SMALLHOLDERS, LIVESTOCK AND HOUSEHOLD INCOME IN RURAL CHINA[*]

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Abstract

The household sector remains the dominant supplier to China's rapidly growing livestock markets. Many of these livestock-producing households are part-time farmers, and are diversifying into non-farm activities, while others are becoming more specialised in livestock production. There is shown to be a long tail of households which earn less than 10% of total income from livestock production and a trend away from livestock production over the sample period, and an increasing concentration of within-sample production in the top-quartile households. We predict U-shaped relationships between household net income and specialisation in livestock production in 2005, most obviously in the East. For the majority of our sample of livestock households we predict that household income will rise as households diversify into other income-earning activities. Households with higher net incomes and lower contributions from livestock were also shown to be more likely to exit livestock production altogether. In the East, higher household incomes are predicted as livestock specialisation increases above a level that was well in excess of the sample median level of specialisation. Our research does not extend to explaining this finding, but economies of scale and access to modern supply chains that scale engenders may be part of the reason.

Introduction

It is well known that demand for livestock products in China has increased rapidly over the past decade or two, driven primarily by income growth and rapidly increasing urbanisation of the population. China has so far largely supplied this growth from domestic production, encouraged by economic reforms and the emergence of markets since the 1980s, including grains and livestock markets, and livestock is increasing its share of the country's agricultural GDP. According to FAOSTAT data, China's total meat consumption increased from 37 to 69 million tonnes between 1991/93 and 2001/03, and meat production increased over the same period from 37 to 68 million tonnes. For milk, both consumption and production rose from 8 million tonnes in 1991/93 to 18 million tonnes a decade later. Starting from a production base of backyard producers, this sector comprising millions of smallholders is still the dominant supplier of livestock products to China's markets. Livestock smallholders make up around 99% of all livestock operations, and produce 73% of hogs, 82% of cattle, over 60% of poultry, 73% of sheep and 65% of dairy cattle (China Animal Industry Yearbook 2003). Most of these smallholders also are part-time farmers, with a significant proportion of household income coming from other sources. Recent structural changes have seen a decline in the proportion of rural households that are raising livestock (Zhang 2006; Zhang and Somwaru 2004), and the emergence of specialist household producers, as well as commercial, large scale enterprises especially in suburban regions of large cities. More recently, some large-scale livestock operations have been relocated away from suburban locations, such as dairy farms shifting out from the Beijing area, and medium/large scale hog farms have been forbidden in Shanghai, due to emerging environmental problems. In the hog sector at least, the most rapid structural change over recent years appears to have been the development of specialist household producers. Based on data gathered for another study (Rae et al 2006), the output share of backyard (non-specialist) hog producers fell at the rate of around 2% per year from 1990 to 2001, while that of specialist hog households rose at the annual rate of 6.5% compared with a growth rate of just under 6% for commercial hog enterprises. The household sector, whether specialised or not, remains dominant in China's livestock production and Chen and Rozelle (2003) suggest that financial difficulties experienced by some of the commercial operations may have been driven by competition from specialist household producers.

In the developing world there is widespread interest in the raising of rural household income through diversification into non-farm activities, as farm households earn an increasing share of their income from non-farm sources (Haggblade 2006). Drivers of this diversification include the desire to accumulate capital, to manage risk and to escape from a sector believed to be in permanent decline. Such trends can eventually result in specialisation of some households in either farm or non-farm activities, especially in richer zones of developing countries where higher incomes may make risk management less of a priority objective. These trends are of course observable in China, which since the 1978 reforms has experienced a remarkable growth of rural industry (Byrd 1990; Oi 1999). Average and marginal returns to rural labour can be far higher in non-farm than farm work, but the development of non-farm activities has been very unevenly spread across provinces, counties and villages due to differences in the households' initial resource endowments, in the opportunities faced, in their proximity to markets, and in access to capital and skills (Knight and Song 2003). Of interest in this paper is the so-called livestock revolution (Delgado et al. 1999) that has occurred most obviously in China, and the opportunities it provides for raising the incomes of rural households in China. To the extent that the revolutionary growth has tended to occur in the white meat and dairy sectors, one point of view is that large-scale integrated operations may be the major beneficiaries. On the other hand, there is hope that the revolution will provide income gains and a pathway out of poverty for millions of smallholders in the developing world (Upton 2000, Brown 2003). Others warn that the livestock revolution will not affect people equally – larger farmers in developing countries with access to credit and knowledge are likely to benefit, but smaller farmers may find it more difficult (Zhou 2003).

In many developing countries farm households are adopting livestock production as part of a diversification strategy to increase household incomes. The pattern has also tended to be an eventual move out of livestock at higher stages of economic development, with an increased emphasis on non-farm income generation often associated with labour market developments. Chen and Rozelle (2003) examine the linkage between market emergence and patterns of backyard hog production in China. They find that rural market development (especially of grain and labour markets) has significant but different effects on hog production depending on the household's level of economic development. For example market development might encourage contraction of hog production in rich coastal areas, where the opportunity cost of farm labour is relatively high, but encourages such production in poorer inland areas.

There exists a rich literature[1] on income inequality among Chinese rural households, and since the 1978 reforms China has experienced the largest increase in income

[1] See for example Benjamin et al. 2005; Kanbur and Zhang 2005; Kung and Lee 2001; Wan and Zhou 2005; Yang 1999.

inequality of all countries for which comparable data are available (Yang, 1999). While much of this literature is motivated by the phenomenal growth of the rural non-farm sector in China, it is of interest to our study in as far as household movements into or out of livestock production might impact on such inequality. Kung and Lee (2001) use rural household data from four counties to undertake a Gini decomposition of income inequality. They find that next to income from non-farm employment, animal husbandry and fisheries contributes the highest percentage share of inequality. They reason that lower income households are constrained from diversifying into these enterprises due to difficulties in acquiring land, feed, and managerial and marketing abilities. Benjamin et al (2005) used household data from 100 villages in nine provinces and found that livestock contributed to income inequality (and by much less in 1999 than in 1987), but by less than it contributes to mean household income. Wage income was the largest contributor to inequality.

Much less appears to have been published on the role of animal production in contributing to income and employment within China's rural households. We extract from the Research Centre for Rural Economy (RCRE) annual survey data, those households which engaged in livestock or fisheries production. Following descriptive analyses from this and the wider RCRE sample, we focus on how increasing household specialisation in livestock production impacts on household income. We find evidence of a U-shaped relationship, especially in the East, with household income increasing as either end of the range of specialisation is approached. We then utilise a longitudinal sample of these households over time, to learn about some of the factors that were associated with a household's decision to remain in or exit livestock production. We found that the higher the household's specialisation in livestock production or their land and labour endowments, the higher the probability that they would remain in livestock production. On the other hand, the probability that a household would leave livestock production increased with total household net income and the proportion of members with at least senior high school qualifications. This probability was also higher for households in the East region, those located close to other sources of employment and with members already employed in state or government organisations.

Data and descriptive analysis

We use the annual RCRE survey data containing individual household data from over 20,000 households in 31 provinces for the years 1995 to 2005. All households keep records of income and spending, as well as other information. Household net income is the sum of net income from cropping, livestock and fisheries, forestry, non-farm businesses, non-farm wages, and other sources such as remittances and interest. All income and expenditure data were deflated using the NSB rural consumer price index for each province with a base year of 1995.

The proportion of the total sample of households that raised some livestock in 1995 was about 76%, but fell steadily through our sample period to reach around 54% by 2005 (Figure 1). At the same time households that earned no income from any farming or forestry activity rose from 5% of the sample in 1995 to 13% ten years later. Household net income earned from livestock held a relatively constant share over the period, between 5% and 10% of total net income (Figure 2). The decline in the proportion of the sample raising livestock suggests that those remaining in livestock production have been increasing their share of income from this activity and becoming more specialised in livestock production. Other points to note from Figure 2 are the rapid increase in the share of household net income earned from wages, and the decline in the share of crop production.

Table 1. Livestock Households: Real Net Income Shares

Income source	1995	2000	2005
Livestock & fisheries	0.11	0.14	0.14
Other farming & forestry	0.43	0.34	0.33
Off-farm business	0.22	0.18	0.13
Wages	0.21	0.29	0.33
Other income	0.04	0.06	0.07
Net income relative to cropping households	0.81	0.76	0.85
Net income relative to non-farm rural households	0.51	0.45	0.46
Sample size	15,376	13,759	11,002

The focus households for this study are those that engage in livestock and/or fisheries production. Those that engage in agricultural activities other than livestock we call cropping households, while those that earn no income from any type of farming are the non-farm rural households. Table 1 indicates that the livestock households, on average, earned over half of their net income from non-farm activities, with a particularly large increase in the importance of wage income. The income share from livestock rose somewhat from 11% in 1995 to 14% on average in 2000, while that from cropping and forestry declined. While the average net incomes of livestock households was less than that of cropping or non-farm households, examination of the data over the 10-year period indicated no obvious trend in these ratios.

Table 2. Livestock Households: Average Outputs and Inputs

Item	1995	2000	2005
Real net income (Yuan)	9,954	8,857	13,039
Real net livestock income (Yuan)	1,115	1,235	1,788
Outputs (kg):			
Pork	145.6	171.8	352.3
Beef & mutton	11.3	12.8	52.5
Poultry meat	59.6	137.7	251.2
Eggs	34.6	100.7	179.1
Milk	35.9	66.2	228.0
Aquatic products	71.3	146.2	218.4
Inputs:			
Total arable land at start of year (mu)	8.5	8.8	8.6
Labour input to livestock (days)	116.9	115.3	113.3
Total grain for feeds (kg)	453.1	610.3	860.9
Share of labour allocated to livestock	0.24	0.25	0.31

Households raising livestock have on average substantially increased their production volumes of meats, milk and aquatic products over the 10 year period (Table 2). The largest proportionate increases are for milk, poultry products and beef/sheep meat. These production gains were achieved with very little change in land inputs, and average labour inputs to livestock production actually fell over time. What has increased is the use of grain in animal feeds, suggesting improvements in the quality of feedstuffs used in livestock raising. Table 2 has insufficient information to make definite statements about productivity gains, but we note that the proportionate increase in grain use over time is smaller than the output increases for all livestock products.

Despite the substantial output increase achieved from 1995 to 2000, average real household income from livestock products increased somewhat less (Table 2). A contributing factor will have been the over-supply problems and price corrections that occurred in virtually all livestock industries in China during the 1990s (Waldron et al. 2003). Such problems occurred in the egg industry in 1996-97, the pork industry in

1999-2000, and the beef industry experienced a sharp market correction in 1996-97. These market developments encourage industry rationalisation, and in the beef industry hundreds of thousands of households left the industry in the late 1990s. Specialised households responded more to the market corrections than did the more diversified households (Longworth et al. 2001). Such nominal price movements are reflected in our data (Figure 3), where national average producer prices are obtained by dividing gross revenue by output for each product. Since 2000 nominal average pork prices have recovered but beef prices have fallen steadily since 2002.

Our sample of livestock households includes both backyard producers and specialised livestock producers. By dividing the livestock household sample into quartiles based on their real net income from livestock, we attempt a separation of these two broad household groups. Results for income and income shares are in Tables 3a and 3b. In terms of the level of livestock net income and its contribution to total household income, there is obviously a long tail of diversified households (quartiles 1 to 3) that derive less than 10% of their income from livestock activities. Further, the gap between the livestock net income of the top and bottom quartiles has widened over time – from yuan 3,894 in 1995 to yuan 7,454 in 2005. This is consistent with others' findings that livestock has been a contributing factor to widening income inequality in rural Chinese households. In each of the first three quartiles, the contribution of non-livestock farming to household income is smaller in 2005 than ten years earlier, whereas the contribution of wages is considerably higher. These households are, on average, therefore diversifying away from farming to non-farm activities for their incomes. In the top quartile households, livestock contributes more to total income in 2005 than it did in1995 at the expense of other types of farming, but the contribution of wage income has also increased over this time period.

Table 3a. Livestock Households Real Income by Quartile: 1995

Item	Quartile 1	Quartile 2	Quartile 3	Quartile 4
Real net income (Yuan)	8,748	8,656	9,179	13,229
Real net income from livestock (Yuan)	-319	354	857	3575
Share of household net income from:				
Livestock & fisheries	-0.04	0.04	0.09	0.27
Other farming & forestry	0.51	0.45	0.46	0.34
Non-farm business	0.22	0.24	0.22	0.20

Wages	0.26	0.23	0.20	0.16

Note: Quartiles defined on real net livestock income

Table 3b. Livestock Households Real Income by Quartile: 2005

Item	Quartile 1	Quartile 2	Quartile 3	Quartile 4
Real net income (Yuan)	10,291	11,118	12,279	18,466
Real net income from livestock (Yuan)	-801	367	935	6653
Share of household net income from:				
Livestock & fisheries	-0.08	0.03	0.08	0.36
Other farming & forestry	0.38	0.36	0.37	0.25
Non-farm business	0.18	0.14	0.14	0.10
Wages	0.43	0.38	0.35	0.22

Note: Quartiles defined on real net livestock income

Production of all livestock products, with the possible exception of pork, is very much concentrated in the top quartile households, and especially so for fisheries products, milk and poultry products (Tables 4a and 4b). This phenomenon is also more noticeable in 2005, where the gap between average output in the top quartile and bottom quartile households has widened considerably compared with ten years earlier. So in terms of livestock production within our sample, there has been an increasing concentration of production in the top quartile households. With poultry meat production for example, the top quartile of households in 1995 accounted for 86% of the sample's total poultry production, and by 2005 this share had risen to 94%. While all quartiles increased their average use of grains for livestock feed, the increase from 1995 is much larger for the top quartile. The lower quartiles would include many smallholders who raise crops as well as livestock, and who are able to use own-produced crop residues and by-products as feedstuffs (Bingsheng; Zhang and Somwaru 2004)

Table 4a. Average Outputs (kg) and Inputs: Livestock Households by Quartile: 1995

	Quartile			
Item	1	2	3	4
Output of Pork	45.3	91.0	148.3	298.4
Output of Beef and mutton	5.4	4.3	8.1	27.5

Output of Poultry meats	11.3	9.5	13.3	203.9
Output of Poultry eggs	11.2	10.6	12.9	103.8
Output of Milk	6.6	1.4	2.7	132.8
Output of Aquatic products	17.5	1.4	11.3	254.8
Total arable land operated at the beginning of the year (mu)	8.69	8.35	8.54	8.20
Labour-days used for animal husbandry	74.6	88.2	117.9	186.9
Total amount of grain used for feeds (kg)	330.1	304.0	365.4	812.3
Share of labour allocated to livestock	0.18	0.20	0.24	0.33

Quartiles based in net income from livestock

Table 4b. Average Outputs (kg) and Inputs: Livestock Households by Quartile: 2005

	Quartile			
Item	1	2	3	4
Output of Pork	145.3	138.7	246.4	878.7
Output of Beef	6.7	3.9	17.8	104.0
Output of mutton	4.3	7.2	15.0	51.3
Output of Poultry meats	22.3	13.3	20.3	948.6
Output of Poultry eggs	55.8	7.4	11.1	641.9
Output of Milk	49.8	3.7	9.5	848.9
Output of Aquatic products	75.2	3.1	19.1	775.9
Total arable land operated at the beginning of the year (mu)	8.9	8.5	8.2	8.7
Labour-days used for animal husbandry	73.6	73.3	100.4	206.0
Total amount of grain used for feeds (kg)	494.9	424.6	580.9	1,942.7
Share of labour allocated to livestock	0.23	0.22	0.28	0.46

Quartiles based in net income from livestock

What has happened to the geographical distribution[2] of livestock households in our sample over time? Figure 4 shows that the western region has become relatively more important; less than 30% of sample households were located there in 1995, but this increased to almost 45% in 2005. This has occurred primarily at the expense of the eastern region. Chen and Rozelle (2003) show that better labour markets in coastal areas increased the opportunity cost of labour and encouraged farm households to direct more family labour to the off-farm labour market. These changes may reflect a central and westward regional drift of livestock-raising households. Livestock households in the east earned higher net incomes and also higher incomes from livestock farming on average than those in other regions, in each year. In terms of

[2] Regions are defined as follows: East – Beijing , Tianjin, Shanghai, Hebei , Liaoning , Jiangsu , Zhejiang , Fujian, Shandong ,Guangdong , Hainan ; Central- Shanxi, Neimengu, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei, Hunan ; West - Guangxi , Sichuan, Guizhou, Yunnan, Xizang, Chongqing, Shaanxi ,Gansu, Qinghai, Ningxia, Xinjiang.

contributing to total net income, livestock became increasingly important in the East and by 2005 its income share was around double that in the Central and West where the share declined somewhat between 2000 and 2005. The income shares of other farming and non-farm business became less important over time in each region, but wages increased their share, especially in western households.

With regard to household average output volumes across regions (Table 6), those of poultry meats, eggs (with the exception of 2000) and aquatic products are greatest in eastern households. Milk output per household is highest in each year in Central households, where beef and mutton production was also highest in 2005. Pork production per household was greatest in the west in 1995 and 2000, but was overtaken by eastern households in 2005. At least within our sample there appears to be an increasing concentration of poultry product production in the east and central regions, of milk in the east and west, of pork in the west and east, of beef and sheepmeat in the central and western regions and of fisheries in the east. By 2005, livestock households in the east were feeding on average 1.15 tonnes of grain, compared with 0.95 and 0.64 tonnes in the Central and West regions respectively.

Table 5. Livestock Households: Real net income and income shares

Income share by source	East			Central			West		
	1995	2000	2005	1995	2000	2005	1995	2000	2005
Real net income (yuan)	13,006	12,187	17,824	8,600	7,651	11,842	8,394	7,361	11,511
Real livestock net income (yuan)	1,635	2,055	3,666	777	885	1,314	991	930	1,192
Livestock & fisheries (%)	0.13	0.17	0.21	0.09	0.12	0.11	0.12	0.13	0.10
Other farming & forestry (%)	0.31	0.24	0.26	0.53	0.42	0.40	0.50	0.38	0.33
Off-farm business (%)	0.27	0.21	0.16	0.17	0.15	0.11	0.20	0.16	0.13
Wages (%)	0.26	0.32	0.32	0.18	0.27	0.33	0.15	0.28	0.34
Other income (%)	0.04	0.06	0.06	0.03	0.04	0.06	0.04	0.06	0.10
Sample size	4939	3943	2464	5936	5247	3784	4501	4569	4754

Table 6. Livestock households: Outputs and Inputs by Region

Item	East			Central			West		
	1995	2000	2005	1995	2000	2005	1995	2000	2005
Output of Pork	134.8	175.8	597.5	140.8	157.8	269.8	164.0	184.6	290.8
Output of Beef and mutton	12.0	10.0	37.1	8.4	9.2	74.1	14.3	19.2	43.4
Output of Poultry meats	114.5	381.7	829.9	19.6	15.7	77.3	52.0	67.1	89.6
Output of Poultry eggs	43.9	95.6	424.8	40.7	166.5	189.5	16.5	29.7	43.4
Output of Milk	16.2	47.3	194.1	69.2	105.2	386.2	13.6	37.8	119.8
Output of Aquatic products	175.7	436.4	806.9	22.0	31.1	63.4	21.8	27.8	36.7
Total arable land operated at the beginning of the year	5.67	5.60	6.00	10.58	11.75	12.48	8.69	8.11	6.82
Labour-days used for livestock and aquaculture	107.3	113.1	134.1	103.2	100.0	97.5	145.5	134.6	115.2
Total amount of grain used for feeds	398.5	629.5	1152.2	443.9	663.1	951.0	525.2	533.0	638.1
Share of labour allocated to livestock	0.24	0.26	0.33	0.24	0.25	0.29	0.25	0.25	0.31

Specialisation in Livestock Production and Household Income

In this section we explore the contribution of livestock production to overall real net incomes of rural livestock households. Is increasing specialisation in livestock production associated with rising household incomes? Important determinants of income in such households are likely to include the household's endowment of land, labour and capital, the skill level of that labour, and regional and topography factors may also play a role. The ease with which family members can earn off-farm wages or establish non-farm businesses to contribute to overall income is influenced by the location of the household with respect to township and other urban regions, along with transport and communications infrastructure. To reflect the skill level of the household workforce, we measure the proportion of the family labourers who have no education and the proportions who have finished elementary school, junior high school or senior high school and above. We also use a variable that measures the proportion of household labourers who possess a professional or vocational qualification. Our measure of a household's location with respect to off-farm income opportunities recognises whether or not the household's village is located in a suburb of a city, large factory or mining area, or within a town where township government offices are located, all of which may provide villagers with more opportunities for off-farm work.

We faced at least two choices in how we measured livestock production specialisation. Our preferred choice was the share of household income from livestock. Since the dependent variable is household income, this choice suggests a possible simultaneity problem as the income share variable may be correlated with the error term. To check this we conducted the test proposed by Gujarati (2003 pp. 754-755) which indicated rejection of no simultaneity problem. Therefore we used instead the share of the household's total labour days worked by its members that the household allocated to livestock or fisheries activities. A problem with this measure is that it does not take account of gains in labour productivity in livestock production, which the earlier descriptive analysis suggests are likely to be substantial. In an effort to control for this we introduce as a partial productivity indicator the real livestock net income per day worked on livestock.

The household real net income equation can be written:

$$\ln (y_i) = \alpha_0 + \alpha_1 \mathrm{LSLAB} + \alpha_2 \mathrm{LSLAB}^2$$

where $\alpha_0 = \beta_0 + \beta_1\mathrm{LND} + \beta_2\mathrm{LBR} + \beta_3\mathrm{K} + \beta_4\mathrm{LOC} + \beta_5\mathrm{SZ} + \Sigma_k\beta_{6k}\mathrm{ED}_k + \Sigma_k \beta_{7k}\mathrm{TOP}_k + \Sigma_k \beta_{8k}\mathrm{REG}_k + \beta_9\mathrm{LPP}$.

The variables are defined as:

y = real household net income

LSLAB = labour allocated to livestock husbandry as a share of total days of household labour

LND = household allocation of land (mu)

LBR = total household labor days worked per year (unit is hundreds of days)

K= total household fixed assets, in thousands of yuan

LOC = dummy with a value of one if the household's village is located in a suburb of a city, large factory or mining area, or within a town containing township government offices.

SZ = number of household members

ED = variables for the educational qualifications (illiteracy is the omitted characteristic)

TOP = dummies to represent plains, hilly or mountainous topography (plains is the omitted classification)

REG = dummies for the household's region with east being the omitted classification

LPP = partial productivity, defined as real livestock net income/labour days allocated to livestock husbandry.

We also explore whether the parameter α_1 is a function of the level of household fixed assets – e.g. when a household allocates less labour to livestock husbandry and more to some other activity, the consequent change in household net income may be influenced by the household's level of capital assets. The equation is quadratic in LSLAB to test whether or not the relationship is linear, and we also explored whether either LSLAB or $LSLAB^2$ interacted with the regional dummies. We also explored the specification of cross-products between region/education levels and location variables, as the impact of closeness to work opportunities may vary among regions or labour skills. The dependent variable is expressed in logarithmic form as the distribution of real household net income was approximately log normal. The equation is estimated by ordinary least squares using the White Hetero-skedasticity-consistent standard errors. We apply the model to the 1995 and 2005 datasets. Results are given in Table 7.

Nearly all estimated parameters in both the 1995 and 2005 models are significant, and often at better than the 1% level. For 2005, the linear and quadratic LSLAB terms are significant. The signs of these parameters suggest a U-shaped relationship between real household income per capita and household specialisation in livestock production. This implies that net household income increases as either end of our specialisation scale is approached. It is consistent with a view that specialist livestock households increase their incomes from further livestock specialisation, while those to whom livestock production is relatively unimportant can increase household incomes by diverting their resources away from animal husbandry. The significant interaction between $LSLAB^2$ and the East regional dummy suggests that the increase in income as livestock specialisation increases is greater in that region than elsewhere. The interaction between LSLAB and household assets is also significant in 2005 - the negative relationship between household income and the LSLAB term was somewhat more negative the higher the household's assets – that is, as livestock specialisation declined, net income increased at a faster rate the higher the household's asset holding. The situation is somewhat different in 1995 for the livestock specialisation variables. The linear term is not significant, but its interactions with both household assets and the East region dummy are significant. The quadratic term is significant, as is its interactions with the East and West regional dummies. This implies a U-shaped relationship between household income and livestock specialisation for the East region in 1995.

All other explanatory variables show the expected sign. Household income increases with the household's endowments of land, labour and capital assets, increases with livestock partial productivity, and is higher for households located in city suburbs or close to factories, mines or government offices (this effect was somewhat enhanced the higher the proportion of household members with a professional qualification, but was less important in the central region). Household incomes tended to be highest in the East and lowest in the West, and highest for those located on plains and lowest for those in mountainous areas. Increased human capital through education had a positive impact on household income, with the size of this effect increasing from the lowest to the highest qualification.

To learn more about the estimated relationship between household income and livestock specialisation, we predict household income at different levels of specialisation, holding all other variables at their means. We estimate separate relationships for the East, Central and West regions, where mean values of the fixed-effect variables were taken over those regional observations. Results are graphed in Figures 5-7. The median values of the LSLAB variable for the East households were 13.1% in 1995 and 14.8% in 2005. The medians in those years in the West region were 19.9% and 20.4% respectively. For the Central regions they were 16.8% in each year. The maximum values in our sample were 100% in each year in these regions.

Therefore the majority of households tended to be grouped towards the left end of the curves.

Table 7. Regression results for the household net income function

Variable	1995		2005	
	Coefficient	t-value	Coefficient	t-value
Land	0.002	5.14	0.003	5.51
Total labour	0.049	25.80	0.019	2.46
Fixed assets	0.012	5.44	0.008	8.94
Household size	0.088	11.19	0.116	14.60
Location	0.109	8.64	0.033	1.92
Partial productivity	0.005	8.11	0.004	3.05
Region:				
Central	-0.299	-14.55	-0.144	-7.48
West	-0.515	-25.78	-0.289	-15.34
Education:				
Elementary	0.003	14.68	0.003	13.30
Junior high	0.004	18.95	0.004	18.49
At least senior high	0.005	15.44	0.006	13.04
Vocational qualification	0.002	5.12	0.002	5.24
Hilly topography	-0.099	-8.85	-0.023	-1.56
Mountainous topography	-0.343	-30.01	-0.190	-12.16
Location * central region	-0.069	-3.34	-0.096	-3.37
Location*Vocational qualification	0.001	2.57	0.002	2.80
LSLAB	..	..	-0.875	-7.38
$LSLAB^2$	-0.588	-4.81	0.674	4.78
LSLAB*Assets	-0.011	-3.11	-0.007	-6.21
LSLAB*East	-1.230	-9.54	..	..
$LSLAB^2$*East	2.187	10.04	0.296	2.44
$LSLAB^2$*West	0.541	3.53+	..	..
Intercept	8.251	222.49	8.534	195.26
Adjusted R^2	0.418		0.387	
F value	497.6		261.4	
Sample size	14,562		8,305	

The U-shapes are most pronounced in the East (Figure 5), especially in 1995. For households with less than about 40% of their total labour allocated to livestock rearing (50% in 2005), that is for much of our sample, predicted real net income per household increased as specialisation in livestock decreased. For the much smaller number of households with specialisations above these values, the reverse applied. Therefore our model predicts that as East households increase their specialisation above these levels, and indeed in doing so may become what are known as 'specialist households', their real household incomes increase and can equal those of livestock households that earn the bulk of their income from non-livestock or non-farm sources. While they are not broken down by region, Tables 3 and 4 clearly show that the top quartile livestock households earn on average much higher incomes than other quartiles, and their allocation of labour to livestock production is also substantially higher. We also argued earlier that while livestock households tended to be moving away from the East region, those remaining in the East tended to be considerably larger in terms of livestock specialisation and output.

For the other regions the U-shape is only discernable for 2005 (Figures 6 and 7). In the earlier year, the model predicts declining household income with increasing livestock specialisation in the Central region, and a level of household income that is hardly affected by varying levels of specialisation in the West. In both these regions for 2005, and for the Central region in 1995, we estimate household income at higher levels of livestock specialisation to be lower than those of households that are less specialised.

Specialist livestock households in the East can be expected to earn similar or higher household incomes than less specialised livestock households in that region – why does a similar situation not apply in the other regions? We have attempted to control for household endowments of land, labour and capital, and labour productivity, and this will help explain vertical differences among the regional relationships for any given year and value of LSLABPST. But why do East livestock households increase their incomes when they approach high levels of livestock specialisation, but those elsewhere do not? It may be that the Eastern specialist producers are on average operating on a much higher scale than elsewhere, and these scale economy effects are boosting marginal net income gains. In other words, Eastern specialist producers may have reached a scale that resulted in comparable household income to that earned by households that are much less reliant on livestock farming for their incomes. The larger scale of livestock production (on average) in the East could also encourage the participation of specialist producers in supply chain developments that result in higher quality outputs and higher prices paid to producers.

Factors that influence household decisions to remain in or exit from livestock production

In this section we address the question of which factors tend to be associated with those households that decided to exit the livestock industry between 1995 and 2005, and how their characteristics differed from those of the households that remained in livestock production. A total of 15,233 households in the RCRE 2005 sample survey were also included in the 1995 survey. For these households, we trace their movement between five classes over the intervening 10-year period (Table 8). We have four classes of livestock households, one of which is those that earned a negative net income from this activity. For the remaining households involved in livestock farming, we recognise households' livestock income distribution by grouping them into three classes defined by the household livestock net income relative to the mean livestock net income plus or minus one standard deviation, with livestock income measured as its natural logarithm. The fifth class comprises rural households that did not earn any income from livestock.

Table 8. Movement of households among classes: 1995 to 2005.

Class 1995\Class 2005	A	B	C	D	E	Total households in 1995
A	2,597	76	80	329	104	3,186
B	861	186	132	639	73	1,891
C	849	82	108	368	43	1,450
D	2,645	594	632	3,216	371	7,458
E	368	76	54	470	280	1,248
Total households in 2005	7,320	1,014	1,006	5,022	871	15,233

Definition of household classes:
A: No livestock farmed
B: Household earned negative net income from livestock
C: Logarithm of household livestock net income (LLNI)< mean LLNI less one standard deviation.
D: LLNI within range of mean LLNI +/- one standard deviation.
E: LLNI > mean LLNI plus one standard deviation.

Looking first at the final row and column of Table 8, a total of 3,186 households in this sample did not farm livestock in 1995, and this number had increased to 7,320 households by 2005. In other words, a net additional 4,134 households took the decision to give up livestock raising some time after 1995 and before 2005. The first table row shows that a total of 589 households that did not raise livestock in 1995, were pursuing this activity by 2005. The first data column shows that 4,723 households were not raising livestock in 2005, but had been ten years earlier. The difference between these two numbers is the net exit of 4,134 households. Of the 4,723 exiting households, 3,862 were making a positive net income from livestock in 1995, most of them within the range of plus or minus one standard deviation from the mean log of livestock net income. In 1995 there were 3,341 households which either made a loss from livestock (class B) or earned an income from livestock that was below one standard deviation below the mean (class C). Over half of these households had given up livestock raising by 2005, but a third were farming livestock profitably and in income classes D or E. For households whose livestock income fell in the higher classes D or E in 1995, the attrition rate was somewhat less, but nevertheless 35% of these households were not farming livestock in 2005. Finally of those households who earned income from livestock in either classes D or E in 1995, one half were still earning incomes in those classes ten years later.

How do the exiting households differ from those that remained in the livestock sector? Mean values of some household characteristics are shown in Table 9. A number of differences are apparent. Exiting households had higher net household incomes on average in 1995, livestock income was relatively and absolutely less important, they had access to a smaller area of land and a smaller household labour force. Exiting households had on average a higher proportion of household members with at least a junior high school education and a smaller proportion of illiterate members. Households that left the livestock sector tended to be concentrated in the East and Central regions, whereas those remaining in livestock production tended to be located in the Central and West regions. Social networks, or guanxi, have been shown to play an important role in increasing an individual's probability of securing non-farm employment (Zhang and Li 2003). These networks can improve relevant information flows through knowledgeable family members or relatives who might for example already be in non-farm employment outside the village, or they may improve the likelihood of off-farm employment where a family member is a local official (cadre). Table 9 shows that the proportion of households with at least one family member working in state or local offices is almost twice as high for the exiting households than for the remainder, and the proportion of households with family members who are township or village cadres is somewhat higher for the exiting households. Not surprisingly, households that were classified as fulltime or mainly farming businesses in 1995 tended to remain in livestock production compared with those classified in 1995 as mainly non-farming businesses.

We use a logit regression model to test the significance of such variables in explaining household exit decisions. The dependent variable takes the value of unity for households which raised livestock in both 1995 and 2005, and a value of zero for the exiting households.[3] We removed from the sample those households that *entered* livestock production after 1995. Results are given in Table 10. A positive coefficient means that a marginal increase in the value of the variable will increase the probability that a household remains in livestock production. Most of the explanatory variables are significant, and are of the expected sign.

The higher the household net income in 1995 the lower the probability that the household will be raising livestock in 2005, and that probability will also be lower the lower the share of livestock income in overall net income. The higher the share of total household labour allocated to livestock, the higher will be the probability that the household will remain in animal production. Therefore specialist livestock households (those that earn a high share of their income from that enterprise and allocate much of their available labour to animal husbandry) are less likely to have left the livestock sector since 1995. The larger the household size, and the larger is the household's endowments of land, labour and (less significantly) capital, the higher the probability that those households will remain in livestock production. However, the higher the proportion of household labourers with at least a senior high school qualification, the higher the probability that the household will cease to raise livestock.

Livestock households are more likely to have left the industry by 2005 if they are located in the East region (where there is most scope for off-farm employment), on plain topography or if the household is located in a city suburb or near a large factory or mine – factors that would also increase the availability of off-farm work. The two guanxi variables have the expected sign (increased participation in the relevant social networks increase the probability of exit) but only that associated with household members working for government or state-owned businesses is significant.

[3] Remember that exit means ceasing to earn income from livestock – the household could, however, continue in other forms of farm production.

Table 9. Some characteristics of households remaining in or exiting livestock production: 1995 averages

Item	Farmed livestock in 1995 & 2005	Farmed livestock in 1995 but NOT in 2005
Net household real income (yuan)	9,284	11,055
Net real income from livestock (yuan)	1247	847
Livestock net income as % total net income	12.9	7.5
Arable land area (mu)	9.7	7.5
Total labour days	634	587
Regional distribution (% of sample):		
East	26.1	43.4
Central	36.6	42.1
West	37.3	14.6
Education of main labourer in household (% of sample):		
Primary or illiterate	56.2	50.3
Junior high or above	43.7	49.4
Education of household labourers:		
% illiterate (no completed education)	19.6	15.0
% with senior high diploma or professional training	9.5	11.9
Type of family business(% of sample):		
Fulltime farming	46.4	38.4
Mainly farming	44.3	42.8
Mainly non-farming	8.0	15.9
Family has members employed by government or state-owned businesses (% of sample)	3.8	6.3
Family has members of township or village cadres (% of sample)	5.1	5.8

Table 10. Logit Regression results

Variable	Coefficient	z-value
Land (mu)	0.025	10.51
Total labour (days)	0.0004	6.07
Fixed assets (yuan)	1.41E-06	0.80
Household size	0.031	2.04
Location[a]	-0.226	-3.97
East region	-0.207	-4.30
West region	1.037	18.54
% labourers who are illiterate	0.004	4.82
% labourers with at least senior high education	-0.002	-2.02
Plain topography	-0.674	-13.72
Mountainous topography	0.257	4.51
Net household income (yuan)	-9.32E-06	-3.46
Share of livestock in net household income	1.395	10.05
Family business dummy	-0.420	-6.33
Guanxi dummy A	-0.423	-4.46
Guanxi dummy B	-0.048	-0.54
LSLAB	0.009	5.55
Intercept	-0.269	-3.121
McFadden R^2	0.114	

a. This differs from the location variable of Table 7, and has a value of unity if the household is located in a city suburb or close to a large factory or mine.

b. Family business dummy =1 if household completely or mainly engaged in farming.

c. Guanxi dummy A =1 if household has members employed in state/government.

d. Guanxi dummy B =1 if household has members as township or village cadres.

Sample size = 11,990 (4,695 with dependent variable =0; 7,295 with dependent variable =1)

Summary

The household sector remains the dominant supplier to China's rapidly growing livestock markets. Many of these livestock-producing households are part-time farmers, and are diversifying into non-farm activities, while others are becoming more specialised in livestock production. Households that raise livestock are becoming proportionately more prevalent in the West (at least within our sample) but production has not necessarily followed this trend, with poultry meat and egg production becoming increasingly concentrated in the East. Dividing the sample livestock households into quartiles on the basis of their net income from livestock reveals a long tail of households which earn less than 10% of total income from livestock production and a trend away from livestock production over the sample period, and an increasing concentration of within-sample production in the top-quartile households. Further, the gaps between top and bottom quartiles in terms of livestock and total household real incomes, and livestock output, widened over the 1995-2005 sample period.

Our econometric results predict U-shaped relationships between household net income and specialisation in livestock production in 2005, most obviously in the East. For the majority of our sample of livestock households, therefore, we predict that household income will rise as households diversify into other income-earning activities. Households with higher net incomes and lower contributions from livestock were also shown to be more likely to exit livestock production altogether. In the East, higher household incomes are predicted as livestock specialisation increases above a level that was well in excess of the sample median level of specialisation. Our research does not extend to explaining this finding, but economies of scale and access to modern supply chains that scale engenders may be part of the reason. A question for further research is why this relationship in the East does not apply to households in the Central and West regions (although the gradual establishment of supermarkets and their supply chains in other parts of the country may help), and if higher household incomes accompanying higher livestock specialisation is considered economically or socially desirable in these regions, what policy interventions might be appropriate?

Many of the above findings relate to the mean or expected situation. Another policy concern might be the prospects for those households whose incomes remain low despite attempts to increase their livestock specialisation, or which for whatever reason are unable to increase production, or which do no have the human capital skills and locational and guanxi advantages that were shown to encourage diversification out of livestock production and the prospect of higher living standards. The current structural trend of exit from livestock production along with greater specialisation within remaining households need not be a socially undesirable outcome (although increased concentration of livestock production may produce adverse environmental consequences to be addressed), but there will always exist those households that for whatever reason are unable to benefit from the structural changes, and for whom further policy initiatives may be desirable.

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Figure 1. Composition of Rural Household Sample

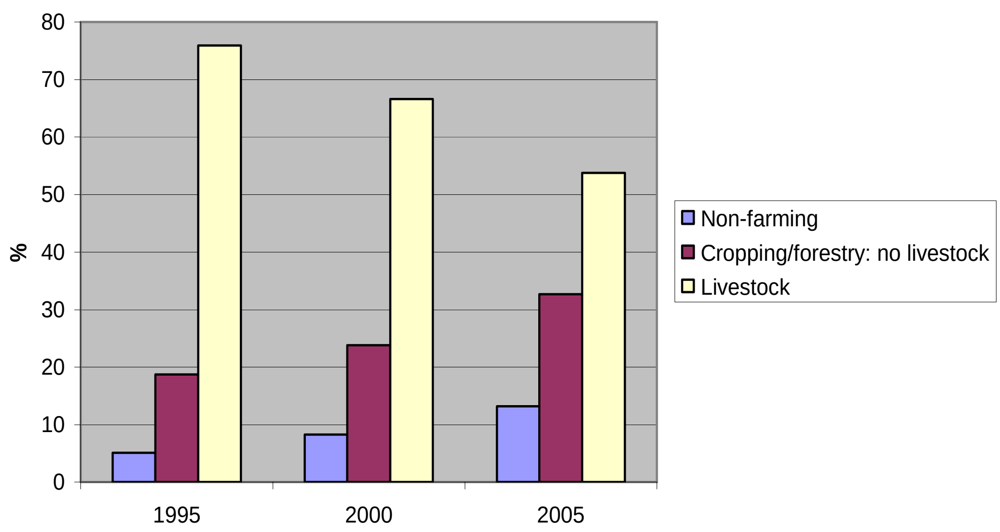
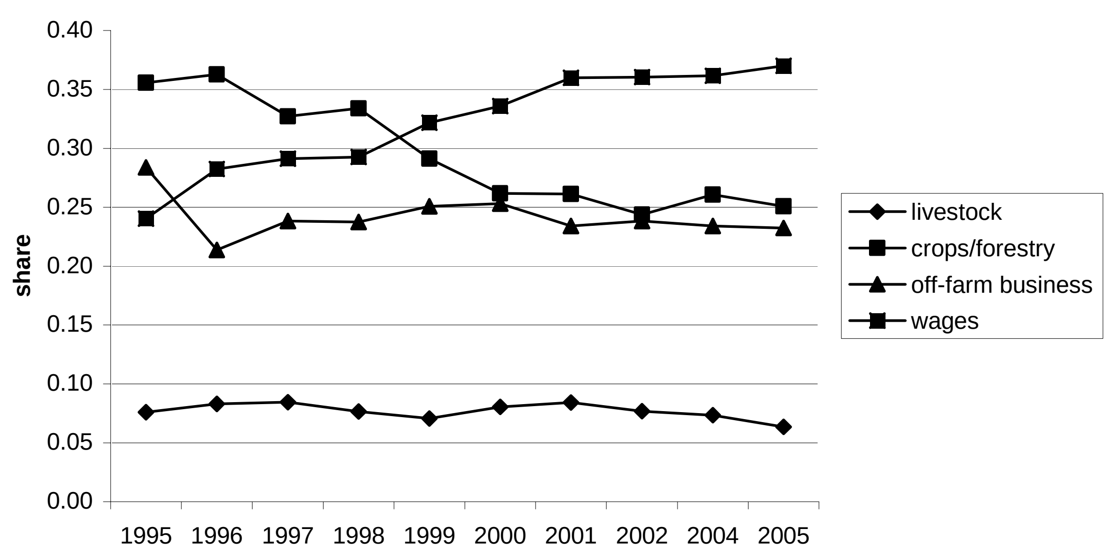


Figure 2. Rural households: Composition of real net income



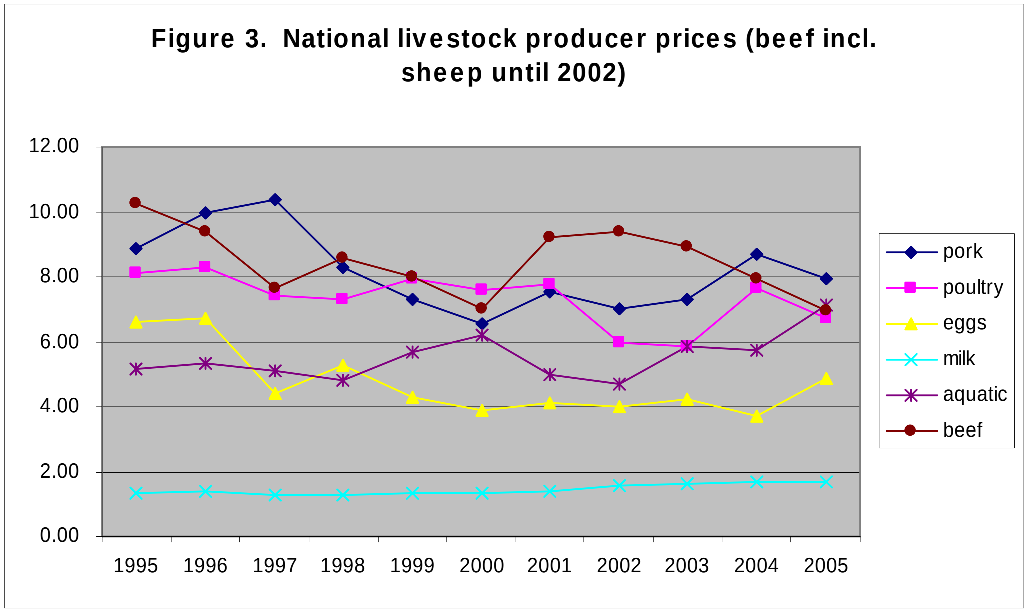


Figure 3. National livestock producer prices (beef incl. sheep until 2002)
12.00
10.00
8.00
6.00
4.00
2.00
0.00
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
pork
poultry
eggs
milk
aquatic
beef

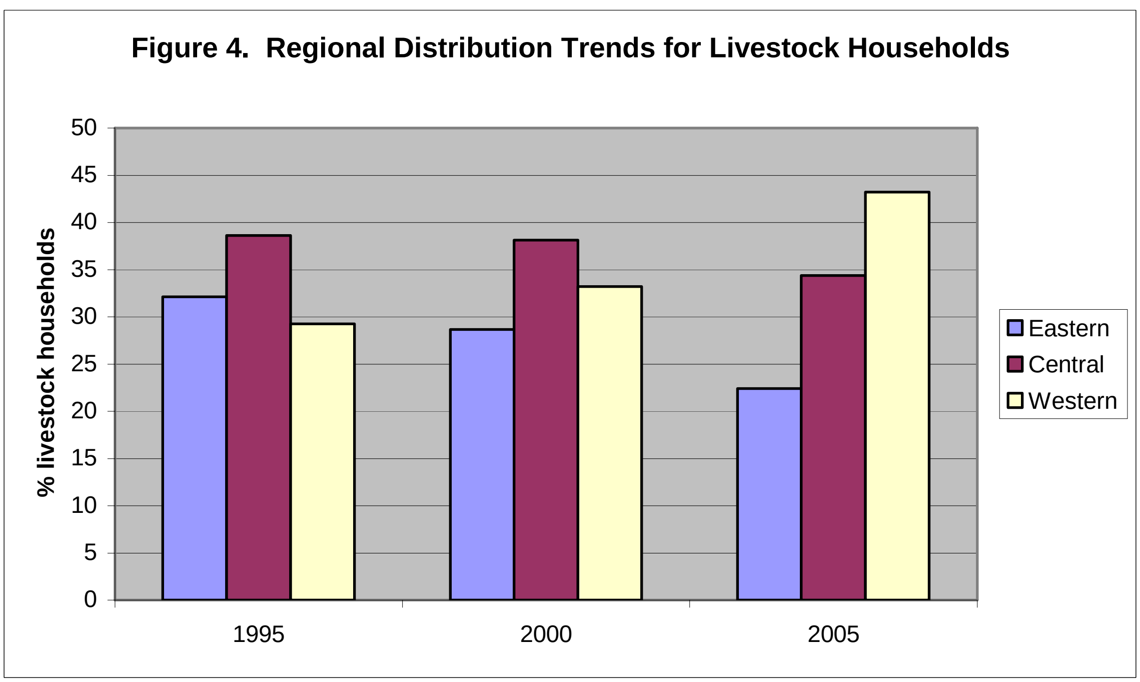


Figure 4. Regional Distribution Trends for Livestock Households
% livestock households
50
45
40
35
30
25
20
15
10
5
0
1995
2000
2005
Eastern
Central
Western

Figure 5. Predicted income versus livestock specialisation: East region

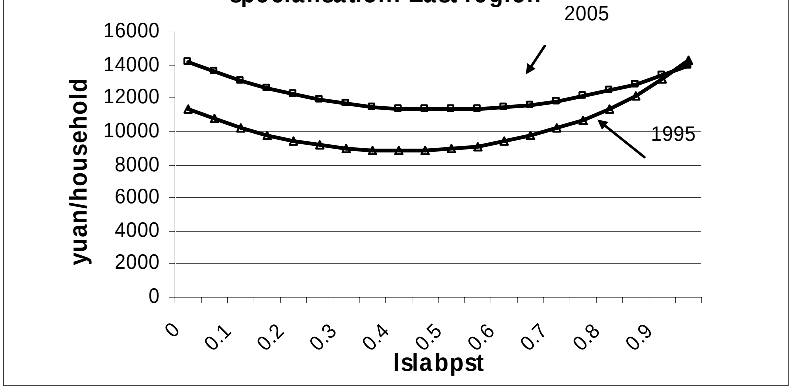


Figure 6. Predicted income versus livestock specialisation: West region

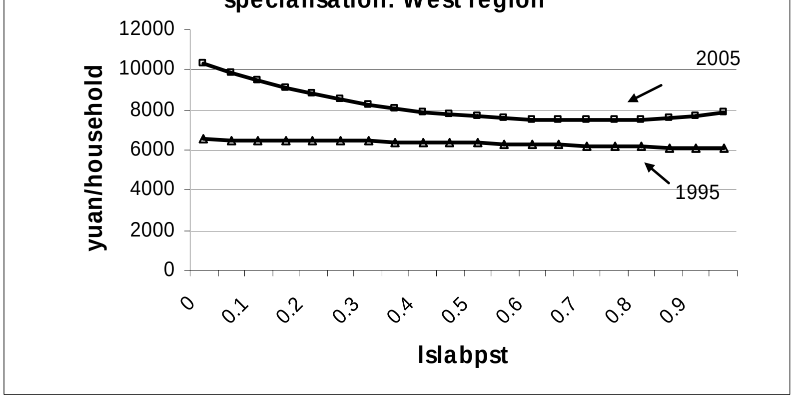


Figure 7. Predicted income versus livestock specialisation: Central region