Vertical coordination mechanisms and farm performance amongst smallholder rice farmers in northern Ghana

Awal Abdul-Rahaman[1] and Awudu Abdulai[1]

[1]Department of Food Economics and Consumption Studies,
University of Kiel, Germany

Corresponding Author's E-mail: aarahaman@food-econ.uni-kiel.de

Selected Paper prepared for presentation at the 2018 Agricultural & Applied Economics Association Annual Meeting, Washington D. C, August 5-7, 2018.

Vertical coordination mechanisms and farm performance amongst smallholder rice farmers in northern Ghana

Abstract

Contracting is widely perceived to facilitate farmer participation in high agrifood value chains. However, evidence on farmers' participation in different forms of contracts and their related implications on farm performance is still limited in empirical literature. This study examines the determinants and impacts of vertical coordination mechanisms-written contracts, verbal contracts and spot market transactions- on net farm incomes in the rice value chain of northern Ghana. We employ a multinomial BFG model to account for selectivity bias arising from observed and unobserved factors. The findings indicate that in output transactions, vertical coordination choice decisions are influenced by age, education, access to credit, paddy price, association membership and sales to institutional buyers. The empirical results also reveal significant net farm income gains from written contract and verbal contract participation, relative to spot market transactions, with the highest net farm income gains associated with the use of written contracts.

Keywords: Vertical coordination mechanisms, farm performance, multinomial BFG model, rice value chain, Ghana.

1. Introduction

Agrifood value chains in developing countries continue to undergo rapid transformation due to increasing incomes, urbanization and consumer consciousness on food quality and safety (Reardon, Barret, Berdegué, & Swinnen, 2009). The expansion of agricultural commodity markets, supermarkets and agribusiness firms and their requirements for food grades and standards have also contributed to the modernization of agrifood value chains (Barrett et al., 2012; Henderson & Isaac, 2017). Some studies have demonstrated smallholder welfare improvement resulting from high value chain participation (Reardon et al., 2009; Rao & Qaim, 2011; Saenger, Terero & Qaim, 2014). However, poor organization of input and output marketing systems, inefficient production and management technologies, underdeveloped market infrastructure, among others, are the challenges limiting smallholder market participation in developing countries (Alene et al., 2008). Another significant challenge is high transaction costs, exacerbated by lack of access to information on input and output prices and lack of smallholder linkages to value chain actors. (Alene et al., 2008; Abdulai & Birachi, 2009). These challenges are still somehow unresolved, and often make it difficult for farmers to take advantage of prevailing market opportunities (Swinnen & Maertens, 2007).

Contracting is recognized as the dominant form of vertical coordination mechanism for facilitating smallholder farmers' participation in high agrifood value chains (Wang, Wang, & Delgado, 2014). It has become widespread in developing countries and addresses constraints related to market imperfections and high transaction costs (Reardon et al. 2009; Bellemare, 2012). Smallholder farmers contract with downstream buyers to reduce transaction costs and obtain other benefits associated with using contracts (Barrett et al., 2012; Wang et al, 2014). For instance, under contractual arrangements, buyers may pre-finance smallholder farmers, by providing them with

inputs, technology and cash credit, which are normally charged against the final produce (Bellemare, 2012).

Spot market transactions and contracting in smallholder output markets have received considerable attention in development economics literature. In particular, some authors have modeled vertical coordination mechanisms in a dichotomous framework, involving farmers' decision to participate in high agrifood value chains by contracting with agribusiness firms and supermarkets, or supply produce in spot markets (eg. Rao & Qaim, 2011; Bellemare, 2012; Michelson, 2013). High value chain participation through contracts has been found to improve farmer welfare in developing countries (eg. Rao & Qaim, 2011; Michelson, 2013). In the vegetables sector in Kenya, Rao and Qaim (2011) show positive impact of high value chain participation on household income, while Michelson (2013) found that farmer participation in supermarket channels through contracts increases their household productive asset holdings in Nicaragua.

In output markets, evidence on smallholder farmers' decisions to participate in different forms of vertical coordination mechanisms such as written contracts, verbal contracts and spot market transactions, and their related impacts on farm performance could be relevant in providing policy makers with insights as to which coordination mechanism is of substantial benefits to farmers. Some previous studies focused on the determinants of farmers' market participation decisions, quantities of produce transacted and choice of market place for output transactions (eg. Alene et al., 2008; Wintet-Nelson & Temu, 2005). However, only few studies have examined the impact of farmers' choice of vertical coordination mechanisms on farm performance, such as net farm income (eg. Ma & Abdulai, 2016).

Our study contributes to the growing literature on coordination mechanisms and impact on household welfare in three fold. First, we provide insights into the factors affecting farmers'

decision to choose vertical coordination mechanisms in output transactions with specific reference to the rice value chain in northern Ghana. Second, we assess the impact of these factors on net farm incomes. We also highlight the role of transaction costs in vertical coordination mechanism choices and on net farm incomes. Finally, we examine the causal effects of written and verbal contracts choices on net farm incomes relative to spot market transactions. Our study employs recent cross-sectional data involving 458 smallholder rice farmers in five selected areas of northern Ghana. To the extent that farmers self-select into coordination mechanisms, we use the selectivity approach for the multinomial logit model introduced by Bourguignon, Fournier and Gurgand (2007) to account for selection bias that could arise from observed and unobserved factors.

The rest of the paper is structured as follows: section 2 presents an overview of rice production and marketing in Ghana. Section 3 captures the data and summary statistics of the variables used in the analysis. Conceptual framework is captured in section 4, followed by empirical specification in section 5. The empirical results are presented in section 6, while the final section concludes.

2. Overview of rice production and marketing in Ghana

Rice production in Ghana is mostly under rain-fed conditions, although some few irrigation facilities exist in certain areas to facilitate all year round production. Northern, Volta and Upper East regions are the main rice producing areas in Ghana with a total production of about 45 000 – 60 000 tonnes annually (Angeluci, Asante-Poku, & Anaadumba, 2013). Rice consumption in Ghana is increasing due to population growth, urbanization and changing habits of consumers, and thus creates a gap between demand and local supply. Domestic rice production covers around 30-40 percent of consumer demand, allowing for imports of larger quantities to address both quantity

and quality differences between local production and demand (Angeluci *et al*., 2013). However, there is a growing opportunity to enhance rice production and marketing in Ghana, because government and donor agencies have in recent times initiated a number of rice value chain interventions[1]. In general, these interventions aim at increasing rice productivity and quality to match with that of imported rice. The rice value chain constitutes agro-input dealers, producers, aggregators, processors, wholesalers and retailers. Agro-input dealers supply basic inputs such as seed, fertilizer and chemicals for rice farmers to undertake rice production. In northern Ghana, rice is grown by over 279, 000 households with average farm size of between 2.33 and 2.79 hectares, and cultivating about 70% of total land area (USAID, 2009). Smallholder rice farmers produce and supply paddy rice to aggregators and processors, using vertical coordination mechanisms such as spot market transactions, written and verbal contracts. These buyers are institutions or private companies[2] mostly located in the regional capitals of northern Ghana and some parts of southern Ghana. They usually enter into seasonal contractual agreements with smallholder rice farmers at the beginning of the growing season and then travel to the contracted farmers after harvest to mobilize the paddy for onward processing and sales. These contractual arrangements, although not without challenges, have been found useful, because they provide assured markets for farmers and also provide buyers with regular supply of paddy for their agribusinesses. However, some smallholder rice farmers do not get the opportunity to enter into contracts with these private

[1] The Feed the Future-USAID/ATT project focuses on rice, maize and soya in Northern Ghana from 2013 – 2018 and aimed at addressing key constraints in relation to the development, availability and adoption of agricultural technologies for the benefit of over 100,000 maize, soya and rice farmers in Northern Ghana. The Ghana Commercial Agriculture Project (GCAP) is aimed at increasing access to land, private sector finance, input and output markets by smallholder farms from public private partnership in commercial agriculture in Accra plains and Northern Savanna zone

[2] Examples of the private companies that contract with smallholder rice farmers in northern Ghana include premium foods limited, AMSIG Resources, SAVBAN limited, BUSAKA enterprise, Investment Protocol Services Limited (IPSL) etc.

companies, compelling them to sell paddy in spot markets, by either selling at farmgate to buyers who randomly travel to the rice growing areas during harvest period, or transport to market centers for sale. In other cases, local rice processors in the communities also provide markets for this category of farmers.

3. Data and Summary Statistics

This study uses data gathered from a household survey conducted from June to August, 2016 in five areas of northern Ghana; Tamale metropolitan area, Savelugu Nanton Municipal, Tolon, Kumbungu and Sagnarigu districts. A multistage sampling approach was employed in selecting the sample for this study. Firstly, we used purposive sampling technique to select these five areas based on the intensity of rice production, as well as their position as some of the major beneficiary areas of rice value chain initiatives in northern Ghana. Secondly, in consultation with officials of development projects (FtF-USAID-Ghana[3]) and MoFA extension agents, about 2 – 3 communities were randomly sampled from each area. Finally, rice farmers were proportionately sampled based on the farmer population in each area. In total, 458 rice farmers were sampled and face-to-face interviews conducted using a structured questionnaire with the help of trained research assistants and under the supervision of one of the authors. The data collected covered information related to 2015 production season. The survey gathered information from farmers on personal, household and farm-level characteristics, asset ownership, access to credit and marketing activities such as vertical coordination mechanisms and transaction costs.

[3] The project components under the FtF-USAID-Ghana programme include Agriculture Technology Transfer project (ATT), Resiliency in Northern Ghana (RING), Agricultural Development and Value Chain Enhancement (ADVANCE), Strengthening Partnerships, Results and Innovations in Nutrition Globally (SPRING) projects.

Table 1 reports the descriptive statistics of the variables used in the analysis. The dependent variables are the vertical coordination mechanisms (spot market, written and verbal contracts) such that the chosen mechanism is assigned a value of one and zero otherwise. The study sample constitutes 43 percent of farmers who supply paddy in spot markets, 33 percent use written contracts and 24 percent transact with buyers through verbal contracts. The outcome variable is the net farm income generated from rice production and marketing, and is computed as gross farm revenues less variable costs. We observe systematic differences in farmer characteristics with respect to the vertical coordination mechanisms. Tables 2 and 3 report these differences in characteristics and statistical significance tests on equality of means between farmers who use written contracts and those who supply paddy in spot market, as well as farmers who engage buyers with verbal contracts and farmers who supply in spot market, respectively. Significant age differences exist between farmers who use verbal contracts in output transactions and those who carry out spot market transactions but no significant differences in age exist between farmers who engage buyers with written contract and those who supply in spot market. In particular, farmers who supply paddy in spot markets and those who supply using written contracts are relatively younger than rice farmers who engage buyers with verbal contracts, suggesting that older farmers are more likely to choose verbal contracts for output transactions. Again, vertical coordination mechanism users significantly vary in terms of education. In particular, farmers who use written contracts for output transactions are more educated than farmers who use verbal contracts and spot market supply. However, no significant differences in education is observed between farmers who supply in spot market and those who use verbal contracts.

Again, farmers who use written contracts and those who engage in transactions via verbal contracts constitute higher proportion of farmers who are not liquidity constrained, receive higher prices for

the paddy as well as generate higher net farm incomes relative to those who supply in spot markets. With regards to differences in transaction costs factors, farmers who use written contracts and those who use verbal contracts mostly own mobile phones, possess advance knowledge of paddy prices, attach greater importance to legal contracts, mostly belong to farmer association and mostly sell paddy to institutional buyers as compared to farmers who supply paddy in spot markets. The reported mean differences also indicate that both farmers who engage buyers with written and those who use verbal contracts earn higher net farm incomes than farmers who supply paddy in spot market. However, this finding may not hold true, especially after controlling for all confounding factors, which we discuss in section 6.

4. Conceptual Framework

4.1. Vertical coordination mechanism choice decision

In this section, we present a conceptual framework in relation to farmers' choice of vertical coordination mechanisms for output transactions. Note that all rice farmers sampled for the study engage in rice production and sales using vertical coordination mechanisms such as written contract, verbal contract or spot market transactions. Farmers who sell in spot market normally transport paddy to community, district or regional markets for sale, or sell to buyers who randomly mobilize paddy at farm gate during harvest period, without any prior sales agreements. However, farmers who use contracts supply paddy to already existing and regular customers mostly at farmgate through pre-established sales agreements at the beginning of the growing season. Building on the structural models presented in Key, Sadoulet & de Janvry (2000) and Ma and Abdulai (2016), we assume that farmers are risk neutral in order to simplify our model. To begin with, we consider a rice farmer i who engages a buyer in an output transaction involving quantity

q_i at a unit price p_i and an associated transaction costs t_i^c, employing coordination mechanism j among M coordination mechanisms. Transaction costs constitute fixed transaction costs and proportional transaction costs (Key et al., 2000). Fixed transaction costs are costs incurred in setting up the transaction and are independent of the quantities of inputs and output transacted. It includes cost of searching for buyers, market and price information. However, proportional transaction costs vary with input and output quantities transacted and include transportation costs and time spent in delivering the produce to buyers or acquiring production inputs. Proportional transaction costs raise prices paid for production inputs and lower prices received for output (Key et al., 2000). Therefore, we incorporate into the framework the effect of proportional transaction costs on prices paid and received in both input and output markets, respectively. Given that the proportional transaction costs in input and output markets are respectively denoted by t_{il}^p and t_{iq}^p, the real price (p_{il}') in the input market is $p_{il}' = p_{il} + t_{il}^p$ and the real output price received by farmer i is $p_{iq}' = p_{iq} - t_{iq}^p$. If we represent fixed transaction costs in input and output markets as t_{il}^f and t_{iq}^f, respectively, and input quantity as φ, farmer i's problem would be to maximize net farm income (V^*) as:

$$V^* = max\left[q_i\left(p_{iq} - t_{iq}^p\right) - \left(p_{il} + t_{il}^p\right)\varphi - t_{iq}^f - t_{il}^f\right] \quad (1)$$

We assume that farmers choose coordination mechanism that yields maximum net farm income (V_{ij}) than any other coordination mechanism ($V_{i\tau}$). However, we cannot directly observe the expected net farm income associated with each coordination mechanism, but can express it as a function of observable factors in a latent variable (V_{ij}^*) model as:

$$V_{ij}^* = Z_{ij}\beta_j + \eta_{ij} \quad (2)$$

where Z_{ij} is a vector of household, farm level and transaction costs factors influencing vertical coordination choices, β_j is the parameter to be estimated and η_{ij} is the error term. Intuitively, a farmer will choose a coordination mechanism j and not any other coordination mechanism τ if:

$$V = \begin{cases} 1 & if\ V_{i1}^{*} > \max(V_{i\tau}^{*})\ or\ \varepsilon_{i1} < 0 \\ & \tau \neq 1 \\ & . \\ & . \\ M & if\ V_{iM}^{*} > \max(V_{i\tau}^{*})\ or\ \varepsilon_{iM} < 0 \\ & \tau \neq M \end{cases} \quad (3)$$

It is also assumed that the observed covariates in Z_{ij} are uncorrelated with the unobserved stochastic component η_{ij}, i.e. $E(\eta_{ij}|Z_{ij}) = 0$. Again, Assuming that η_{ij} are independently and identically Gumbel distributed, the selection equation (2) leads to a multinomial logit (MNL) model (McFadden, 1973). The probability that vertical coordination mechanism j is chosen by farmer i is expressed as:

$$P_{ij} = P(\varepsilon_{ij} < 0|Z_{ij}) = \frac{\exp(Z_{ij}\beta_j)}{\sum_{\tau\neq 1}^{m}\exp(Z_{ij}\beta_\tau)},\ j = 1,2,3 \quad (4)$$

As stated earlier, three vertical coordination mechanisms are identified in the present study; spot market transactions ($j = 1$), written contract ($j = 2$), and verbal contract ($j = 3$). Note that farmers who carry out spot market transactions is the base group for comparison in the analysis. The multinomial logit (MNL) model constitutes the first stage, and follows a general trend that equation (4) be estimated using maximum likelihood method to obtain coefficients associated with each coordination mechanism. However, we compute marginal effects of the coefficients to allow a better interpretation of the determinants of the vertical coordination choices (Wooldridge, 2010). Moreover, since the independence of irrelevant alternatives (IIA) is assumed in MNL analysis, we

test the MNL model for the IIA assumption by conducting suest-based Hausman test which is a modification of Hausman and McFadden test (Long & Freese, 2005).

4.2. Impact evaluation and selection Bias

This study also investigates the impact of each coordination mechanism j on net farm income. In doing so, we assume that the net farm income is a linear function of a vector of household, farm level and transaction costs related factors X_{ij} and a coordination mechanism choice dummy (V_{ij}). The outcome equation is then specified as:

$$Y_{ij} = X_{ij}\gamma + V_{ij}\delta + \mu_{ij} \quad (5)$$

where Y_{ij} is the net farm income per hectare of farmer *i* conditional on the choice of coordination mechanism j, γ and δ are vectors of parameters to be estimated; μ_i is the error term and satisfies $\mu_i \sim N(0, \sigma)$. It is noteworthy that the parameter δ captures the impact of vertical coordination mechanism on net farm incomes. However, given that farmers self-select into choice of coordination mechanisms for output transactions, using OLS method could result in selectivity bias. In this case, the error terms in the coordination choice model η_{ij} and the net farm income equations μ_{ij} would be correlated and the expected values of μ_{ij} conditional on sample selection are nonzero, which leads to inconsistent estimates. To account for the potential selectivity bias, we consider the methods proposed by Lee (1983), Dubin & McFadden (hereinafter DMF, 1984) and Bourguignon et al. (hereinafter BFG, 2007).

Lee makes restrictive assumptions and fails to take into account the risk of multi-collinearity argued in DMF's approach. Moreover, Lee's (1983) approach estimates only one selectivity term, even when there are multiple choices (Bourguignon et al., 2007). However, the DMF approach is also restrictive because it only extends the number of correction parameters to *M*-1 for *M* choices.

Given the limitations of the two approaches, Bourguignon et al. (2007) proposed an approach to account for selectivity bias with multiple outcomes, which has advantages over Lee and DMF's approaches. It relaxes the restrictive assumption by estimating different selectivity correction terms for each coordination mechanism choice (Khanal & Mishra, 2014), that is, the number of selectivity correction terms is equal to the number of vertical coordination alternatives. It also identifies the direction and source of the bias (Park, Mishra, & Wozniak, 2014; Khanal & Mishra, 2014). In our context, we use the selectivity bias correction method by Bourguignon et al. (2007) which we refer to as "Multinomial BFG Model". It provides deeper insights into the impact of coordination mechanisms on net farm incomes.

5. Empirical specification

5.1. Multinomial BFG model

The multinomial BFG model is a two-stage impact assessment procedure. In the first stage, we estimate a MNL model (eq. 4) to examine the determinants of coordination mechanism choices and then compute selectivity correction terms, which are included in the second stage, to estimate the net farm incomes consistently. The impact of coordination mechanisms on net farm incomes is estimated in the second stage by specifying the following three regimes of outcome equations;

$$\text{Regime 1 (Spot Market):} \quad Y_{i1} = X_{i1}\gamma_1 + \mu_{i1} \quad if\ V = 1 \tag{6a}$$

$$\text{Regime 2 (written contract):} \quad Y_{i2} = X_{i2}\gamma_2 + \mu_{i2} \quad if\ V = 2 \tag{6b}$$

$$\text{Regime 3 (Verbal Contract):} \quad Y_{i3} = X_{i3}\gamma_3 + \mu_{i3} \quad if\ V = 3 \tag{6c}$$

where Y_{i1}, Y_{i2} and Y_{i3} are net farm incomes from participating in spot markets, written and verbal contracts, respectively; X is a vector of household, farm level and transaction costs factors; γ is a vector of parameters to be estimated and μ is the error term. We identify the model since variables

in Z in eq. (2) and X in eqs. (6a-6c) are allowed to overlap during estimation. In such cases, at least one variable in Z should not feature in X (see section 6.1). Therefore, to obtain unbiased and consistent estimates of γ in the net farm income equations, we estimate the following regimes of selection bias corrected net farm income equations (Bourguignon *et al*., 2007):

$$\text{Regime} \quad 1: \; Y_{iSM} = X_{i1}\gamma_1 + \sigma_1 \left[\rho_1 m(P_{i1}) + \sum_j \rho_j m(P_{ij}) \frac{P_{ij}}{(P_{ij} - 1)} \right] + \omega_{i1} \quad \text{if } V = 1 \qquad (7a)$$

$$\text{Regime} \quad 2: \; Y_{iWC} = X_{i2}\gamma_2 + \sigma_2 \left[\rho_2 m(P_{i2}) + \sum_j \rho_j m(P_{ij}) \frac{P_{ij}}{(P_{ij} - 1)} \right] + \omega_{i2} \quad \text{if } V = 2 \qquad (7b)$$

$$\text{Regime} \quad 3: \; Y_{iVC} = X_{i3}\gamma_3 + \sigma_3 \left[\rho_3 m(P_{i3}) + \sum_j \rho_j m(P_{ij}) \frac{P_{ij}}{(P_{ij} - 1)} \right] + \omega_{i3} \quad \text{if } V = 3 \qquad (7c)$$

where P_{ij} is the probability that farmer i chooses coordination mechanism j, ρ_j represents the correlation between μ_{ij} and η_{ij}, and $m(P_{ij})$ is the conditional expectation of η_{ij} and is used to correct for selection bias, ω_{ij} is the error term. Note that a significant selectivity correction term $m(P_{ij})$ related to any coordination specification indicates the presence of selection bias and insignificant term suggests that selection bias is absent and OLS method could produce consistent estimates.

5.2. Estimating Treatment Effects of Vertical Coordination Mechanisms

The average treatment effects on the treated (ATT), which is the causal effect of vertical coordination mechanisms can also be estimated using the multinomial BFG model. Here, farmers who engage buyers through written contracts and those who use verbal contracts constitute the treatment groups and separate predictions of the treatment effects are carried out relative to farmers who supply paddy in spot markets. In particular, the conditional expectations of the net farm

incomes from written contract ($j = 2$) and verbal contract ($j = 3$) choices, with spot market used as base can be expressed as (Bourguignon *et al.*, 2007):

$$E(Y_{i2}|V = 2) = X_{i2}\gamma_2 + \sigma_2 \left[\rho_2 m(P_{i2}) + \rho_1 m(P_{i1}) \frac{P_{i1}}{(P_{i1} - 1)} + \rho_3 m(P_{i3}) \frac{P_{i3}}{(P_{i3} - 1)}\right] (8a)$$

$$E(Y_{i3}|V = 3) = X_{i3}\gamma_3 + \sigma_3 \left[\rho_3 m(P_{i3}) + \rho_1 m(P_{i1}) \frac{P_{i1}}{(P_{i1} - 1)} + \rho_2 m(P_{i2}) \frac{P_{i2}}{(P_{i2} - 1)}\right] (8b)$$

The conditional expectations of net farm incomes of farmers who use written contracts and those who use verbal contracts in output transactions in the counterfactual case that they sell in spot market is then given as;

$$E(Y_{i1}|V = 2) = X_{i1}\gamma_1 + \sigma_1 \left[\rho_1 m(P_{i2}) + \rho_2 m(P_{i1}) \frac{P_{i1}}{(P_{i1} - 1)} + \rho_3 m(P_{i3}) \frac{P_{i3}}{(P_{i3} - 1)}\right] \quad (9a)$$

$$E(Y_{i1}|V = 3) = X_{i1}\gamma_1 + \sigma_1 \left[\rho_1 m(P_{i3}) + \rho_2 m(P_{i1}) \frac{P_{i1}}{(P_{i1} - 1)} + \rho_3 m(P_{i2}) \frac{P_{i2}}{(P_{i2} - 1)}\right] \quad (9b)$$

The ATT, representing the impact of written and verbal contract choices on net farm income relative to spot market transactions is computed as the difference between equations $(8a)$ and $(9a)$ and $(8b)$ and $(9b)$, respectively. If we represent the inverse mills ratios in the brackets of equations $(8a)$ and $(9a)$ and $(8b)$ and $(9b)$ by λ, the ATTs for written contract $(10a)$ and verbal contract $(10b)$ specifications are, respectively expressed as:

$$ATT_{WC} = E(Y_{i2}|V = 2) - E(Y_{i1}|V = 2) = X_{i2}(\gamma_2 - \gamma_1) + \lambda_{i2}(\sigma_2 - \sigma_1) \quad (10a)$$

$$ATT_{VC} = E(Y_{i3}|V = 3) - E(Y_{i1}|V = 3) = X_{i3}(\gamma_3 - \gamma_1) + \lambda_{i3}(\sigma_3 - \sigma_1) \quad (10b)$$

Based on the fact that access to credit and coordination mechanism choice may be jointly determined, could pose potential endogeneity problem. We address this issue by employing the two-stage approach by Rivers and Vuong (1988) due to the dichotomous nature of access to credit. Farmer knowledge of credit sources, which influences access to credit and not coordination choice, is used as an instrument and both the observed access to credit variable and the predicted residuals

from the first stage are featured in the coordination mechanism choice (MNL) to obtain consistent parameter estimates. A *t*-test for the significance of access to credit variable will determine its exogeneity (Wooldridge, 2010).

6. Empirical Results

6.1. Drivers of vertical coordination mechanism choices among rice farmers

The marginal effects of vertical coordination mechanism choices, estimated using multinomial logit (MNL) model are presented in table 4. Note that farmers who supply paddy in spot market constitute the base group for comparison in the analysis. We accounted for unobserved heterogeneity to ensure unbiased and consistent estimates of net farm incomes, by including in the coordination choice model, two valid instruments that significantly influence coordination mechanism choices but uncorrelated with net farm income. In particular, farmer advance knowledge of prices and importance attached to legal contracts were used as instruments for proper model identification. Further, we performed diagnostic tests to check the validity of these instruments. In a two-stage procedure, these instrumental variables were included in both stages of the multinomial BFG model and their significance level tested in each stage (Dimova & Gang, 2007). The chi-square tests indicate the significance of these instruments at 1% level in the coordination choice model and insignificant in the net farm income estimations for all the three coordination mechanism specifications, indicating that our instruments are valid (see Table A1 in appendix). The results from further diagnostic tests, such as the suest-based Hausman tests of Independence of Irrelevant Alternatives (IIA) and Wald test for combining alternatives indicate that the null hypotheses fail to be rejected, implying that the farmers have been appropriately categorized based on the coordination mechanism choices.

The marginal effect of the credit residuals for all the coordination specifications are not statistically significant, implying that the credit access variable has been estimated consistently (Wooldridge, 2010). The marginal effect of credit access variable is positive and significant for written contracts and significantly negative for spot market specification, suggesting that rice farmers who are not liquidity constrained are more likely to engage buyers using written contracts and less likely to supply paddy in spot markets. Age exhibits a positive effect on verbal contract choice, indicating that relatively older farmers are more likely to choose verbal contracts in output transactions, and are less likely to choose written contracts and spot market transactions. This is explained by farming experience because of its positive correlation with age. Better educated farmers are more likely to choose verbal contracts and are less likely to supply paddy in spot market, revealed by a significantly positive and negative marginal effects for the education variable in the verbal contracts and spot market specifications, respectively.

Mobile phone ownership appears to be an important determinant of coordination mechanism choices. It shows a significant positive effect on written contracts and negative effect on spot market transactions, indicating that farmers who own mobile phones are more likely to transact with paddy buyers via written contracts and less likely to sell in spot markets. This is explained by the fact that farmers who use written contracts already have their produce buyers and have carried out successful business exchanges with the farmers over the past five years. This category of farmers easily contact and notify their buyers to make arrangements for produce pick-up, especially when paddy delivery is at farmgate.

The marginal effect of advance price knowledge is positive and significant for written contracts and verbal contracts and significantly negative for spot market choice, suggesting that farmers with advance price knowledge are more likely to engage buyers using written contracts and verbal

contracts and less likely to choose spot markets for output transactions. This finding is consistent with the results obtained by Abdulai and Birachi (2009) on producer-buyer transactions for milk supply chain in Kenya. Again, farmers who sell their produce to institutions and produce buying companies are more likely to engage these buyers via written contracts, and less likely with verbal contracts and spot markets. Association membership exhibits a positive and significant impact on written contracts and verbal contracts choices but negative and significant impact on spot market transactions. This finding suggests that farmers who belong to farmer associations are more likely to engage in output transactions using written contracts and verbal contracts, but less likely to supply paddy in spot markets. The findings on location variables reveal that, relative to Tamale metropolis (reference area), rice farmers in Sagnarigu, Tolon, Kumbungu and Savelugu-Nanton districts are more likely to use written contracts, but less likely to engage buyers through spot markets and verbal contracts.

6.2. Net farm income effects of vertical coordination mechanisms

Table 5 reports the estimates of the second stage multinomial BFG estimation. Note that the dependent variable is the logarithm of net farm incomes. We addressed heteroscedasticity by bootstrapping the estimator variances with 100 replications (Huesca & Camberos, 2010). Three selectivity correction terms related to the three coordination mechanisms have been revealed by the study, which are used to control for sample selection bias. However, Dimova and Gang (2007) state that, for each net farm income specification, a negative (positive) selectivity correction term related to any coordination choice indicates lower (higher) net farm income than those of randomly chosen farmers, suggesting that farmers with better (worse) unobserved attributes switch from using the given coordination mechanism into using the alternative coordination mechanism.

The results show significant selectivity correction terms for spot market and written contract specifications, indicating the presence of selection bias. In particular, the selectivity correction term related to written contracts in the spot market specification is negative and statistically significant, implying that net farm income from spot market transactions are downward biased relative to randomly chosen farmers. This means that for farmers using written contracts, shifting to spot market transactions would lead to a significantly negative impact on their net farm incomes. Also, in spot markets, farmers with unobserved attributes linked to higher net farm incomes have switch towards using written contracts in output transactions. The results also reveal a positive and significant selectivity correction term related to verbal contract in the written contract specification. In other words, net farm incomes from participating in written contracts are upward biased because farmers with worse unobserved attributes switch from using written contracts to engaging buyers with verbal contracts. The significant selectivity correction coefficients with respect to spot market and written contract specifications suggest that the multinomial BFG model is appropriate in accounting for the effects of unobserved (better or worse) farmer attributes on net farm incomes.

We further examine the determinants of net farm incomes conditional on the choice of coordination mechanisms from the multinomial BFG model (see table 5). We find a positive and statistically significant impact of farm size on net farm income for all coordination mechanism users. In particular, a 1% increase in farm size contributes to 0.33% and 0.73% and 0.50% increase in net farm incomes of farmers participating in spot markets, written contracts and verbal contracts, respectively. While our finding is consistent with studies by Park et al. (2014), other studies found negative and statistically significant impact of farm size on net farm incomes (eg. Ma & Abdulai, 2016). Price of paddy is found to have a positive and statistically significant impact on the net farm

incomes of farmers participating in spot markets and verbal contracts and positive but insignificant impact on the net farm incomes of farmers who engage buyers using written contracts. Education exhibits positive and statistically significant impact on written and verbal contracts but negative and insignificant on spot market transactions, suggesting that better education contributes to higher net farm incomes for farmers participating in written contracts and verbal contracts. Similar conclusion was drawn by Bellemare (2012) on welfare impacts of contract farming in Madagascar. Another interesting finding is that, for all the transaction costs variables featured in the analysis, only variable representing sales to institutional buyers and ownership of farm vehicle have statistically significant impact on net farm incomes. Specifically, the institutional buyer variable has a negative and statistically significant impact on net farm incomes from spot market transactions, implying that this category of farmers who get the opportunity to sell to institutions and other private companies earn significantly lower net farm incomes. Several factors could account for this finding. Firstly, farmers who supply in spot markets may not be able to produce paddy to meet the quality requirement of institutional buyers due to resource constraints, thus resulting in lower produce prices and ultimately lower net farm incomes. Again, this category of farmers may also lack the capacity to negotiate effectively for better prices for their produce, also contributing to reduced net farm incomes.

6.3. Average treatment effects of vertical coordination mechanisms on net farm incomes

Table 6 reports the average treatment effects on the treated (ATT) of written and verbal contracts choices on net farm incomes using the BFG method. In this context, farmers using written contracts and those using verbal contracts constitute the treatment groups and separate estimations of the causal effects of these coordination mechanisms on net farm incomes are carried out relative to farmers who engage in spot market transactions (base group). The results reveal that written

contracts contributes significantly to increasing net farm income of smallholder farmers by 14.47% relative to their counterpart farmers who supply paddy in spot markets. In addition, the use of verbal contracts in output transactions significantly increases net farm incomes of smallholder farmers by 10.62%. These findings are in line with conventional wisdom and consistent with other studies, which report that the use of contracts in output marketing contributes significantly to promoting market access and increasing incomes of smallholder farmers (Bellemare, 2012; Ma & Abdulai, 2016).

7. Conclusions

This study examined the determinants of smallholder choice of vertical coordination mechanisms and their related impacts on net farm incomes, using multinomial BFG model to account for sample selection bias. The three vertical coordination mechanisms considered include spot market, written and verbal contracts. The empirical results revealed that contracting (written or verbal) in smallholder output transactions contribute to higher net farm incomes relative to that of farmers who supply paddy in spot markets. It is noteworthy that farmers who use written contracts earn higher net farm incomes than their counterparts who engage buyers using verbal contracts. Transaction costs remain crucial in farmer coordination mechanism choice decisions in output markets. Farmers who own mobile phones, attach more importance to legal contracts and possess advance price knowledge as well as belong to farmer associations are less likely to supply paddy in spot markets, but more likely to use written and verbal contracts for output transactions. Again, access to credit, education and paddy prices also play significant roles in the choice of coordination mechanisms. With respect to the net farm income implications of these variables, sales to institutional buyers and ownership of farm vehicle are the only transaction costs variables with

significant impact on net farm incomes. Better educated farmers and those with larger farm size earn higher net farm incomes when written and verbal contracts are used in output transactions. Our estimates also show that accounting for selection bias using multinomial BFG model is more appropriate, because not only does it consistently estimate the impact on net farm incomes, but also provides information on the source and direction of the bias. The presence of selection bias is revealed by the significant selectivity correction terms in the spot market and written contract specifications. Net farm incomes of farmers who supply in spot markets are downward biased, because farmers who are better suited to supplying paddy in spot markets have moved away from it.

The findings do have some policy implications and clearly suggest that contracting in farmer output transactions generally improves smallholder net farm incomes. This calls for promotion of contracts in smallholder output transactions, especially with the renewed interests of government and donor agencies in transforming the rice value chains in Ghana. Government and NGOs intensifying their engagement with smallholders on the importance of using legal contracts in output transactions could be the starting point for effective contract transactions with buyers. The positive impact of education and access to credit on contractual choices and on net farm incomes calls for government investment in rural education as well as incorporating credit schemes in agricultural value chain interventions to enhance smallholder welfare. Furthermore, collective action of smallholder farmers could also be re-examined because of its role in reducing transaction costs and enhancing market access. Therefore, policies and programs aimed at formation of farmer groups should be promoted. Paddy price play important role in coordination mechanism choices and net farm incomes. Availability of price information prior to planting could guide farmers to negotiate for better prices of paddy, especially in contractual engagements.

References

Abdulai A., and E.A. Birachi 2009. Choice of Coordination Mechanism in the Kenyan Fresh Milk Supply Chain. *Review of Agricultural Economics* 31 (1): 103–121.

Alene D.A., Manyong, V.M., Omanya, G., Mignouna, H.D., Bokanga, M., Odhiambo, G., 2008. Smallholder market participation under transactions costs: Maize supply and fertilizer demand in Kenya. *Food Policy* 33 (2008) 318–328.

Angelucci F., Asante-Poku A. and Anaadumba P., 2013. Analysis of incentives and disincentives for rice in Ghana. *Technical notes series*, MAFAP, FAO, Rome.

Barrett, C.B., M.E. Bachke, M.F. Bellemare, H.C. Michelson, S. Narayanan, and T.F. Walker. 2012. Smallholder Participation in Contract Farming: Comparative Evidence from Five Countries. *World Development* 40(4): 715-730.

Bellemare, M.F. 2012. As You Sow, So Shal You Reap: The Welfare Impacts of Contract Farming. *World Development* 40 (7): 1418-1434.

Bourguignon, F., M. Fournier, and M. Gurgand. 2007. Selection bias Corrections Based on the Multinomial Logit Model: Monte Carlo Comparisons. *Journal of Economic Surveys* 2 (1): 174-205.

Dimova, R. and I. N. Gang. 2007. Self-selection and wages during volatile transition. *Journal of Comparative Economics* 35 (2007): 612-629.

Dubin, J.A. and D.L. McFadden. 1984. An econometric analysis of residential electric appliance holdings and consumption. *Econometrica* 52: 345-362.

Green, W. H., (2012). Econometric Analysis, Prentice Hall, Uppeer Saddle River, NJ.

Heckman, J. J., (1979). Sample selection bias as a specification error. *Econometrica*, 47, 153-161.

Henderson, H and A. G. Isaac 2017. Modern value chains and the organization of agrarian production. *American Journal of Agricultural Economics* 99(2): 379-400.

Huesca, L. and M. Camberos. 2010. Selection bias correction based on the multinomial logit: an application to the Mexican labour market, 2nd Stata Users Group Meeting Mexico, Universidad Iberoamericana Campus Mexico, April 29.

Khanal, A. R. and A.K. Mishra. 2014. Agritourism and Off-farm Work: Survival Strategies for Small Farms. *Agricultural Economics* 45 (2014): 65-76.

Key, N., E. Sadoulet, A. de Janvry 2000. Transaction costs and agricultural household supply response. *American Journal of Agricultural Economics* 82(2000): 245-259.

Lee, L.F. 1983. Generalized econometric models with selectivity. *Econometrica* 51: 507-512.

Long, J. and Freese, J. 2005. Regression models for Categorical dependent variables using Stata (2nd ed.). *College Station*, TX: Stata Press.

Ma, W. and A. Abdulai. 2016. Linking Farmers to Markets. Determinants and Impacts of Marketing Contracts in China. *China Agricultural Economic Review* 8 (1): 1-21.

Michelson, H. C. 2013. Small farmers, NGOs, and a Walmart world: welfare effects of Supermarkets operating in Nicaragua. *American Journal of Agricultural Economics* 95 (3): 628-649.

Park, T.A. 2009. Assessing the Returns from Organic Marketing Channels. *Journal of Agricultural and Resource Economics* 34 (3): 483-497.

Park, T., A.K. Mishra and S.J. Wozniak. 2014. Do farm operators benefit from direct to consumer marketing strategies? *Agricultural Economics* 45 (2014): 213-224.

Rao, E.J.O. and M. Qaim. 2011. Supermarkets, farm household income, and poverty: insights from Kenya. *World Development* 39 (5): 784-796.

Reardon, T., C.B. Barret, J.A. Berdegué,and JFM. Swinnen. 2009. Agrifood Industry Transformation and Small Farmers in Developing Countries. *World Development* 37 (11): 1717-1727.

Rivers, D. and Q. H. Vuong 1988. Limited information estimators and exogeneity tests for simultaneous probit models. Journal of Econometrics, 39 (1988): 347-366.

Saenger, C., M. Torero and M. Qaim. 2014. Impact of Third-Party Contract Enforcement In Agricultural Markets- A Field Experiment in Vietnam. *American Journal of AgriculturalEconomics*96 (4): 1220-1238.

Swinnen, J.F.M., and M. Maertens. 2007. Globalization, Privatization, and Vertical Coordination in Food Value Chains in Developing and Transition Countries. *Agricultural Economics* 37 (s1): 89–102.

Trifkovic, N. 2016. Vertical Coordination and Farm Performance: Evidence from the Catfish Sector in Vietnam. *Agricultural Economics* 47 (2016): 547–557.

USAID. 2009. Global food security response, West Africa rice value chain analysis. MicroREPORT #156.

Winter-Nelson, A. and A. Temu 2005. Impacts of process and transaction costs on input usage in a liberalizing economy: evidence from Tanzanian coffee growers. *Agricultural Economics* 33 (2005): 243-253.

Wang, H. H., Y. Wang and S. Delgado 2014. The transition to morden agriculture: Contract farming in developing countries. *American Journal of Agricultural Economics* 96 (5): 1257-1271.

Wooldridge, J.M., 2010. Econometric Analysis of Cross Section and Panel Data, MIT Press, Cambridge, MA.

Table 1: Variable definition and summary statistics

Variable	Definition	Mean (Std. Dev.)
Spot market	1 if farmer chose spot market, 0 otherwise	0.43(0.49)
Written contract	1 if farmer chose written contract, 0 otherwise	0.32(0.47)
Verbal contract	1 if farmer chose verbal contract, 0 otherwise	0.24(0.42)
Net farm Income	Gross revenue from rice production less variable input cost (GH¢)	1,152.29(1,816.18)
Age	Age of respondent (years)	37.46(11.65)
Education	Education of respondent (years)	2.71(4.40)
Gender	1 if farmer is male, 0 otherwise	0.88(0.32)
Farm Size	Size of farm (hectares)	1.14(1.26)
Access to credit	1 if farmer is not liquidity constraint, 0 otherwise	0.40(0.49)
Mobile phone	1 if farmer owns a mobile phone, 0 otherwise	0.45(0.49)
Distance to market	Distance to market (km)	6.57(4.08)
Advance price knowledge	1 if farmer has advance knowledge of price, 0 otherwise	0.65(0.47)
Importance of legal contracts	1 if farmer considers legal contracts important, 0 otherwise	0.51(0.50)
Institutional buyer	1 if farmer sells to institution, 0 otherwise	0.21(0.41)
Association	1 if farmer belongs to farmer group, 0 otherwise	0.50(0.50)
Farm vehicle	1 if farmer owns farm vehicle, 0 otherwise	0.07(0.26)
Price	Average selling price of paddy rice (GH¢/kg)	1.20(0.27)
Sagnarigu	1 if farmer is located in Sagnarigu district, 0 otherwise	0.12(0.33)
Tolon	1 if farmer is located in Tolon district, 0 otherwise	0.22(0.41)
Kumbungu	1 if farmer is located in Kumbungu district, 0 otherwise	0.24(0.42)
Savelugu Nanton	1 if farmer is located in Savelugu nanton Municipal, 0 otherwise	0.20(0.40)
Tamale	1 if farmer is located in Tamale metropolitan area, 0 otherwise	0.20(0.40)

Note: GH¢ is Ghanaian currency (US$1 = GH¢ 4.19), Std. Dev.: Standard Deviation

Table 2: Differences in characteristics between farmers participating in written contracts and spot markets.

Variable	Written contract		Spot market		Difference (t-stat.)
	Mean	Std. Dev.	Mean	Std. Dev.	
Age	37.370	10.789	36.451	11.534	0.75
Credit access	0.516	0.501	0.289	0.454	4.41***
Education	3.046	0.366	2.269	4.153	1.66 *
Gender	0.887	0.317	0.888	0.315	0.02
Price	1.258	0.292	1.167	0.237	3.19***
Farm Size	1.190	1.592	1.071	0.941	0.86
Advance price knowledge	0.834	0.372	0.370	0.484	9.76***
Dist. to market	6.465	3.607	6.545	3.925	0.19
Mobile phone	0.582	0.494	0.299	0.459	5.51***
Importance of legal contract	0.728	0.446	0.355	0.479	7.41***
Association	0.774	0.419	0.187	0.391	13.44***
Farm vehicle	0.039	0.195	0.086	0.281	1.73 *
Institutional buyer	0.364	0.482	0.101	0.302	6.20***
Net farm income	1,223.066	1,690.43	929.992	1,365.047	1.78 *
Sample size	**151**		**197**		

Table 3: Differences in characteristics between farmers participating in verbal contracts and spot markets

Variable	Verbal contract		Spot market		Difference
	Mean	Std. Dev.	Mean	Std. Dev.	(t-stat.)
Age	39.427	12.828	36.451	11.534	2.08 **
Credit access	0.463	0.500	0.289	0.454	3.10***
Education	3.054	4.648	2.269	4.153	1.52
Gender	0.872	0.334	0.888	0.315	-0.40
Price	1.218	0.316	1.167	0.237	1.60 *
Farm Size	1.207	1.252	1.071	0.941	1.07
Advance price knowledge	0.909	0.288	0.370	0.484	10.65***
Dist. to market	6.788	4.940	6.545	3.925	0.473
Mobile phone	0.563	0.498	0.299	0.459	4.68***
Importance of legal contract	0.527	0.501	0.355	0.479	2.96***
Association	0.718	0.451	0.187	0.391	10.75***
Farm vehicle	0.100	0.301	0.086	0.281	0.39
Institutional buyer	0.218	0.414	0.101	0.302	2.82***
Net farm income	1,453.282	2521.677	929.992	1,365.047	2.36 **
Sample size	**110**		**197**		

Table 4: Determinants of farmer's vertical coordination mechanism choices: MNL regression

Variable	Spot market		Written contract		Verbal contract	
	Marginal effects	S.E	Marginal effects	S.E	Marginal effects	S. E
Age	-0.003	0.003	-0.002	0.002	0.005 **	0.002
Credit access	-0.211***	0.067	0.154 **	0.059	0.571	0.051
Education	-0.014 *	0.008	0.003	0.006	0.010 *	0.006
Gender	-0.009	0.120	0.096	0.084	-0.086	0.098
Price	-0.347 **	0.144	0.261 **	0.105	0.085	0.095
Farm Size (log)	-0.017	0.053	-0.001	0.047	0.018	0.040
Adv. price knowledge	-0.560***	0.059	0.221***	0.055	0.338***	0.043
Dist. to market (log)	0.072	0.068	-0.064	0.055	-0.007	0.048
Mobile phone	-0.181 **	0.071	0.109 *	0.064	0.071	0.055
Import. of legal contract	-0.317***	0.067	0.320***	0.055	-0.003	0.050
Association	-0.548***	0.054	0.333***	0.054	0.214 **	0.049
Farm vehicle	0.093	0.128	-0.152	0.094	0.059	0.103
Institutional buyer	-0.303***	0.071	0.344***	0.074	-0.040	0.058
Sagnarigu	0.056	0.147	0.161	0.139	-0.218***	0.056
SaveluguNanton	-0.155	0.098	0.316***	0.104	-0.161***	0.060
Tolon	-0.119	0.103	0.178	0.108	-0.058	0.072
Kumbungu	0.025	0.111	0.117	0.106	-0.143 **	0.064
Credit residual	-0.020	0.292	-0.004	0.251	0.025	0.222

Note: Based group is spot market; *, **, *** mean significant at 10, 5 and 1 percent levels, respectively

Table 5: Impact of vertical coordination mechanisms on net farm income: BFG estimation

Variable	Spot market		Written contract		Verbal contract	
	Coefficients	S.E	Coefficients	S.E	Coefficients	S.E
Constant	3.984***	0.813	7.894 ***	1.390	3.221 **	1.422
Age	0.012	0.008	-0.021**	0.009	0.001	0.012
Credit access	-0.305	0.206	0.084	0.257	0.247	0.267
Education	-0.006	0.022	0.038 **	0.018	0.046 *	0.026
Gender	0.999***	0.318	-0.162	0.501	0.645	0.517
Price	0.857***	0.291	0.160	0.329	1.131 ***	0.405
Farm Size (log)	0.332 **	0.147	0.737 ***	0.152	0.503 **	0.243
Dist. to market (log)	-0.203	0.160	-0.183	0.191	-0.075	0.272
Mobile phone	-0.029	0.237	0.127	0.198	0.234	0.306
Association	-0.213	0.331	-0.059	0.316	0.209	0.403
Farm vehicle	0.375	0.271	-0.748	0.579	0.929 **	0.395
Institutional buyer	-0.838 **	0.421	0.192	0.302	0.528	0.462
Sagnarigu	-0.381	0.312	0.240	0.494	0.305	0.704
SaveluguNanton	0.469 *	0.281	0.372	0.453	0.657	0.551
Tolon	0.000	0.261	0.326	0.365	0.790 **	0.336
Kumbungu	0.865***	0.250	0.852 **	0.444	0.690	0.613
m(P1)	-0.786	0.526	0.290	1.121	-0.799	1.230
m(P2)	-2.066 *	1.245	-0.199	0.516	0.229	1.429
m(P3)	-0.841	1.067	1.774 **	0.795	0.147	0.513

Note: The dependent variable is the log of net farm income; *, **, *** represent significance at 10, 5, and 1 percent levels, respectively.

Table 6: Average treatment effects of vertical coordination mechanisms on net farm incomes

Mean net farm income		ATT	t-value	Change (%)
Written contract	Spot market			
6.566 (0.055)	5.736 (0.085)	0.830	8.133***	14.47
Verbal contract	Spot market			
6.491 (0.082)	5.868 (0.084)	0.623	5.262***	10.62

Note: ATT: average treatment effect on the treated, the dependent variable is the log of net farm income. Computation of ATT is based on the log of the predictions. *** means significant 1% level.

Appendix

Table A1: Exclusive restrictions and diagnostic tests

Exclusive restrictions test (advance price knowledge and importance of legal contracts)			
Multinomial logit model			
		$chi-square(X^2)$	$p-value$
Vertical coordination mechanisms choices		78.98	0.0000
BFG			
VCM Specification		$chi-square(X^2)$	$p-value$
1. Open market		0.67	0.714
2. written contract		2.75	0.253
3. verbal contract		1.51	0.4700
Diagnostic tests results			
Suest-based Hausman tests of IIA assumption (N=458)			
Ho: Odds (Outcome-J vs Outcome-K) are independent of other alternatives			
Choice alternative	$chi-square(X^2)$	df	$P>chi2$
1	7.658	19	0.990
2	13.715	19	0.800
3	14.181	19	0.773
Wald tests for combining alternatives (N=458)			
Ho: All coefficients except intercepts associated with a given pair of alternatives are 0 (i.e., alternatives can be combined)			
Choice alternative	$chi-square(X^2)$	df	$P>chi2$
1 & 2	117.368	18	0.000
1 & 3	100.069	18	0.000
2 & 3	40.393	18	0.002

Note: A significant test is evidence against Ho; df means degrees of freedom