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ABSTRACT *China has achieved spectacular growth since 1949. Rapid growth in the non-agricultural sectors has been assisted by massive resource transfers out of agriculture. Prior to economic reforms before 1978, agriculture was heavily taxed by the state to subsidize urban and industrial development. Economic reforms since 1978 have reduced the burden on agriculture, but lack of state investments still remains a constraint on its development. This paper demonstrates how agriculture has contributed to China's economic development using both empirical data and a cointegration analysis. Two important conclusions are drawn. First, although agriculture's share in GDP declined sharply over time, it is still an important force for the growth of other sectors. Second, the growth of non-agricultural sectors had little effect on agricultural growth. This was largely due to government policies biased against agriculture and restriction on rural–urban migration.*

1. Introduction

Agriculture's role in economic development has been debated from two viewpoints. The first view argues that agriculture only plays a passive role as a major source of resources for the development of industry and other non-agricultural sectors. This is reflected in the dualistic models developed by Lewis and others (Lewis, 1954; Hirschman, 1958; Fei & Ranis, 1964). In a typical dualistic model, agriculture provides materials, capital and labour for the rest of the economy (forward linkage effects). It suggests that since the industrial sector is more productive than agriculture, resources should be transferred from the latter to the former in order to modernize the economy and raise total national output.

The second view retains the forward linkage effects of agriculture but also emphasizes its backward linkage to other sectors of the economy. In other words, agriculture not only provides materials, capital and labour to, but also a huge market for, the non-agricultural sectors. This view is reflected in Kuznets (1964), Mellor & Lele (1973), Hazell & Roell (1983) and many others.

The contribution of agricultural growth to economic development varies markedly from country to country and from one time period to another within the same economy. For example, in an industrialized country where agriculture has a very small

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share in GDP, the agriculture role may not be important. In a developing economy where agriculture is usually a major production sector and accounts for a large proportion of GDP, the role is crucial.

Within the same economy agriculture's contribution to economic development tends to change over time. For example, it has a relatively more important place when the economy is predominantly agrarian. As the economy grows, the share of agricultural output in GDP and the share of rural population in total population tend to decline gradually over time. Consequently, the contribution of agriculture to the national economy declines. Almost all the industrialized nations have passed this stage of structural transformation. In the developing world, however, the structural change did not begin until the 1950s and the pace of transformation varies sharply in different economies.

Owing to unrealistic ambition and poor foresight, most governments of the developing world have been trying to industrialize their economies at so high a speed that agricultural growth is suffocated, resulting in low efficiency in industries and poor performance of the entire economy. In many countries, real outcomes contradict the initial policy objectives. The philosophy behind the industry-biased strategy is essentially based on the first view of agriculture's role.

China provides a good example of this strategy. Before economic reforms, the government over-emphasized the development of capital-intensive industries at the expense of agriculture, light industry and services. The industrialization strategy resulted in weak agricultural production and low efficiency of the state-industrial sector. With better price and marketing incentives as well as institutional reform, especially the dismantling of the commune system, China has achieved better agricultural growth and industrial efficiency since 1978. One important reason for success during economic reforms and openness is that policies are designed to adjust the unbalanced development structure between agriculture and industry and to encourage farm production. On the one hand, the prices of many agricultural products were raised progressively to increase the return to agricultural production. In the late 1980s some goods, such as vegetables and livestock products, were allowed to be marketed freely in local markets. On the other hand, the rigid administrative control imposed by the former commune system was scrapped to give farmers more freedom and choice in production and marketing.

China has experienced many economic cycles of booms and busts but it is interesting to note that most boom years were positively related to more favorable agricultural policies, whereas all the poor years were negatively related to inadequate agricultural performance. Although economic growth has not been entirely determined by agricultural production, the Chinese experience indicates that agriculture has been the most important driving force of the economy since 1949, even though its share of output in GDP has been declining sharply over time.

In this paper, the assessment of agriculture's role follows the conventional approach by dividing the contributions of agriculture into four different categories and examining each one in the Chinese economy since 1949. The four contributions proposed by Kuznets (1964) and discussed in Ghatak & Ingersent (1984) include: (1) the product contribution or the forward linkage effect; (2) the market contribution or backward linkage effect; (3) the factor contribution deriving from inter-sectoral transfers; and (4) the foreign exchange contribution. Descriptive analysis of these contributions is presented in Section 2.

To understand more precisely how agriculture has been driving the whole national economy, an econometric model is established to unveil the extent of the linkages

Table 1. Gross domestic products by sector (billion yuan)

	GDP at current price		GDP index (1952 = 100)		GDP sectoral composition		
Year	Total (billion yuan)	Per capita (yuan)	Total	Per capita	Agriculture (%)	Industry (%)	Others (%)
1952	67.9	119	100	100	50.5	17.6	31.9
1960	145.7	218	205	175	23.4	39.0	37.6
1965	171.6	240	214	170	37.9	31.8	30.3
1970	225.3	275	299	208	35.2	36.8	28.0
1975	299.7	327	399	248	32.4	41.5	26.1
1978	362.4	379	471	281	28.1	44.3	27.6
1980	451.8	460	547	317	30.1	44.2	25.7
1985	898.9	853	912	492	28.4	38.5	33.1
1990	1859.8	1634	1334	6 666	27.0	37.0	36.0
1995	5749.5	4854	2305	1105	20.5	42.3	37.2
1996	6685.1	5576	2530	1198	20.4	42.8	36.8
			Average annual growth: pre-reform period				
1952–78	—	4.56	6.15	4.05	−2.23	3.61	−0.56
			Average annual growth: post-reform period				
1978–96	—	16.11	9.79	8.40	−1.76	−0.19	1.61

Source: SSB (1998).

between agriculture and other economic sectors. As conventional econometric models using ordinary least squares (OLS) may yield spurious regression results if time-series data are not cointegrated, a vector autoregression (VAR) model developed in Johansen & Juselius (1992) is particularly useful for this purpose. Based on a VAR model and time-series data for sectoral GDP indices over 1952–96, three cointegrated vectors are identified among five economic sectors in China, including agriculture, industry, transportation, construction and services.[1]

Two important conclusions can be drawn from the VAR results. First, all economic sectors tended to move together (cointegrate) over time. Second, agriculture is the major driving force for the growth of all the other sectors, but the converse is not true. It suggests that agriculture did not benefit from the growth of other sectors. This finding is in agreement with the analyses in other studies (e.g. Won & Lin, 1992). It is a striking result and has important policy implications on the whole development strategy in China.

2. A Review of Agriculture's Role

This section discusses agriculture's contributions to the economic development in China since 1949. It follows the conventional approach of examining agriculture's role in four different aspects in terms of product, market, factor and foreign exchange earning contributions.

2.1 Product Contribution

A product contribution is usually measured by the size of agriculture in the national economy, which declines steadily over time. In the early 1950s, agriculture accounted for over half of China's GDP but by 1996 it made up just over one-fifth. Over 1952–78, agriculture's share in GDP declined by 2.23% per year (Table 1).

Table 2. Income elasticities of demand for agricultural products (1988 and 1952–88)

Agricultural products	Urban		Rural	
	Time-series	Cross-section	Time-series	Cross-section
Cereals	−0.20	−0.33	−0.06	0.15
Pork/beef/mutton	0.34	0.57	0.73	0.26
Poultry	1.66	0.93	1.48	2.16
Eggs	0.52	0.58	1.06	1.66
Fish	0.04	0.59	0.89	4.54

Sources: Data: SSB (CSYB, 1989) household income and expenditure data. Estimates: World Bank (1991), p. 12.
Notes: Significant differences between the time-series and cross-sectional results suggest that the estimates are very crude. They have to be interpreted with caution.

There are two main reasons for a declining share of agriculture in GDP. One is the inevitable trend of economic development which requires a higher growth rate of non-agricultural sectors than agricultural sectors, as dictated by Engel's law—as personal disposal income grows as a result of economic development, consumers tend to spend a lower proportion of incremental income on food products. In China, the law is verified by the very low income elasticities of food demand. For example, the income elasticities of cereals are close to zero or negative, although the demands for animal products are more elastic (Table 2).

A second reason for slow agricultural growth is government policy, which has discriminated against agriculture and the rural population. Before the economic reforms, farmers were forced to deliver grain and other agricultural products to the state at very low prices. For example, before 1978 the procurement prices of grains were less than half the market prices (Lardy, 1983; Yao, 1994). Market liberalization, price reform and other policy measures more favourable to agriculture since 1978 have stimulated faster agricultural growth. As a result, the declining rate of agriculture's share in GDP was reduced to 1.76% per annum in the reform period (Table 1).

Although the share of agricultural output in GDP tends to decline because of Engel's law and government policy being biased against agriculture, it is important not to overlook the critical importance of the product contribution of domestic agriculture to the maintenance of an adequate rate of economic growth. More importantly, it needs to be stressed that government policies deliberately designed to achieve unbalanced development against agriculture can result in overall poor performance of the entire economy. The comparison of economic performance between the pre-reform and reform periods of the Chinese economy supports this argument. It is obvious that economic performance was very poor in the pre-reform period when agriculture was squeezed hard (through explicit and implicit taxation) to support industrial development. In addition, the institutional framework under the commune and a whole set of other political and economic policies (e.g. grain self-sufficiency for every locality and the suppression of commercial activities in the rural areas) had helped suffocate agriculture. The more favourable policies for agriculture in the reform period achieved better performance not only in agriculture but also in the rest of the economy, even though the bias against agriculture in the reform period still persists (Yao, 1994; Bhalla, 1990).[2] Measured in constant 1952 prices, China's GDP rose by 6.15% per year during the pre-reform period 1952–78. Although this was a rather impressive performance by

Table 3. Output values of agriculture-based industries and their shares in total industrial output values (current prices)

Year	Gross output values of agriculture-based industries (billion yuan)	As per cent of gross light industrial output values (%)	As per cent of gross industrial output values (%)
1952	19.5	86.7	55.9
1960	40.5	74.0	24.7
1965	50.5	69.8	36.0
1970	70.7	73.6	34.0
1975	96.3	70.0	30.8
1980	163.9	71.0	33.5
1985	283.2	69.3	32.3
1990	611.9	69.7	32.7
1991	700.0	68.4	31.7
1992	827.9	67.8	29.9
1994	1462.6	67.5	28.5
1996	1798.6	66.6	28.7

Sources: Ministry of Agriculture (Planning Bureau, 1989), pp. 52–53 and pp. 60–61 for 1852–85. SSB (CSYB), (1991), p. 399 for 1990; (1992), p. 411 for 1991; (1993), p. 417 for 1992; (1995), p. 388 for 1994; (1997), p. 424 for 1996.

international standards, it was substantially lower than the 9.79% annual growth rate achieved during the post-reform period 1978–96 (Table 1).

The importance of agriculture's product contribution is not only through the provision of food and other agricultural products for a huge population, but also through its ability to provide massive amounts of raw materials for industrial production. In addition, although agriculture's share in GDP is less than one-fifth, over two-thirds of the total population are still living directly on agriculture. In the early 1950s, over 60% of total industrial production was agriculture-based. Although the dependency of industrial production on agriculture declined over time, by 1996 two-thirds of light industrial output, or 29% of the total industrial production, still relied on agriculture for raw materials (Table 3).

2.2 Market Contribution

The market contribution refers to the demand by agriculture for different inputs, such as fertilizers, insecticides, machinery, electricity, or transportation, and farmers' consumption effects on the rest of the economy. Demand for industrial inputs was accelerated by the increasing constraints of arable land and crop area. Per capita arable land and crop area declined, respectively, at 2.08 and 1.69% per year between 1953 and 1989 (Yao, 1994, table 4.6).

Despite the acute shortage of land, China managed to achieve significant growth in agricultural output in relation to population, especially during the reform period. Per capita grain output increased by 0.44% per year during 1953–78 and by 1.56% during 1978–89. Per capita agricultural output value increased by 0.7% during 1953–78 and 4.67% during 1978–89 per year (Yao, 1994, tables 2.10 and 2.11).

Sustainable growth has been achieved through steady improvements in land productivity. That, however, has relied on increased use of industrial products, such as

Table 4. Fertilizer use, irrigation and mechanization indices

Year	Grain yield (kg/ha)	Fertilizer application (kg/ha)[a]	Irrigated area/ arable land	Tractor plough area[c]/ arable land
1950	1155	0.75	0.09	0.00
1960	1170	4.50	0.27	0.02
1965	1635	13.50	0.32	0.15
1970	2010	24.75	0.35	0.18
1975	2355	36.00	0.43	0.33
1980	2745	87.00	0.45	0.41
1985	3480	123.60	0.45	0.36
1989	3690	160.86	0.47	0.45
1992	4004	196.63	0.51	0.54
1994[b]	4500	223.82	0.51	0.56
1996	4895	251.21	0.53	0.58

Sources: 1950–86: Ministry of Agriculture (Planning Bureau, 1989); 1987–89: Ministry of Agriculture (*Statistical Materials of Chinese Agriculture*, various issues); 1992: SSB (1993), pp. 332, 349, 359, 371; 1994, SSB (1995), pp. 350, 331, 336, 344; 1996: SSB (1997), pp. 386, 380, 373, 368.

[a]Fertilizer use is calculated as effective contents per hectare of crop area.

[b]During 1950–92, grains include just wheat, rice and corn; after 1994, they also include soybeans and tuber crops (e.g. sweet potatoes). The yield level is slightly higher if grains include soybeans and tuber crops. For example, the comparable yield in 1992 would be 4342 kg/ha if grains also included soybeans and tubers.

[c]The tractor ploughed areas for 1994 and 1996 are personal estimates.

fertilizers, insecticides, farm machinery and equipment, electricity and many others. This suggests that an increasing share of agricultural output value is accounted for by the non-farm sectors. For example, grain yield increased by almost three times from 1155 kg/ha in 1950 to 4895 kg/ha in 1996. But the use of fertilizers jumped by a factor of 335 from 0.75 kg/ha to 251.21 kg/ha over the period. After over 46 years of development, agricultural land became well irrigated and agricultural production well mechanized (Table 4). Irrigation and mechanization involved a large amount of industrial input into agriculture, creating a strong backward linkage effect driving the rapid development of agro-industries.

Farmers' income is largely determined by the rate of agricultural growth. As income grows farmers are able to buy more consumer goods produced by agriculture and non-agricultural sectors. This consumption effect has been widely recognized. Mellor (1976), Mellor & Lele (1973) and Hazell & Roell (1983), in particular, have called attention to the potential power of agricultural consumption linkages. Hirschman's (1958) assessment of agriculture as a low-linkage, underpowered engine of growth erred because it neglected these important consumption linkages.

As China is still basically agrarian and 80% of the total population is living in the countryside, the rural community is inevitably a dominant market for many domestically produced consumer goods. Economic reforms have brought about sustainable and significant increase in farmers' incomes, with farmers spending a higher proportion of incremental expenditure on manufactured products. For instance, many traditional durable goods, such as TV sets, watches and bicycles, have a limited market in the urban areas, but they have a very strong and expanding market in the countryside (Nolan, 1991).

Table 5. Capital transfers from agriculture (billion yuan)[a]

	Total transfers[b,d]	As per cent of state budget	State subsidy to agriculture[c]	Net transfer
1957	22.1	71	—	—
1965	35.8	76	—	—
1971	38.4	52	—	—
1978	44.2	39	—	—
1984	67.7	—	—	—
1986	89.4	—	—	—
1987	104.5	—	—	—
1988	130.2	—	—	—
1953–85	680.0	—	—	—
1978–85	481.5	47.5	224.9	176.8

Source: Ministry of Agriculture (Research Centre of Economic Policy, 1991), pp. 139–141 and p. 159.
[a]Values are calculated at current prices.
[b]Calculated according to the "scissors difference" and the volumes of trade between agricultural and non-agricultural sectors (for more explanation, see note 2).
[c]State subsidies to agriculture include state investment in agriculture, input subsidies and all the other possible subsidies to agriculture and the rural areas.
[d]Most agricultural taxes are in the form of indirect taxation by paying farmers at below market prices for their products and charging them at above market prices for inputs and consumer goods. The main beneficiaries are urban industries and consumers.

2.3 Factor Contribution

The two basic factors, capital and labour, can be provided by agriculture to the national economy. Capital transfers from agriculture in China took place mainly in the form of indirect agricultural taxes through forced procurement of agricultural products at below market prices. The Ministry of Agriculture estimated that about 70–80% of total state revenue was from taxing agriculture in the 1950s. Although that share of state revenue declined over time, by the mid-1980s about half of the state revenue still relied on agriculture (Table 5).[3]

Tax revenue from agriculture in Table 5 does not include taxes collected from the rural township and village enterprises (RTVEs), a new and dynamic production force since economic reforms. If these were included, it would add 4.2 billion yuan in 1978 and 36.5 billion yuan in 1989, or 4.2 and 13.4% of the total state tax revenues (Yao, 1994, table 3.6). In other words, the total rural-to-urban capital transfers were much greater than those from agriculture to the non-agricultural sectors.

A logical industrialization process should benefit from capital transfers and increased use of cheap agricultural labour. In China, however, industrial development in the pre-reform period did not use much labour from agriculture, although rural-to-urban migration since 1979 has been substantial. Farmers were largely excluded from the industrialization process although they had contributed almost all the accumulated capital assets of the state industries. This was an inevitable outcome of the state industrial policy characterized by high capital intensity and urban bias.

There were two undesirable consequences of this development strategy. First, labour could not be quickly transferred from agriculture to industries, leading to huge under-utilized human resources and depressed labour productivity in agriculture. Second, industrial labour was very expensive as enterprises had to employ only the urban workers who were entitled to various state subsidies. However, high labour costs had to be entirely borne by the enterprises. As a result, domestic industrial goods were not competitive internationally and required heavy protection from the state.

Significant labour transfers from agriculture to industries and other non-farm enterprises were possible during economic reforms. However, such transfers were confined within the rural economy. This is characterized by the dramatic development of the RTVEs. Obviously the development of agriculture and non-agricultural enterprises in the rural areas has been mutually beneficial. One great advantage of RTVEs over the state-owned industrial sector is that the former have benefited substantially from using cheap labour released from agriculture. The state sector has "selfishly" excluded farmers from participation but it has had to bear the inevitable consequences: low profitability—low growth—and eventually self-destruction as competition from the collective and private sectors, particularly from the RTVEs, intensifies over time.

2.4 Foreign Exchange Contribution

Agricultural exports have been a dominant source of foreign exchange earnings in China, accounting for more than 80% in the 1950s. Although by the 1980s their dominant position was gradually supplemented by manufacturing goods, they still contributed about 38–45% of total exports. The trade figures in Table 6 include direct imports/exports of agricultural goods and the indirect imports/exports of goods that use agricultural inputs, such as cotton and other related textile products. As imports of agricultural goods and related products (e.g. chemical fertilizers) are much smaller than agricultural exports, the sector has been a large net foreign exchange earner.

3. A Cointegration Analysis

In this section, a multivariate cointegration analysis is conducted using the VAR model developed in Johansen (1988) and Johansen & Juselius (1992). It is based on the estimation of a VAR by maximum likelihood. As the approach is too complicated to explain in full detail in this paper, readers are referred to Muscatelli & Hurn (1992), Banerjee, *et al.* (1993) and Harris (1995) for explanations and reviews of the technique. Here we only present the general model, the results and their interpretations.

3.1 The VAR Model

As our objective is to investigate whether agriculture and the rest of the economy are cointegrated, there is a division into five sectors, i.e. agriculture, industry, transportation, construction and services. If it is possible to find one, or more than one, cointegration vector among these sectors, it will be apparent that different sectors of the Chinese economy moved closely together over time. It is also possible to test the hypothesis of weak exogeneity for any particular sector. In this study, it is particularly interesting to test the null hypothesis that agriculture is weakly exogenous in the system. If the null cannot be rejected it will have very important economic implications, suggesting that agricultural growth can cause the growth of other sectors, but the growth of other sectors cannot cause agriculture to grow.

The time-series data of GDP indices in constant prices of the five sectors over 1952–96 (State Statistical Bureau (SSB), 1998) are used in setting up the model. Although the number of observations (45) is not large for a VAR model, the data

Table 6. External trade of agricultural products (billion US$ and %)

	Exports		Imports		Export–imports:[a–c]	
Year	Value	As percent of national total	Value	As percent of national total	Value	As percent of total national imports
1953	0.83	81.60	—	—	—	—
1960	1.36	73.30	—	—	—	—
1965	1.54	69.10	—	—	—	—
1970	1.68	74.40	—	—	—	—
1975	4.41	60.70	—	—	—	—
1980	8.82	48.66	6.76	33.75	2.06	10.29
1985	11.99	43.84	8.23	19.48	3.76	8.90
1989	23.88	45.45	15.31	25.89	8.57	14.49
1990	24.50	39.45	13.93	26.12	10.56	19.80
1991	28.12	39.15	15.64	24.52	12.48	19.57
1992	37.02	43.55	22.83	28.32	14.19	17.61
1994	54.16	44.76	22.02	19.04	32.14	27.78
1996	57.17	37.84	16.68	12.01	40.49	29.16

Sources: Ministry of Agriculture (Planning Bureau, 1989), pp. 517–519 for 1953–80. SSB (CSYB): (1991), pp. 618–619; (1992), pp. 630–631; (1993), pp. 636–637; (1995), pp. 539–540; (1997), pp. 591–592.
[a]Data for 1953–80 were provided by the import–export departments. Data after 1980 were provided by the customs. These two sources of data may not be consistent.
[b]Imports and exports under agriculture include two categories: (i) agricultural primary products: foods and processed foods (e.g. live animals, livestock products, fishery products, vegetables, tea and coffee), beverage and tobacco products, industrial raw materials (e.g. leather and cotton) and others (e.g. animal feeds and unclassified live animals); and (ii) agriculture-based light industrial products: cotton yards, clothing and other related textile products for exports; fertilizers, clothing and other related textile products for imports.
[c]All the import and export values are calculated at current prices in US dollars.

provide the longest possible time-series for the Chinese economy. They are compiled by the Department of National Economic Accounting of the State Statistical Bureau. The variables to be included have been tested for orders of integration, and the results (not reported here to save space) suggest that all of them are $I(1)$ non-stationary series.[4]

Let $\mathbf{x}_t$ denote a (5×1) column vector of the logs of GDP indices for agriculture (a), industry (i), transportation (t), construction (c) and services (s), or $\mathbf{x}_t = (a\ i\ t\ c\ s)'$. The VAR model as in Johansen & Juselius (1992) is replicated by equation (1):

$$\Delta \mathbf{x}_t = \sum_{i=1}^{p} \pi_i\, \Delta \mathbf{x}_{t-i} + \pi \mathbf{x}_{t-1} + \psi \mathbf{z}_t + \varepsilon_t \tag{1}$$

where π_is ($i = 1, \ldots, p$) are (5×5) matrices for the variables Δx_{t-i}; $\Delta \mathbf{x}_t$ is a (5×1) column vector of the first differences of x_t; π is a (5×5) matrix for the variables x_{t-1} which is a (5×1) column vector of the lagged dependent variables; $\mathbf{z}_t$ is a $(5 \times s)$ matrix containing s deterministic variables (such as a time trend, a constant and any other exogenous variables with $I(0)$ property) for each dependent variable; ε_t is a (5×1) column vector of disturbance terms normally distributed with zero means and constant variances.

The first term in equation (1) will capture the short-run effects on $\Delta \mathbf{x}_t$. The lagged length (i.e.) the value of p) is taken arbitrarily simply to ensure that the residuals are normally and independently distributed (NID) with zero means and constant variances. In our model, it is found that $p = 2$ will be sufficient.

The second term in equation (1) will capture the effect on $\Delta \mathbf{x}_t$ of the disequilibrium

Table 7. Statistics from the residual analysis

Equation	Mean	SD	Normality[a]	R^2
a	0.000	0.046	1.720	0.509
i	0.000	0.090	1.517	0.676
t	0.000	0.081	4.531	0.723
c	0.000	0.051	3.506	0.589
s	0.000	0.051	0.418	0.629

[a]The Jarque–Bera normality test statistics has a χ^2 distribution with two degrees of freedom under the null. The critical value at 5% is 5.99. Full details of the statistics are given in Hendry (1989).

from the long-run relationship. As this is our main concern of this study, it is necessary to understand the meaning of the coefficient matrix π, which can be factored into $\alpha\beta'$ where both α and β are $(5 \times r)$ matrices of rank r $(5 \geq r \geq 0)$ and β' is the transpose of β. The value of r indicates the number of cointegrating vectors among $\mathbf{x}_t$. The cointegrating vectors can be written as $\beta'\mathbf{x}_t$. All these vectors will be integrated of degree zero, or $I(0)$, because the elements in $\mathbf{x}_t$ have been tested to be $I(1)$. The loading matrix α gives the weights attached to each cointegrating vector for all the equations.

A time trend is added to both the cointegrating space and the model. It is also necessary to add a dummy variable for the "Great Leap Forward" movement period of 1958–62 when agricultural production was strongly affected by the unprecedented disastrous harvests and defective policies for that period. Another dummy variable is added to capture the effect of the post-Mao economic reform. Thus, the deterministic variables in $\mathbf{z}_t$ involve a time trend and two dummy variables for 1958–62 and 1979–1996.

3.2 Estimation and Results

The model is run in the CATS subroutine of RATS developed by Hansen for VAR regression (for detailed technical explanations, see Hansen & Juselius, 1994). Examination of the companion matrix, different residual tests (mean, standard deviations, autocorrelation and normality), the L-max and Trace test statistics indicates that there are three cointegration vectors ($r = 3$). With two lagged differences, all the residuals are NID as indicated by the residual analysis in Table 7.

The first three rows of β' are selected to be normalized as there are three cointegration vectors. A close examination of the α matrix indicates that agriculture may be weakly exogenous as the α values for agriculture are significantly lower than the corresponding α values for other sector (Table 8). The LR test fails to reject the null that agriculture is weakly exogenous (p value $= 0.16$ when $\chi^2(3) = 5.14$). Similar tests are carried out on other variables in the system but all yield the same conclusion that none of the other variables are weakly exogenous. Therefore, a final conclusion is drawn that agriculture is the only exogenous variable in the system. Weak exogeneity in agriculture means that agricultural growth can cause the growth of the non-agricultural sectors. The rejection of weak exogeneity of the non-agricultural sectors means that the growth of these sectors cannot cause agriculture to grow.

By imposing the restriction on α so that agriculture is treated as a weakly exogenous variable, the first three rows of β' are reproduced and normalized. The results are reported in Table 9. As agriculture is found to be weakly exogenous, it is necessary to test whether it is also strongly exogenous. If the null hypothesis cannot be rejected, it

Table 8. The α matrix and *t* values with three cointegration vectors

The α matrix			*t* values for α		
0.052	−0.137	0.090	0.811	−1.471	0.812
0.632	−0.458	−0.221	4.145	−3.386	−2.871
0.772	−0.210	−0.217	5.723	−1.766	−3.088
0.304	−0.686	−0.499	1.177	−3.005	−3.789
0.266	−0.298	−0.075	2.869	−3.591	−1.553

implies that agriculture is not part of the cointegration space al all. In other words, if agriculture is found to be strongly exogenous, the finding of weak exogeneity is overruled, implying that agricultural growth cannot cause the growth of other sectors even if it is found to be weakly exogenous.

To conduct the strong exogeneity test, a hypothesis is set up to test whether the three coefficients in the β matrix under agriculture are jointly equal to zero. In the present context, the following version of the estimated β′ matrix in Table 9 is tested:

$$\hat{}\beta' = \begin{bmatrix} 0{*}{*}{*}{*} \\ 0{*}{*}{*}{*} \\ 0{*}{*}{*}{*} \end{bmatrix}.$$

The LR results reject the null at a 1% significance level (p value = 0.01 when $\chi^2(2) = 10.42$). This verifies the conclusion that agriculture is part of the cointegration space and the above conclusion on weak exogeneity is confirmed. Therefore, the analysis below is based on the weak exogeneity of the agricultural sector.

For easy understanding, the three cointegration vectors in Table 9 can be represented by the following equations:

$$c = 0.340a + 0.521i + 1.007t - 0.151s - 0.037\,Trend \tag{2}$$

$$i = 0.626a + 0.786t - 0.701c - 0.357s + 0.055\,Trend \tag{3}$$

$$t = 0.326a + 1.085i - 0.821c + 1.120s - 0.019\,Trend. \tag{4}$$

The next problem is that of identity. As equations (2)–(4) include a whole range of variables on the right-hand side, each equation is not uniquely defined. Following Johansen's approach (Johansen, 1995), we imposed a number of restrictions on the β coefficients to see whether some of these parameters may be equal to zero so that unique relationships can be found. Without knowing which restrictions may be statistically acceptable, many alternative restrictions on β are conducted. The most acceptable restriction is that the coefficients of s in equation (2), of c in equation (3) and of *Trend* in equation (4) are set to zero. The probability of rejection, according to the χ^2 test, is

Table 9. Cointegration vectors from VAR

Cointegration vectors	Beta transposed, or β′					
	a	*i*	*t*	*c*	*s*	*Trend*
V1	−0.340	−0.521	−1.007	1.000	0.151	0.037
V2	−0.626	1.000	−0.786	0.701	0.357	−0.055
V3	−0.326	−1.085	1.000	0.821	−1.120	0.019

above the 10% significant level. Other restrictions are all rejected below the 1% significant level. The final cointegration equations are presented as equations (5)–(7):

$$c = 0.335a + 0.416i + 0.914t - 0.047\ Trend \tag{5}$$

$$i = 0.481a + 0.812t - 0.533s + 0.028\ Trend \tag{6}$$

$$t = 0.391a + 1.101i - 0.532c + 0.921s. \tag{7}$$

The coefficients on the right-hand side are interpreted as long-run elasticities. In equation (5), for example, the coefficient of a is 0.335. It suggests (*ceteris paribus*) a 10% rise in agricultural GDP would raise construction GDP by 3.35%. In equations (6) and (7), the results indicate that a 10% increase in agricultural GDP would raise the GDPs of industry and transportation by 4.81 and 3.91%, respectively. A positive *Trend* coefficient of 0.028 in equation (6) suggests that the industrial sector grew much faster than the general trend of economic growth. The negative *Trend* coefficient in equation (5) suggests that construction lagged behind the general trend of economic growth. The existence of bottlenecks in construction over the sample period is clearly reflected in the results.

The existence of three cointegration vectors implies that the economic sectors move together in the long run. It is interesting to notice that inter-sectoral relationships are not always positive. The signs of the coefficients in equation (6) suggest that industry had a negative relationship with services. This may reflect the fact that service industries were under-invested, particularly in the pre-reform period.

Transportation is a special sector. Although empirical evidence indicates that transportation has been under-invested in throughout the entire development process, the development of transportation has a strong and positive impact on industry and construction as reflected by the positive coefficients of transportation in equations (5) and (6). The development of transportation is also driven by the growth of the industrial and service sectors, although it may have been hampered by the under-investment in the construction industry (the coefficients in equation (7)).

Indeed, the government was much in favour of the industrial sector at the expense of other sectors, especially agriculture. Such bias towards industries often created bottlenecks in the economy, such as insufficient transportation, lack of raw materials and under-development of services and agriculture. These bottlenecks persisted for decades, but periodic efforts were also made to tackle them through large-scale state investments in the areas concerned (e.g. energy and transportation).

3.3 A Short-run Dynamic Model

Equations (5)–(7) are considered to be three parsimonious vector error correction mechanisms (VECM) that can be used to estimate the short-run dynamic model represented by equation (8):

$$\Delta \mathbf{x}_t = \theta + \sum_{i=1}^{p} \Delta \mathbf{x}_{t-i} + \sum_{j=1}^{3} v_{j-1} + \mu_t \tag{8}$$

Where $\Delta \mathbf{x}_t$ is a (5×1) column vector of the first differences, or $\Delta \mathbf{x}_t = (\Delta a\ \Delta i\ \Delta t\ \Delta c\ \Delta s)'$; Δx_{t-i} is the ith lagged term of $\Delta \mathbf{x}_t$. v_{j-1} ($j = 1, 2, 3$) are the lagged terms of the VECMs as shown in equations (5)–(7). The system is estimated in a seemingly unrelated manner. OLS is an efficient way to estimate the equations in (8) given that each equation has a common set of (lagged) regressors. Since all the variables in the system are now $I(0)$, statistical inference using standard t- and F-tests is valid.

Table 10. OLS estimates of the short-run equation system

Explanatory variables	First difference equations Δa	Δi	Δt	Δc	Δs
Constant	0.013	0.021	0.002	−0.026	0.020
	(1.23)	(0.68)	(0.06)	(−0.54)	(1.15)
Δa_{t-1}	0.636**	1.183**	1.145**	2.251**	0.681**
	(5.10)	(3.19)	(3.25)	(3.63)	(3.15)
Δi_{t-1}	0.038	0.279	−0.267	0.561	−0.648*
	(0.18)	(2.53)**	(−0.54)	(0.64)	(−2.01)
Δt_{t-1}	−0.212	0.471	0.944*	0.174	0.910**
	(−1.50)	(1.00)	(2.11)	(0.20)	(3.01)
Δc_{t-1}	−0.032	0.126	0.178	−0.101	0.080
	(−0.51)	(0.88)	(1.36)	(−0.41)	(0.97)
Δs_{t-1}	0.234*	−0.585*	−0.401	−0.311	0.017
	(2.15)	(−2.18)	(−1.52)	(−0.74)	(0.10)
$v1_{t-1}$	−1.168**	−0.640	−0.654	−0.02	−0.900**
	(−4.78)	(−0.95)	(−1.03)	(−0.34)	(−2.40)
$v2_{t-1}$	−0.149	−0.262*	0.315	0.111	0.001
	(−0.74)	(−2.11)	(0.61)	(0.110)	(0.01)
$v3_{t-1}$	0.246	−1.139**	−1.599**	−1.934*	−0.105
	(1.01)	(−2.66)	(−2.63)	(−2.11)	(−0.39)
Diagnostics					
σ	0.042	0.114	0.105	0.188	0.062
F_{ar} (1, 32)	0.441	1.717	1.111	0.519	0.110
F_{arch} (1, 32)	0.641	0.003	0.032	0.344	0.109
F_{het} (20, 17)	0.640	0.802	0.642	3.396*	1.611
$\chi^2_{normality}$ (2)	0.241	0.684	5.001	3.391	0.756

Vector diagnostics: F_{ar} (54, 80) = 1.021; F_{het} (256, 28) = 0.301; $\chi^2_{normality}$ (10) = 3.578.
F-test *against* unrestricted variable (constant): F_{ur} (44, 124) = 3.521**.

**Rejection at the 1% significance level; *rejection at the 5% significance level. Values in parentheses are *t*-statistics.

With some experiments, it is found unnecessary to include more than one lagged term for the regressors. Initially, a time trend and two dummy variables for the periods 1958–61 and 1979–92 are also included, but they are found to be insignificantly different from zero. The final specifications of the model and their estimated results are presented in Table 10.

All the equations pass various evaluation tests except the construction equation, which appears to have some degree of heteroscedasticity. However, taking the vector as a whole, the problem of heteroscedasticity disappears. The results in Table 10 confirm that there are three cointegration vectors and that all the variables are endogenous. On the whole, agriculture has a significantly positive effect on all the other sectors. Another interesting point is that there is little inter-sectoral impact between the non-agricultural sectors. This may be explained by the short-run competition for investments.

The finding that agriculture is exogenous to the system is striking. On the one hand, it suggests that agricultural growth could cause other sectors to grow. Any increase in agricultural output had a positive and sizeable effect on the rest of the economy. This can be easily understood by the arguments and evidence presented in Section 1. On the other hand, it suggests that the growth in other sectors did not cause agriculture to grow. It is very difficult to understand this result without further consideration.

The first argument to support this is by examining available studies conducted by other researchers. There are very few of them, but the work by Won & Lin (1992) provides some useful information. Although their study was based on a simple regression analysis with the OLS technique and involves only agriculture and industry as two separate sectors, their results suggest that agricultural production has a strong and positive effect on industrial growth but the converse is not true. As the present analysis is based on a rigorous regression system and involves all the economic sectors, it is more conclusive to say that the development of non-agricultural sectors had little effect on agriculture in the Chinese economy.

A possible explanation is that agriculture has been unfairly treated by government policies. Before economic reforms agriculture was a dominant source of capital accumulation for industrialization and the major net contributor of foreign exchange. Any agricultural surplus was mostly taken away from farmers with little left behind for investment in agriculture itself. Even after economic reforms, agriculture was still unfairly treated in terms of low investments by the state, high prices of inputs, and numerous duties and taxes forced on the rural communities. It is obvious that if the terms of trade always work against agriculture, as in China, no matter how fast the other sectors grow they will have little positive effect on agricultural income. On the other hand, had agriculture not been unfairly treated, it would have been possible for it to benefit from the growth of the rest of the economy through equal competition.

Another possible explanation is urban bias and rural–urban segmentation. After 1949, China developed a strict registration system to separate urban and rural residents. Urban residents were given rights to enter non-agricultural employment, whereas rural people were strictly confined to farming. This rural–urban segmentation implied that no matter how quickly the non-agricultural sectors developed, there was no effect on rural employment. An increasing labour force had to work on a declining area of land. As farmers could not move to the cities and work in the non-agricultural sectors, agriculture was effectively isolated from the rest of the economy. However, it has been noticed that economic reforms have significantly reduced this urban–rural divide as the RTVEs have managed to siphon 20% of workers from agriculture, but the non-agricultural and agricultural linkage effects may require some more time to become established at the national level.

4. Conclusions

This paper presents empirical evidence and a cointegration analysis to demonstrate that agriculture is an important driving force of economic growth in China. Although development experiences in many industrial and developing countries indicate that agriculture's share in GDP declines over time, the share of agricultural labour declines much more slowly, resulting in an increasing income gap between agricultural and non-agricultural workers. A declining role of agriculture is mainly caused by Engel's law, but government intervention can affect the trend. The experience of China suggests that policy biased against agriculture in an attempt to industrialize the economy quickly has undermined agriculture's contribution to national economic development. However, the Chinese experience is not unique. Many similar developing economies (e.g. Indonesia, the Philippines, Malaysia, Thailand, India and Pakistan) have gone through exactly the same process. The question is whether a deliberate policy against agriculture is good or bad in transforming a developing economy. The answer is the second, according to the analysis in this paper.

The importance of agriculture lies not only in its ability to provide food for the population, ample raw materials for domestic industries, tax revenues for the government and exports for foreign exchange, but also in its ability to sustain a decent income growth rate for the rural population which in turn provides a huge market for the products and services of domestic industries.

A comparison of economic performance before and after the economic reforms in China indicates that speedier capital transfer from agriculture does not necessarily result in higher growth in the rest of the economy. Sustainable economic growth has to depend on a balanced development of agriculture and the industrial sectors. This argument is strongly supported by the regression results in Section 3, which suggest that agriculture is a driving force for the growth of all the other sectors. Without agriculture providing enough food for the population, materials for industries, large capital transfers to state revenue and foreign exchange, the entire economy can suffer enormously.

The finding that agricultural growth can cause other sectors to grow but the growth of other sectors does not lead to agricultural growth is striking. Excessive taxation on agriculture and strict policy on rural–urban labour movement may have been two important factors to blame for this result. Economic reforms since 1978 have allowed large-scale rural–urban migration and have improved the terms of trade for agriculture. Hence, it may be expected that in future, growth in the non-agricultural sectors and the urban economy will prompt simultaneous agricultural growth. However, one should not be too optimistic about the outcome for agriculture. First, massive rural–urban migration may have a harmful rather than a positive effect on agriculture because it may suffer from labour and skill shortage in the long term if too many people move out completely. Second, state investments in agriculture as a share of total investments have declined sharply since economic reforms, causing another important constraint on future agricultural growth (Liu & Yao, 1997). Therefore, it is important to stress that if agriculture is to benefit from the growth of the non-agricultural sectors, the government has to increase investments in agriculture, especially in infrastructure, research, education, marketing and extension services. In the meantime, the state should continue to reduce and eventually eliminate resource transfers from agriculture, either in the form of direct taxation or in the form of price and marketing control.

Notes

1. According to the SSB, industrial production at and below the village level was included in agriculture before 1984 but has been included in industry since 1984. For consistency, the data before 1984 are adjusted in line with the new definition (SSB, CSYB, Chinese edition, 1993, pp. 402–403).
2. The share of agricultural GDP in total GDP declined much less sharply after the economic reform than before (Table 1), providing indirect evidence showing that agriculture was excessively undermined by government policies in the pre-reform era. However, during the economic reform, agriculture has been highly under-invested. The state council agreed in 1979 that the share of agricultural investment as total state investment would be raised to 18% for the period of 1980–84, from 14% in 1979 and 12% in the pre-reform period. This is quoted by Lardy 1983). In implementation, the share was curtailed to about 5%. In the most recent years, the share was reduced to less than 3%. This reflects the legacy of how agriculture is neglected and how investment decisions are myopic. The heart of the matter lies in a strong tendency for politicians to achieve quick and high economic growth through expanding industries without thoughtful consideration of long-term efficiency and the need to balance the structure of the economy.
3. Government intervention in pricing results in lower prices being paid for agricultural goods and higher prices of industrial goods charged to farmers than their respective "real market values". The diversion curves of regulated prices away from their real market values look like

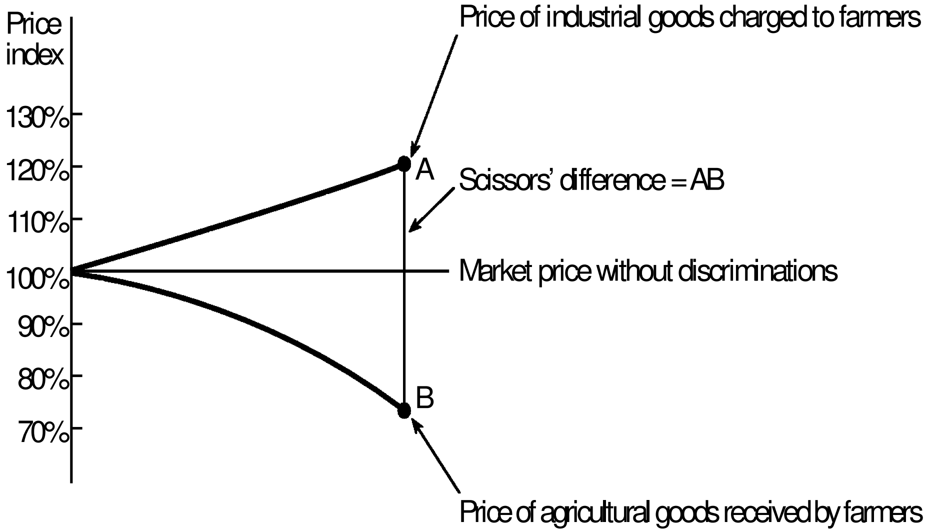

Figure 1. The principle of the scissors difference.

the two blades of scissors when they are open. The distance of the two blades from the central axis (implicitly referred to the real market values) measures the degree of diversion of regulated prices from their respective real values. The "scissors difference", therefore, refers to the sum of the difference between the regulated prices and their real market values of agricultural goods, and that of industrial goods sold to the rural areas. This scissors difference can be illustrated by Figure 1.

4. Standard augmented Dickey–Fuller tests based on the null of non-stationarity, as well as non-standard multivariate ADF tests based on the null of stationarity (obtained from the Johansen modelling procedure), were undertaken. In any event, because of the uncertainty surrounding unit root testing it is useful to proceed with estimating the cointegration model (see Harris, 1995, Chapter 3).

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