# Chapter 5
# Exploring Future Rural Development in the Poyang Lake Region

**Abstract** An agent-based computer model is developed to explore the effects of different subsidy policies and resilience of rural development in the PLR. The model represents land-use and livelihood decision making of farmer households in three types of villages that have poor, average, and rich farmland. Household agents allocate their labor between nonfarm and agricultural work, and make rice cropping choices. They also exchange farmland in a land rental market. Three policy scenarios are examined: subsidies to rice growers, subsidies to large farms, and subsidies to households that rent out their farmland for the long term. The model experiments are not intended to make quantitative predictions but to aid our understanding about (1) the nature and potential effects of these policies across different villages at different stages of development, and (2) how rural development may be affected by economic and environmental shocks. I discuss how policy may need to differentiate across locations and adapt in the near future to effectively promote rural development amid social and environmental changes.

**Keywords** Subsidy policy • Rural development • Land rental markets • Agent-based modeling • Economic and environmental shocks • Resilience

## 5.1 Modeling Future Rural Development

### *5.1.1 Shaping the Future: Three Different Subsidy Policies*

Recent agricultural policies in China target farmer households to improve agriculture and rural income. These include cash subsidies to grain producing households, in effect since 2004, and subsidies to households that manage large farms, introduced more recently. In this study I propose another subsidy to households that subcontract their farmland to other households for 20 years under a formal contract. Formulated from the empirical analysis of rural livelihoods in Chap. 4, this subsidy is expected to stimulate farmland rental markets, increase the scale of farming

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operations, and help secure use rights on rental farmland. It could also encourage migrant families that do well in cities to actually settle in cities and exit agriculture to facilitate other rural households specializing in agriculture. An agent-based model is developed to explore how these three subsidies might influence rural income and agriculture in three village types that reflect poor, average, and good farmland conditions, respectively—as nonfarm work wages rise.

### *5.1.2 Plausible Economic and Environmental Shocks and Resilience of Rural Development*

Future rural development can be affected by social and environmental change. Severe floods cause the major environmental shocks in the Poyang Lake area. A straightforward method for calculating the impacts of a worst-case flood scenario will be provided later in this chapter.

Social shocks, especially those associated with economic crisis or technological innovation in the industrial sector, can produce long-lasting and complex impacts on rural development. When the industrial sector experiences a crisis and slows, migrant workers are usually the first to lose their jobs. They can also be displaced when innovative technologies make the repetitive manual labor that is their niche obsolete. (According to a report by Bloomberg Businessweek on June 11 [2016], the impact of technology has already been observed in Dongguan, a highly developed rural industrial area in Guangdong.)

Economic crises or dramatic technological innovations essentially reduce the chances for migrant workers to find nonfarm work. The return of many migrant workers to the countryside can then produce rippling effects through interactions in the land rental market. It is difficult to calculate the effects of these changes directly; I use model experiments to explore how villages with poor, average, and good farmland resources might respond differently to economic shocks of varying severity.

## 5.2 Model Conceptualization: Entities, Interactions, and Feedbacks

The agent-based model simulates a village and represents typical village households whose members engage in some combination of migratory work and rice cultivation (Fig. 5.1). In other words, farmer households are agents in the model; each household agent makes individual decisions about how much labor it will spend in agricultural work and how much in migratory work. Household agents also allocate farmland for growing one-season and two-season rice. They exchange farmland in a land rental market and sometimes exchange information, such as land rental prices. They carry out their livelihoods to different degrees of success, mostly determined by the availability of labor, capacity for agricultural and migratory

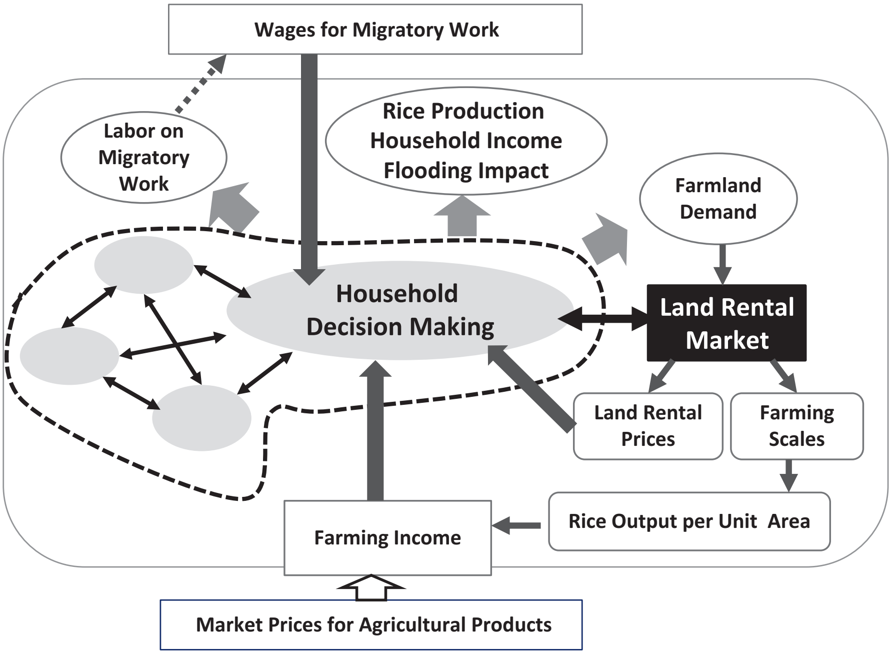



**Fig. 5.1** Modeled system: Boundary, agents, interactions, and feedback (adapted from Tian et al. 2016)

work, and farmland endowments. Note that throughout this chapter, I use the term "household agents" when I refer to simulated households in the model.

Wages for migratory work and prices for rice are important factors affecting household decisions. They are treated as exogenous because an individual village that the model simulates have relatively little influence on average wages or prices. Two kinds of feedback between individual decisions and the global state of the system are modeled. The first is that the decisions of household agents collectively determine total farmland demand in a village, which then affects land rental prices and subsequent decision making of household agents. The second is that the total farmland demand affects the farmland area each household agent can obtain, which then influences agricultural productivity and, ultimately, the decisions of household agents.

The model has several major assumptions. First, farmers in the model can always find migratory work at some wage if they want to work in cities. Second, household agents do not hire labor. Third, rice yields increase as the area of farmland a household agent manages increases. Fourth, input use of household agents is not affected by subsidies. Fifth, current grain subsidies are given based on actual planted areas with rice. Sixth, all farmland rental contracts involve payments. Among these assumptions, that household agents do not hire labor in the model is a deliberate choice. I discuss the rationale behind it, and how this assumption may affect model outcomes in the section on model limitations.

The assumption that farmers in the model can always find migratory work at some wage is justified by the fact that most young and middle-aged villagers are doing migratory work, and by calibrating a household migratory work efficiency function (described in Sect. 5.4.3). The assumption that rice yields increase as the farm size increases can be largely justified by the specific context in which farmland is currently highly fragmented and the scale of farming is very small. As we observed in the field, when households manage large farmland, they usually put more effort into management, improve irrigation systems, and invest in machinery and other innovations. A yield function for one- and two-season rice is calibrated separately to reflect yield increase as a result of these efforts and activities (described in Sect. 5.4.4).

Farmers do not seem to increase the use of fertilizers or pesticides because of grain subsidies, based on the interviews and field observations in the villages. Rice cultivation practices, including the types and amounts of fertilizers and pesticides used, are similar among households and across villages. A main difference is that farmers in farmland-rich villages put in more effort in agriculture than those in the other villages, but this is because they have larger, more fertile farmland, and rice cultivation generates larger returns. After all, the current grain subsidy is small, especially relative to nonfarm income, and probably does not provide sufficient incentive for farmers to increase input use.

Land rental relationships often take place between relatives and do not involve payments (Gao et al. 2012; Ma et al. 2015). There are also variations in the implementation of the grain subsidy policy; in some areas, subsidies are given based on historical grain production or contracted land areas instead of actual planted areas (Heerink et al. 2006; Gale 2013; Huang et al. 2013; Yi et al. 2015). Additional experiments are conducted, to test how contracts between relatives, and grain subsidies based on contracted land areas, may affect model outcomes. The experiment results are reported in Sect. 5.8 on robustness analysis.

## 5.3 Empirical Data Used in the Model

Empirical data obtained from surveys, interviews, and field observations in three villages are compiled and used to represent three types of villages: with poor (V1), average (V2), and rich (V3) farmland (Table 5.1). The purpose is not to use these data to fit the model or simulate these villages in detail, but to explore policy effects in different types of villages with respect to the biophysical environment.

The empirical data are also used for model validation purposes. I compare observed values of several outcome variables at the village level with model outputs, to test the model's ability to generate differences between villages of differing farmland endowments. The important facts that guide the model validation are: (1) in V1 and V2, there is a reduction in two-season rice, with households currently emphasizing one-season rice; in V3, there is no obvious change, and two-season rice still dominates; (2) the average land rental price compares as follows: V1 < V2 < V3; (3) the proportion of income from migratory work compares as follows: V1 > V2 > V3;

**Table 5.1** General characteristics of three representative villages selected for use in setting model parameter values, calibrating rice-yield functions and comparing system-level outcomes in villages with different farmland endowments

| Characteristics | | V1 | V2 | V3 |
|---|---|---|---|---|
| Natural environment and farmland | | Remote and isolated. Plots are hilly and highly fragmented. Farmland is scarce | Plots are flat. About average in fragmentation and total farmland area | Plots are flat, least fragmented. Farmland is relatively abundant |
| Data relevant to rice yields | Soil fertility | Poor | Good | Good |
| | Efforts in crop cultivation | Poor | Average | Good |
| | Collective irrigation system condition | No longer functioning. Small pumps are used to get water from a pond to the fields, and can be rented with an hourly fee | Similar to V1 | Well functioning and maintained with the help from the government |
| Data used for setting model parameters | Farmland area per household | 3 mu | 7 mu | 13 mu |
| | Average yield of one-season rice (kg per mu) | 350 | 450 | 500 |
| | Average yield of two-season rice (kg per mu) | 500 | 600 | 800 |
| Data relevant to model validation | Land rental price (YUAN per mu) | About 50 (Small plots on hills are free) | Between 100 and 150 | About 300 |
| | Pct. nonfarm income | 76.6% | 72.4% | 47.6% |
| | Pct. two-season rice | 8.5% (very little two-season rice) | 0% (no two-season rice) | 70% (with some one-season rice in low-lying areas) |
| | Pct. cultivated area | 91.3% (some fallowed plots observed, mostly small plots on hills) | 100% (no fallowed plots observed) | 100% (no fallowed plots observed) |
| | Land-use change | In the past, two-season rice was widely cultivated | In the past, two-season rice was widely cultivated | No major changes |

Note: 1 mu is about 0.067 ha. The rice yields used for setting model parameters in V1 and V2 are not strictly from the surveys. For a description on how these numbers are derived, please see Appendix: Table 5.1

and (4) a small portion of farmland is left fallow in V1, while farmland is mostly cultivated in V2 and V3.

Additionally, the three villages represent different situations that are associated with different rice yields. These differences are used to calibrate the rice-yield functions with increasing scales of farming operations. Further details on the use of empirical data for model validation and yield calibration can be found in the supplement materials (Appendix: Tables 5.1 and 5.2).

## 5.4 Model Design and Implementation

In this section, I briefly describe some major components of the model. Further details on the implementation of these components can be found in Tian et al. (2016). Some components in this basic model are modified for the policy scenario of subsidizing large farms, which I describe in Sect. 5.6.1. New components are also implemented in the model to represent economic shocks and explore the resilience of rural development, which are addressed in Sect. 5.7.2.

### *5.4.1 Agents: Farmer Households*

Farmer household agents have initial endowments of wealth, labor, and farmland. They differ in their abilities with respect to migratory and agricultural work, social interaction, and cognition (Table 5.2). They know the costs and labor needed per unit area for rice cultivation, and the market price for rice. Each year they try to increase household income based on their past performance in migratory work and rice cultivation, as well as their experience with the land rental market. Details on the representation and implementation of household decision making can be found in the supplement materials (Appendix: Table 5.3).

### *5.4.2 Land Rental Market*

The land rental market is implemented as a two-round exchange process. When the subsidy for a long-term contract is not an option, a household agent wanting to "sublease" more farmland for itself begins the process. It visits a number of randomly chosen household agents, with the number specified by the model parameter *NumHouseholdTrade* (described in Table 5.3). If a targeted household agent does not have a good social relationship with the household agent seeking to sublease the land—and this chance is determined by the social capability of the initiating household agent—no contract is made. If the offered price is greater than asking price, the deal is done at the price offered. If the difference between the two prices is within

**Table 5.2** Endowments and attributes of household agents: description and range

| Endowment/attribute | Description | Distribution among households | Lower bound | Upper bound |
|---|---|---|---|---|
| Initial wealth | An initial endowment of wealth (in YUAN) | Uniform | 5000 | 20,000 |
| Labor amount | An endowment of labor (in persons) | Normal (3.6, 1.4) | 1.0 | 7.0 |
| Farmland area | Initially contracted farmland (in mu) | First assigned proportional to labor amount, and then adjusted to reflect demographic changes (described in detail in the section of model initialization) | | |
| Migratory work capability | A unitless multiplier on the average wage for migratory work set by model parameter *AvgWageInitial* (in YUAN per workday). For instance, if a household has a migratory work capability of 0.8, its first member sent to do migratory work gets paid at 0.8**AvgWageInitial* per workday. Migratory work capability of subsequent household members is modeled by a migratory work efficiency function (Fig. 5.2) | Normal (1.0, 0.2) | 0.5 | 1.5 |
| Agricultural work capability | A unitless multiplier on the average yields in a village set by two model parameters *AvgAgriOutput1sRiceInitial* for one-season rice and *AvgAgriOutput2sRiceInitial* for two-season rice | Normal (1.0, 0.1) | 0.5 | 1.5 |
| Social capability | Percentage of households with whom a given household has good relations, affecting the probability of success in negotiating land rental contracts. For instance, a social capability of 0.8 means a household having good relations with 80% of the households in the village, and it will fail in negotiating rental contracts with a chance of 20% if model parameter *SocialEffects* is set to true | Normal (0.75, 0.1) | 0.5 | 1.0 |
| Cognitive capability | Determines how many livelihood plans a household forms and evaluates. The average number is set by model parameter *AvgNumPlans*. | Uniform | *AvgNumPlans*-2 | *AvgNumPlans*+2 |

Note: The two values associated with normal distributions are mean and SD. In general, the households do not differ greatly in all these capabilities. A standard deviation of 0.2 for migratory work capability reflects a larger spread among households in migratory work. The parameters of labor amount are set based on the survey data. Model parameters are described in detail in Table 5.3

one-tenth of the farming income estimated by the household agent that wants to sublet, the deal is done at the average of the two prices. After the first round of exchange, if some household agents that wish to rent out their land still have farmland available for rent, they each randomly choose several other household agents with whom to negotiate rental contracts.

When the subsidy for long-term rental contracts is available, a household agent that hopes to sublease farmland to other agents for the long term begins the process first. This household agent visits five more households than it would visit for a single-year contract. If its asking price is lower than the offered price, the deal is done at the price asked. Otherwise, if the asking price is no more than 5% higher than the offered price, the deal is done at the average of the two prices. Then the household agents that intend to subcontract more farmland for themselves through long-term contracts, and whose needs have not been fully met, sample household agents looking to subcontract. After two rounds of exchange through long-term contracts, the household agents update their remaining farmland demands. Those household agents whose needs for long-term rental are not met, and those household agents that have decided to sublease yearly, perform another two rounds of negotiation to make yearly contracts, as described in the previous paragraph.

### 5.4.3 *Migratory Work Efficiency Function*

An efficiency function (Fig. 5.2) is used to capture the different levels of labor quality for a household agent's migratory work. This represents field observations that the first members from a household to enter the urban labor market are of the

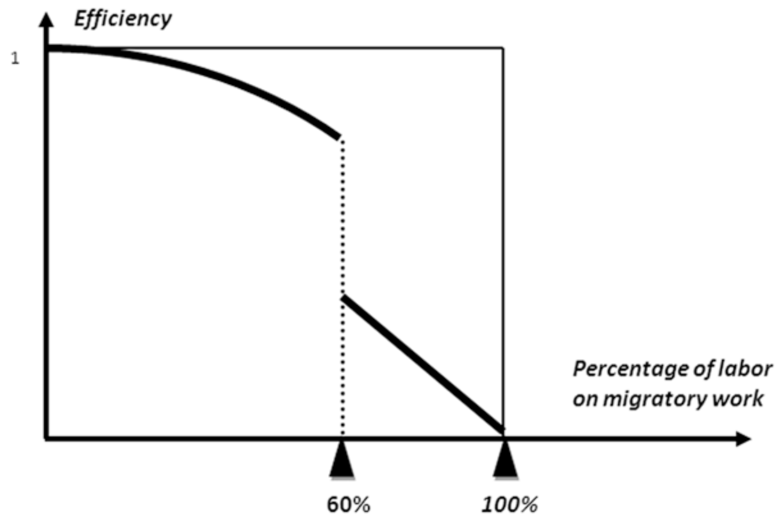
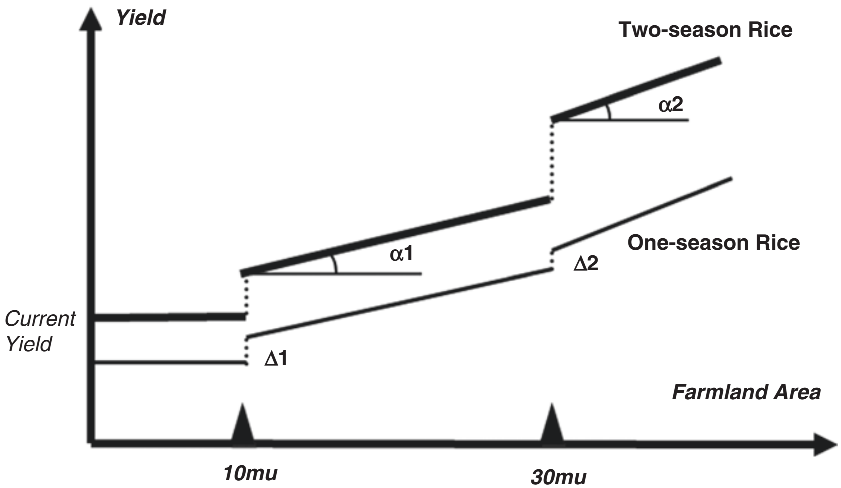



**Fig. 5.2** Migratory work efficiency function (Tian et al. 2016)

highest quality (e.g., young men and women with higher skills and/or education). With every increment of household labor spent on migratory work, the marginal economic return decreases because the quality of labor decreases (i.e., includes lower-skilled and less capable workers).

### 5.4.4 *Rice Yield Functions*

Rice yield per unit area is determined by several major factors: fertility of farmland, quality of the irrigation system, management efforts, and machinery usage and other technology. The forms of the rice-yield functions (Fig. 5.3) reflect the effects of changes in effort and capital investments as the area of farmland managed by a household agent increases. Δ1 reflects the increase in yield associated with increased efforts when the area of farmland managed by a household agent reaches 10 mu. Δ2 reflects the increase in yield associated with the improvements in the irrigation system when the area of farmland managed by a household agent reaches 30 mu. Observed yield differences in the three actual villages, which reflect their differences in farmland fertility, irrigation system condition, and management efforts, and other published information, are used to calibrate yield functions for three representative villages in the model.




α1 = α2 = 2.5 for both one-season and two-season rice
Δ1 = 25kg for one-season rice
Δ1 = 50kg for two-season rice
Δ2 = 25kg for one-season rice if the current irrigation condition is NOT good
Δ2 = 150kg for two-season rice if the current irrigation condition is NOT good

**Fig. 5.3** Rice yields as a function of the area of farmland managed by a household agent (Tian et al. 2016)

### *5.4.5 Major Model Parameters and Model Initialization*

Several model parameters are designed to facilitate systematic model experiments (Table 5.3). Their default values are used unless specified otherwise in the model experiments. To initialize the model, at the beginning of each model run, 100 household agents are created to reflect approximately the average size of a natural village (i.e., the smallest level of social organization) in the Poyang Lake Region. Each household agent is assigned an initial amount of wealth, labor, farmland area, and capabilities, as described in Table 5.2. Household agents are first assigned an area of farmland that is proportional to household labor amount. This reflects the equality principle used when farmland was first contracted out to individual households in the late 1970s. But since then, there have been demographic changes and farmland areas are no longer equitably distributed. The land areas initially assigned in the model are adjusted by randomly reassigning either one-half, one-third, or one-quarter of the farmland from half of the household agents to other randomly selected households in the village.

## 5.5 Model Verification and Validation

The model is built on the .NET version of the Repast platform using C# programming language. To ensure appropriate development of the model, a simple structure was implemented first, with more components gradually added. Many extreme cases were also used to test the program. The model was run interactively numerous times to inform the design of systematic experiments and the decisions on how to represent the state of the system.

To enhance the credibility of the model, validations at conceptual, micro, and macro levels have been addressed (Axtell and Epstein 1994; Robinson 1997; Grimm et al. 2005; Brown et al. 2008). The empirical analysis of household surveys and interviews offers important insights into the key elements and the dynamics of the system, and informs the design of the conceptual model. At the micro level, survey data are used to calibrate model parameters and initialize the model when applicable, as just described. At the macro level, three exercises are carried out for formal validation, examining three different processes in the model, as described next. The results from all these model validation efforts suggest that the model captures the dynamics of the actual system reasonably well and are adequate to address the research questions.

The first validation exercise tested the model's ability to reproduce differences among the three surveyed villages in several outcome variables, including average land rental price per unit area, percentage of nonfarm income, percentage of area planted with two-season rice, and percentage of cultivated area. The model

**Table 5.3** Model parameters: description and default value

| Parameter group | Parameter name | Description | Unit | Default value | Experimental values |
|---|---|---|---|---|---|
| Agricultural market | *PriceOfRice* | Rice price on the market | YUAN per kg | 2 (current level) | |
| Industrial sector | *AvgWageInitial* | Average wage for migratory work | YUAN per workday | 40 (current level) | 0.5: for experiments on land-use change; 40, 60, 80, 100: for policy experiments |
| Shocks in industrial sector | *ProbFindwork* | Probability that migrant workers find nonfarm work | % | 100% | 100% to 20%: for resilience experiments |
| Agricultural sector | *CostCrop1* | Cost associated with fertilizer use and other inputs for one-season rice | YUAN per mu | 300 | |
| | *CostCrop2* | Cost associated with fertilizer use and other inputs for two-season rice | YUAN per mu | 600 | |
| Policy-related | *SubsidyCrop1* | Subsidy to one-season rice cultivation | YUAN per mu | 50 (current policy) | 50–600: for policy experiments |
| | *SubsidyCrop2* | Subsidy to two-season rice cultivation | YUAN per mu | 100 (current policy) | Double the amount of *SubsidyCrop1* |
| | *SubsidyRenter* | Subsidy to long-term renters | YUAN per mu | 0 | 50–600: for policy experiments |
| | *SubsidyBigfarm* | Subsidy to large farms | YUAN per mu | 0 | 50–600: for policy experiments |

(continued)

**Table 5.3** (continued)

| Parameter group | Parameter name | Description | Unit | Default value | Experimental values |
|---|---|---|---|---|---|
| Household behavior | *AvgNumPlans* | Average number of land-use and livelihood plans households form and evaluate | | 5 | |
| | *NumHouseholdTrade* | Number of households a household visits to negotiate land rental contracts | | 6 | |
| | *SocialEffects* | Whether social relations affect the success of land-use-right rental deals (when set false, this social effect is ignored) | | True | |
| Village-specific | *AverageArea* | Average area of farmland per household | 1: Good | Village-specific parameters are set as described in Table 5.1 for three villages respectively | |
| | *Irrigation System* | Condition of the collective irrigation system | 0: Poor | | |
| | *AvgAgriOutput1sRiceInitial* | Average yield of one-season rice | kg per mu | | |
| | *AvgAgriOutput2sRiceInitial* | Average yield of two-season rice | kg per mu | | |

experiments successfully generated those patterns in V1, V2, and V3, as described in Sect. 5.3 on empirical data. The second validation exercise tested the model's ability to re-create historical land-use changes in the three surveyed villages. Comparing two scenarios in which nonfarm work is widely available and is limited, the model reproduced the conversion of two-season rice to one-season rice in V1 and V2, and no changes in V3. The third exercise tested the behavior of the modeled land rental market. Model experiments were conducted to examine how modeled land rental prices respond to changes in total farmland area, yield of two-season rice, and migratory work wage. And the results show that the modeled market functions as the microeconomic theory would suggest (see Varian 2002). Further details on validation experiments and results can be found in Tian et al. (2016).

## 5.6 Effects of Subsidy Policies at Different Stages of Development

### *5.6.1 Model Experiments for Exploring the Effects of Policies*

The model looks at three policy scenarios: subsidies to rice growers, subsidies to large farms, and a proposed subsidy to households that subcontract their farmland to other households for 20 years. To explore the effects of these subsidies, the model is run for each type, ranging from 50 YUAN per mu to 600 YUAN per mu, with an increment of 25 YUAN per mu, under four levels of migratory work wages: 40 YUAN per workday, 60 YUAN per workday, 80 YUAN per workday, and 100 YUAN per workday. Currently, the average wage is 40 YUAN per workday, based on the survey data. The other scenarios represent 50%, 100%, and 150% increases in wages, which are plausible in the near future. Under the current grain-subsidy policy, farmer households receive 50 YUAN per mu for cultivating one-season rice and 100 YUAN per mu for two-season rice. Data on subsidies to large farms are not available from the survey.

Policy effects are examined in terms of changes in average household income, total rice production, and percentage of farming income that indicates potential flood impacts. The total costs associated with each subsidy policy are also considered and compared. Two additional state variables are used to examine farmland concentration and utilization: percentage of farmland managed by the top ten household agents and percentage of farmland planted with rice.

For each village, the model is run 200 times for each scenario of wage, subsidy type, and subsidy amount. Each model run includes 40 time steps divided into two 20-step periods. The first 20-step period serves as the baseline for measuring the effects of a policy implemented in the second 20-step period. At the end of the first 20 steps, the simulated system typically settles into a quasi-equilibrium, following adjustments of household agents' decisions and activities in the land rental market.

The values of all the state variables are recorded at each time step, and in the second period, the total cost (subsidy amount) is also recorded. The values of each of the state variables over the last five steps in each 20-step period are averaged for each model run. These represent the state of the system before and after the implementation of a subsidy policy and are compared to measure the effects of the policy. The variations of these state variables between model runs are also examined, and they are reasonably small (Appendix: Tables 5.4, 5.5 and 5.6).

Land rental contracts of large farms usually are not negotiated between individual households; they are often arranged at meetings that involve discussions of all farmer households in a village. It is difficult to simulate this process in the model, and a simulation is not necessary because it is the outcome—all the farmland in a village is rented out to one or very few households—that matters. Households in the village receive a rental fee for their farmland based on areas. The few households that receive use rights for farmland may not be from the same village.

The basic model is modified as follows to estimate household income in a village under the scenario of subsidizing large farms. Household agents do not negotiate in the land rental market. All household agents put their full labor in nonfarm work and become independent of rice cultivation. A household agent's income is determined by its abilities for nonfarm work, according to the migratory work efficiency function. The model therefore becomes a microsimulation. The household income is estimated by averaging the last five steps of the first 20-step period.

Rice production in a village under the scenario of subsidizing large farms is estimated using the following method. Because farmland becomes extremely concentrated under this scenario, rice production in each village is assumed to reach its full potential, i.e., all farmland is used for two-season rice. While this may overestimate rice production, it represents the optimal level of rice production in a village and is useful for examining the effects of other types of subsidies as well. Based on our field observations and a government report on emerging large farms (Jiangxi government 2014), large farms tend to plant two-season rice to make best use of farmland. The yield for two-season rice used for estimating total rice production in V1, V2, and V3, respectively, is 800 kg, 1000 kg, and 1200 kg, and these are estimated based on the biophysical conditions of farmland in the villages.

Total subsidies are estimated by multiplying the subsidy per unit area by the total farmland area of the village. Because the few households that receive use rights for farmland may not be from the same village, total subsidies are not included in total income of a village. This may slightly underestimate farmer income resulting from this policy. The farmland rental fee per unit area is estimated mostly based on the current average economic return from rice cultivation in a village and is slightly adjusted, considering the current rental fee and the potential productivity of farmland in the village. The estimated rental fee in V1, V2, and V3, respectively, is 400 YUAN per mu, 800 YUAN per mu, and 1000 YUAN per mu.

### 5.6.2 *Future Development in Villages with Poor, Average, and Good Farmland*

The three simulated villages share several patterns of projected development (Figs. 5.4, 5.5, and 5.6). First, as wages for nonfarm work increase, rice production in each village will decrease, and rice cultivation will eventually be discarded in V1 and V2, without any policy intervention. Second, the average household income in each village rises with nonfarm work wages. Third, as wages increase, the proportion of farming income will decrease, thereby reducing flood impacts on rural livelihoods. These results from model experiments are in agreement with the understanding developed from the household analysis.

Surprisingly, rising wages do not naturally lead to farmland consolidation in the simulated villages. In V1, farmland becomes more widely distributed among household agents as wages rise. In V2, farmland first becomes slightly more concentrated as wages rise to 60 YUAN per workday, but then less concentrated as wages further increase. In V3, the degree of farmland concentration is low at the current wage level of 40 YUAN per workday and stays relatively stable at relatively low wage levels. It increases slightly as wages continue to rise, but eventually declines as wages further rise to 100 YUAN per workday. Farmland consolidation does not happen because when wages are sufficiently high, even larger farms in the model cannot generate returns comparable to nonfarm work, and some farmland is consequently left uncultivated (Fig. 5.7).

These different trajectories of the simulated villages in farmland arrangement reflect their relative farmland profitability. Farmland in V1 is marginally productive, and its household agents already rely mostly on nonfarm work at the current wage level. They quickly drop rice cultivation as wages rise, and larger farms in V1 cannot compete with nonfarm work, even at low wage levels. Farmland in V3 is highly productive, and most of its household agents find it more profitable to combine nonfarm work with rice cultivation. This leads to a low degree of farmland concentration and full use of farmland. Farmland concentration in V3 remains low until wages rise to very high levels.

Farmland productivity in V2 is at an intermediate level, and the household agents respond to rising wages in a more complex way. As wages rise, at first most of the household agents find it more profitable to do more nonfarm work, with some household agents finding it more profitable to manage larger farms. This results in greater farmland concentration and near full use of farmland. But as wages further rise, those household agents that manage larger farms begin to find it more profitable to do nonfarm work, resulting in a proportion of farmland in the village left uncultivated. This suggests that at some wage levels, farmland in villages with average farmland resources could become more concentrated and fully utilized, which, however, may not be a stable arrangement.

This result is relevant to agricultural development in some other Asian countries that have the same issues of small farm sizes. Farms are expected to become

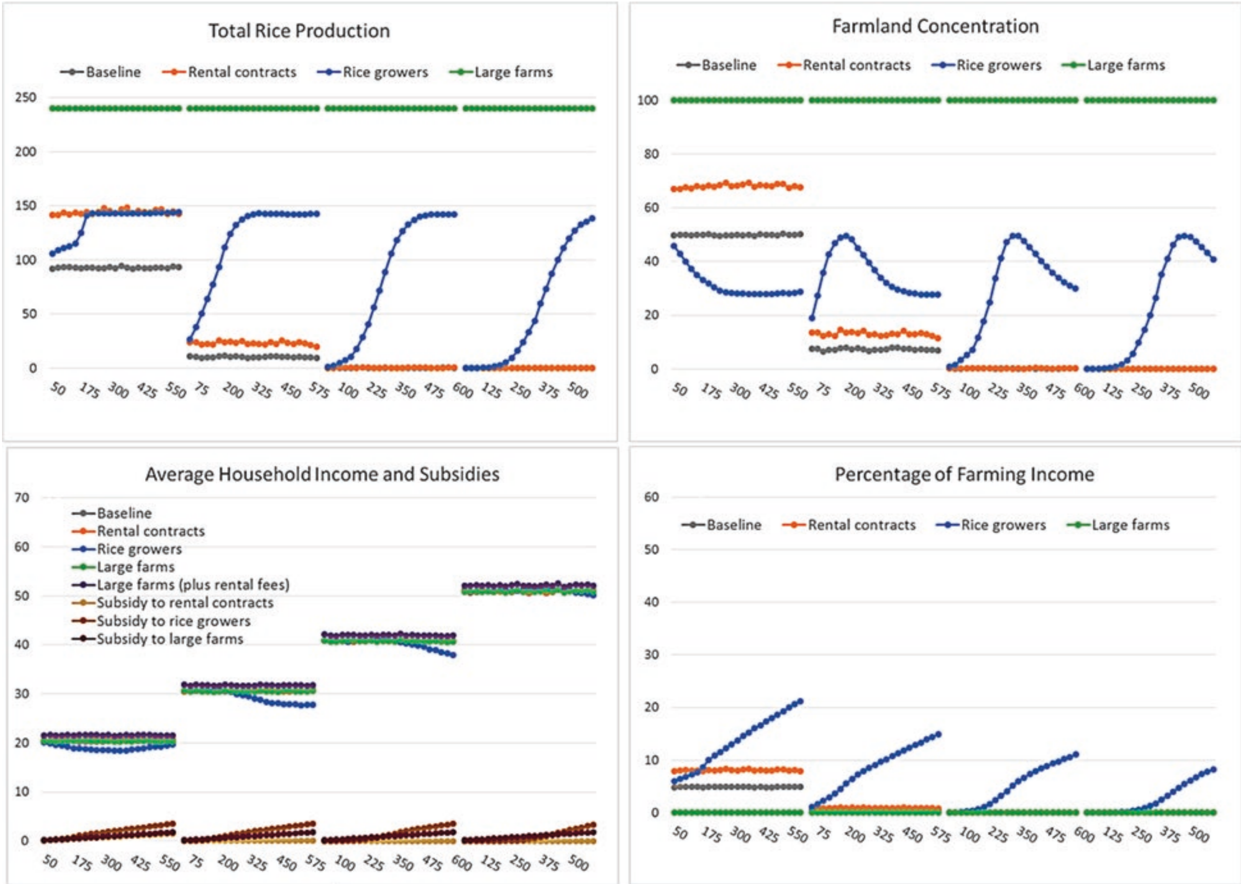



**Fig. 5.4** Effects of different subsidies in V1 with poor farmland resources (see Appendix: Table 5.4 for data). The degree of farmland concentration is represented by the percentage of farmland managed by the top ten households in a village. The horizontal axis represents subsidy amount in YUAN per mu. The four groups of diagrams from left to right represent wages at 40, 60, 80, and 100 YUAN per workday. The unit is 1000 kg for total rice production, and 1000 YUAN for average household income and subsidies

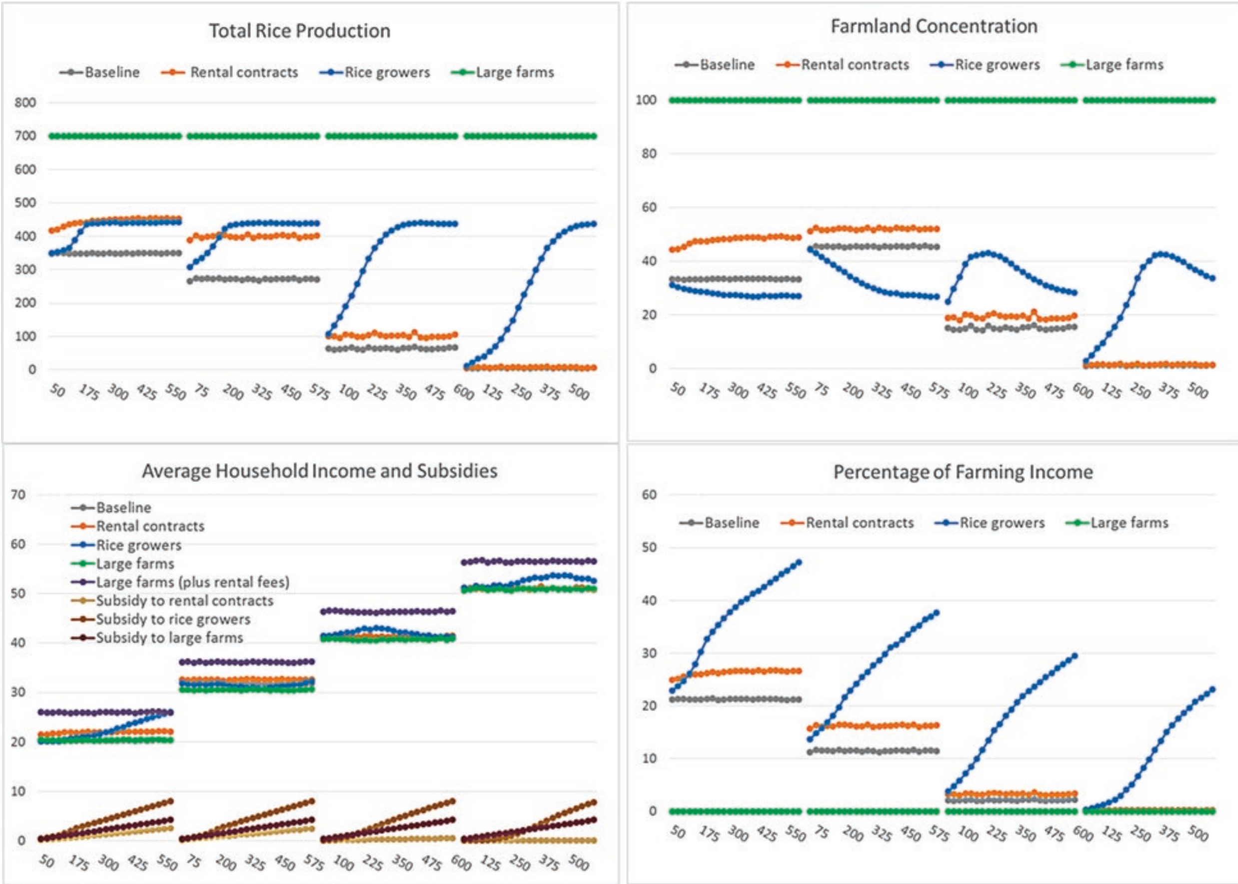



**Fig. 5.5** Effects of different subsidies in V2 with average farmland resources (see Appendix: Table 5.5 for data). The degree of farmland concentration is represented by the percentage of farmland managed by the top ten households in a village. The horizontal axis represents subsidy amount in YUAN per mu. The four groups of diagrams from left to right represent wages at 40, 60, 80, and 100 YUAN per workday. The unit is 1000 kg for total rice production, and 1000 YUAN for average household income and subsidies

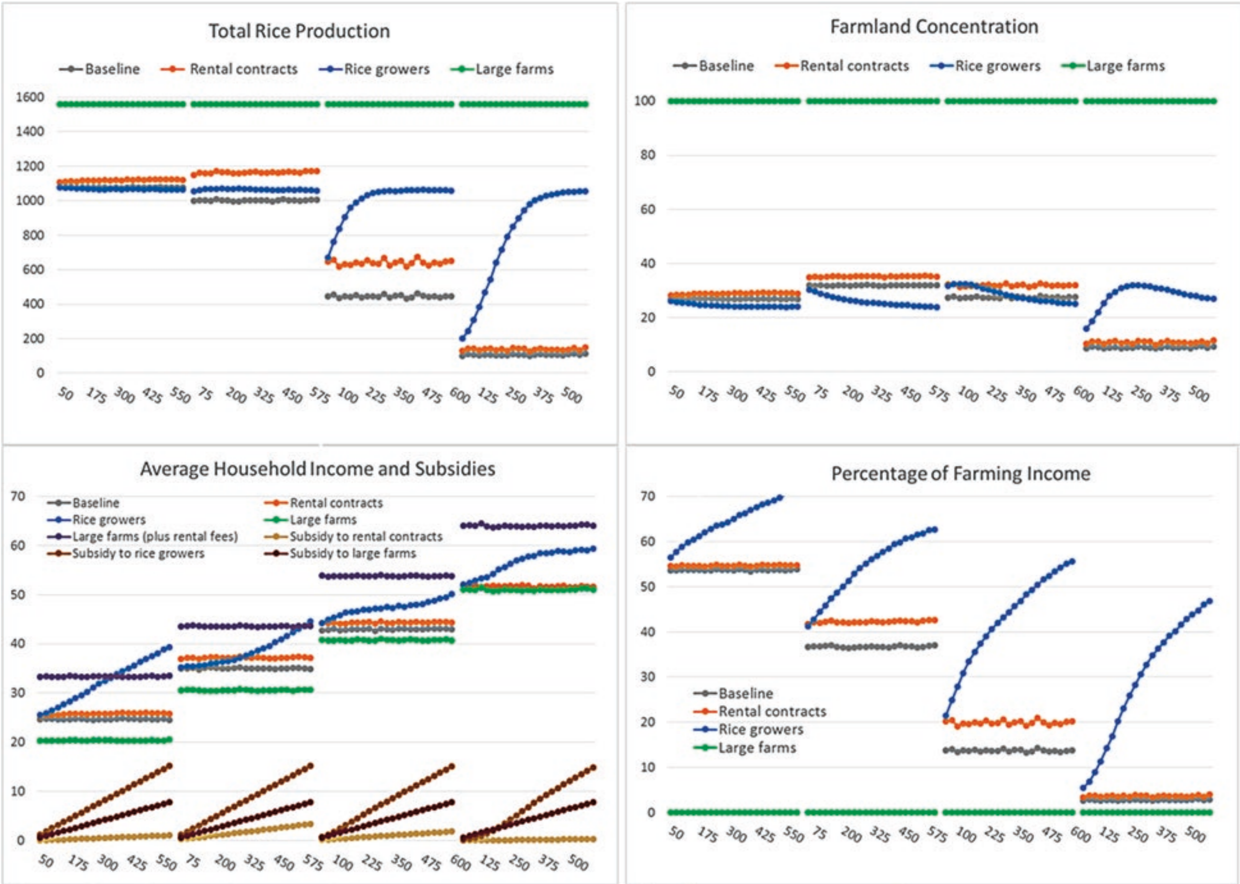



**Fig. 5.6** Effects of different subsidies in V3 with rich farmland resources (see Appendix: Table 5.6 for data). The degree of farmland concentration is represented by the percentage of farmland managed by the top ten households in a village. The horizontal axis represents subsidy amount in YUAN per mu. The four groups of diagrams from left to right represent wages at 40, 60, 80, and 100 YUAN per workday. The unit is 1000 kg for total rice production, and 1000 YUAN for average household income and subsidies

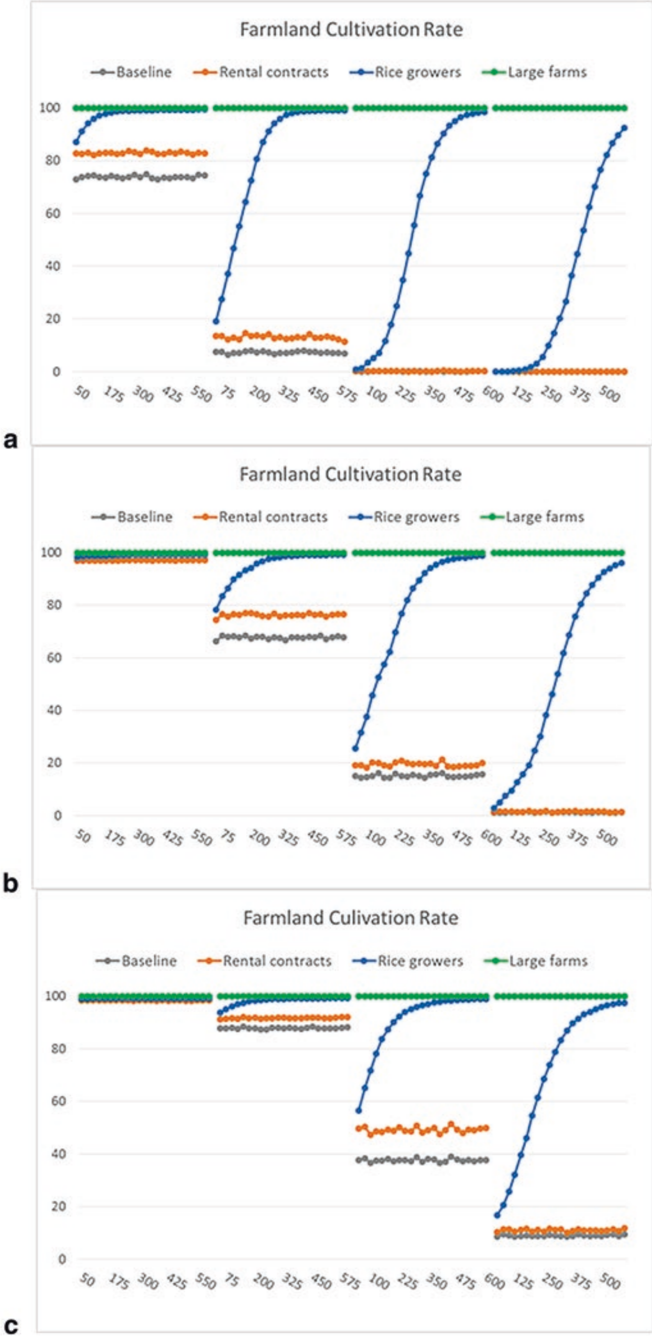



**Fig. 5.7** Farmland utilization rates in three simulated villages as wages for nonfarm work increase from 40 to 60, 80 and 100 YUAN per workday. (**a**) V1, (**b**) V2, and (**c**) V3. The horizontal axis represents subsidy amount in YUAN per mu. Data associated with these figures can be found in supplement materials (see Appendix: Tables 5.4, 5.5, and 5.6)

progressively larger, as per capita income rises and migrant workers leave agriculture (Hazell and Rahman 2014). However, a decrease in farm size has been observed in some Asian countries, such as Thailand, the Philippines, and Indonesia, where massive socioeconomic transformations have occurred (FAO 1990, 2000, 2010). The small farm size may render Asia as a whole losing comparative advantages in agriculture in the world markets (Otsuka 2013; Otsuka et al. 2014).

The empirical household analysis in Chap. 4 shows that a range of factors can limit farm sizes in China. These model experiments expand our understanding by demonstrating the complex micro-level dynamics and macro-level outcomes as wages rise. Policy could play a role to influence the evolution of smallholder farms in the future (see also Rigg et al. 2016).

The differences in future development among the three simulated villages, again, mostly reflect their differences in economic returns from rice cultivation relative to nonfarm work. The farmland productivity decreases from V3 to V2 and V1. As wages rise in the future, economic returns from rice cultivation in V2 and V3 will decrease relative to nonfarm work. Without further policy intervention, what happens in V1 now will likely happen in V2, and what happens in V2 now will likely happen in V3.

### *5.6.3 Policy Effects in Villages with Poor, Average, and Good Farmland*

First, the impacts of all three subsidies on improving income across the simulated villages at all wage levels are small. Of interest, there is a noticeable decrease in average income in V1 as the subsidy to rice growers per unit area increases. This is because increasing the subsidy attracts more labor to rice cultivation and increases the competition for farmland among the household agents as well. Without subsidies to rice growers, the household agents in V1 would spend more labor in nonfarm work and obtain higher incomes. Also, notice that subsidies to rice growers produce a perceptible and relatively larger increase in average income in V3 than the other villages. This is because the household agents in V3 receive large amounts of subsidies, i.e., with high government costs.

Second, the policy effects on improving rice cultivation vary across the simulated villages and at different levels of wages. Rental subsidies are in general most effective at relatively low wage levels, and become less effective, or even ineffective, at high wage levels. In contrast, the increase in rice production resulting from subsidies to rice growers is highly sensitive to the amount of subsidy, with a higher subsidy amount producing more rice.

There appears to be a maximum amount of rice that a village can produce under subsidies to rice growers at each wage level, referred to as “maximum rice amount.” This maximum rice amount results from farmland in a village being fully planted with rice. But because farmland is not all planted with two-season rice, it is considerably less than the optimal level of rice production that may be achieved under subsidies to large farms. Subsidies to large farms can potentially optimize rice production in each village with a cost that is comparable to subsidies to the rice growers. The costs associated with rental subsidies are in general the lowest in each village and at all wage levels.

In V1, rental subsidies produce a large increase in rice production at the current wage level of 40 YUAN per workday with very little cost. This is because household agents in V1 find it more profitable to rent out their farmland for long terms, with even a small amount of rental subsidies. But as wages rise to 60 YUAN per workday and higher, even larger farms in V1 cannot produce income comparable to nonfarm work, and rice cultivation is largely abandoned. Consequently, rental subsidies become ineffective at affecting land exchanges.

In V2, rental subsidies also result in a relatively large improvement in rice production at the current wage level with relatively little cost. At the wage level of 60 YUAN per workday, rental subsidies still produce a large effect on rice production in V2. However, subsidies to rice growers begin to outperform rental subsidies when the subsidy to rice growers rises to about 200 YUAN per mu and higher, with higher costs than rental subsidies. As wages rise further to 80 YUAN per workday and higher, rental subsidies become ineffective in V2. Then, it also needs a substantially large amount of subsidies to rice growers to achieve the maximum rice amount in V2.

In V3, both subsidies to rental contracts and rice growers produce no noticeable effects on rice production at the current wage level. This is because most household agents in V3 find it more profitable to combine nonfarm work and rice cultivation. They do not rent out their farmland, and farmland in V3 is fully utilized even without subsidies. At the wage level of 60 YUAN per workday, rental subsidies produce a slightly better, but overall small, effect on improving rice cultivation than do subsidies to rice growers. As wages rise to 80 YUAN per workday, subsidies to rice growers begin to outperform rental subsidies, but with much higher costs. Rental subsidies become ineffective in V3 as wages rise to 100 YUAN per workday, and it needs substantially large amounts of subsidies to rice growers to achieve the maximum rice amount in V3.

Notice that the patterns of policy effects on rice production in V1 at lower wage levels are similar to those in V2 and V3 at higher wage levels. And the differences, again, largely reflect the differences among the villages in farmland profitability relative to nonfarm wages.

Third, subsidies to large farms lead to independence of farmer households from rice cultivation, thereby reducing flood impacts on rural livelihoods, except for the few large-farm holders. Both subsidies to rental contracts and rice growers can potentially increase flood impacts on rural livelihoods when they are effective at increasing rice production. Under policy scenarios of subsidizing rice growers and rental contracts, the proportion of farming income at the village level is mainly determined by wages and farmland productivity in a village.

In V3, the proportion of farming income is generally higher than V1 and V2, and can be quite high when the subsidy to rice growers per unit area is large. But because farmland-rich areas are usually protected by high-quality levees, flood impacts on rural livelihoods and agriculture in villages like V3 are generally low. Rental subsidies slightly increase the dependence of rural livelihoods on agriculture at the current wage level of 40 YUAN per workday in V1, and at 40 YUAN per workday and 60 YUAN per workday in V2. Subsidies to rice growers in general increase dependence of farmer households on rice cultivation more than rental subsidies, and to a larger degree as the subsidy becomes larger. These differences in potential flood impacts resulting from subsidy policies need to be taken into account, particularly in villages like V1, because these villages are usually protected by low-quality levees.

Of note, the subsidy to rice growers produces a nonlinear effect on farming scales at higher wage levels while showing a negative effect on farmland consolidation at lower wage levels. Specifically, the subsidy to rice growers makes farmland more widely distributed among household agents, notably in V1 at the current wage level, and in V2 at the wage level of 60 YUAN per workday. This is because the subsidy to rice growers attracts more labor to rice cultivation at relatively low wage levels. The nonlinear effects on farming scales show at wage levels of 60, 80 and 100 YUAN per workday in V1; at 80 and 100 YUAN per workday in V2; and at 100 YUAN per workday in V3. During these periods, farmland first becomes more concentrated and then more widely distributed as the subsidy to rice growers per unit area increases.

At relatively high wage levels, under the subsidy to rice growers, household agents begin to pick up rice cultivation, and some household agents find it more profitable to manage larger farms. But as the subsidy further increases, most household agents find it profitable to include rice cultivation and decide not to rent out their farmland. Therefore, full utilization of farmland at relatively high wage levels under large subsidies to rice growers is achieved through rice cultivation by many individual household agents. This is not considered in general to be a desirable farmland arrangement because small farms tend to remain inefficient in the long run.

Another interesting pattern is that the subsidy to rental contracts shows a nonlinear effect on rice production in V2 at the current wage level. As the rental subsidy increases, rice production in V2 first increases quickly but then slows down and levels off. This shows that household agents in V2 are sensitive to the size of the subsidy. The nonlinear pattern could be used to choose efficient subsidy size.

### *5.6.4 Differentiating Policy Interventions across Villages and Adaptive Policy*

What do these modeling results mean for policy interventions in the Poyang Lake region? As demonstrated, future rural development and policy effects are likely to be different in different types of villages and at different stages of development. This suggests that differentiating policy interventions across villages is likely to produce better outcomes than will uniform policy interventions, and that adapting policy will be necessary.

The variations in future development and potential policy effects across the three types of villages largely reflect their differences in farmland profitability. As wages for nonfarm work rise, relative economic returns from rice cultivation in V2 and V3 will decrease, making their situations similar to the current situation in V1. And this will happen sooner in V2 than in V3. Therefore, differentiating policy interventions across the three villages is essentially not that different from adapting policy interventions at different stages of development.

First of all, farming can increase rural income to a limited degree, due to limited farmland and large rural populations. Urbanization will likely continue to play an important role in absorbing rural labor. As discussed in Chap. 4, it is important that policy considers the quantity and diversity of rural populations to guide urbanization to the benefit of rural households. Development, migration, and land policies need to synergistically foster healthy rural-urban development dynamics and promote simultaneous growth of the agricultural and industrial sectors so that rural households can build robust livelihoods via different paths.

Second, it will become increasingly challenging to maintain grain production as nonfarm income continues to rise, and some forms of subsidies will likely be necessary to promote agriculture. A decline of agriculture has also been observed in some other rural areas, especially in those areas with relatively high industrial development (Liu et al. 2005; Deng et al. 2006; Lichtenberg and Ding 2008; Seto et al. 2011). Besides rice production and costs, flood impacts should be taken into account when making policy choices in the PLR, especially for places with high flood risks.

Subsidies to large farms could produce best outcomes with regard to rice production. However, when many households in a village still rely on farming to some extent, subsidizing large farms may not be effective and could increase inequality. Also, it would be more beneficial to all rural households if the degree of farmland concentration is in accord with the amount of rural labor employed in the urban sector. Farmland utilization can provide some clue as to when the timing may be right to implement this policy in different types of villages.

Based on the model experiments, farmland cultivation rate drops below 25% when wages rise to 60 YUAN per workday in V1, 80 YUAN per workday in V2, and 100 YUAN per workday in V3. We may expect that the subsidy to large farms is likely to start taking effect first in villages with poor farmland, then in villages with average farmland, and finally in villages with rich farmland. However, the poor farmland in V1 is not attractive to rice growers unless it is changed to other uses, and the increase in rice production in V1 would be affected by flooding. Another new study with my colleagues at Jiangxi Normal University, Professor Lin Zheng and Dr. Shuhua Qi, shows that the large farms that emerged in the past few years in Jiangxi Province are mostly in areas with soils favorable for rice growing.

Subsidies to large farms may be more effective for villages with average farmland resources. Farmland in V2 is suitable for rice growing but is not fully planted with two-season rice, as in V3, for two reasons. First, the farmland area per household is smaller in V2 than in V3. Second, the collective irrigation system has stopped working in V2, whereas the irrigation system in V3 is well maintained and functioning with assistance from the township government. If farmland in V2 is consolidated, it will be worth investing in irrigation systems, which will help realize farmland's full potential.

Demographic changes can affect the effectiveness of subsidies to large farms. As their children are attending college and settling in cities, middle-aged farmers begin to see that rice cultivation, which costs labor and involves hard work, is no longer essential for their livelihoods. If they are given a rental fee comparable to what their farmland can produce, many of them are willing to consider giving up farming. Based on conversations with college students at Jiangxi Normal University who are from different villages in the PLR, this happened in some villages where farmer households collectively decided to rent out their farmland. Therefore, the policy of subsidizing large farms can start taking effect now in some villages, though it will probably become more widely effective as nonfarm wages rise.

The proposed rental subsidy policy, with the least costs, could be an appropriate choice for villages with poor or average farmland resources when nonfarm wages are relatively low. In villages like V2 with average farmland, household decisions are sensitive to the amount of rental subsidies. Subsidizing households that subcontract their farmland to others for long terms could effectively stimulate land rental markets, and the subsidy amount could be chosen to achieve highest efficiency. The subsidy amount could also be adjusted as development advances such that the degree of farmland concentration is in accord with the amount of rural labor employed in the industrial sector to facilitate healthy rural-urban dynamics.

In villages with poor farmland like V1, the rental subsidy policy could also address the issue of inequality in natural resources. Because farmland is marginally productive in these villages, land rental prices are relatively low. Farmer households that intend to specialize in agriculture can rent in large areas at relatively low costs. This compensates their poor natural resources to some degree. Additionally, most farmer households in these villages already rely largely on migratory work for their livelihoods. If they receive subsidies for subleasing their farmland to other households under long-term contracts, they will be more willing to sign such contracts; and this also makes it easier for those households that intend to specialize in agriculture to acquire large farmland areas. Once consolidated, the marginal farmland may be used in other ways to increase land profitability and reduce flood impacts. The subsidies the renters receive can help improve their urban livelihoods. Thus, every farmer household can improve its situation. There are a variety of arrangements that can be made with rental subsidies to further address farmland inequality among villages (Tian et al. 2016).

Subsidizing rice growers does not seem to be a good policy choice, considering its economic performance. It appears to have very limited positive effects, even with undesirable outcomes, and would involve substantially large costs to be effective at improving rice production. Particularly in villages with poor farmland it may make farmland more decentralized and lead to a reduction in total income. Households in these villages receive much lower subsidies than those in farmland-rich villages, further increasing inequality in natural resources and levee systems. Its effects are also immediate and lack the potential for continuous growth (Tian et al. 2016).

However, our interviews show that the subsidies to rice growers makes farmer households feel that the government cares about them, and thus have a positive social effect. And farmland-rich villages like V3 produce much more rice than farmland-poor villages like V1. The social effect and the large rice production in farmland-rich villages may justify subsidies to rice growers. The issue of inequality could be mitigated by other policy interventions, such as facilitating and assisting households in farmland-poor villages to develop secure urban-based livelihoods, and through the proposed rental subsidies.

It will probably not be a good idea to increase the amount of subsidies to rice growers to promote agriculture, for two reasons. At lower wage levels, rental subsidies could produce larger positive effects than would subsidies to rice growers, and with much lower costs. At higher wage levels, subsidies to large farms could produce larger positive effects than subsidies to rice growers, with similar costs. Some economists also agree that despite significant increases in agricultural subsidies, these subsidies in general have limited impacts on increasing agricultural outputs, due to influences of nonfarm income (Gale et al. 2005; Heerink et al. 2006; Huang et al. 2011; Gale 2013). Subsidies to rice growers could also produce complex outcomes on farmland arrangements at relatively high wage levels and might have unintended consequences on farmland consolidation.

Third, the insight generated from the model experiments—that rising wages for nonfarm work may not naturally lead to farmland consolidation and, consequently, improved land-use efficiency—can have policy implications. There appears to be a critical period during which rising wages can help farmland consolidation in most villages. But that outcome of increased farmland concentration may not be a stable arrangement, unless luck has it that the critical period coincides with the generational transition. Policy could ride that momentum to push farmland consolidation through. Promoting long-term legal rental contracts would be helpful for stabilizing the farmland arrangement. Migration policy that facilitates farmer households that do well in cities to settle there permanently could also play an important role. Subsidies to households managing large farms could further enlarge scales of farming operations.

## 5.7 Resilience of Rural Development

### *5.7.1 Potential Effects of Severe Floods*

The impacts of severe floods in the worst scenario can be estimated as follows: Rice production would be totally lost, and the amounts would total 89,170 kg in V1, 344,264 kg in V2, and 1,065,479 kg in V3 (Table 5.4). Income would be reduced, and the reduction of average household income would total 931 YUAN in V1, 4,252 YUAN in V2, and 13,133 YUAN in V3 (Table 5.4). V1 would most likely be affected, due to poor levee protection. However, farming income is only about 5% of income in V1, and rice production in V1 is only about 6% of what is produced in V2 and V3 together. Therefore, the loss in income would not be felt strongly by farmer households in villages like V1, and the reduction in rice output in these villages would not be significant for overall food production in the region. The loss in

**Table 5.4** Worst effects caused by severe floods

| Village | Loss in total rice production (kg) | Reduction in household income (YUAN) | Percentage of reduction in income (%) | Likelihood |
|---|---|---|---|---|
| V1 | 89,170 | 931 | 4.92 | Very high |
| V2 | 344,264 | 4252 | 21.29 | Low to medium |
| V3 | 1,065,479 | 13,133 | 53.85 | Very low |

income could be felt by households in V2 and V3 because about 20% and 50%, respectively, of income is from rice cultivation. However, the negative effects of severe flooding on income would likely be for just one year in all villages. Following a severe flood, more farmers would probably seek nonfarm work in cities, as happened after the massive 1998 flood.

Agriculture could be affected by severe floods longer because farmers might give up rice cultivation in the following years, fearing that floods will recur. Rice production in V3 could be affected the most, but the chance that this worst-case scenario happens in V3 is relatively small. Not only are important agricultural centers in the region protected by high-quality levees, the government also puts significant effort into strengthening these important levees when severe floods occur. Overall, the major impact of severe floods would be a reduction in agricultural production in farmland-rich areas, which could last for more than one year, but with a relatively small chance. In general, rural development is likely to bounce back in relatively short terms.

### *5.7.2 Modeling Potential Effects of Economic Shocks*

A shock with a certain degree of severity, defined by duration and probability of finding nonfarm work, is introduced to the model at the 21st time step, after the simulated system settles into a quasi-equilibrium (Fig. 5.8). The model is run for 200 times under a slight shock, a moderate shock, and a severe shock, respectively, for each type of villages. Each time, the model runs for 20 more steps following the introduction of the shock to explore the effects of the shock. Current subsidies to rice growers and the current wage level of 40 YUAN per day are used in these experiments.

The same state variables for exploring policy effects are recorded for each time step. Additionally, average farmland rental price is recorded because economic shocks most likely create ripping effects through household interactions in the land rental market. The values of all state variables from 200 runs are averaged for each time step to represent typical responses of a village to a shock. Their variations between model runs for each village are also examined and are reasonably small (Appendix: Tables 5.7, 5.8, and 5.9).

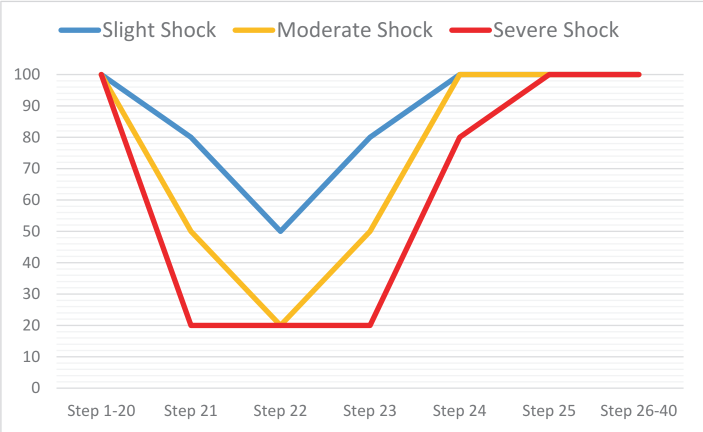



**Fig. 5.8** Three scenarios of economic shocks, introduced at the 21st time step in the model, represented by changes in probability of finding nonfarm work following a shock

### *5.7.3 Rural Development under Economic Shocks*

The three simulated villages respond to economic shocks in several similar ways. Following an economic shock, average household incomes drop immediately, and dependence on farming increases simultaneously (Figs. 5.9, 5.10, and 5.11). Other variables representing the state of the agricultural system, i.e., rice production, farmland concentration, and farmland utilization, also change, but their changes are not as dramatic as the change in income. The agricultural system in each simulated village shows a series of adjustments as household agents make adjustments, which cause fluctuations on the land rental market.

The average rental prices rise significantly, but this occurs later than the drop of income, and prices also recover more slowly. The average rental price in each village peaks several time steps after the probability for finding nonfarm work already bounces back to 100%. It takes almost twice as long as the duration of a shock for the average rental price to bounce back to the normal range. Consequently, it takes quite some steps (years) for all aspects of the agricultural system to recover, although the system does eventually recover. Among all aspects of the agricultural system, farmland concentration is relatively quick to respond to shocks, as household agents each begin to cultivate more farmland immediately after a shock kicks in.

There are some notable differences in villages' responses to economic shocks. Income drops and the percentage of farming income increases at much higher rates in V1 than in V2 and V3 under any shocks (Table 5.5; Fig. 5.12). This is expected because household agents in V1 rely heavily on nonfarm work. The significant reduction in income and an increase in dependence on agriculture could render

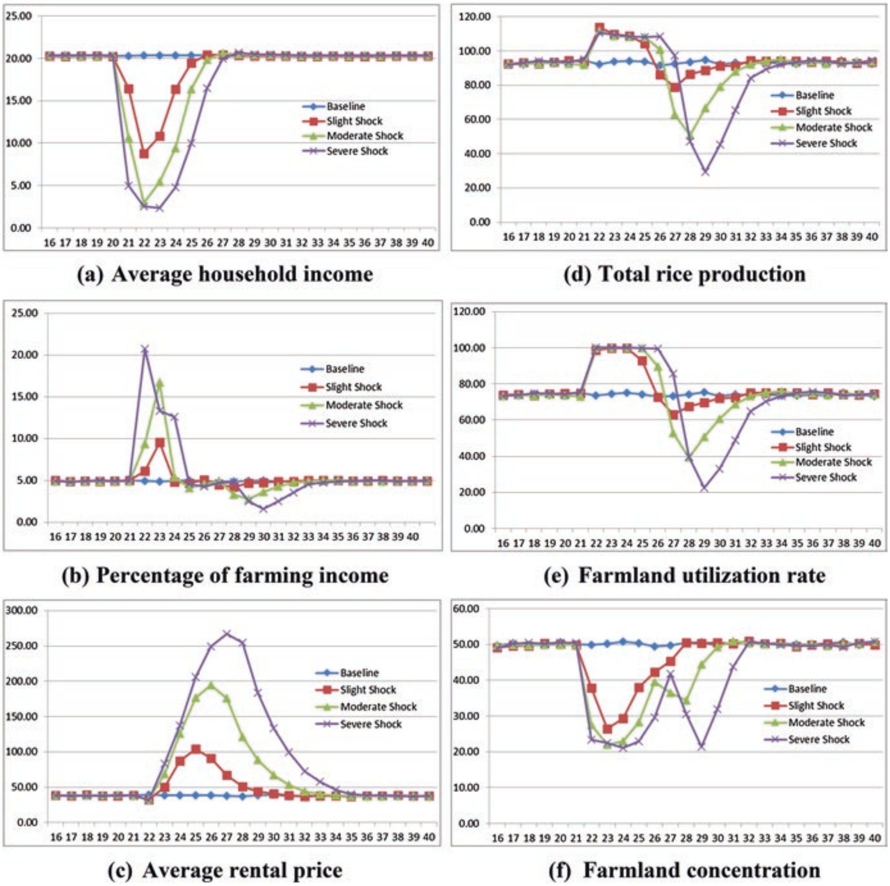



**Fig. 5.9** Responses to economic shocks in V1. Data associated with these figures can be found in supplement materials (Appendix: Table 5.7). (**a**) Average household income in 1000 YUAN. (**b**) Percentage of farming income. (**c**) Average rental price in YUAN per mu. (**d**) Total rice production in 1000 kg. (**e**) Farmland utilization rate. (**f**) Farmland concentration

households in V1 helpless if a severe flood happens during the same period. The rates of change in income and percentage of farming in V3 are the smallest among the three villages, also as expected. The amounts of change in V3 are also relatively small and are probably not felt significantly by the village households. These differences suggest a cushioning effect of farmland resources in times of economic difficulty.

How the agricultural system responds to shocks differs in the three simulated villages, depending also on the severity of shocks. The magnitude of adjustments in the agricultural system in V1 overall appears larger than in V2 and V3 (Figs. 5.9, 5.10, and 5.11). The average land rental price in V2, however, increases more significantly under severe shocks than in V1 and V3 (Fig. 5.12; Table 5.5).

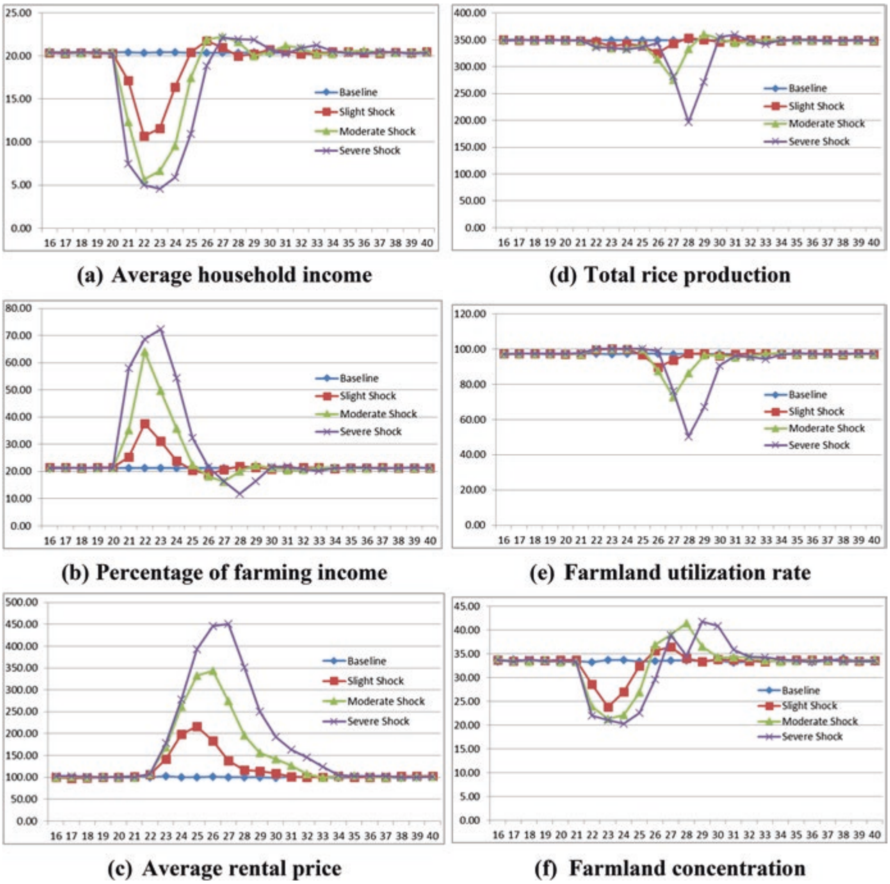



**Fig. 5.10** Responses to economic shocks in V2. Data associated with these figures can be found in supplement materials (Appendix: Table 5.8). (**a**) Average household income in 1000 YUAN. (**b**) Percentage of farming income. (**c**) Average rental price in YUAN per mu. (**d**) Total rice production in 1000 kg. (**e**) Farmland utilization rate. (**f**) Farmland concentration

This again reflects the fact that farmland in V2 has an intermediate level of productivity, and the land rental market in V2 is sensitive to external influences.

In general, the degree of farmland concentration decreases and then increases in all villages after a shock starts. Of note, there is a period in which farmland concentration goes beyond the normal range before finally falling back to the normal range in V2 and V3. This is because household agents have no complete, precise information about the future, and their adjustments are trials and errors, causing ripping effects through interactions in the land rental market.

Farmland concentration in V1 bounces back to the normal range under a slight shock; but under more severe shocks, it drops again, following an initial rise, before it finally recovers. This suggests that farmland arrangements in V1 may be relatively

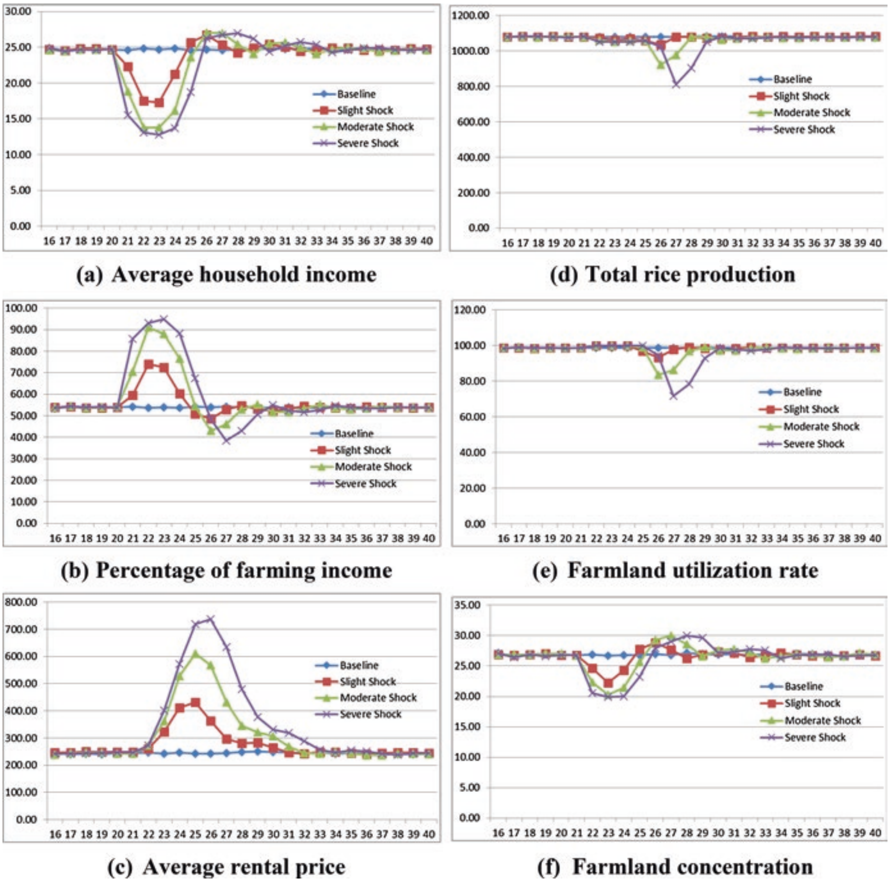



**Fig. 5.11** Responses to economic shocks in V3. Data associated with these figures can be found in supplement materials (Appendix: Table 5.9). (**a**) Average household income in 1000 YUAN. (**b**) Percentage of farming income. (**c**) Average rental price in YUAN per mu. (**d**) Average rental price in YUAN per mu. (**e**) Farmland utilization rate. (**f**) Farmland concentration

easy to restore under slight shocks because household agents quickly pick up nonfarm work as the economic situation begins to improve. However, longer durations of severe shocks could make their quick adjustments ineffective, and they might have to go back to farming in the middle of the recovery.

The changes in rice production, which is closely related to the cultivation rate, show different patterns in V1 than in V2 and V3. Rice production in V2 and V3 does not change much immediately following a shock because their farmland is almost fully planted with rice before the shock. But later rice production in V2 and V3 experiences a slight decrease as a consequence of the decline in farmland concentration. Rice production in V1 increases immediately following the shocks because household agents each pick up more rice cultivation. But later rice production in V1 drops significantly as they pick up more nonfarm work again and farmland cultivate rate decreases.

**Table 5.5** Potential effects of economic shocks. The time step at which extreme values of the state variables occur following a shock are recorded, as shown in the column Step

| | | | Light shock | | | Moderate shock | | | Severe shock | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| State variable | Village | Baseline | Extreme value | Change rate | Step | Extreme value | Change rate | Step | Extreme value | Change rate | Step |
| Average income (1000 YUAN) | V1 | 20.33 | 8.77 | −56.86 | 22 | 2.94 | −85.54 | 22 | 2.32 | −88.59 | 23 |
| | V2 | 20.38 | 10.67 | −47.64 | 22 | 5.65 | −72.28 | 22 | 4.54 | −77.72 | 23 |
| | V3 | 24.71 | 17.29 | −30.03 | 23 | 13.75 | −44.35 | 22 | 12.75 | −48.40 | 23 |
| Percentage farming income (%) | V1 | 4.92 | 9.58 | 94.72 | 22 | 16.71 | 239.63 | 22 | 20.72 | 321.14 | 21 |
| | V2 | 21.29 | 37.57 | 76.47 | 22 | 64.04 | 200.80 | 22 | 72.39 | 240.02 | 23 |
| | V3 | 53.85 | 74.11 | 37.62 | 22 | 90.94 | 68.88 | 22 | 94.95 | 76.32 | 23 |
| Average rental price (YUAN per mu) | V1 | 37.91 | 104.47 | 175.57 | 25 | 194.40 | 412.79 | 26 | 166.86 | 340.15 | 27 |
| | V2 | 100.18 | 216.47 | 116.08 | 25 | 343.28 | 242.66 | 26 | 451.61 | 350.80 | 27 |
| | V3 | 244.17 | 431.55 | 76.74 | 25 | 610.55 | 150.05 | 25 | 736.89 | 201.79 | 26 |

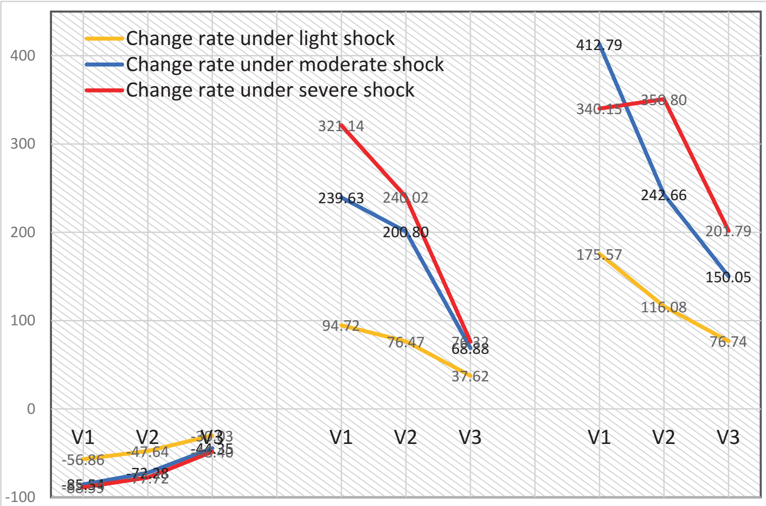



**Fig. 5.12** Severity of economic shocks and impacts in three simulated villages. The first group of lines represent average household income, the second group percentage of farming income, and the third group average rental price

### 5.7.4 *Enhancing Resilience amid Social and Environmental Changes*

The policy recommendations for improving rural development in Chaps. 3 and 4, and in this chapter, could also enhance the resilience of rural development. In villages with poor farmland resources, where the impacts of economic shocks are likely to be felt the most, those same policy recommendations that aim to assist farmer households in securing urban-based livelihoods could also reduce the impacts from economic shocks. Strengthening the levee system in important agricultural areas, where severe floods could cause a significant reduction in rice production, would minimize the chance for an occurrence of this worst-case scenario. Household decisions in villages with average farmland are sensitive to external influences, and policy can effectively stimulate land rental markets to further farmland consolidation. This would increase agricultural production and improve rural income in these villages. As their farmland becomes consolidated, it will become necessary to improve the levee and irrigation systems to mitigate potential flood impacts and promote agriculture.

Healthy macro development dynamics are important not only for improving rural livelihoods but also for enhancing the resilience of rural development. Technological advances are inevitable, and significant structural changes in the industrial sector could have impacts beyond rural households—they could affect the resilience of the whole economy if the structural changes lead to a great mismatch between the quality of labor and the demand of the industrial sector.

The development history of the western world shows that great depressions and recessions seem to have involved significant sectoral changes that are often a consequence of significant technological changes. Depressions and recessions may have started with crises in the financial or some other markets, but the impacts might have been contained had there been no significant sectoral changes that put considerable numbers of people out of work, greatly reducing overall consumption (housing included) and causing ripples across the entire economy for a lengthy period.

The rise of any new technology is likely to cause over-investments due to incomplete information and uncertainty, naturally creating some bubbles. The bursting of these bubbles can serve the purpose to filter out inefficient firms, not unlike natural selection, and may be a necessary part of economic development. This likely affects a relatively small number of firms and workers, with harm limited to a relatively small scope of the economy. Often the rise of a new technology also causes speculations in the financial markets. These speculations further inflate the "natural" bubbles, and bring more damage to the economy when the bubbles burst. Still, if the new technology does not result in significant structural changes in the industrial sector, the damage may not be devastating as a recession/depression.

The Great Depression in the 1920s, the dot-com bubble in the 1990s, and the great recession in the late 2000s are examples that illustrate these mechanisms and differences. The Great Depression involved a structural shift from agriculture to industrial development, and an industrial revolution of large-scale production. The dot-com bubble involved the rise of the high-tech industry; and the great recession may be seen as a broader manifestation of deepened impacts of the high-tech revolution on the whole economy. In fact, the impacts of the great recession in the late 2000s are still felt, and could deepen, because a relatively large segment of workers lost jobs, and those jobs are not very likely to come back amid globalization and the widening adoption of automated technologies.

Thus whether significant sectoral changes are involved may mark the difference between a recession/depression, and a crisis that is more associated with financial speculations on a rising new technology. The magnitude of structural changes and, consequently, the numbers of people affected may be key factors distinguishing a depression and a recession. There may be a threshold for the number of workers affected by structural changes that, once crossed, may lead to a phase transition. Further empirical work and modeling are needed and may indeed illustrate such processes. The Great Depression is relevant to development in China now, and may provide some lessons. If significant sectoral changes happen while a developing economy is in transition to a developed one, and rural-urban gaps are still large, the impacts could be dramatic. Developing and expanding various service industries could mitigate such potential impacts.

## 5.8 Robustness Analysis

To test how rental contracts between relatives affect the inferences on policy effects, a new model parameter, Pct Contracts without Payment, is introduced to represent the percentage of household agents that rent in farmland but do not pay for rental farmland. Its potential values range from 0 to 100%, with an increment of 10%. To examine how specific implementations of the grain subsidy policy may affect policy inferences, an alternative scenario under which grain subsidies are given based on contracted farmland areas—and which therefore do not affect planting decisions of farmers—is explored. These robustness analyses enhance our understanding of policy effects, but do not qualitatively alter the inferences on policy effects (Tian et al. 2016).

## 5.9 Limitations of the Model

A major limitation of the model is that it underestimates rural income in general. The model only includes major economic activities of rice cultivation and migratory work, excluding other activities, such as animal husbandry, cotton and vegetable production, and business. And it only examines direct payments to farmer households and does not include other types of subsidies, such as machine subsidies and price support. Additionally, as farming operations become larger, and as farmer households are assured of their long-term land-use rights, new and more profitable land-use practices will become feasible and can generate higher economic returns. This should further improve the agricultural system, especially in places with poor farmland resources.

Second, the way farmer households decide to sublease farmland for the long term in the model is not based on empirical data. Additional research is needed to investigate the conditions under which farmer households are willing to sign long-term contracts. Third, market prices for rice in the model remain constant. While China's price support policy helps stabilize prices for major agricultural products, future market prices for rice will likely change. Further modeling work is needed to explore how changes in rice price will increase uncertainty of rice production and interact with rising nonfarm wages to affect agriculture. This will generate more useful insights for promoting agriculture as wages increase, and may identify robust policy that produces satisfactory results across plausible scenarios.

Finally, the assumption that household agents do not hire labor can affect model outcomes. When farming operations grow, it is necessary to use hired labor, and large farms do hire laborers for commercial rice production. Allowing labor hiring would not change the inference that raising rural income will depend largely on nonfarm employments, because only few households' incomes would be improved. Allowing labor hiring would most likely intensify farmland concentration and consequently rice production. To the extreme, it would lead to the same maximum degree of farmland concentration as subsidizing large farms.

Under the policy scenario of subsidizing rice growers, the potential effect of labor hiring could be counterbalanced because most farmer households would be less willing to sublease their farmland to other households when receiving subsidies for growing rice. Under the policy scenario of subsidizing rental contracts, the potential effect of labor hiring could be enhanced, but the advantages of subsidizing rental contracts lie at lower wage levels. And at lower wage levels, it would better benefit all rural households to avoid extreme farmland concentration. The government may place some regulations to guide healthy labor hiring practices so that farmland concentration increases according to growth of the industrial sector and the amount of rural labor employed in that sector. As wages for nonfarm work rise, when most households in a village would no longer care about farming, subsidizing large farms would become an obviously better policy than subsidizing rental contracts. Therefore, allowing labor hiring in the model would not alter policy recommendations.

## 5.10 Conclusions

The model experiments in this chapter expand our understandings about rural development in the Poyang Lake area. They allow us to better understand the nature and potential effects of three subsidy policies on increasing rural income, promoting agriculture, and mitigating flood impacts, and particularly how these effects may change as wages for nonfarm work rise, and differ in villages with different farmland endowments. The experiments also demonstrate some of the possible impacts from economic and environmental shocks, and further illustrate the connections between rural and urban development. Overall, they provide useful insights about how policy may need to vary across local contexts and adapt at different stages of development to increase the well-being of rural households and promote agriculture amid social and environmental changes.

Agreeing with and enhancing the empirical analysis in Chap. 4, rural development in the PLR, and in China more generally, is closely linked to urban development. There is a limit on the degree to which farming can increase rural income, and raising rural income will depend largely on increasing nonfarm income. Urbanization will likely continue to play an important role in creating nonfarm work opportunities for rural households. Let us repeat here: It is important that policy interventions consider the quantity and the diversity in labor quality of rural populations to promote healthy urban-urban development dynamics and guide urbanization to benefit rural households.

Rising nonfarm income in the future may not naturally lead to farmland consolidation or consequently improved land-use efficiency—it can actually create challenges for agriculture. Farmland-rich villages contribute to rice production significantly more than do other villages and therefore are extremely important for food security. The good news is that intensive rice cultivation in farmland-rich areas will likely continue in the near future. Villages with average farmland resources are critical for increasing food production because their farmland potential is not fully realized yet, and household decisions can be influenced by policy incentives. At relatively low wage levels, subsidies could be given to households that sublease farmland to others to stimulate land rental markets in these villages. This rental subsidy policy would involve relatively low costs. Furthermore, the subsidy amount could be chosen to optimize current economic efficiency, or more usefully, be adjusted as development advances such that the degree of farmland concentration is in accord with the amount of rural labor employed in the industrial sector.

Subsidizing households managing large farms can achieve best outcomes in rice production and will likely become more effective as wages rise in the future. As young generations from rural areas are getting college education and settling in cities, their parents may no longer look at farming essential for their livelihoods. This generational transition facilitates growth of large farms and enhances the effectiveness of subsidies to large farms. Subsidies to rice growers, by contrast, are not effective in general, and may not be a good policy choice in the long run. But these subsidies are received broadly by rural households and make rural households feel that the government cares about them. This social effect of the grain subsidy policy is worth of consideration.

Many households in villages with poor farmland might become better off seeking urban-based livelihoods. Their livelihoods already rely largely on nonfarm activities; subsidizing households that sublease farmland to others for the long term could effectively facilitate farmland consolidation with low costs. Once consolidated, the marginal farmland could be used for alternative purposes to improve land productivity while reducing flood impacts. Such rental subsidies could also mitigate the issue of inequality in farmland resources for these villages and make every household in these villages grow economically more secure.

While severe floods could affect rice production in important agricultural areas for more than one year, the chance of this is relatively small. Economic shocks, such as economic crises, or dramatic technological changes in the industrial sector, especially if they lead to significant job losses for migrant workers, could produce more complex dynamics in rural development. Villages with poor farmland would be significantly affected by economic shocks; farmer income would be reduced to a very low level, and households could become extremely vulnerable to floods. Severe economic shocks would likely produce relatively large impacts on the dynamics of the land rental market in villages with average farmland. In all villages, the recovery of the agricultural system may not be fast or straightforward. The policy recommendations for improving rural development in general could also mitigate the potential impacts from economic and environmental shocks, enhancing the resilience of rural development in the PLR.

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