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The Effect of Consignment Farming on Total Factor Productivity of Farm Households

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위탁영농이 농가의 총요소생산성에 미치는 효과

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Abstract Labor shortage in agriculture has become an important issue in many countries. In addition, the Coronavirus (COVID-19) pandemic precluded the hiring of seasonal workers during the farming season. Hence, consignment farming is an alternative owing to the decrease in the family or hired labor in agricultural production. This paper utilizes the propensity score matching approach with a double-selection Least Absolute Shrinkage and Selection Operator (LASSO) to evaluate the effects of consignment farming on the total factor productivity (TFP) of farm households. The double-selection LASSO found the most relevant control variables for consignment farming and the TFP. Selected control variables are utilized to match treatment and control group samples in propensity score matching. We found that the effect of consignment farming participation on the farm's TFP is approximately 5.6 % on average. Our results provide implications for the labor shortage problem and deserve attention from policymakers.

요 약 최근 세계적으로 다수의 농업생산 국가에서는 농업 노동력 부족 문제가 농정의 주요 현안으로 부상하고 있다. 코로나19 펜데믹 사태가 발생한 이후에 외국인 계절노동자의 국내 입국이 제한되고, 외국인 농업인력에 의존도가 높은 국가의 경우 농업인력 부족으로 농번기 농작업에 차질이 발생하고 있다. 위탁영농은 농작업의 전부 또는 일부를 외부인력에 맡기고, 농업생산과 관련한 가족 및 고용 노동력이 감소하는 등 농업인력이 부족한 상황에서 농업생산 유지를 위한 대안으로 고려된다. 본 논문은 double-selection LASSO를 적용한 성향점수 매칭 기법을 활용하여, 위탁영농이 농가의 총요소생산성에 미치는 효과를 평가하였다. Double-selection LASSO를 통해 결과변수인 총요소생산성과 설명변수인 위탁영농과 관련한 통제변수를 찾고, 선별된 통제변수는 성향점수 매칭을 통한 처지그룹과 대조그룹 간 매칭에 활용되었다. 본 논문은 농가의 위탁영농 참여가 평균적으로 농가의 총요소생산성을 5.6 % 가량 향상시키는 등 농업생산 유지에 대한 위탁영농의 정(+)의 효과를 보였다. 위 결과는 농업 노동력 부족 문제가 심화하는 상황에서 정책 입안자의 의사결정에 활용할 수 있도록 위탁영농 활용의 시사점을 제공하였다는 점에서 의의가 존재한다.

Keywords : Consignment Farming, COVID-19, Labor Shortage, Double-Selection LASSO, Total Factor Productivity

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1. Introduction

Over the past decades, the global agro-food market has been proliferating, driven by expansion in global food consumption, particularly in developing countries. However, the risk of supplying food could expand due to several factors in agricultural production. In particular, the labor supply shortage receives attention in the era of over-depopulation and an aging rural society, which causes uncertainty in food production. As the Coronavirus Disease 2019 (COVID-19) restricts seasonal foreign workers' mobility across borders, some agricultural production countries suffer from a shortage of migrant workers. This phenomenon questions how to increase agricultural productivity in the face of a rapid increase in world food consumption.

Consignment farming, which left some or entire part of farm work on commission with payment, has been active as the alternative for family or hired labor decrease in the agricultural sector. In Korea, farmers utilize consignment farming for providing a specialized labor force during a farming season when the labor demand soars. In detail, agricultural corporation companies provide consignment work services through large-sized agricultural machines replacing the shortage of labor or capital of mainly small and medium-sized farms[1].

According to the Korean Farm Household Economy Survey data set, family and hired labor have been declined consistently, while consignment work has been increasing. Along with changes in farm labor structure, consignment farming plays a critical role in boosting farm household productivity on average. Despite the importance of consignment work in farm productivity, little is known about the impact of consignment farming empirically. Thus, the effect of consignment farming needs to be thoroughly investigated to drive farm labor policy reflecting the imbalance in labor supply and demand.

The purpose of this paper is to evaluate the effect of consignment farming on the total factor productivity (TFP) of farm households. This papers' research subject, consignment farming, is distinguished from contract farming or farming with hired labor which is frequently evaluated in previous literature. In addition, this paper moves beyond the previous literature in that we use carefully designed identification strategies that produce more credible estimates than previous studies.

Theoretically, consignment farming is expected to increase farm household productivity, thus allowing efficient resource allocation and creating more time for farm managers to focus on productive tasks[2,3]. The empirical results indicate the transformation of the agricultural labor force from the farm as a residence to the farm as a source of business. In particular, Korea needs more than 1.16 million additional workers by 2023[4]. Our results could provide insights for the establishment of the labor policy to balance the labor supply and demand.

The structure of this paper is as follows. The next section discusses the literature review. In section 3, we provide data used for the empirical analysis. Section 4 presents the empirical model for production function and the identification strategy of the effects of consignment work on farm TFP. Section 5 provides the estimated results of the production function and the effect of consignment farming on TFP, respectively. The final section concludes with the policy implications drawn from the estimated results.

2. Literature Review

This paper reviews previous literature related to farming with hired labor and consignment farming, respectively. These two concepts are different; however, recognizing the differences

helps us to understand the effects of consignment farming better.

The effects of hired labor on agricultural productivity have been widely investigated[5-7]. According to recent studies, hired workers tend to produce a quality performance on agricultural productivity. One of the main reasons for high performance can be summarized as the concept of specialization and division of the labor force[8,9]. According to [3], small and medium-sized farms in France and Germany produce improved farm productivity by increasing the ratio of hired workers. They conclude that hiring workers allows the farm manager to allocate their labor to specialized tasks while family labor focuses only on managerial tasks[3].

However, family farm theory argues that hiring workers from outside the family could be less effective than utilizing only family labor, supported by the following arguments[8,10-13]. (i) The technological scale economies are only active when the size of farm labor is less than family labor capacity. (ii) Hiring labor force induces supervision costs. In particular, hired labor receives payment regardless of work performance; they have less incentive to work hard. Thus, supervision costs arise in managing hired workers' behaviors, which can be hardly observed.

Note that consignment farming, the subject of this study, is different from hired work. The definition of consignment farming in the previous literature is as follows. First, consignment farming is an act of outsourcing some or entire agricultural production jobs to others[14,15]. Second, consignment farming is a general administration done by an external contractor or service provider[16]. The main concept of consignment farming is strongly related to outsourcing, which guarantees an external contractor's agricultural output. On the contrast, hired work has no duty to produce quality goods, because responsibility is on farm owners. In Korea, farm operators who cannot engage in farming are eligible to utilize consignment work services at a part of or in an entire cultivation area.

Even though the previous paper insists that consignment work is a substitute for hired work[17], others argue that consignment work and hired work complement each other[15]. Thus, the effects of consignment farming on agricultural productivity remain an empirical question. A recent study found that farm productivity increased in utilizing consignment work to the extent of outsourcing[18-20]. In addition, the effects of consignment work on agricultural technique propagation and productivity[21-25], agricultural consultation service[26,27], the utilization rate of a machine[28] are widely investigated. We need more empirical evidence for whether strong points of hired work could be applied to consignment work cases or not. The following explanations are likely applied[2]. (i) Consignment work reduces production cost by outsourcing farm work. (ii) Scaled farm operation is possible by strengthening the specialized division of labor, (iii) by optimizing the organization of agricultural production (the balance between family operation and hired labors), (iv) and by widely applying advanced farming technology.

Even though some papers discuss the effect of outsourcing in agriculture, their discussion is limited to specific crop varieties[14,29,30]; hence, their findings cannot be generalized. In addition, they do not consider farm TFP in the productivity context, which reveals the level of efficiency achieved rather than labor and capital use. This paper believes that TFP is a more appropriate variable to be considered if the effects of consignment farming are related to the specialized division of the labor force instead of simply expanding the total physical labor force.

Thus, our effort in estimating change in the level of TFP as the decision on consignment farming can produce insights into the previous studies.

3. Data

We use a farm-level panel data set from the Korean Farm Household Economy Survey. The data set covers a period of 10 years (2008-2017). The data contains farm production, financial records, and farm characteristics. Following the approach of [31], we define output and input variables. We aggregate 12 different output categories (e.g., rice, barley, other grains, bean, potatoes, vegetables, fruits, flowers, special crops, large animals, small animals, and livestock) to define the output. We also define the labor variable as the sum of family labor, hired labor, and communal sharing of labor. To define the capital variable, we take the average of a farm's assets, including building, machine, animal, inventory, plant, and land. The intermediate variable includes the expenses of seed, fertilizer, pesticides, forage, and light and heat. We deflate input and output variables by the agriculture production index, the farm selling and purchase price index, and the gross fixed capital formation index. The variable of interest, consignment farming, is defined as the indicator of whether a farm is involved with consignment farming. Thus, the variable is equal to one if a farm participates in consignment farming and equal to zero otherwise.

Table 1. Summary Statistics of Selected Variables

VARIABLES	(1) Unit	(2) Mean	(3) Standard Deviation
Output	Million KRW	35.83	83.90
Capital	Million KRW	534.17	1,262
Labor	Hours	1,309	1,389
Intermediate	Million KRW	10.20	42.08

Note: KRW indicates Korean Won
Source: Statistics Korea. 「Korean Farm Household Economy Survey」

In Table 1, we report the summary statistics of selected variables used in estimating a production function. Output, capital, and intermediate variables are measured in KRW; the labor variable is a summation of several labor types in a time unit.

4. Empirical Strategy

4.1 Estimation of production function: control function approach

We use a control function approach to overcome biased estimates of inputs in estimating a production function. Assuming a Cobb-Douglas technology, a farm's production function can be specified as follows:

$$y_{it} = \beta_0 + \beta_k k_{it} + \beta_l l_{it} + \beta_m m_{it} + \omega_{it} + \epsilon_{it} \qquad (1)$$

Where, y_{it} is the log of output (revenue) farm i in year t, k_{it} is the log of the capital stock input, l_{it} is the log of the labor input, m_{it} is the log of the intermediate input, ω_{it} is unobservable productivity, ϵ_{it} is a measurement error of random shocks experienced by the production process.

The essential of the control function approach is to control the unobservable endogenous variable using observable proxy variables properly. If we can properly control the unobservable productivity with an observable proxy, we can mitigate the potential correlation between the number of inputs and unobserved productivity. The core assumption of our estimation strategy[32] is that the unobserved productivity can be expressed as a function of labor inputs, capital inputs, and intermediate inputs. In contrast, it is a function of capital inputs and the proxy variable (e.g., investment, intermediate inputs) in previous approaches[33].

We obtain farm-specific, time-varying total factor productivity, tfp_{it}, using the production function parameter estimates. The total factor productivity can be obtained as follows:

$$tfp_{it} = \exp\left(y_{it} - \hat{\beta}_l l_{it} - \hat{\beta}_k k_{it} - \hat{\beta}_m m_{it}\right) \quad (2)$$

4.2 Selecting control variables: double-selection LASSO

Double-selection LASSO is an extension of LASSO to provide high-quality inference about model parameters. Consider the following linear model:

$$y_i = \beta_0 + \alpha D_i + X_i\beta + \epsilon_i \quad (3)$$

Where, D_i is the variable of interest for farm i and X_i is the vector of control variables, α is the parameter of interest.

To mitigate OVB (Omitted Variable Bias) problem and do inference about α, [34] suggest applying variable selection methods to each of the two variables in the following ways. First, apply variable selection methods to select variables which predict the outcome variable, y_i. Second, try variable selection methods to choose variables which predict the variable of interest, D_i. Third, regress y_i on D_i and all the variables which were selected in either of the first two steps. [35] conducted a simulation exercise and found that the strong OVB is mitigated from the distribution of the double-selection LASSO.

4.3 Estimating the effect of consignment farming: Propensity Score Matching

Once the double-selection LASSO selected control variables, we use the PSM by including the selected control variables. As shown in equation (3), we are primarily interested in the coefficient, α, where it indicates the impact of consignment farming on productivity. The potential problem of estimating α is that consignment farming is endogenously determined. We address this endogeneity problem by matching treatment and control units using the propensity score matching method based on the control variables selected by the double-selection LASSO.

Following the propensity score theorem [36], the effect of consignment farming on productivity can be expressed as the average treatment effect on the treated (ATT). The propensity score matching can be estimated by a logit model.

We checked the robustness of our results. To do so, we exploit two different matching algorithms and caliper sizes: nearest neighbor matching with a caliper size of 0.1, nearest neighbor matching with a caliper size of 0.01, and kernel matching with a caliper size of 0.1, and kernel matching with a caliper size of 0.01. A caliper is a distance that is acceptable for any match.

5. Estimation Results

5.1 Estimation of agricultural productivity

Estimation results for production function models are shown in Table 2. Column (1) reports the Ordinary Least Square (OLS) estimates, column (2) provides fixed effects regression (FE),

Table 2. The Estimation Results of Production Function

Variables	(1) OLS	(2) FE	(3) ACF
Intermediate	0.68*** (0.01)	0.26*** (0.01)	0.46*** (0.12)
Labor	0.26*** (0.01)	0.36*** (0.01)	0.52*** (0.17)
Capital	0.04*** (0.001)	0.16*** (0.02)	0.03*** (0.01)
Observations	25,768		
R-squared	0.951	0.757	-

Note1: Standard errors in parentheses are clustered for farms.
Note2: Asterisks ***, **, and * denotes significance at the 0.01, 0.05 and 0.10 levels, respectively.
Note3: ACF denotes [32]'s estimation approach.

and column (3) reports estimates from the Ackerberg, Caves, and Frazer (ACF) estimator. We have expected signs and a statistical significance at parameters from all estimated production function models.

5.2 Selection of control variables

Table 3 represents the top 5 variables most predictive of productivity and consignment farming with the value of their standardized coefficients. Beginning of year sideline liabilities is the most predictive factor of productivity, followed by End of year other liabilities, Profit margin, Rent, and Sideline revenue. On the other hand, Annual average fixed liabilities is the most important variable in predicting consignment farming.

Table 3. Variables Most Predictive of Productivity and Consignment Farming

(1) Productivity		(2) Consignment Farming	
Variables	Coef	Variables	Coef
Beginning of year sideline liabilities	0.040	Annual average fixed liabilities	-0.032
End of year other liabilities	-0.013	Beginning of year individual liabilities	0.020
Profit margin	0.010	Annual average individual liabilities	0.014
Rent	-0.005	Sideline income	0.011
Sideline revenue	-0.004	Rent	-0.010

5.3 Effect of consignment farming on productivity

Fig. 1 displays the distribution of the estimated propensity scores by participants (treated) and non-participants (untreated) in consignment farming. PSM requires substantial overlap in propensity scores between treatment and control groups, which strengthens the estimation of the average treatment effect of consignment farming.

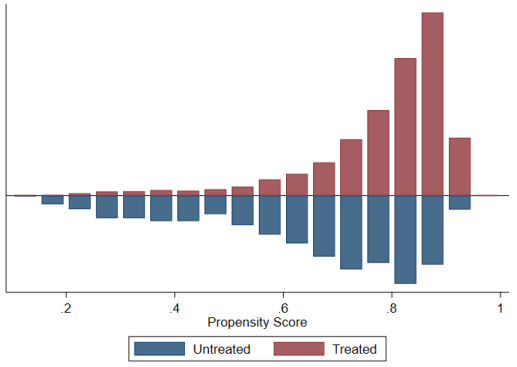

Fig. 1. The Distribution of the Estimated Propensity Scores

Another vital assumption of PSM is no statistical differences for covariates between the treatment and control group. Table 4 presents results from balancing tests that compare the mean of the top 5 covariates after matching. Although there are still statistical differences for some covariates after matching, PSM achieves a significant improvement in narrowing down differences for covariates.

Table 5 shows that consignment farming participation has positive effects on TFP with strong statistical significance. In addition, the empirical results produce robustness of consignment farming effects regardless of matching methods were used. The figure tends to decrease in ATT in relation to unmatched sample cases demonstrating the positive effects of consignment farming on TFP could be overestimated without considering individual agents' self-selection issues. The ATT shows the actual effect of consignment farming participation; consignment farming participation, on average, increased the farm's TFP by about 0.02. In particular, as the farm's TFP with consignment farming is 0.285 while the farm's TFP without consignment farming is 0.271, consignment farming increased the farm's TFP by about 5.6 %. Thus, utilizing consignment work could be an alternative for the labor shortage in farming

caused by over-depopulation and an aging rural society in the context of TFP.

Table 4. Balancing Tests

VARIABLES	Matched Sample		
	Treatment	Control	P-value
Beginning of year sideline liabilities	-3.8552	-3.8482	0.902
End of year other liabilities	-3.2247	-3.3002	0.313
Profit margin	15.936	15.968	0.142
Rent	8.1529	8.2210	0.392
Sideline revenue	2.0336	2.3738	0.016
Annual average fixed liabilities	6.0667	6.5997	0.004
Beginning of year individual liabilities	1.0887	1.0584	0.799
Annual average individual liabilities	2.0788	2.0975	0.884
Sideline income	6.7318	7.2048	0.010

Table 5. Estimation Results: the Impact of Consignment Farming on Productivity

Sample	Nearest Caliper 0.1	Nearest Caliper 0.01	Kernel Caliper 0.1	Kernel Caliper 0.01
Unmatched sample	0.03*** (0.005)	0.03*** (0.005)	0.03*** (0.005)	0.03*** (0.005)
ATT	0.02*** (0.007)	0.02*** (0.006)	0.02*** (0.005)	0.02*** (0.005)

Note1: Standard errors in parentheses are calculated from bootstrapping.
Note2: Asterisks ***, **, and * denotes significance at the 0.01, 0.05 and 0.10 levels, respectively.

6. Conclusion

From the global perspective, the agricultural labor shortage issue has become a priority in agricultural policy worldwide, specifically in the COVID-19 era. In particular, an aging rural society readjusted the agricultural labor structure in Korea, thereby indicating that the alternatives for labor shortage could be the most urgent concern of policymakers. This study suggests that the utilization of consignment farming should be considered strong support for sustainable farming in relation to farms characterized by low mechanization and lacking labor force. In Korea, the COVID-19 pandemic has precluded hiring seasonal workers in a farming season; consignment farming would be an attractive option for solving the labor shortage issue.

Our results suggest that consignment farming policy should be thoroughly designed to reflect the varying labor demand according to farm characteristics. Due to agricultural labor demand varies to farm types, the revised policy better understands the heterogeneity effects of different farm types.

Despite our contributions on the impacts of consignment farming on agricultural productivity, we believe our paper still has a limitation. We use the Korean Farm Household Economy Survey data which covers two 5-year panels, 2008-2012 and 2013-2017. However, since the sample changes significantly every five years, future works wold be needed to separate two panels and estimate the effect of consignment farming, respectively.

References

[1] M. K. Jang, "Utilization of agricultural corporate for agriculture in the future", *Food, Agricultural&Rural Policy*, Vol.69, pp.171-200, 2019.

[2] E. Arnalte, V. Estruch, Il sistema di produzione dell'agrumicoltura valenciana, In: Cavazzani, A., Sivini, G. (eds): Catanzaro, Italy, Rubbettino Editore, 1997, pp.139-150

[3] M. Kloss, M. Petrick, The productivity of family and hired labour in EU arable farming, Discussion Paper, Leibniz Institute of Agricultural Development in Transition Economies, Germany, pp.1-30.

[4] S. Ma, J. Eom, K. Kim, The possibility of youth job creation and task in agro-industry, p.14, Korea Rural Economic Institute, 2017, pp.4

[5] M. Blanc, E. Cahuzac, B. Elyakime, G. Tahar, "Demand for on-farm permanent hired labour on family holdings", *European Review of Agricultural Economics*, Vol.35, No.4, pp.493-518, Dec. 2008.

[6] A. Darpeix, C. Bignebat, P. Perrier-Cornet, "Demand for seasonal wage labour in agriculture: What does

family farming hide?", *Journal of Agricultural Economics*, Vol.65, No.1, pp.257-272, May. 2014.
DOI: https://doi.org/10.1111/1477-9552.12019

[7] Eurostat, Eurostat statistical books: Agriculture, forestry and fishery statistics, p.202, European Union, 2016, pp.1-202

[8] D. W. Allen, D. Lueck, "The Nature of the Farm", *Journal of Law and Economics*, Vol.41, No.2, pp.343-386, Oct. 1998.
DOI: https://doi.org/10.1086/467393

[9] A. Kimhi, "Demand for on-farm permanent hired labour on family holdings: A comment", *European Review of Agricultural Economics*, Vol.36, No.3, pp.447-452, Oct. 2009.
DOI: https://doi.org/10.1093/erae/jbp024

[10] J. M. Brewster, "The machine process in agriculture and industry", *Journal of Farm Economics*, Vol.32, No.1, pp.69-81, Feb. 1950.
DOI: https://doi.org/10.2307/1233164

[11] G. Schmitt, "Why is the agriculture of advanced western economies still organized by family farms? Will this continue to be so in the future?", *European Review of Agricultural Economics*, Vol.18, No.3-4, pp.443-458, Dec. 1991.
DOI: https://doi.org/10.1093/erae/18.3-4.443

[12] Y. Hayami, K. Otsuka, The economics of contract choice: An agrarian perspective, p.220, Clarendon Press, 1993, pp.1-220

[13] R. Eastwood, M. Lipton, A. Newell, Farm Size: Handbook of Agricultural Economics, p.75, Elsevier, 2010, pp.3323-3397

[14] W. Zhigang, S. Hongfang, "Scale agricultural operations: From outsourcing of rice production process", *Chinese Rural Economy*, pp.5-12, 2011.

[15] P. Dupraz, L. Latruffe, "Trends in family labour, hired labour and contract work on French field crop farms: The role of the common agricultural policy", *Food Policy*, Vol.51, pp.104-118, Feb. 2015.
DOI: https://doi.org/10.1016/j.foodpol.2015.01.003

[16] T. Vernimmen, W. Verbeke, G. V. Huylenbroeck, "Transaction cost analysis of outsourcing farm administration by Belgian farmers", *European Review of Agricultural Economics*, Vol.27, No.3, pp.325-345, Sep. 2000.
DOI: https://doi.org/10.1093/erae/27.3.325

[17] J. Kim, N. Oh, J. Heo, Supply and demand of hired farm labour and policy, p.113, Korea Rural Economic Institute, 2014, pp.23-49

[18] U. Arnold, "New dimensions of outsourcing: A combination of transaction cost economies and the core competencies concept", *European Journal of Purchasing & Supply Management*, Vol.6, No.1, pp.23-29, Mar. 2000.
DOI: https://doi.org/10.1016/S0969-7012(99)00028-3

[19] L. Yaofu, F. Xinhong, C. Chunbei, "The definition of agricultural outsourcing", *Interdisciplinary Journal of Contemporary Research in Business*, Vol.4, No.11, pp.40-45, Mar, 2013.

[20] Q. Zhang, B. Yan, X. Huo, "What are the effects of participation in production outsourcing? Evidence from Chinese apple farmers", *Sustainability*, Vol.10, No.12, pp.4525, Nov. 2018.
DOI: https://doi.org/10.3390/su10124525

[21] W. M. Rivera, "Agricultural extension into the next decade", *European Journal of Agricultural Education and Extension*, Vol.4, No.1, pp.29-38, Jul. 1997.
DOI: https://doi.org/10.1080/13892249785300131

[22] A. Fulton, D. Fulton, T. Tabart, P. Ball, S. Champion, J. Weatherley, D. Heinjus, Agricultural Extension, Learning and Change, Report, Rural Industries Research and Development Corporation, Australia, pp.1-81.

[23] A. J. Picazo-Tadeo, E. Reig-Martínez, "Outsourcing and efficiency: The case of Spanish citrus farming", *Agricultural Economics*, Vol.35, No.2, pp.213-222, Jan. 2006.
DOI: https://doi.org/10.1111/j.1574-0862.2006.00154.x

[24] Z. Wenqi, "Application of technology outsourcing mode in agricultural technology extension", *Journal of Jilin Agricultural Sciences*, Vol.33, No.3, pp.62-65, Mar. 2008.

[25] L. Hua, "Agricultural technology promotion process outsourcing risk analysis", *Anhui Agricultural Sciences*, Vol.37, No.31, pp.15491-15511, 2009.

[26] J. R. Anderson, Agricultural advisory services, Background Paper, World Bank, United States, pp.1-44.

[27] W. Heemskerk, S. Nederlof, B. Wennink, Outsourcing agricultural advisory services: Enhancing rural innovation in sub-Saharan Africa, p.150, KIT Royal Tropical Institute, 2008, pp.1-150

[28] L. J. Chikuse, C. A. T. Katsvanga, L. Jimu, L. Mujuru, "Impacts of outsourcing forestry operations in the hyperinflationary economic environment of Zimbabwe", *African Journal of Agricultural Research*, Vol.7, No.1, pp.107-114, Jan. 2012.
DOI: https://doi.org/10.5897/AJAR10.066

[29] C. Chao, L. Yinqiu, "Outsourcing the production efficiency of rice production chain analysis: Based on the panel data of the three counties in Jiangsu Province", *Chinese Rural Economy*, pp.86-96, 2012.

[30] C. Ji, H. Guo, S. Jin, J. Yang, "Outsourcing agricultural production: Evidence from rice farmers in Zhejiang Province", *PLoS One*, Vol.12, No.1, e0170861, Jan. 2017.
DOI: https://doi.org/10.1371/journal.pone.0170861

[31] K. Ban, O. Kwon, "Regional Differences in Agricultural Productivity and Agricultural Meta Frontier Production Function in Korea", *The Korean Journal of Agricultural Economics*, Vol.57, No.4, pp.1-

36, Dec. 2016.

[32] D. Ackerberg, K. Caves, G. Frazer, Structural identification of production functions, MPRA Paper, UCLA, United States, pp.1-42.

[33] G. S. Olley, A. Pakes, "The dynamics of productivity in the telecommunications equipment industry", *Econometrica*, Vol.64, No.6, pp.1263-1297, Nov. 1996. DOI: https://doi.org/10.2307/2171831

[34] A. Belloni, V. Chernozhukov, C. Hansen, "High-dimensional methods and inference on structural and treatment effects", *Journal of Economic Perspectives*, Vol.28, No.2, pp.29-50, 2014. DOI: https://doi.org/10.1257/jep.28.2.29

[35] A. Belloni, V. Chernozhukov, "Least squares after model selection in high-dimensional sparse models", *Bernoulli*, Vol.19, No.2, pp.521-547, 2013. DOI: https://doi.org/10.3150/11-BEJ410

[36] P. R. Rosenbaum, D. B. Rubin, "The central role of the propensity score in observational studies for causal effects", *Biometrika*, Vol.70, No.1, pp.41-55, Apr. 1983. DOI: https://doi.org/10.1093/biomet/70.1.41

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