisfying:

$$\begin{vmatrix} -a_{11}X_1^* - \lambda & a_{12}X_1^* \\ a_{21}X_2^* & -a_{22}X_2^* - \lambda \end{vmatrix} = 0.$$

$$\Rightarrow \; 2\lambda = -(a_{11}X_1^* + a_{22}X_2^*) \pm \sqrt{(-a_{11}X_1^* - a_{22}X_2^*)^2 + 4(a_{12}a_{21}X_1^*X_2^* - a_{11}a_{22}X_1^*X_2^*)}.$$

The stability requirement hence becomes:

$$a_{11}a_{22} > a_{12}a_{21}.$$

Remark. The positive intersectoral interactions, a_{12} and a_{21}, are not stabilising. Stability derives from the self-regulatory effects, a_{11} and a_{22}.

PROPOSITION 2 *An increase in intrasectoral competition in agriculture, an increase in the beneficial effect of agriculture on rural industry, a fall in intrasectoral competition in rural industry, or a fall in the beneficial effect of rural industry on agriculture is sufficient for structural transformation on the basis of agricultural-rural industrial articulation (Phase II).*

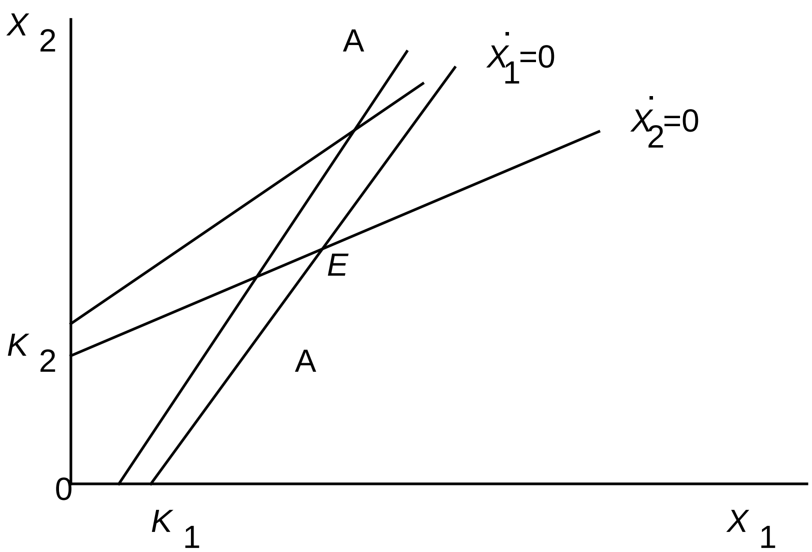
Proof. Structural transformation implies that the ratio of agricultural to rural industrial output falls over time. Define $\overline{X}$ as the ratio of the equilibrium values of agriculture to rural industry:

$$\overline{X} = \frac{X_1^*}{X_2^*} = \frac{K_1 + \alpha_{12} K_2}{K_2 + \alpha_{21} K_1}. \tag{11}$$

Recalling that the intrasectoral and intersectoral coefficients are strictly positive, as are the carrying capacities, $\partial \overline{X} / \partial a_{11} < 0$, $\partial \overline{X} / \partial a_{12} > 0$, $\partial \overline{X} / \partial a_{22} > 0$ and $\partial \overline{X} / \partial a_{21} < 0$. A fall in $\overline{X}$ over time is consistent with increases in a_{11} and a_{21}, and decreases in a_{12} and a_{22} over time.

The changes are depicted in Figure 2, with both isoclines shifting upwards. Note the change in the intercepts to reflect the new carrying capacities of each sector as intersectoral resource flows take place. A locus of equilibrium points (AA) is drawn to indicate the fall in the agricultural-rural industrial output ratio.

Figure 2 *Structural transformation*



Remark. The intrasectoral competition coefficient in agriculture, a_{11}, is likely to rise as fewer resources become available to agriculture with the resource flow to rural industry. As rural industry purchases fewer agricultural products or as it changes the composition of its output to supply fewer inputs to agriculture, the positive feedback coefficient from rural industry to agriculture, a_{12}, is likely to fall. An increase in the carrying capacity of rural industry, K_2, decreases a_{22}, the intrasectoral competition coefficient. This could result from the flow of resources from agriculture to industry with the easing of restrictions on rural enterprises. As agriculture expands in output value, the beneficial effect of agriculture on rural industry, a_{21}, may rise as increasingly wealthier farmers purchase inputs and consumer goods from rural industry. (Note that an increase in a_{21} is consistent with a rising a_{11}, since agricultural output value could increase in absolute terms even with a labor outflow if agricultural productivity rises enough.) The effect of these changes is to decrease the per unit growth rate of the agricultural sector and raise that of rural industry, a change which is consistent with the structural transformation of the Chinese rural economy as agriculture decreases in sectoral importance (see Islam and Jin (1994:1647) for a description of the structural transformation of rural China between 1980-92).

6 Competition with state industry

State industry is now explicitly added to the sectoral analysis. Assume that rural industry and agriculture continue to exhibit positive feedback, but that agriculture and state industry are connected by only one unidirectional link (from agriculture to industry). This section focuses on the interactions between rural and state industry, where it is assumed that the two industrial sectors compete with one another in net terms. The concept of intersectoral competition is now widened to include competition in output markets as well as for resources.

Determining whether the relationship between rural and state industry is one of overall competition is clouded by a number of issues. On the one hand, output produced by rural enterprises is sold to urban producers (Wu 1992:22), and in some areas state enterprises assist rural industry in a number of ways, including the provision of specialist training (Zweig 1992:425), technology, funds and marketing opportunities (Jefferson and Rawski 1995:133). State enterprises in turn expand their sales by subcontracting or establishing rural subsidiaries to take advantage of cheaper labor, avoid problems of planning targets (Christiansen 1992:82) and gain access to vital inputs, including land, whose supply may be restricted in the state sector.

On the other hand, the geographical distribution of rural industries and strong community identities associated with them reduce the extent of beneficial rural-state industrial linkages (Findlay and Watson 1992:76). The two sectors also compete for resources such as energy and other inputs (Putterman 1992:480). Raw material prices increase with the expansion of rural industry, inducing localities to retain resources in their own region to the detriment of state industry (Zweig 1992:431). The greater market prices received by some rural industries for their output have allowed them to outbid state enterprises in markets for inputs (Ody 1992:19). J. Lin (1995:12) suggests that as investment demand rises in an economic boom, strong competition arises between state and non-state enterprises for credit, foreign exchange and raw materials. When government regulations are not effectively enforced, bureaucrats and managers have incentives to divert resources from the state to the non-state enterprises under their control, where the rates of return are higher (Wong 1995:21, s.a. Woo, Hsueh, Shi and Zhang 1993:255).

On the output side, rural and state industry compete for (monopoly) profits (Naughton, 1994:474; Naughton 1992) and in the supply of light industrial goods (Zweig 1992:419); such direct competitive effects have precipitated state intervention in restricting the scope of rural industrial activity. Singh and Jefferson suggest that 1982-90 provincial data show that the fall in state industry profits was greatest in provinces where rural industry grew the most rapidly (Singh and Jefferson 1994:7), while national data suggest rapid rural industrial output growth at the expense of state industry (Jefferson and Rawski 1995:142). Naughton (1994:479) also presents evidence of a consistent decline in the profits of state industry resulting from the rapid entry of and competition from rural industries (for a counter view, see Woo 1994:285).

The intersectoral competitive effects arise indirectly as well. Failure to reform state industry and come to grips with the soft budget constraint potentially imposes tax burdens (indirectly) on non-state sectors and perpetuates cycles of inflation and macroeconomic retrenchment, all of which inhibit the growth of rural industry (eg., see Islam (1991)). In 1993, industrial investment increased by 71 percent; to the extent that state industry accounted for 62 percent of these investments, much investment credit failed to be channelled to rural industry (Singh and Jefferson 1994:8). In sum, then, it is assumed that rural and state industry are net competitors.

The interrelationships between the three sectors can be modelled in terms of the familiar linear growth equations:

$$\begin{aligned} \dot{X}_1 &= (r_1 - a_{11}X_1 + a_{12}X_2 + a_{13}X_3)X_1 \\ \dot{X}_2 &= (r_2 + a_{21}X_1 - a_{22}X_2 - a_{23}X_3)X_2 \\ \dot{X}_3 &= (r_3 + a_{31}X_1 - a_{32}X_2 - a_{33}X_3)X_3 . \end{aligned} \qquad (12)$$

As reflected in the signs of the coefficients, a_{ij} (i,j=1,2,3), the system (12) models beneficial interactions between agriculture and rural industry and between agriculture and state industry, while rural and state industry compete with one another.

The agriculture-rural industry and rural industry-state industry interactions have already been discussed, while the positive links between agriculture and state industry are well-known, at least in terms of the flow from agriculture to state industry. These resource flows were pronounced during China’s period of heavy industrial development. With the current emphasis on a socialist market economy, agriculture can again be expected to contribute to state industrial growth. For example, agriculture provides raw materials and foodstuffs to state industry. All other things being equal, as grain output increases, the price of food in the cities tends to fall, putting downward pressure on wages in state industry. The reverse flow, from state industry to agriculture is more difficult to determine. Naughton (1992:18) mentions the flow of financial resources from state industry in support of agriculture, for example. On the other hand, the econometric evidence from Yao (1994) finds no causal supportive link from state industry to agriculture, although he finds unidirectional causality from agriculture to state industry; Chowdhury and Chowdhury (1993) also provide partial support of this view.

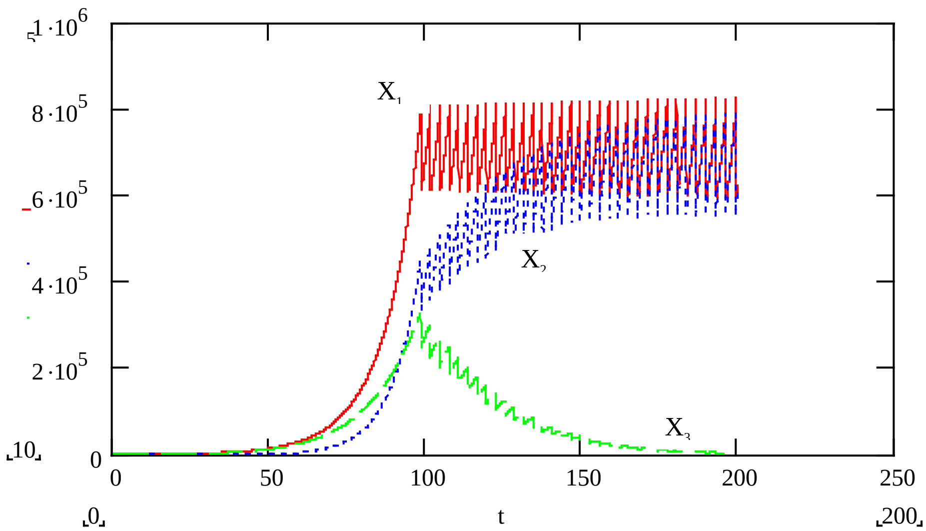
The system (12) may now be used to derive the following proposition:

PROPOSITION 3 *Given the system (12), state industry is more likely to decline the higher the intrinsic growth rate of rural industry* (r_2) *relative to that of state industry* (r_3)*, the lower the intrasectoral competition in rural industry* (a_{22})*, the higher the intersectoral competition from rural industry on state industry* (a_{32})*, and the higher the beneficial impact of agriculture on rural industry* (a_{21}) *relative to agriculture's impact on state industry* (a_{31})*.*

Remark. The coefficient a_{32} is likely to be high given the intense rivalry between the two sectors, while a_{22} is probably relatively low due to the large flow of resources to rural industry, which increases rural industry's carrying capacity. Coefficient a_{21} is likely to be relatively high as farmers purchase the producer and consumer goods offered by rural enterprises.

Figure 3 illustrates time paths of X_1, X_2 and X_3 based on parameters related to Proposition 3.

Figure 3 *Simulated time paths*



Proposition 3 presents the Chinese leadership with a dilemma. A growing and prospering rural industrial sector puts competitive pressure on state industry. State industry faces the prospect of a decline, with the attendant urban unrest and "betrayal" of proletarian interests high on the leadership's mind. Support of the urban sector may be a true test of the Party leadership's commitment to socialism (Keidel 1992:130), social justice (Chou and Xu 1993:213) and job security (Putterman 1992:479), and state industry serves as an instrument of state power. Yuan Mu has recently claimed that state-owned enterprises "still represent our country's general economic power and are the chief source of the state budget and the main force for social stability" (Cottrell 1995:16). Over 100m workers are employed in the state owned enterprises, and the enterprises themselves fulfil a welfare function by providing their workers and families with housing, medical benefits, education and pensions. For a variety of reasons, then, the Party has been reluctant to allow state industry to suffer from the growth of the rural industrial sector. (Although the desire to protect state industry is presented here as a non-economic objective, economic considerations might also be considered, especially with regard to important areas such as energy provision by state industries. Nevertheless, to the extent that approximately one-third of state enterprises are estimated to be making explicit losses and one-third implicit losses (J. Lin 1995:11), non-economic objectives must account for some of the leadership's aversion to a decline in state industry.)

The other side of the dilemma is that rural industry is a very dynamic and important sector in China's modernisation drive in terms of output, employment and tax revenues (rural industries have supplied over fifty percent of new state taxes since 1980 (Zweig 1992:422), although the ability of the state to tax rural industry is currently less clear). The suppression of rural industry in 1989 by the then dominant planning faction of the Party leadership and the back peddling from this policy in 1990 highlight the anxiety that this dilemma has caused. Either the social objective of protecting an inefficient state sector must be downgraded or rural industry must face the potential for further suppression by the state.

7 Suppression of rural industry

In seeking to avoid widespread unemployment and urban unrest, the leadership has demonstrated sufficient political resolve to retrench rural industry; in fact this was one of the goals of the 1989 austerity program (Sicular 1992:362, Putterman 1992:480), although state industry also suffered as a result. Two million rural enterprises were closed or taken over by other firms (Zweig 1992:422). The state has implemented a raft of policies to restrict rural industries directly or to place them at a competitive disadvantage versus state industry. Non-state enterprises have been the victims of forced plant closures, taxes and other financial pressures. The state has been able to stop rural enterprises from withdrawing their own funds from the bank and has bankrupted them by having banks call in all outstanding loans (Zweig 1992:427). Conversely, state industries have been favoured by subsidised inputs, including capital, raw materials and energy, soft budget constraints and purchases of stocks unable to be sold on the market (Jefferson and Rawski 1992:55).

This section seeks to show that such a strategy has the potential to harm state industry: given the positive feedback between rural industry and agriculture, the restrictions placed on rural enterprises hurt agriculture, which in turn indirectly hurts state industry, given the mutualism between state industry and agriculture.

In the following model, the size of the state industrial sector is fixed and the focus is solely on the mutualistic relationship between agriculture and rural industry. The model of agricultural and rural industrial growth is given in the generalised form:

$$\dot{X}_1 = h_1(X_1, X_2)X_1$$
$$\dot{X}_2 = h_2(X_1, X_2, \beta)X_2. \tag{13}$$

β is a measure of government suppression of rural industry, with higher values of β reflecting increasing suppression.

The effect of a change in β on the equilibrium values of X_1 and X_2 is given in the following proposition:

PROPOSITION 4 *Let the model of agriculture and rural industry be given by (13), in which the derivatives satisfy:*

$$\frac{\partial h_1}{\partial X_1} < 0\,,\quad \frac{\partial h_2}{\partial X_2} < 0\,,\quad \frac{\partial h_1}{\partial X_2} > 0\,,\quad \frac{\partial h_2}{\partial X_1} > 0\,,\quad \frac{\partial h_2}{\partial \beta} < 0$$

for all X_1, X_2, β. *For* $\beta \geq 0$, *let* (X_1^β, X_2^β) *represent the intersection of the curves:*

$$h_1(X_1, X_2) = 0, \quad h_2(X_1, X_2, \beta) = 0.$$

If:

$$\frac{\partial h_1}{\partial X_1}\frac{\partial h_2}{\partial X_2} - \frac{\partial h_1}{\partial X_2}\frac{\partial h_2}{\partial X_1} > 0$$

for all β, *then* (X_1^β, X_2^β) *is a stable equilibrium of the dynamical system (13). Further, both* X_1^β *and* X_2^β *are decreasing functions of* β.

Proof. As noted in an earlier stability condition, the intersection point of the curves $h_1 = 0$, $h_2 = 0$ is a stable equilibrium point of the dynamic system if:

$$\frac{\partial h_1}{\partial X_1}\frac{\partial h_2}{\partial X_2} - \frac{\partial h_1}{\partial X_2}\frac{\partial h_2}{\partial X_1} > 0.$$

As β varies, these stable equilibrium points (X_1^β, X_2^β) vary and are functions of β. Differentiate the system $h_1 = 0$, $h_2 = 0$ with respect to β:

$$\frac{\partial h_1}{\partial X_1}\frac{\partial X_1}{\partial \beta}+\frac{\partial h_1}{\partial X_2}\frac{\partial X_2}{\partial \beta}=0$$
$$\frac{\partial h_2}{\partial X_1}\frac{\partial X_1}{\partial \beta}+\frac{\partial h_2}{\partial X_2}\frac{\partial X_2}{\partial \beta}+\frac{\partial h_2}{\partial \beta}=0.$$

This is a linear system which may be solved for $\frac{\partial X_1}{\partial \beta},\frac{\partial X_2}{\partial \beta}$:

$$\frac{\partial X_1}{\partial \beta}=\frac{\frac{\partial h_1}{\partial X_2}\frac{\partial h_2}{\partial \beta}}{\frac{\partial h_1}{\partial X_1}\frac{\partial h_2}{\partial X_2}-\frac{\partial h_1}{\partial X_2}\frac{\partial h_2}{\partial X_1}}, \qquad \frac{\partial X_2}{\partial \beta}=\frac{-\frac{\partial h_1}{\partial X_1}\frac{\partial h_2}{\partial \beta}}{\frac{\partial h_1}{\partial X_1}\frac{\partial h_2}{\partial X_2}-\frac{\partial h_1}{\partial X_2}\frac{\partial h_2}{\partial X_1}}.$$

Given the assumptions on the signs of the derivatives, including that:

$$\frac{\partial h_1}{\partial X_1}\frac{\partial h_2}{\partial X_2}-\frac{\partial h_1}{\partial X_2}\frac{\partial h_2}{\partial X_1}>0,$$

it follows that $\frac{\partial X_1}{\partial \beta}<0, \frac{\partial X_2}{\partial \beta}<0.$

Thus, assuming a mutualistic relationship between agriculture and rural industry, and intrasectoral competition in both, it follows that suppression of rural industry by the government is damaging. The effect of the suppression is to lower both rural industrial and agricultural output.

Remark. All other things being equal, the decline in agriculture in turn reduces the size of the state industrial sector, due to the positive linkage effects between the two sectors. On the other hand, the suppression of rural industry releases resources to state industry, increases state industry's carrying capacity and, all other things being equal, raises the growth rate of state industry. Thus, whether the policy of protecting state industry by suppressing rural enterprises harms state industry overall depends on the relative sizes of the two opposing effects.

A corollary of Proposition 4 is given in the following proposition, such that decreases in rural industrial and agricultural output may inhibit the structural transformation of the rural economy.

PROPOSITION 5 *Consider the system (13) and the assumptions concerning the signs of the derivatives. Let* (X_1^e, X_2^e) *represent the stable equilibrium when* $\beta=0$. *Assuming that* $X_1^e > X_2^e$ *and that* $\partial h_1/\partial X_1<0$, $\partial h_1/\partial X_2>0$, *then for* $\beta>0$ *:*

$$\frac{X_1^\beta}{X_2^\beta} > \frac{X_1^e}{X_2^e}.$$

That is, government suppression of rural industry leads to a rise in the ratio of agriculture to rural industry.

Proof. All equilibria (X_1^β, X_2^β) lie on the curve $h_1(X_1, X_2) = 0$. This equation implicitly defines X_1 as a function of X_2. The derivative $\partial X_1 / \partial X_2$ on this curve may be computed as follows. Differentiating with respect to X_2 and rearranging:

$$\frac{\partial X_1}{\partial X_2} = \frac{-\partial h_1}{\partial X_2} \Big/ \frac{\partial h_1}{\partial X_1}.$$

Let (X_1^β, X_2^β) be the equilibrium corresponding to some $\beta > 0$. Then, applying the mean-value theorem:

$$\frac{X_1^\beta}{X_2^\beta} = \frac{X_1^e + (X_2^\beta - X_2^e)\left.\frac{\partial X_1}{\partial X_2}\right|_c}{X_2^\beta}, \qquad X_2^\beta \le c \le X_2^e$$

$$= \frac{X_1^e - (X_1^e - X_2^\beta)\left.\frac{\partial X_1}{\partial X_2}\right|_c}{X_2^e - (X_2^e - X_2^\beta)}.$$

By Proposition 4, $X_2^e - X_2^\beta \ge 0$. By assumption:

$$\frac{\partial X_1}{\partial X_2} = \frac{-\partial h_1}{\partial X_2} \Big/ \frac{\partial h_1}{\partial X_1} < 1$$

and thus $0 \le (X_1^e - X_2^\beta)\left.\frac{\partial X_1}{\partial X_2}\right|_c \le X_1^e - X_2^\beta$. That is, a larger value is being subtracted from the denominator than from the numerator. With the assumption that $X_1^e > X_2^e$, this is sufficient to give $\frac{X_1^\beta}{X_2^\beta} > \frac{X_1^e}{X_2^e}$.

Note the assumptions needed in this proof. The proof assumes that the initial size of agriculture is higher than that of rural industry. This is the case for China, as it is for many other developing economies, especially if we consider the total number of workers in each sector. The assumption that:

$$\frac{-\partial h_1}{\partial X_2} \Big/ \frac{\partial h_1}{\partial X_1} < 1$$

demands that the positive impact of rural industry on agriculture be lower than the effects of intrasectoral competition in agriculture.

Proposition 5 has important implications for the growth of the rural sector as a whole. Assume that structural transformation arising from an initial intersectoral disequilibrium increases economic growth. The increase results from the reallocation of inputs from less productive to more productive sectors of the economy (B. Lin 1995b:2; s.a. Putterman 1992:467 for a related view). That is, given an initial intersectoral disequilibrium where the marginal product of a resource is lower in one sector than another, the reallocation of resources to the intersectoral equilibrium maximises aggregate output.

This could correspond, for example, to the rural situation in the mid-1980s as resources shifted from agriculture to rural industry in response to the initial disequilibrium (excess agricultural labor supply) and subsequent rural economic liberalisation. An impact of the HRS was to save farm labor, which was then released to more productive uses in rural industry. Woo and others provide evidence that by 1986 the per capita output of rural industries was nearly five times as great as that of agriculture, leading them to conclude that raising the share of non-agriculture in total rural labor should have increased the rural social output value (Woo, Hsueh, Shi and Zhang 1993:244).

(Note that these authors seem to be talking about average revenue product - their point is clouded by the artificially suppressed price of farm products, for example, which also contributed to the structural transformation of the rural economy and reallocation of labor. If agricultural price suppression were the only cause of the reallocation, it would by no means be clear that the resulting structural transformation would be optimal, especially if the agricultural output were valued at its higher, shadow price (eg., see Putterman 1992:480).)

If Proposition 5 and the assumption that structural transformation contributes to aggregate economic growth hold, it follows that the suppression of rural industry must decrease the growth rate of the rural sector overall. (In our three-sector model, we define the rural sector to be the sum of the rural industrial and agricultural sectors.) The direct impact is that rural industrial output falls and drags down agricultural output, given the complementary linkages between the two sectors. This effect is reinforced by the *reversal* of the path of structural transformation, as the number of agricultural to rural industrial firms rises.

8 Policy implications

The suppression of rural industry to protect state industry has two adverse consequences: state industry faces the possibility of being harmed indirectly through the rural industry-agriculture-state industry linkages, and the structural transformation of the rural economy is impeded. The harm done to rural industry may be reduced by the selective targeting of individual rural enterprises to be discriminated against, as opposed to a general sector-wide retrenchment. For example, rural enterprises with weak or non-existent linkages with agriculture could be targeted for close-down. The "39 Points" proposed at the 5th Plenum in November 1989 also suggested that product lines be shifted away from those of state industry and that rural enterprises be restricted to processing local materials (Zweig 1992:422).

Despite such policies, other aspects of the intersectoral competition problem remain difficult to resolve. There are resources which are used by almost all rural enterprises. Intersectoral competition exists for energy and transport (Findlay, Watson and Wu 1994b:15). Shifts in product line are not likely to have a large impact on total use of such resources by a sector. The shifting of product lines entails producer and consumer welfare costs, as rural producers move against comparative advantage and market demand. Most importantly, the suppressing of rural industry diverts attention from the area most in need of overhaul - the inefficient state sector. A long term solution to the problem involves state sector industrial reform and greater privatisation. As Keidel suggests, in the absence of urban labor and management reforms, inefficient state enterprises will "hold the much more competitive non-state economy at bay by means of a hated taxing authority, restrictions on the scope of the non-state economy, and inflationary state finances" (Keidel 1992:121).

The impetus for these changes comes from competition with rural enterprises (Rawski 1993:4). Singh and Jefferson suggest that the growth of the non-state sector (ie., town and village enterprises) has led state industry to increase its productivity: "For every 10 percent increase in the non-state sector's share of industrial output, productivity in state industry - depending on the initial level of productivity - has risen by an average of 2.5 to 4.0 percent" (Singh and Jefferson 1994:7; see also Ratha, Singh and Xiao 1994). In terms of the state industry growth model in equation (6), these intersectoral competitive pressures raise the carrying capacity of state industry and therefore its growth rate. Removing the obligation of state enterprises to provide social services for its workers, greater input and output market flexibility, and the imposition of financial responsibility and accountability, would contribute significantly to easing the current problems of state industry.

To the extent that intersectoral competition is encountered in output markets, this competition might be reduced by redirecting sales to external markets. In this regard, the three-sector model of (12) implicitly incorporates the international trade sector as a vent for reduced intersectoral competition, since the competition coefficients (for outputs, at least) tend to decline with the introduction of new, overseas outlets for the outputs of state and rural industries. Rural industries, for example, have played an active role in this area in becoming an important vehicle for China’s export-led growth (Lee 1994:190).

In the longer term, an increase in export markets for rural industrial output can contribute indirectly to the growth of state industry. Rural industry provides foreign exchange, with which more resources and technology may be imported to aid state industry. The short-run "zero-sum" scenario of rural-state industrial competition may partially give way to positive impacts provided by rural industry. As Rozelle (1994:385) suggests, policies that slow down rural industry impair the growth of the Chinese economy as a whole.

The growth of rural industry may even facilitate the transition to a privatized urban industrial sector. State industrial sector reform becomes more tenable politically when redundant state workers are able to find alternative employment. Given that the required educational levels of the workforce in rural enterprises are substantially above those in agriculture and are only slightly below the average levels in the state industrial sector (Wu 1994:132), an expansion of rural industry may be a source of labor absorption as state industry is reformed and urban workers are displaced. Competitive pressure from state industry obliges rural enterprises to increase capital accumulation and technology (Findlay, Watson and Wu 1993:16), so that rural enterprises are likely to gain from the urban-rural migration of technically-trained urban workers.

9 Conclusions

The models used in this and the preceding paper have attempted to characterize important elements of intersectoral interaction in the Chinese economy and highlight the implications of major policy interventions. The analysis began by deriving the conditions under which rural industry might emerge and occupy a resource niche between agriculture and state industry. With growth in rural industry, mutually supportive linkages with agriculture could develop, with the size of both sectors increasing relative to that in the absence of supportive linkages. It was shown that under certain conditions rural industry could grow more rapidly over time than agriculture, resulting in the structural transformation of the rural sector.

The growth of rural industry had potentially adverse implications for state industry due to intersectoral competition for resources and product markets; as a result, state industry could even decline. The Chinese leadership would then face an unpalatable choice of either suppressing rural industry to protect state industry or compromising the social and political objective of protecting the urban proletariat. The choice reflects the problems associated with meshing multiple objectives, ie., protecting state industry coupled with the desire to make greater use of the market, including the forging of intersectoral links, on efficiency grounds. The suppression of rural industry and the protection of the state industrial sector could fail to achieve the twin objectives. Market outcomes, including structural transformation of the rural economy, could be compromised by a decline in the growth rates of agriculture and rural industry, and the protection of state industry might be undermined by the indirect adverse effects arising from the suppression of rural industry.

Depending on the magnitude of the relevant impacts, intervention to protect state industry may or may not be optimal; if the costs were low over some range of intervention, some protection might be desirable, given the objectives of the Party leadership.

These issues suggest that quantification of the trade-offs, perhaps with the aid of input-output or CGE models, may well be an important line of future research, especially if the prospects of thorough state sector reform remain as bleak as some have suggested (eg., J. Lin 1995:14) and if China wishes to extend its market reforms.

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