Received 9 August 2016
Revised 17 November 2016
23 February 2017
Accepted 14 March 2017

# The interplay of production commercialisation and specialization

## An empirical study on Chinese smallholders

Lihua Li
*State Key Laboratory of Grassland Agro-ecosystems, Lanzhou University, Lanzhou, China and School of Science and Health, Western Sydney University, Penrith, Australia*
Maria Estela Varua
*DAP Economics, Finance & Property, School of Business, Western Sydney University, Sydney, Australia*
Adam M. Komarek
*International Food Policy Research Institute, Washington, District of Columbia, USA*
Sriram Shankar
*Centre for Social Research and Methods, College of Arts and Social Sciences, Australia National University, Canberra, Australia, and*
William D. Bellotti
*School of Science and Health, Western Sydney University, Penrith, Australia*

**Abstract**

**Purpose** – The purpose of this paper is to explore the endogenous relationship between production specialisation and market commercialisation with an empirical study of farmers in Northwest China.
**Design/methodology/approach** – The three-stage least squares were used to address simultaneity and over-identification problems in comparison with two-stage least squares (2SLS). The Durbin-Wu-Hausman test was employed to identify the endogeneity of the commercialisation and specialisation variables. The validity, relevance, and strength of the instruments were tested using the Stock-Yogo weak instrument diagnostics test.
**Findings** – A two-way interrelationship between specialisation and commercialisation were confirmed, and suggest that farmers' decisions on farm commercialisation and production specialisation are actually separate and interacting.
**Social implications** – By demonstrating that a virtuous cycle exists between agricultural commercialisation and on-farm specialisation, policies can be formulated to complement these two effects that may help increase small holders' income. Farmers' market participation can be indirectly improved by combining market improvement and risk management tools to encourage production specialisation.
**Originality/value** – The insights of this study cast further light onto the farm market participation theory by emphasising that higher asset endowments enable small farmers to specialise in production with comparative advantage.

**Keywords** China, Commercialisation, Smallholders, Specialisation, Interplay
**Paper type** Research paper

## 1. Introduction

After decades of rapid growth in agriculture, together with technological change and market liberalisation, China's agricultural sector is now in a stage of diversifying in high-value horticulture and livestock in response to growing domestic and international demand

This study is funded by the Australian Centre of International Agricultural Research (ACIAR) John Allwright Fellowship. The authors declare that they have no conflict of interest.

China Agricultural Economic Review
Vol. 9 No. 4, 2017
pp. 504-521

1756-137X
DOI 10.1108/CAER-08-2016-0122

(World Bank, 2007; Huang *et al.*, 2004). From the production perspective, agricultural diversification is viewed as a transformation of food production from subsistence to commercial systems, a course of agricultural sector diversification and commercialisation accompanied by farm-level production specialisation (Pingali, 1997; Timmer, 1997). This process involves integrating output into markets, substituting traded inputs for non-traded inputs, and shifting mixed production to monoculture farming to capture economies of scale (Pingali and Rosegrant, 1995; Chavas, 2008).

Although China has experienced rapid growth and deep structural change, the gap between agriculture's share of both GDP and employment remains substantial (around 10 vs 35 percent in 2013). This share differential indicates a remarkable income inequality between China's rural and urban populations, showing that marginalisation of the rural economy is worsening. In the less-favoured regions, where farmers face higher level risks in adapting to difficult agro-climatic conditions and inadequate infrastructure, options for diversifying subsistent production into high-value cash crops and livestock can be constrained. Together with the imperfect land and labour markets, those farmers are further disadvantaged in being too small (0.078 hectares per person, World Bank, 2012), probably not profitable, and less competitive when they get their products to market.

The recommended strategy to reduce the disparities and to promote inclusive growth and development is to facilitate smallholders' transformation from subsistence to more specialised and market-oriented systems (World Bank, 2007). This policy recommendation might be widely accepted, limited research guidance, however, is available for policy making on smallholder market participation, especially from the perspective of structural change of farm production specialisation.

The purpose of this study is to examine smallholders' market participation in relation to farm specialisation. It is proposed that macro-level agricultural transformation is accompanied by farm specialisation, and that farm-level decisions on production specialisation/diversification are conditioned to the degree of market participation. An in-depth empirical study of the relationship between China's small farmers' market participation and production specialisation explores factors which may determine how specialisation and productivity growth can raise household incomes through greater market participation. The findings of this research will advance our understanding of issues pertaining to the structural change from subsistence to the more specialised and market-oriented systems, and provide policy guidance on promoting smallholders' market participation.

## 2. Theoretical foundations

Understanding the process of agricultural diversification and commercialisation has been a focus of interest in the structural change literature. Timmer (1997) suggests that the macro-level agricultural diversification and commercialisation is normally accompanied by production specialisation at the micro-level, and von Braun (1995, p. 187) emphasises that "Specialisation and commercialisation of farming households within a more diversified economy is part of the development process". This trend of macro-level diversification and micro-level specialisation during agricultural transformation has been witnessed in many developing countries, including South Korea, Thailand, Kenya, and Nigeria (World Bank, 1990; Kim *et al.*, 2012; Huang *et al.*, 2004; Timmer, 1997; Pingali, 1997; Udoh *et al.*, 2011; Dorsey, 1999).

The existing research has studied commercialisation and specialisation either as interchangeable concepts for market participation, or separately whereby one factor determines another. For example, Dorsey (1999) used commercialisation as an explanatory variable in determining the pattern and extent of specialisation. A few other studies treat specialisation as a factor affecting market participation (Gebreselassie and Ludi, 2007;

Gebreselassie and Sharp, 2008). Only a limited scope of research has suggested, yet explicitly demonstrated, the interaction between householders' market participation and production specialisation. For instance, Wickramasinghe and Weinberger (2013) stated that productivity changes stimulated by structural transformation from subsistence to specialised production enable greater commercialisation, while commercialisation encourages better use of comparatively advantaged resources (apparently production specialisation is one of the cases).

The idea that there is a two-way relationship between specialisation and commercialisation dates back to the classic Smithian account. It is noted that "the greatest improvements in the productive powers of labour…seem to have been the effects of the division of labour (Smith, A, 1776/1976, Book 1, Chapter1)", and "it is the power of exchanging that gives rise to the division of labour" (Book 1, Chapter 3). Young (1928) further explicitly states that division of labour depends on the extent of the market, but the extent of market also depends upon the extent of the division of labour.

Theoretically, the link between market and specialisation can be explained as: specialisation over tasks and products improves productivity, increases production and supply, and in turn stimulates market participation (Wickramasinghe and Weinberger, 2013; Emran and Shilpi, 2012). Meanwhile larger markets ensure adequate demand for large-scale production and higher profit for non-staple crops. Well-functioning markets reduce transaction costs and provide traded inputs and promote sales of farm products. The increasing opportunity costs of family labour, however, induce farmers to reduce farm activities and concentrate production on a few enterprises to increase profitability per unit (Timmer, 1997; von Braun, 1995; Pingali and Rosegrant, 1995).

At the farm level, the link between householders' market participation and specialisation of production can be explained by transaction cost economics theory within the agricultural household framework: as production specialises, unit costs of market participation such as transportation and communication decline, while organising production associated costs rise because the increasing volume and consistency for supply. In order to maximise household utility, farmers are assumed to makes optimal decisions on how much to produce, consume, buy and sell, subject to income constraint, production technology, resource constraints and non-tradable availability constraint (Wickramasinghe and Weinberger, 2013).

Smallholders in developing countries are typically both producer and consumer, and normally face missing or incomplete markets for inputs and output, including labour and capital. As a result, their decisions on production, resource especially labour allocation and consumption may be interdependent upon one another (Taylor and Adelman, 2002). This classic household-farm-model provides an explanatory framework for an interdependent relationship between smallholders' market participation and production specialisation.

## 3. Research methodology

### *3.1 The definition and measure of specialisation and commercialisation*

The concept of specialisation comes together with diversification. Farms are rarely completely specialised, therefore, specialisation is often a matter of degree relative to diversification. In more general terms, specialisation implies a limited scope of farm production. Farmers specialise in the products they produce, or in the processes performed to reduce the number of activities (Chavas, 2008). The Herfindahl index of product concentration was used to compute the farm level specialisation index:

$$S_i = \sum P_i^2 \tag{1}$$

$$P_i = A_i \Big/ \sum A_i \tag{2}$$

Where $A_i$ refers to the value of product $i$, $\Sigma A_i$ is the total value of crops. Therefore $p_i$ denotes the value share of product $i$, in total farm value. This specialisation index ranges from 0 to 1, with the value approaches 1 when specialisation is increasing, and approximates to zero as householder's production is getting diversified.

A total 14 categories of crops were included in the formulation: wheat, maize, forage, buckwheat, millet, beans, potato, rapeseed, fruits, vegetables, melons, seedlings, sunflower, Chinese herbs for different farms the number of crops produced varies. On average, farms were engaged in six different cropping activities across the study areas. Both the commercialisation and specialisation indices are a continuum rather than binary structures, therefore no absolute distinctions between "commercialised/specialised" and "non-commercialised/specialised" farms are defined in this study.

By the same token, the conception of farm level commercialisation is evaluated as the degree of participation in output markets[1]. Following von Braun *et al.* (1991), the commercialisation indices were calculated as:

$$C = \frac{Value\ of\ agricultural\ sales\ in\ markets}{Total\ agricultural\ production\ value} \tag{3}$$

The indices indicate percentage of crop production marketed by a household, implying total subsistence when the index value is zero, while a value approaching one indicating a higher degree of output market participation.

### *3.2 Study area*

The study areas are located in Qingyang Prefecture, Gansu Province, in the Northwest of China. Qingyang Prefecture is in eastern Gansu and accounts for approximately 10 per cent of the value of Gansu's agricultural production and farm employment (Brown *et al.*, 2009). Farming systems in this region are mainly integrated crop-livestock systems (Nolan *et al.*, 2008; Hou *et al.*, 2008). Farmers in the higher rainfall areas of the south predominately grow wheat and maize, where farmers in the more arid northern areas focus mainly on small ruminant livestock production (Nolan *et al.*, 2008). In the central part of the prefecture, mixed farming systems are more prevalent.

Table I shows the structural changes in Qingyang's agricultural sector between 1995 and 2010. Overall, agriculture is no longer the dominant source of income, as non-farm earnings have become increasingly important to household livelihoods. Like elsewhere in China, the relative importance of staple grain production has declined. Production of cash crops and livestock has become more prevalent, but these are also more volatile. Secondary data show that household income from farming decreased from about 66 per cent in 1995 to 40 per cent in 2010, with the exception of the increase in 2005 (Qingyang Yearbook, 1994-2011)[2].

Overall, the importance of wheat sown area and total output in Qingyang's production mix has declined. By contrast, the sown area of the major cash crop maize increased significantly from 56,000 to about 150,000 hectares between 2006 and 2010. This increase is mainly explained by the rise of maize prices (from 1.32 Yuan/kg in 2007 to 2.09 Yuan/kg in 2011, Gansu Yearbook, 2007-2011). Fruit, vegetable, and fishery production also recorded rapid growth over the same period. The decline in the grain production, together with the increase in the non-grain sector, indicates that the overall agricultural sector has been diversifying in this region.

| | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|
| *Farm income share* | | | | |
| Income from farm (%) | 66.37 | 40.78 | 61.00 | 39.51 |
| Wage-earning (%) | 12.43 | 30.32 | 22.85 | 37.52 |
| Other income (%) | 21.20 | 28.90 | 16.15 | 22.97 |
| *Production, sown area, and yield* | | | | |
| Wheat | | | | |
| Production (kt) | 173.39 | 170.50 | 376.00 | 342.40 |
| Area (kha) | 196.51 | 205.25 | 162.92 | 130.12 |
| Maize | | | | |
| Production (kt) | 142.40 | 159.00 | 294.10 | 604.60 |
| Area (kha) | 39.92 | 42.37 | 56.26 | 150.46 |
| *Other production* | | | | |
| Soybean (kt) | 67.9 | 51.5 | 91.1 | 83.3 |
| Oil crops (kt) | 307.6 | 415.8 | 874.9 | 1207.4 |
| Fruits (kt) | 2474.8 | 2016.5 | 2262.9 | 4764.1 |
| Meats (kt) | 760.1 | 472.28 | 671.6 | 596.2 |
| Fishery (kt) | 1.03 | 4.18 | 4.5 | 7.8 |
| Vegetables (kt) | 40.12 | 19.52 | 75.1 | 76.3 |

**Source:** Qingyang Yearbook (1994-2011)

**Table I.**
Farm income composition and growth of selected commodities in Qingyang, 1995-2010

### *3.3 Household survey*

To better understand household livelihoods among heterogeneous farmers, a household survey was conducted in December 2012 in three townships: Shishe, Quzi and Tianshui. These three locations were chosen because they represent different geography, farming conditions, and degree of market development (Table II).

A survey of 317 households was conducted across these three locations using a stratified random sampling. Three different townships of Shishe, Quzi and Tianshui were chosen to form the strata and within each stratum households were randomly selected.

The sampling frame involved several meetings with village leaders to establish rapport and gather information prior to survey implementation. With the help of village leaders, a list of households was developed within their village and households were randomly selected for interview from this list. The majority (98 per cent) of households on the list was available for interview. Most interviews occurred around lunchtime or in the evening to minimise disturbance to agricultural activities. Data were collected by interviewing household heads using a written survey and mostly refer to agricultural activities in the 2010-2011 cropping period, thus capturing one summer and one winter crop.

| Characteristic | Shishe | Quzi | Tianshui |
|---|---|---|---|
| Altitude (m) | 1,421 | 1,218 | 1,556 |
| Land type | Tableland | Terraces | Sloping land |
| Average temperature (°C) | 8.2 | 9.2 | 8 |
| Average annual rainfall (mm) | 550 | 480 | 300 |
| Soil type | Loam | Light loam | Sandy soil |
| Distance to Qingyang city centre (km) | 19 | 38 | 90 |
| Average annual income per capita Yuan (in 2012) | 5,390 | 3,946 | 3,705 |

**Notes:** Shishe is located in the Xifeng District. Quzi and Tianshui are located in Huanxian County
**Sources:** Xifeng Yearbook (2013), Huanxian Yearbook

**Table II.**
Environmental and geographical data for the three study areas

The survey was designed to capture differentiation among the three locations regarding agro-ecological potential and market access. A structured questionnaire was used to collect data on the biophysical and socioeconomic features, including crop production, input quantities, crop yields and prices, livestock feeding patterns and off-farm employment patterns.

Production conditions are comparatively favourable in Shishe because of relatively higher rainfall, fertile soil (loam), and closer distance to major markets. By contrast, Tianshui lacks agro-ecological and market potential, while Quzi is geographically and economically between the other two locations. These facts are thought to have impact on the levels of specialisation and commercialisation.

Table III summarises the farm characteristics of the surveyed farms in the three study areas. The results show that farms in Shishe have the lowest average land-labour ratios (0.11, compared to 0.17 and 0.68 for Quzi and Tianshui, respectively) and cropped areas (0.50, over 0.85 and 3.44 for Quzi and Tianshui, respectively). Shishe households are the least active in crop and livestock production, engaging in the smallest number of livestock and crop enterprises. However, farmland is more consolidated and divided into fewer plots in this district (number of plots are 2.8, 5.2, and 5.5 for Shishe, Quzi and Tianshui, respectively). Furthermore, Shishe incomes (on-farm, off-farm, and total income per capita) and yield for both grain (wheat) and cash crops are highest among the three locations. Although it is not statistically significant, Shishe farms tend to have relatively higher fertiliser input and hire more farm labour.

Quzi has both productive river valleys that are suitable for cropping production and terraced slopes for livestock grazing, perennial crops, and trees. Farmers in Quzi thus tend to integrate with crop-livestock production, and farm productivity is higher than in Tianshui.

By contrast, Tianshui farmers use more labour in farm activities with a relative focus on livestock production. Productivity in Tianshui is particularly low compared to the other two. For example, wheat yields were 1,126 kg/ha (compared with 4,341 kg/ha and 3,467 kg/ha in Shishe and Quzi, respectively), and its overall land productivity is only about a quarter of that for Shishe and Quzi (4,920 Yuan/ha, compared to 21,000 and 16,785 Yuan/ha, respectively).

| Items | Shishe ($N = 120$) | Quzi ($N = 94$) | Tianshui ($N = 103$) | $F$ statistic |
|---|---|---|---|---|
| Land-labour ratio (people/ha) | 0.11 (0.01) | 0.17 (0.12) | 0.68 (0.347) | 225.9** |
| Cultivated area (ha) | 0.50 (4.33) | 0.85 (9.6) | 3.44 (27.5) | 225.2** |
| Wheat yield (Kg/ha) | 4,341 (2,176) | 3,467 (1,905) | 1,126 (964) | 73.57** |
| Number of plots | 2.8 (1.6) | 5.2 (3.1) | 5.6 (3.4) | 35.8** |
| Number of livestock (type) | 0.25 (1.26) | 0.94 (2.23) | 1.35 (0.88) | 14.8** |
| Number of crops grown | 2.4 (2.13) | 2.7 (3.1) | 3.9 (2.74) | 57.194** |
| Off-farm income (Yuan) | 24,513 (24,706) | 16,701 (20,416) | 17,804 (23,938) | 3.648* |
| Total income (Yuan) | 46,525 (37,987) | 29,273 (23,343) | 30,228 (29,260) | 10.63** |
| Income per capita (Yuan/person) | 9,368 (7,166) | 5,810 (5,422) | 5,680 (5,306) | 13.143** |
| Migrants (persons) | 1.23 (1.18) | 0.93 (0.9) | 0.87 (0.77) | 4.4* |
| Total labour input (man-days/farm) | 169.6 (237) | 199.9 (135) | 258.4 (166) | 6.16** |
| Hired labour (man-days/farm) | 11.8 (114) | 3.0 (9.2) | 1.5 (9.2) | 0.49 |
| Machinery cost (Yuan/farm) | 504 (385) | 538 (499) | 249 (566) | 10.88** |
| Fertiliser applied (Yuan/farm) | 1,591 (1,877) | 1,327 (995) | 1,450 (974) | 0.95 |
| Land productivity (Yuan/ha) | 21,000 (2,025) | 16,785 (2,109) | 4,920 (754) | 10.91** |

**Notes:** 6.285 Yuan = 1 US$ at the survey time. Figures in parentheses are standard errors. *,**Significant at 1, 5 per cent, respectively

**Table III.** Farm characteristics of the surveyed farms in the three study areas

*3.4 The model*

The two-way causality between specialisation and commercialisation can be empirically analysed by using the following general equations:

$$C_i = f(S_i, X_{ci}) + \varepsilon_i \tag{4}$$

$$S_i = f(C_i, X_{si}) + \delta_i \tag{5}$$

Where $C_i$ is the crop commercialisation index and $S_i$ is the specialisation index for farm $i$. $X_c$ and $X_s$ are variables identified in the literature that influence/determine commercialisation and specialisation, respectively.

*3.4.1 Specification and variables affecting commercialisation.* Factors suggested by theoretical and empirical studies that facilitate or hinder farmers' decision on market participation include households' resource endowments, availability of new technologies, infrastructure and markets, cultural and social factors affecting consumption, and household characteristics (von Braun, 1995; Barrett, 2008; Goletti *et al.*, 2003a, b; Tipraqsa and Schreinemachers, 2009).

Thus, the specification for Equation (4) is expressed as:

$$C_i = \alpha_0 + \alpha_1 S_i + \alpha_2 Asset_i + \alpha_3 Land_i + \alpha_4 LP_i + \alpha_5 Market_i + \alpha_6 Tech_i + \alpha_7 Household_i + \varepsilon_i \tag{6}$$

The definition of variables is summarised in Table IV. Previous studies (von Braun, 1995; Barrett, 2008) indicate that a farmers' decision on commercialisation is strongly affected by resource endowments including land, labour, and capital. Labour is a key factor in restricting function of land, capital and technology (Ping, 2010). Specialising in cash crops not only reflects farmers' labour availability and attitude to risk, but also implies the increased labour productivity for capturing the gains from economics of scale (Govereh and Jayne, 2003). Therefore, labour productivity and Land-labour-ratio, instead of a general labour variable, are used in this study to explore their different efforts on commercialisation and specialisation. Labour productivity is an indicator of labour quality. As the central premise of specialising in commercial crops is to gain the highest returns labour and land (Timmer, 1997). In question (6), it is hypothesised that households with average higher labour productivity are likely to produce more farm surplus to participate in market. While land-labour-ratio measures labour quantity and indicates the relative scarcity of labour at the household level. It is therefore used in Equation (7) to capture households' labour availability to specialise their production. Holding other variables constant, it is hypothesised that farmers with higher land-labour ratios (meaning less labour availability for the same farm size) are more likely to specialise, rather than diversify their crops to save labour. Empirical research also shows households that have more land relative to family labour are likely to adopt a labour-saving cropping pattern such as specialisation (Heltberg and Tarp, 2002).

The variable asset is defined as any kind assets held by a household in value term, including building, agricultural and non-agricultural equipment, etc. Research suggests that households' assets, especially land and equipment affect households' participation in markets and how much to sell (Wickramasinghe and Weinberger, 2013). Accordingly, this study hypothesises that wealthier households with bigger land holding and higher average labour productivity have declining demand for subsistence production, and are more likely to sell their surplus into markets.

| Variables | Unit | Definition | Mean | SD | Min. | Max. |
|---|---|---|---|---|---|---|
| $S_i$ (specialisation index) | | | 0.6055 | 0.239 | 0 | 1 |
| $C_i$(commercialisation) index) | | | 0.232 | 0.3015 | 0 | 1 |
| Asset | Yuan* | Household's productive assets in value term | 55872.4 | 182,462 | 0 | 2.6e +06 |
| Land | Mu* | Arable land area under the Household contract Responsibility System (HCRS) | 23.86 | 2.38 | 0 | 143 |
| LLR (land-labour-ratio) | Mu/person | Arable land area/labour force | 0.503 | 2.38 | 0 | 34 |
| Land-productivity | Yuan/Mu | Market value of produce/planted area | 969.5 | 1802.56 | 0 | 188,850 |
| LP (Labour-productivity) | Yuan/ person | Gross value of farm products/labour input | 4411.2 | 6,160 | 0 | 62833.3 |
| Plot | No. | Number of plots the household's farm is divided | 4.48 | 3.007 | 0 | 28 |
| Tech (fertiliser) | Yuan | Proxy for technology, fertilizer applied (aggregate of quantity x price) | 1,491 | 1393.4 | 0 | 12,040 |
| Dummy-Shishe | | Location dummy. Shishe is closer to the central market, better production condition for cropping, compared to the base case Quzi | 0.376 | 0.486 | 0 | 1 |
| Dummy-Tianshui | | Location dummy. In Tianshui, both production condition and extent of market are less favored, compared with Quzi | 0.324 | 0.469 | 0 | 1 |
| Head gender | | Male = 0, female = 1 | 0.154 | 1.533 | 0 | 1 |
| Head schooling | Year | Years of schooling the household head attended | 5.66 | 3.104 | 0 | 14 |
| Farm experience | Year | Years of the head working on farm | 31.51 | 11.88 | 0 | 68 |

**Notes:** 1 Yuan≈0.156 AU$ in the surveyed year of 2011; 1 Mu = 0.066 ha

**Table IV.** Definition and descriptive statistics of the variables studied

The development level of technologies and markets, captured by Tech (fertiliser) and location dummy variables, respectively, are expected to affect households' decisions on commercialisation. Adoption of new production technologies can increase agricultural productivity because of the reduction of per unit costs. Households are therefore in a better position of net marketable surplus; this, in turn, affects their market participation choices. Besides, research has proven there are strong associations between households' market access and the level of commercialisation (von Braun, 1995; Barrett, 2008). Poor market and infrastructure conditions raise transaction costs that substantially hinder production and market participation decisions. In the current research, the market access is indicated by the two dummy variables of Dummy-Shishe and Dummy-Tianshui. Shishe is closer to the central market and has better biophysical potential and marketing options compared to Quzi. On the other hand, both production conditions and access to markets in Tianshui are less favoured compared with Quzi.

The vector Household is to capture the influence of household characteristics on commercialisation, including data on head gender, household head's schooling (years) and farm experience (years). Those households' characteristics are considered endogenous when related to decision-making regarding production, consumption, and resource allocation. For example, different gender and age groups have different preferences in income and time allocation, which may affect households' level of market participation.

*3.4.2 Specification and variables affecting specialisation.* Literature on farm specialisation emphasises that land holdings and land conditions, determine whether or not farmers specialise their production. Imperfect markets make specialised farms, especially those

smallholders in developing countries who are more dependent on purchased inputs and credit, to be more exposed to higher price variability and food insecurity (Govereh and Jayne, 2003). The price and food risks can be offset by relatively larger-scale specialised production with comparative advantage (Langemeier and Jones, 2000). Besides, the endowment and market efforts also affect farm specialisation.

Therefore, the Equation (5) is specified as follows:

$$S_i = \beta_0 + \beta_1 C_i + \beta_2 Asset_i + \beta_3 Land_i + \beta_4 LLR_i + \beta_5 Plot_i + \beta_6 Market_i + \beta_7 Household_i + \delta_i \quad (7)$$

*Plot* is an indicator of land consolidation/segmentation. Land consolidation may save labour and equipment during farm operations (Deininger *et al.*, 2013), while segmentation implies more labour input and is more likely to discourage farm specialisation (Brown and Kai, 1999; Mesfin *et al.*, 2011; Acharya *et al.*, 2011). Vectors Market and Household are defined as those used in Equation (6).

### *3.5 Estimation of the simultaneous-equations model*

The proposed two-way correlation between commercialisation and specialisation is implied by the hypothesis that households that sell more farm output have a higher specialisation level, and households with higher specialisation levels sell more farm output.

The simultaneity problem arises because the values of these two endogenous variables are jointly determined in a simultaneous-equations system. In this case, ordinary least squares (OLS) estimators would be inefficient and inconsistent (Lin and Shao, 2000). In addition, the application of the order condition to the simultaneous Equations (6) and (7) reveals that both equations are over-identified, implying that the simultaneous model as a whole is over-identified, which further suggests that the OLS method is not the appropriate method to use (Gujarati, 2008).

Both simultaneity and over-identification problems suggest that the methods to use are either the two-stage least squares (2SLS) or three-stage least squares (3SLS). It is more likely that some unconsidered factors influencing commercialisation could also affect specialisation, that is, the error terms $\varepsilon_i$ and $\delta_i$ may be correlated. If this is true, then the single equation estimation of 2SLS could also be inappropriate and inefficient. The system estimates made by 3SLS is supposed to produce more efficient estimates than 2SLS. This is because by using generalised least squares (GLS) methods, 3SLS entails simultaneous solution of all equations and incorporates the additional correction for heteroscedasticity to 2SLS. However, as a norm and as a comparison of some of the approaches, the three methods of OLS, 2SLS, and 3SLS are presented in this study.

In specifying the 2SLS and 3SLS estimators, it is critical to obtain valid instruments for the endogenous variables. The valid instruments should be relevant, uncorrelated with the error term and correctly excluded from the estimated equations (Rios *et al.*, 2009). The possible instruments in this study are land productivity and elderly (number of elderly people in the household). Literature on small farm commercialisation suggests that there is a strong association between households' farm productivity and market participation (Barrett, 2008). The rationale for choosing the variable elderly to serve as an instrument for crop specialisation is that most of the specialised farm production, such as orchard, tends to be run or supervised by elderly people with hired labour (Li *et al.*, 2013). Therefore, the availability of elderly family labour is assumed to be related to the specialisation decision, but not with other exogenous variables and the error term.

The validity, relevance, and strength of the two instruments identified, as well as the endogeneity of the commercialisation and specialisation variables, are tested using a serial

diagnostics approach. The results of the Sargan statistic for over-identifying restrictions, the Stock-Yogo weak instrument test, and the Durbin-Wu-Hausman test are reported as part of post estimation tests (Tables VI and VII). First, the endogeneity of commercialisation and specialisation is confirmed by the Durbin-Wu-Hausman test (both $P < 0.01$), showing an instrumental-variables estimator is necessary. Second, in the first-stage 2SLS regression, the statistically significant coefficients of land-productivity on commercialisation ($\gamma = 0.00003$, $P < 0.01$) and elderly on specialisation ($\lambda = -0.03$, $P < 0.001$) have reasonable explanatory power over the relevance of those two instruments (second section of Tables VI and VII). Third, the validity of the instruments is confirmed by the over-identification tests: the *J*-statistics is 0.86 ($p = 0.64$) in the commercialisation regression and *J*-statistics of 1.104 ($p = 0.5769$) in the specialisation regression. This result indicates that the error terms are uncorrelated with the instruments, implying the validity of the instruments. Fifth, land-productivity and elderly are verified to be reasonably strong instruments, as the *F* statistic for the joint significance of the instruments excluded from the structural model are 38.49 and 15.94, respectively, which are much larger than the rule of thumb value of 10. The strength of the instruments can be further verified by the reported minimum eigen value statistics exceeding the Stock-Yogo critical values for 10 per cent maximal size and 5 per cent maximal bias.

The descriptive statistics of the variables included in this study and the corresponding correlation matrix of the variables are shown in Tables IV and V.

All the correlation coefficients are smaller than 0.5, and suggest that the individual coefficient estimates of the remaining exogenous variables are not affected by the multicollinearity problem[3].

## 4. Results and discussion

The estimation results using the OLS, 2SLS and 3SLS methods are summarised in Tables VI and VII.

Compared to 2SLS and 3SLS techniques, the OLS estimation yields either insignificance correlation between the hypothesised specialisation and commercialisation, or signs that are contrary to what is expected for control variables such as Land, Head-schooling, Dummy-Shishe and Head-gender. These unexpected signs and less significance of coefficients may be attributed to the simultaneous-equation bias, indicating the inappropriateness of the OLS method in the system equations.

| | CI | SI | Asset | Land | LLR | LDP | LP | Plot | Tech | DS | DT | HG | HS | FE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CI | 1.0 | | | | | | | | | | | | | |
| SI | 0.14 | 1.0 | | | | | | | | | | | | |
| Asset | −0.053 | 0.058 | 1.0 | | | | | | | | | | | |
| Land | −0.14 | −0.41 | −0.01 | 1.0 | | | | | | | | | | |
| LLR | −0.02 | 0.08 | −0.019 | 0.052 | 1.0 | | | | | | | | | |
| LDP | 0.38 | 0.23 | 0.13 | −0.22 | −0.07 | 1.0 | | | | | | | | |
| LP | 0.34 | 0.075 | 0.18 | 0.08 | 0.76 | 0.76 | 1.0 | | | | | | | |
| Plot | −0.08 | −0.40 | 0.087 | 0.42 | −0.04 | −0.023 | 0.21 | 1.0 | | | | | | |
| Tech | 0.39 | 0.01 | 0.018 | 0.13 | −0.06 | 0.28 | 0.45 | 0.28 | 1.0 | | | | | |
| DS | 0.21 | 0.30 | 0.02 | −0.48 | 0.036 | 0.18 | −0.004 | −0.43 | 0.07 | 1.0 | | | | |
| DT | −0.215 | −0.36 | 0.03 | 0.76 | 0.05 | −0.25 | −0.03 | 0.28 | −0.001 | −0.54 | 1.0 | | | |
| HG | 0.043 | −0.04 | −0.01 | 0.21 | 0.024 | −0.02 | −0.024 | 0.07 | −0.02 | −0.04 | 0.09 | 1.0 | | |
| HS | 0.027 | −0.02 | −0.012 | −0.12 | −0.04 | 0.07 | 0.079 | 0.005 | 0.05 | 0.19 | −0.15 | −0.09 | 1.0 | |
| FE | 0.13 | 0.06 | −0.029 | −0.13 | −0.009 | 0.10 | 0.1006 | −0.12 | 0.06 | 0.17 | −0.13 | −0.08 | −0.31 | 1.0 |

**Notes:** CI, commercialisation index, SI, specialisation index, LDP, land productivity, DS, dummy-Shishe, DT, dummy-Tianshui, HG, head gender HS, head schooling, FE, farm experience

**Table V.** Correlation matrix of the variables under consideration

| | Commercialisation | | |
|---|---|---|---|
| | 3SLS | 2SLS | OLS |
| Specialisation | 0.788 (4.19)*** | 0.57 (2.77)** | 0.048 (0.7) |
| Asset | −1.95e-07 (−2.18)* | −1.87e-07 (−2.04)* | −1.63e-07 (−1.95)* |
| Land | 0.0014 (1.25) | 0.0006 (0.62) | −0.0001 (−1.05) |
| LP (labour productivity) | 8.09e-06 (3.62)*** | 8.92e-06 (2.90)** | 0.00001 (3.86)*** |
| Tech (fertilizer) | 0.00005 (5.00)*** | 0.000063 (4.67)*** | 0.00006 (5.33)*** |
| Market (Dummy-Shishe) | 0.01 (0.26) | 0.023 (0.55) | 0.06 (1.59) |
| Market (Dummy-Tianshui) | −0.034 (−0.61) | −0.035 (−0.61) | −0.049 (−0.94) |
| Head-gender | 0.01 (0.99) | 0.012 (1.09) | 0.0136 (1.37) |
| Head-schooling | 0.0034 (0.59) | 0.0017 (0.30) | −0.0014 (−0.28) |
| Head-farm-experience | 0.0025 (1.71)* | 0.0022 (1.43) | 0.0015 (1.10) |
| Constant | −0.49 (−3.22)** | −0.34 (−2.09)* | 0.027 (0.33) |
| *First stage 2SLS: commercialisation, endogenous specialisation* | | | |
| | Specialisation | | |
| Elderly (instrument) | −0.03 (−2.4)*** | | |
| LLR (land-labour-ratio) | 0.009 (7.92)*** | | |
| Plot | −0.27 (−4.68)*** | | |
| Asset | 8.83e-08 (1.81)** | | |
| Land | −0.0018 (−2.4)*** | | |
| LP (labour productivity) | 4.07e-06 (2.47)*** | | |
| Tech (fertiliser) | 0.00002 (2.61)*** | | |
| Market (Dummy-Shishe) | −0.0037 (−0.11) | | |
| Market (Dummy-Tianshui) | −0.073 (−1.88)* | | |
| Head-gender | 0.004 (1.89)* | | |
| Head-schooling | −0.0028 (−0.75) | | |
| Head-farm-experience | −0.0005 (−0.46) | | |
| *Post-estimation/tests* | | | |
| Obs. | 311 | 311 | 311 |
| Wald $\chi^2(10)$ | 104.28 | 112.07 | 11.01 ($F$ statistic) |
| Prob > $\chi^2$ | 0.000 | 0.000 | 0.000 |
| $R^2$ | 0.157 | 0.17 | 0.268 |
| AIC | −150.18 | | |
| BIC | −67.91 | | |
| *Durbin-Wu-Hausman test* | | | |
| Robust $\chi^2$ (1) | | 9.65 | |
| $P$-value | | 0.00019 | |
| *Over identifying restrictions* | | | |
| Hansen-Sargan over-identification statistic | 0.624 | 0.867 | |
| $P$-value | 0.7321 | 0.64 | |
| *The strength of instruments* | | | |
| Joint significance of instruments ($F$ statistic) statistic) | | 38.49 | |
| *Tests of weak instruments* | | | |
| Minimum eigenvalue statistic | | 24.51 | |
| Stock-Yogo weak Id Critical values | | | |
| 5% maximal IV relative bias | | 13.91 | |
| 10% Maximal IV size | | 22.3 | |

**Notes:** $z$ statistics are in parentheses.*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$

**Table VI.**
Regression on crop commercialisation (Equation (6))

By contrast, all 3SLS and 2SLS estimates correspond to the theoretical expectations or turn out sensible results. In particular, both of the estimators confirm a strong two-way causality correlation between specialisation and commercialisation. Overall, there is little difference in the estimates of the two methods. The closeness of the value of the parameter estimates

| | Specialisation | | |
|---|---|---|---|
| | 3SLS | 2SLS | OLS |
| Commercialisation | 0.363 (4.18)*** | 0.328 (3.65)*** | 0.06 (1.5) |
| Asset | 1.32e-07 (1.92)* | 1.37e-07 (1.96)* | 1.17e-07 (1.8)* |
| Land | −0.0021 (−2.71)** | −0.0019 (−2.39)** | −0.0017 (−2.24)* |
| LLR (Land-labour-ratio) | 0.0056 (1.52) | 0.0096 (1.82)** | 0.0088 (1.79)* |
| Plot | −0.019 (−4.41)*** | −0.022 (−4.60)*** | −0.23 (−4.98)*** |
| Market (Dummy-Shishe) | −0.004 (−0.13) | −0.011 (−0.34) | 0.0097 (0.30) |
| Market (Dummy-Tianshui) | −0.028 (−0.62) | −0.039 (−0.86) | −0.074 (−1.76)* |
| Head-gender | −0.00095 (−0.11) | −0.00068 (−0.08) | 0.0024 (0.31) |
| Head-schooling | −0.0042 (−0.96) | −0.0036 (−0.82) | −0.003 (−0.78) |
| Head-farm-experience | −0.0019 (−1.69) | −0.0018 (−1.56) | −0.001 (−1.08) |
| Constant | 0.75 (12.47)*** | 0.762 (12.53)*** | 0.797 (14.01)*** |
| *First Stage 2SLS, Specialisation: Endogenous Commercialisation* | | | |
| | | Commercialisation | |
| *Land-productivity (instrument)* | | 0.00003 (1.79)** | |
| LP (labour productivity) | | 3.36e-06 (0.66) | |
| Tech(fertiliser) | | 0.0075 (3.89)*** | |
| Asset | | −1.34 (−2.29)*** | |
| Land | | −0.00003 (−0.05)** | |
| Plot | | −0.014 (−3.32)*** | |
| Market (Dummy-Shishe) | | 0.019 (0.44) | |
| Market (Dummy-Tianshui) | | −0.072 (−1.75)* | |
| Head-gender | | 0.0014 (4.75)*** | |
| Head-schooling | | −0.014 (−0.30) | |
| Head-farm-experience | | 0.0011 (0.82) | |
| *Post-estimation/tests* | | | |
| Obs. | 311 | 311 | 311 |
| Wald $\chi^2(10)$ | 115.3 | 310.24 | 11.39 ($F$ statistic) |
| Prob > $\chi^2$ | 0.000 | 0.000 | 0.000 |
| $R^2$ | 0.1882 | 0.176 | 0.275 |
| AIC | −150.18 | | −26.05 |
| BIC | −67.9 | | 56.221 |
| *Durbin-Wu-Hausman test* | | | |
| Robust $\chi^2$ (1) | | 8.14 | |
| $P$-value | | 0.0043 | |
| *Over identifying restrictions* | | | |
| Hansen-Sargan over-identification statistic | 0.624 | 1.104 | |
| | 0.1365 | 0.5769 | |
| *The strength of instruments* | | | |
| Shea's partial $R^2$ | | | |
| Joint significance of instruments ($F$ statistic) | | 15.91 | |
| Tests of weak instruments | | | |
| Minimum eigenvalue statistic | | 30.34 | |
| Stock-Yogo weak ID test | | | |
| 5% maximal IV relative bias | | 13.91 | |
| 10% Maximal IV size | | 22.3 | |

**Notes:** $z$ statistics are in parentheses.*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$

**Table VII.**
Regression on crop specialisation (Equation (7))

implies that $\varepsilon_i$ and $\delta_i$ in Equations (6) and (7) might be uncorrelated. Since 3SLS is generally consistent and more efficient than 2SLS asymptotically (Cameron and Trivedi, 2010), the following discussion of results is based on 3SLS estimates.

The strong two-way causality and the interrelationship between specialisation and commercialisation support the main hypothesis of this study; that is, the specialisation

affect, and is also affected by commercialisation. Specifically, the results imply that households that sell more farm output have a higher specialisation level, and households with higher specialisation levels sell more farm output. For the studied smallholders, this jointly determined correlation between commercialisation and specialisation denotes that farm production is concentrated towards market-oriented activities, rather than on the production of a larger range of farm products for subsistence purposes.

Households' asset is negatively associated with crop commercialisation but positively related to specialisation. This means that households in a relatively advantaged financial position are more likely to specialise in crop production but sell less of their output. The result, however, does not hold when using total income and/or income per capita as dependent variables, with insignificant effect as well as opposite sign (see Table AI). The puzzle and inconsistency of the influence of income and asset holding on commercialisation, however, is in line with a study by Muriithi and Matz (2015), which find that households' income and asset holdings have different impact on commercialisation. Investigating effects of vegetable commercialisation on Kenyan smallholders' welfare, their results show commercialisation is positively associated with income per capita, but no evidence for a positive association with asset holdings. They speculate that households' income is not necessarily used for farm investment or asset accumulation. In fact, studies on this issue are controversial and the results are inconclusive (Muriithi and Matz, 2015). A possible reason is that the definition/concept of household assets is often vaguely defined and the scope of asset holdings varies in different research settings. For example, productive assets, household income and wealth are all used but not distinguished from one of each other, but vaguely indicated to be associated with smallholders' market participation (Michelson, 2013; Von Braun, 1995). The literature on small farm market participation suggests that households' asset holdings have a positive effect on commercialisation, and that wealthier households appear more likely to sell to the market than are other households (Barrett, 2008). This theory, however, is based on a broad context, in which market participation/commercialisation is conceptually considered either equivalent or exchangeable to specialisation (McCalla, 1997). The current study, argues that farmers' decisions on farm commercialisation and production specialisation are separate processes, and respond differently to other exogenous factors. Findings of this research cast light on the farm market participation theory by emphasising that higher fixed assets indeed enable small farmers to specialise in production where they have a comparative advantage, while farmers who possess higher value of assets such as building and equipment seem to lack the incentives to sell farm surplus. The possible reason could be that asset holdings are more likely to relax credit constraints (such as equipment can service as collateral in some cases) for households' relatively long-term investment, rather than generating cash by selling farm products (Goetz and Stephen, 1993). As von Braun and Díaz-Bonilla (2008, p. 189) points out "some factors have more immediate effects on farmers' decisions to become more integrated in the market, whereas others may only have long-term effects".

In terms of other factors affecting farmers' decisions on commercialisation and specialisation, most of the results are consistent with the theoretical assumptions and previous empirical studies. For example, the finding that higher farm productivity and new technologies significantly promote market participation, are similar to the findings of Barrett (2008) and von Braun and Díaz-Bonilla (2008). They found that the interaction between technology adoption and increasing farm productivity directly increases the marketable surplus, which is followed by the expansion of commercialisation.

Land holding is found to be significantly negatively associated with specialisation, but an insignificant factor to commercialisation. Previous empirical studies show that smaller farmers are more likely to adopt new crops or technologies (von Braunand and Díaz-Bonilla, 2008).

Furthermore, farmers' decisions to specialise are hindered by land segmentation as indicated by the negative and significant coefficient of plot against specialisation. This outcome is consistent with the finding of Mesfin *et al.* (2011) that a negative relationship exists between the number of operational plots and crop specialisation. Location dummies and household characteristics (head's gender, schooling, and farm experience) are found to have no correlation with the farmers' decisions on specialisation and commercialisation. The insignificant result of market on commercialisation and specialisation is unexpected, perhaps indicating that the location dummies used in the model were unable to capture the variations of households' access to market. Unfortunately, the information regarding the distance of each individual household to markets was not available in this study. If available, the difference in transaction cost amongst households may be captured and allow the influence of market and specialisation to be ascertained.

## 5. Conclusion and policy implication

The strong two-way interrelationship found by this study suggests that farmers' decisions on farm commercialisation and production specialisation are actually separate and interacting. The insights of the interrelated relationship between specialisation and commercialisation show these two activities facilitate each other, and respond to other exogenous factors differently in different processes. The findings cast further light onto the farm market participation theory by emphasising that higher asset endowments enable small farmers to specialise in production with comparative advantage.

Commercialising the small subsistence farms in underdeveloped rural areas is fundamental to reducing China's regional development disparity. This study shows that facilitating production specialisation can indirectly stimulate smallholders' agricultural commercialisation. The interplay between commercialisation and specialisation can be used by policy-makers to combine market improvement and risk management tools to more effectively increase farmers' incomes.

Although in a relatively early stage of agricultural transformation, farmers in Western China are apparently influenced by market liberalisation and integration. They are shifting away from mixed subsistence farming and specialising in less on-farm and more off-farm activities for their livelihood, and the specialisation is positively related to farmers' market participation. It is well recognised that smallholders' commercialisation and on-farm specialisation is a pathway out of poverty. However, governments, especially those in less-favoured areas, usually struggle to deliver effective policy practice to make the majority of small farms integrate into the market. The "virtuous cycle" between farmers' commercialisation and specialisation found in this study provides new insights into the small farms' commercialisation process, and thereby offers moderate guidance for policy implication. It emphasises that farmers' market participation can be indirectly improved by implementing policies that encourage specialisation, and to open an alternative policy channel for enhancing commercialisation.

## 6. Limitations of the study

Based on the current literature, this paper attempts to provide a general theoretical reasoning as to how specialisation and commercialisation are related. However, it is acknowledged that a comprehensive theory needs to be developed in order to establish a relationship between specialisation and commercialisation at the farm level, which needs to be addressed in future research.

In the present study, only cross-sectional data were able to be collected. However, in order to capture the endogenous relationship between production specialisation and market commercialisation, this study employed 2SLS and 3SLS estimation methodology, which is ideally suited for this purpose. Further, appropriate statistical tests (Hansen-Sargan test,

Stock-Yogo test etc.) were also conducted in order to confirm the bi-directional nature of relationship between specialisation and commercialisation at the farm level. When household panel data becomes available, a further study should be conducted with more sophisticated panel-data methods (such as fixed effects, difference GMM and System GMM estimators) to better understand the dynamic nature of relationship between commercialisation and specialisation.

## Notes

1. Commercialisation can also be measured by the degree of input markets participation, which reflects the increasing reliance on hired labour, and a move from production diversification to specialisation (Pingali and Rosegrant, 1995; Leavy and Poulton, 2007; Alemu, 2007).
2. This increase was due to a series of policies that were implemented to stimulate farmers' grain production incentives and the relative profitability of grain production, when grain production decreased by 16 per cent between 1998 and 2003. These policies included ending agricultural taxes, direct subsidy payments to grain producers, grain crop support price, input subsidies for fertiliser and farm equipment, and increased investment in infrastructure (Carter *et al.*, 2012).
3. 2SLS and 3SLS methods reduce the endogenous variables' collinearity with the remaining independent variables, but do not preclude the possibility of collinearity between the exogenous variables.

## References

Acharya, S.P., Basavaraja, H., Kunnal, L.B., Mahajanashetti, S.B. and Bhat, A.R.S. (2011), "Crop diversification in Karnataka: an economic analysis", *Agricultural Economics Research Review*, Vol. 24 No. 2, pp. 351-358.

Alemu, D. (2007), "Determinants of smallholder commercialization of food crops: theory and evidence from Ethiopia", *Ifpri Discussion Papers*, Vol. 30 No. 30, pp. 286-288.

Barrett, C.B. (2008), "Smallholder market participation: concepts and evidence from eastern and southern Africa", *Food Policy*, Vol. 33 No. 4, pp. 299-317.

Brown, C. and Kai, C. (1999), "Land reform, household specialisation and rural development in China", Agricultural and Natural Resource Economics Discussion Paper No. 8, Christchurch.

Brown, C., Waldron, S., Yuman, L. and Longworth, J. (2009), "Forage-livestock policies designed to improve livelihoods in Western China: a critical review", *China Agricultural Economic Review*, Vol. 1 No. 4, pp. 367-381.

Cameron, A.C. and Trivedi, P.K. (2010), "Microeconometrics using stata".

Chavas, J.-P. (2008), "On the economics of agricultural production", *Australian Journal of Agricultural and Resource Economics*, Vol. 52 No. 4, pp. 365-380.

Deininger, K., Jin, S., Xia, F. and Huang, J. (2013), "Moving off the farm: landinstitutions to facilitate structural transformation and agricultural productivity growth in China", Policy Research Working Paper No. 5949, Development Research Group, The World Bank.

Dorsey, B. (1999), "Agricultural intensification, diversification, and commercial production among smallholder coffee growers in central Kenya", *Economic Geography*, Vol. 75 No. 2, pp. 178-195, doi: 10.2307/144250.

Emran, M. and Shilpi, F. (2012), "The extent of the market and stages of agricultural specialization", *Canadian Journal of Economics/ Revue canadienne d'économique*, Vol. 45 No. 3, pp. 1125-1153, doi: 10.1111/j.1540-5982.2012.01729.x.

Gansu Yearbook Editorial Board (2007-2011), *Gansu Yearbook*, China Satistics Press, Beijing.

Gebreselassie, S. and Ludi, E. (2007), "Agricultural commercialisation in coffeegrowing areas of Ethiopia", Paper read at Fifth International Conference on the Ethiopian Economy, EEA, Addis Ababa.

Gebreselassie, S. and Sharp, K. (2008), "Commercialisation of smallholder agriculture in selected tef-growing areas of Ethiopia", *Ethiopian Journal of Economics*, Vol. 16 No. 1, pp. 55-86.

Goetz and Stephen, J. (1993), "Interlinked markets and the cash crop-food crop debate in land-abundant tropical agriculture", *Economic Development & Cultural Change*, Vol. 41 No. 2, pp. 343-361.

Goletti, F., Purcell, T. and Smith, D. (2003a), "Concepts of commercialization and agricultural development", Agrifood Discussion Paper No. 8.

Goletti, F., Purcell, T. and Smith, D. (2003b), "Concepts of commercialization and agricultural development", Agrifood Discussion Paper No. 9.

Govereh, J. and Jayne, T. (2003), "Cash cropping and food crop productivity: synergies or trade-offs?", *Agricultural Economics*, Vol. 28 No. 1, pp. 39-50.

Gujarati, D. (2008), *Basic Econometrics*, Tata McGraw-Hill Education.

Heltberg, R. and Tarp, F. (2002), "Agricultural supply response and poverty in Mozambique", *Food Policy*, Vol. 27 No. 2, pp. 103-124.

Hou, F., Nan, Z., Xie, Y., Li, X., Lin, H. and Ren, J. (2008), "Integrated crop-livestock production systems in China", *The Rangeland Journal*, Vol. 30 No. 2, pp. 221-231, available at: http://dx.doi.org/10.1071/RJ08018

Huang, J., Bi, X. and Rozelle, S. (2004), "Market, specialization and China's smallholder agriculture", Food and Agricultural Organisation.

Kim, K., Chavas, J.-P., Barham, B. and Foltz, J. (2012), "Specialization, diversification, and productivity: a panel data analysis of rice farms in Korea", *Agricultural Economics*, Vol. 43 No. 6, pp. 687-700, doi: 10.1111/j.1574-0862.2012.00612.x.

Langemeier, M.R. and Jones, R.D. (2000), "Measuring the impact of farm size and specialization on financial performance", *Journal of the ASFMRA*, Vol. 63 No. 1, pp. 90-96.

Leavy, J. and Poulton, C. (2007), "Commercialisations in agriculture: a typology", paper read at Proceedings of the fifth international conference on the Ethiopian economy, Addis Ababa.

Li, L., Wang, C., Segarra, E. and Nan, Z. (2013), "Migration, remittances, and agricultural productivity in small farming systems in Northwest China", *China Agricultural Economic Review*, Vol. 5 No. 1, pp. 5-23.

Lin, W. and Shao, B. (2000), "The relationship between user participation and system success: a simultaneous contingency approach", *Information & Management*, Vol. 37 No. 6, pp. 283-295.

McCalla, A. (1997), "From subsistence systems to commercial agriculture: the need for a new development paradigm: discussion", *American Journal of Agricultural Economics*, Vol. 79 No. 2, pp. 643-645.

Mesfin, W., Fufa, B. and Haji, J. (2011), "Pattern, trend and determinants of crop diversification: empirical evidence from smallholders in Eastern Ethiopia", *Journal of Economics and Sustainable Development*, Vol. 2 No. 8, pp. 78-89.

Michelson, H.C. (2013), "Small farmers, NGOs, and a Walmart World: welfare effects of supermarkets operating in Nicaragua", *American Journal of Agricultural Economics*, Vol. 95 No. 3, pp. 628-649.

Muriithi, B.W. and Matz, J.A. (2015), "Welfare effects of vegetable commercialization: evidence from smallholder producers in Kenya", *Food Policy*, Vol. 50, pp. 80-91.

Nolan, S., Unkovich, M., Yuying, S., Lingling, Li. and Bellotti, W. (2008), "Farming systems of the Loess Plateau, Gansu Province, China", *Agriculture, Ecosystems & Environment*, Vol. 124 Nos 1-2, pp. 13-23, available at: http://dx.doi.org/10.1016/j.agee.2007.08.009

Ping, Z. (2010), "Human capital, fertility rate and labor productivity of agricultural scale of operation: evidence from China 1980-2007", *International Conference on E-Business and E-Government. IEEE Computer Society*, pp. 951-953.

Pingali, P. (1997), "From subsistence to commercial production systems: the transformation of Asian agriculture", *American Journal of Agricultural Economics*, Vol. 79 No. 2, pp. 628-634, doi: 10.2307/1244162.

Pingali, P. and Rosegrant, M. (1995), "Agricultural commercialization and diversification: processes and policies", *Food Policy*, Vol. 20 No. 3, pp. 171-185, available at: http://dx.doi.org/10.1016/0306-9192(95)00012-4

Qingyang Yearbook Editorial Board (1994-2011), *Qingyang Yearbook*, China Statistics Press, Beijing.

Rios, A., Shively, G. and Masters, W. (2009), "Farm productivity and household marekt participation: evidence from LSMS data", *International Association of Agricultural Economists Conference, Beijing*.

Smith, A. (1776/1976), *An Inquiry into the Nature and Causes of the Wealth of Nations*, University of Chicago Press, Chicago, IL.

Taylor, J.E. and Adelman, I. (2002), "Agricultural household models: genesis, evolution, and extensions", *Review of Economics of the Household*, Vol. 1 No. 1, pp. 33-58.

Timmer, C. (1997), "Farmers and markets: the political economy of new paradigms", *American Journal of Agricultural Economics*, Vol. 79 No. 2, pp. 621-627.

Tipraqsa, P. and Schreinemachers, P. (2009), "Agricultural commercialization of Karen Hill tribes in northern Thailand", *Agricultural Economics*, Vol. 40 No. 1, pp. 43-53.

Udoh, E., Akpan, S. and Effiong, E. (2011), "Economic analysis of land allocation use and intensification among arable crop farmers in Uruan local government area of Akwa-Ibom State, Nigeria", *Journal of Economics and Sustainable Development*, Vol. 2 Nos 11&12, pp. 1-10.

von Braun and Díaz-Bonilla, E. (2008), "Globalization of agriculture and food: causes, consequences, and policy implications", in von Braun, J. and Díaz-Bonilla, E. (Eds), *Globalization of Food and Agriculture and the Poor*, Oxford University Press, Oxford, pp. 1-45.

von Braun, J. (1995), "Agricultural commercialization: impacts on income and nutrition and implications for policy", *Food Policy*, Vol. 20 No. 3, pp. 187-202, available at: http://dx.doi.org/10.1016/0306-9192(95)00013-5

von Braun, J., de Hean, H. and Blanken, J. (1991), "Commercialization of agriculture under population pressure: effects on production, consumption, and nutrition in rwanda", *Research Reports*, Vol. 6 Nos 7/8/9, pp. 160-171.

Wickramasinghe, U. and Weinberger, K. (2013), *Smallholder Market Participation and Production Specialisation*, Centre for Alleviation of Poverty through Sustainable Agriculture, Working Paper No. 107.

World Bank (1990), "Agricultural diversification: policies and issues from East Asian experience", Policy and Research Series, The World Bank, Washington, DC.

World Bank (2007), "World development report 2008: agriculture for development", The World Bank, Washington, DC.

World Bank (2012), "World Bank Indicators".

Young, A.A. (1928), "Increasing returns and economic progress", *Economic Journal*, Vol. 38, pp. 527-542.

Xifeng Yearbook Editorial Board (2013), *Xifeng Yearbook*, China Statistics Press, Beijing.

## Further reading

Barrett, C.B., Bachke, M.E., Bellemare, M.F., Michelson, H.C., Narayanan, S. and Walker, T.F. (2012), "Smallholder participation in contract farming: comparative evidence from five countries", *World Development*, Vol. 40 No. 4, pp. 715-730.

Culas, R.J. (2006), "Causes of farm diversification over time: an Australian perspective on an Eastern Norway model", *Australian Farm Business Management Journal*, Vol. 3 No. 1, p. 1.

Huanxian Yearbook Editorial Board (2013), *Huanxian Yearbook*, China Statistics Press, Beijing.

Kurosaki, T. (2013), "Dynamics of household assets and income shocks in the long-run process of economic development: the case of rural Pakistan", *Asian Development Review*, Vol. 30 No. 2, pp. 76-109.

Morris, S., Carletto, C., Hoddinott, J. and Christiaensen, L. (2000), "Validity of rapid estimates of household wealth and income for health surveys in rural Africa", *Journal of Epidemiology and Community Health*, Vol. 54 No. 5, pp. 381-387.

Omamo, S. (1998), "Farm-to-market transaction costs and specialisation in small-scale agriculture: explorations with a non-separable household model", *The Journal of Development Studies*, Vol. 35 No. 2, pp. 152-163, doi: 10.1080/00220389808422568.

Pope, R. and Prescott, R. (1980), "Diversification in relation to farm size and other socioeconomic characteristics", *American Journal of Agricultural Economics*, Vol. 62 No. 3, pp. 554-559.

## Appendix

| | | | |
|---|---|---|---|
| | Specialisation | | |
| Commercialisation | 0.36 (4.13)*** | Commercialisation | 0.36 (4.03)*** |
| Total income | 1.46e-07 (0.35) | Income per capita | 8.41e-07 (0.69) |
| Land | −0.02 (−2.89)** | Land | −0.02 (−2.86)** |
| LLR (land-labour-ratio) | 0.054 (1.48) | LLR (Land-labour-ratio) | 0.055 (1.50) |
| Plot | −0.185 (−4.21)*** | Plot | −0.186 (−4.21)*** |
| Market (Dummy-Shishe) | −0.050 (−0.14) | Market (Dummy-Shishe) | −0.055 (−0.16) |
| Market (Dummy-Tianshui) | −0.21 (−0.46) | Market (Dummy-Tianshui) | −0.23 (−0.50) |
| Head-gender | −0.0085 (−0.10) | Head-gender | −0.0085 (−0.10) |
| Head-schooling | −0.0063 (−1.42) | Head-schooling | −0.0062 (−1.42) |
| Head-farm-experience | −0.002 (−1.74)** | Head-farm-experience | −0.002 (−1.70)** |
| Constant | 0.76 (12.67)*** | Constant | 0.76 (12.56)*** |
| | Commercialisation | | |
| Specialisation | 0.8112 (4.13)*** | Specialisation | 0.8009 (4.05)*** |
| Total income | 6.52e-08 (0.12) | Income per capita | 1.42e-06 (0.52) |
| LP (Labour productivity) | 7.39e-06 (3.34)*** | LP (Labour productivity) | 7.09e-06 (3.20)*** |
| Tech (Fertilizer) | 0.00005 (4.97)*** | Tech (Fertilizer) | 0.000055 (5.04)*** |
| Land | 0.0.0017 (1.42) | Land | 0.0.00165 (1.38) |
| Market (Dummy-Shishe) | 0.028 (0.07) | Market (Dummy-Shishe) | −0.0009 (−0.02) |
| Market (Dummy-Tianshui) | −0.01 (0.99) | Market (Dummy-Tianshui) | −0.41 (−0.72) |
| Head-gender | 0.01 (0.92) | Head-gender | 0.0108 (1.00) |
| Head-schooling | 0.0026 (1.77) | Head-schooling | 0.0052 (0.88) |
| Head-farm-experience | 0.0026 (0.07)* | Head-farm-experience | 0.0026 (1.78)* |

**Table AI.** Robustness check of the effect of asset vs total income/income per capita

**Corresponding author**
Lihua Li can be contacted at: 17184104@student.westernsydney.edu.au