The Australian Journal of
Agricultural and Resource Economics
AARES
AUSTRALASIAN AGRICULTURAL & RESOURCE ECONOMICS SOCIETY

Australian Journal of Agricultural and Resource Economics, 66, pp. 118–135

Effects of direct payments on rice income variability in Japan*

Atomu Nitta, Yasutaka Yamamoto, Simone Severini, Katsunobu Kondo and Daisuke Sawauchi†

The effects of direct payments on rice income variability in Japan are analysed based on a balanced panel dataset of Japanese rice farms for 2012–2016. Firstly, the contribution of income components to rice income variability and the effects of a direct payment reduction are discussed by applying variance decomposition. Secondly, robust regression techniques are used to measure the correlation between direct payments and rice income variability. The originality of this paper is that it disaggregates the effects of payments using a regression analysis of the effects of direct payments on income variability for Japan. This contrasts with the existing literature on this topic, which has largely focused on European Union countries. This paper discusses to what degree the reduction in direct payments increases income variability. The results reveal that direct payments decrease Japanese rice income variability. Indeed, after controlling for various farm characteristics, we find a negative relationship between the amount of direct payments linked to rice production and rice income variability. Finally, the results suggest that reducing direct payments when the rice price is falling would increase rice income variability.

Key words: direct payments, income variability, Japan, rice income, variance decomposition.

1. Introduction

Managing risk is an important part of farming, and providing greater stability has long been an aim of agricultural policy (Jones, 1969; Meuwissen et al., 2008). Various agricultural policy measures, including market price supports and direct payments, contribute to reducing risk for farm households (OECD, 2009). Although market price support measures

* The authors would like to thank Dr. Ju-Chang Song and Mr. Siyuan Dong for assistance with the literature survey. Further thanks go to the Japanese Ministry of Agriculture, Forestry and Fisheries for providing the *Production Cost of Rice, Wheat and Barley* data. This work was supported by JSPS KAKENHI grant numbers 18K19243, 20J10895 and 20K06261.

†Atomu Nitta is at the Graduate School of Agriculture, Hokkaido University, Kita 9 Nishi 9 Kita-ku, Sapporo, Hokkaido 060-8589, Japan and Research Fellow of Japan Society for the Promotion of Science, Kojimachi Business Center Building, 5-3-1 Kojimachi, Chiyoda-ku, Tokyo 102-0083, Japan. Yasutaka Yamamoto (e-mail: yamay@agecon.agr.hokudai.ac.jp) is Professor at the Research Faculty of Agriculture, Hokkaido University, Kita 9 Nishi 9 Kita-ku, Sapporo, Hokkaido 060-8589, Japan. Simone Severini is Professor at the Università della Tuscia, Via S. C. De Lellis, snc., Viterbo 01100, Italy. Katsunobu Kondo is Professor at the Faculty of Economics, Asahikawa University, 3-23, Nagayama, Asahikawa, Hokkaido 079-8501, Japan. Daisuke Sawauchi is Lecturer at the Research Faculty of Agriculture, Hokkaido University, Kita 9 Nishi 9 Kita-ku, Sapporo, Hokkaido 060-8589, Japan

generally reduce domestic price variability (OECD, 2009), many developed countries have been reforming their agricultural policies and replacing price supports with direct payments, with the long-run aim of reducing support and trade distortions (OECD, 2000).[1]

Many studies have explored how direct payments impact income variability (Bojnec & Fertő, 2018, 2019; Castañeda-Vera & Garrido, 2017; El Benni et al., 2012; Enjolras et al., 2014; Knapp & Loughrey, 2017; Lim et al., 2018; Severini et al., 2016a, 2017). Many of these studies find that direct payments stabilise farm income. However, some studies report that, in some cases, subsidies increase farm income risk (Bojnec & Fertő, 2018; Enjolras et al., 2014; Knapp & Loughrey, 2017). Therefore, the effect of direct payments on income variability is an empirical problem.

This paper focuses on the variability of rice income in Japan and direct payments granted to Japanese rice farms. The Japanese rice sector has not been exempt from the agricultural policy reforms, as market price support has been replaced with direct payments. Given that rice is one of Japan's most important agricultural commodities, rice policy is a central aspect of its agricultural policies. Indeed, rice-related policies account for close to 40% of Japan's producer support estimate (OECD, 2019). Significant differences have been found in levels of income variability depending on the type of farming involved (Severini et al., 2016b). Thus, by focusing on a single crop—rice—and the income from this crop, we can remove the effects of differences between farming types to address the effects of direct payments and their reduction of rice income variability appropriately.

In this paper, we consider two types of direct payments: the Direct Payment for Rice Production (DPr) and the Direct Payment for the Utilization of Paddy Fields (DPu). Both were implemented in 2010 for the purpose of ensuring farm viability and to maintain domestic production potential (MAFF, 2011). First, as explained by Nitta et al. (2020), DPr was based on the current planted area of staple rice, with the payment rate set at JPY 150,000 (USD 1,281)[2] per ha of rice planted area. Second, DPu was granted to all farms that cultivated non-staple rice products (e.g. feed rice, rice flour, wheat and soybeans)[3] instead of staple rice in paddy fields (Hattori, 2012; Kobari, 2018). The amount of DPu that farms received was based on the current area of paddy planted with non-staple rice products. The payment rate was JPY 200,000 (USD 1,708) to JPY 800,000 (USD 6,832) per ha, with

[1] Note that this paper follows the definition of direct payments as 'payments made directly from public authorities' budgets to individual farmers that have the effect of increasing farmers' incomes' (OECD, 1994).

[2] 1 JPY = 0.00854 USD as of 30 December 2016.

[3] DPu was paid based on the current planted area of wheat, barley, soybeans, rice for flour and livestock feed, rice for processing, other feed crops, buckwheat, rapeseed and other crops defined for each prefecture before 2014. Buckwheat and rapeseed were excluded after 2014.

payments fixed for each crop.[4] However, in 2014, the Japanese government reformed the income support direct payments (OECD, 2014). Specifically, the predetermined rate of DPr was halved to JPY 75,000 (USD 640) per ha.[5] In 2010, the first year of these payment programs, approximately 1.2 million farms, received payments under these programs (OECD, 2011).

Based on the background above, the purpose of this paper was to investigate the effects of the direct payments on rice income variability in Japan by asking the following research question: Do direct payments decrease Japanese rice income variability? If the answer to the question is 'yes', then the direct payments contributed to the achievement of one of the policy objectives, that is ensuring farm viability, through stabilising farm incomes.

This paper makes three main contributions to the literature. First, to address the effect of direct payments on rice income variability, we use variance decomposition and regression analyses, following previous studies that assess the effects of direct payments on farm income variability (Bojnec & Fertő, 2018, 2019; Kimura et al., 2010; Severini et al., 2016a, 2017). Compared with many of the previous studies, one of the novelties of this paper is that it disaggregates the effects of payments using regression analysis. To our knowledge, only Knapp and Loughrey (2017) and Lim et al. (2018) disaggregate the effects of different types of payments.

Second, most existing studies have been conducted in relation to the European Union (EU) countries or the United States, with the exception of Lim et al. (2018) for South Korea in Asia. The rice sector, which is the focus of this paper, has been subject to a number of policy interventions in other Asian countries, not just Japan, because of its strategic and political importance. There are similarities between the domestic rice policies of Japan and other Asian countries, as all aim to provide high incomes to rice farmers while ensuring reasonable prices for the public (Tobias et al., 2012). Consequently, this case study fills the gap in the existing literature and can indicate the outlook for other countries, particularly other Asian countries.

Third, because of the need to reduce public spending, direct payments have been reduced in developed countries, including the US and EU countries (European Commission, 2018b; Zulauf & Orden, 2014). Japan has also implemented significant reductions in direct payments, as described above.

[4] As such, DPu is not a payment granted for rice production. However, DPu can affect rice production. Specifically, both DPr and DPu were made based on the current area planted and, thus, were not fully decoupled from production. Therefore, to increase the amount of DPu received, farms might increase the area planted with non-staple rice products and decrease that planted with staple rice as a percentage of their paddy cultivated area. Thus, DPu may affect the variability of rice income through changes in the percentage of the rice planted area over a cultivated paddy area.

[5] The Japanese government reformed DPu in 2014, changing the payment rates of DPu for each crop. Further, from 2014, the payment rates for rice for flour and feed were set higher for farms with higher unit yields of these crops. However, we cannot observe the crop-specific amount of DPu from our dataset.

However, the expected effects of such reductions on farm income variability remain unclear. Therefore, we provide a preliminary discussion of the effects of the direct payment reduction on income variability using the variance decomposition.

2. Literature review

Income from farming is volatile as a result of stochastic factors that affect production and prices (Meuwissen et al., 2008). The direct payments that we consider can affect income variability directly or indirectly. Direct payments are a more stable income source than market income (total income minus direct payments) and, therefore, could reduce the variability of total income (Severini et al., 2016a). While this effect is small (Kimura et al., 2010), it is recognised as important, for example, in the EU (European Commission, 2018a). The indirect effect refers to the fact that direct payments are claimed to affect farmer behaviour (Enjolras et al., 2014; Hennessy, 1998).

Several empirical studies have applied variance decomposition (Burt & Finley, 1968) to identify the sources of risk for farm income (Bojnec & Fertő, 2019; Kimura et al., 2010; Severini et al., 2016a), farm household income (Mishra & Sandretto, 2002) and farm revenue (El Benni & Finger, 2013; Hadrich, 2013). In particular, Severini et al. (2016a) and Bojnec and Fertő (2019) decompose farm income into three components—revenue, costs and subsidies (including direct payments)—and show that direct payments account only for a small part of the farm income variability relative to revenue and costs.

Other studies assess how much direct payments impact income variability using regression analyses (Bojnec & Fertő, 2018; El Benni et al., 2012; Enjolras et al., 2014; Knapp & Loughrey, 2017; Severini et al., 2017). El Benni et al. (2012) and Severini et al. (2017) reveal that direct payments decrease income variability by regressing the coefficient of variation (CV) of farm income or farm household income on the direct payment variable and other control variables. By contrast, Enjolras et al. (2014) and Knapp and Loughrey (2017) regress the standard deviation (SD) of market income on direct payment variables and other control variables and show that direct payments could increase income risks. Bojnec and Fertő (2018) show that direct payments slightly increase farm income variability for a less favoured area and the full sample, but decrease it for an area that is not less favoured. The results showing that direct payments and farm income variability are positively associated can be interpreted as arising because direct payments induce farms to take on greater risks, or because direct payments are targeted towards farms with a higher risk profile (Knapp & Loughrey, 2017). However, using the SD as an indicator of income risk seems problematic because the higher the average income, the higher the SD of income. Thus, the effect of direct payments on income risk may be overestimated when the market income increases as a result of receiving direct payments (e.g. when receiving direct payments makes it possible to increase farm size). Therefore, we use the farm-level CV of rice income as an indicator of income variability in the regression analysis and assess the effect of direct payments on the CV of rice income.

To our knowledge, only Lim et al. (2018) analyse the effects of direct payments on income variability for an Asian country. Lim et al. (2018) simply compare the CV of total farm income (the sum of market income and direct payments) and market income and show that the effects of the fixed-rate payments and price-contingent payments on income variability differ by groups of farms. Further, Knapp and Loughrey (2017) and Lim et al.(2018) disaggregate the effects of different types of payments. Using regression analysis, Knapp and Loughrey (2017) show that decoupled payments increase income risks. As described above, few previous studies disaggregate the effects of different types of payments. Therefore, we disaggregate the effects of DPr and DPu on rice income variability.

The literature on the effects of agricultural policy reforms on income variability is limited. Regarding the introduction of direct payments, El Benni et al. (2012) and Lee (2006) examine the effects of the change from market price support to direct payments on income variability, and both studies conclude that the switch reduced farm income variability. Regarding direct payment reforms, Carvalho and Godinho (2006) conclude that, in the Mediterranean area, the 2003 Common Agricultural Policy (CAP) reform, which decoupled support from production, decreased the variability of total farm income, but increased relative risk when only the expected production income without the decoupled payment was taken into account. Feil et al. (2014) indicate that the MacSharry reform of the CAP, which introduced direct payments, decreased farm income variability, but the Fischler reform and the introduction of the German Renewable Energy Sources Act did not have a significant effect on farm income variability. Kastens and Featherstone (1997) argue that the 1996 Federal Agricultural Improvement and Reform (FAIR) Act in the United States increased farm income risk because government payments were no longer tied directly to production levels or commodity prices.

In summary, Carvalho and Godinho (2006) and Kastens and Featherstone (1997) examine the effects of decoupling government payments, while Feil et al. (2014) address the overall impact of the CAP reforms. However, to our knowledge, there is a lack of research on the effects of direct payment reductions on income risk, especially on income variability. Therefore, the Japanese experience, in which direct payments were significantly reduced, can provide useful implications for other countries, especially Asian countries, that are planning direct payment reductions.[6] We provide a preliminary discussion of the effects of the direct payment reduction on income variability using the variance decomposition.

3. Data and methods

3.1 Data

The analysis is based on a balanced sample of Japanese rice farms included in the Production Cost of Rice, Wheat and Barley dataset for 2012–2016. We select this period for analysis because data by payment prior to 2012 are not available and the 2016 data were the latest available at the time of our analysis. Following Severini et al. (2016a, 2017) and Bojnec and Fertő (2019), we constructed a balanced panel dataset covering 661 individual farms over the period, and the total number of observations is 3,305 (661 farms * 5 years). We then deflated all data by the GDP deflator (2011 = 100) sourced from the Cabinet Office, Japan, allowing for comparison over time.

The focus is on total rice income (TRI), which is defined as the sum of market rice income (MRI) and total direct payments (TDP):

$$TRI = MRI + TDP = REV - EC + TDP \tag{1}$$

where REV is gross revenue from rice, EC is costs of external (i.e. non-family owned) factors, and MRI is defined as REV minus EC. TDP here refers to the sum of the two direct payments considered (i.e. DPr + DPu). When EC is larger than REV, MRI is negative. Further, TRI can be negative when TDP is not large enough to compensate for negative MRI.

On the one hand, DPr is paid based on the current planted area of staple rice; therefore, it can affect TRI variations. On the other hand, DPu is paid based on the current area of paddy planted with non-staple rice products instead of staple rice; therefore, if farms reduce the planted area of staple rice to receive DPu, their MRI, REV and EC could also be affected.

Table 1 shows the annual average income components per farm. MRI and REV decreased in 2014 because of a significant decrease in the market price of rice (Fujibayashi, 2015; Kobari, 2018). TDP and DPr also decreased in 2014 because of the policy reform halving the DPr payment rate. Thus, TRI decreased in 2014 because of a decrease in both MRI and TDP.

[6] In Japan, no study has dealt with the effects of direct payments on income variability, although the literature explores the effects of direct payments for less-favoured area support and environmental/ecosystem services in terms of preventing farmland abandonment and promoting collective stewardship of common property resources (Ito et al., 2018, 2019; Takayama et al., 2020). In addition, the distributional effects of the direct payments that are the focus of this study have been examined (Nitta et al., 2020).

Table 1 Average income components per farm (million JPY)

	2012	2013	2014	2015	2016
TRI (= MRI + TDP)	3.15	2.63	1.29	1.54	2.24
MRI (= REV – EC)	2.43	1.91	0.86	1.13	1.80
REV	6.39	5.96	4.86	4.90	5.60
EC	3.96	4.04	4.00	3.77	3.79
TDP (= DPr + DPu)	0.72	0.72	0.43	0.41	0.44
DPr	0.60	0.62	0.29	0.28	0.29
DPu	0.12	0.10	0.14	0.13	0.15

Note: REV is the gross revenue from rice, EC is the costs for external (i.e. non-family owned) factors, DPr is a predetermined fixed-rate direct payment for rice production, and DPu is a direct payment for the utilisation of paddy fields for non-staple rice products. All entries are deflated by the GDP deflator (2011 = 100).

In this paper, variance decomposition and regression analyses are conducted. The variance decomposition is based on the whole balanced sample of 661 farms, whereas the regression analysis is based on a subsample of 514 farms (i.e. 77.8% of the whole balanced panel data) that have a positive mean value for TRI because we use the farm-level CV of rice income as an indicator of income variability, as described below. Variances and CVs are calculated over the five-year analysis period, and subsequent analyses are conducted using cross-sectional data with sample sizes of 661 for the variance decomposition and 514 for the regression analysis.

3.2 Variance decomposition analysis

First, the contribution of the income components of equation (1) to TRI variability is assessed by applying the variance decomposition by income sources that rely on additive identities (Bojnec & Fertő, 2019; Burt & Finley, 1968; Kimura et al., 2010; Mishra & Sandretto, 2002; Severini et al., 2016a). As noted above, the variance decomposition analysis is based on the whole balanced sample, which comprises 661 farms.

Applying the variance decomposition to the variance of TRI as expressed in equation (1) leads to equation (2) (Kimura et al., 2010):

$$\begin{aligned} Var(TRI) = {} & Var(REV) + Var(TDP) + Var(EC) + 2Cov(REV, TDP) \\ & -2Cov(REV, EC) - 2Cov(TDP, EC) \end{aligned} \tag{2}$$

Dividing equation (2) by the sum of the first three terms provides the following standardised form for interpretation (El Benni & Finger, 2013; Severini et al., 2016a):

$$\frac{Var(REV)+Var(TDP)+Var(EC)+2Cov(REV,TDP)-2Cov(REV,EC)-2Cov(TDP,EC)}{Var(REV)+Var(TDP)+Var(EC)}$$
$$=\frac{Var(REV)}{Var(REV)+Var(TDP)+Var(EC)}+\frac{Var(TDP)}{Var(REV)+Var(TDP)+Var(EC)}$$
$$+\frac{Var(EC)}{Var(REV)+Var(TDP)+Var(EC)}+\frac{2Cov(REV,TDP)}{Var(REV)+Var(TDP)+Var(EC)}$$
$$-\frac{2Cov(REV,EC)}{Var(REV)+Var(TDP)+Var(EC)}-\frac{2Cov(TDP,EC)}{Var(REV)+Var(TDP)+Var(EC)} \tag{3}$$

where the first, second and third terms on the right-hand side of equation (3) are the direct effects of REV, TDP and EC, respectively, while the fourth, fifth and sixth terms on the right-hand side of equation (3) are the indirect covariance effects. The three direct effects sum to unity and an increase of the variance of any one of them increases the variability of TRI. A positive (negative) covariance between two components shows that they move in the same (opposite) direction over time (El Benni & Finger, 2013). In this approach, the direct effect of TDP becomes larger when the variance of TDP is relatively larger than that of other components due to the halving of DPr. Furthermore, if REV or EC decreases at the same time that DPr is halved, the indirect effect between REV and TDP or between EC and TDP becomes larger.

3.3 Regression analysis

Robust regression techniques are used to measure the effect of direct payments and farm characteristics on TRI variability following Barry et al. (2001) and Severini et al. (2017). The estimation model has the following general form:

$$Y_i=\boldsymbol{\beta}\boldsymbol{x}_i+e_i \tag{4}$$

where subscript i refers to each farm, $\boldsymbol{\beta}$ represents the parameters to be estimated and is related to the independent variables x, and e is the error term. The dependent variable Y is the CV of TRI computed at farm level. The independent variables are the following: the amount of TDP per ha of cultivated paddy area, the rice planted area as a proxy for farm size, fixed costs over total costs as a proxy for fixity of resources, work time over rice planted area as a proxy for labour intensity, diverted area over rice planted area as a proxy for the diversion ratio and dummy variables indicating plains and hilly and mountainous areas. The summary statistics are shown in Table 2. Following Severini et al. (2017), a cross-sectional approach and robust regression techniques, with the M-estimator provided by the command rreg of Stata 16, have been used.

Table 2 Summary statistics of the variables used in the regression analysis (514 obs.)

	Mean	SD	Min	Median	Max
CV of TRI	1.31	6.02	0.04	0.48	91.28
TDP per ha (thousand yen/ha)	70.35	39.77	0.00	71.51	241.88
DPr per ha (thousand yen/ha)	54.35	25.41	0.00	59.03	99.96
DPu per ha (thousand yen/ha)	16.00	28.45	0.00	1.38	226.93
Rice planted area (ha)	6.26	7.97	0.22	2.66	55.51
Fixed costs over total costs	0.15	0.09	0.00	0.15	0.42
Work time over rice planted area (hours/ha)	233.18	133.67	53.24	197.91	1256.31
Diverted area over rice planted area	0.35	0.47	0.00	0.20	4.61
Plains (base category: city)	0.52	0.50	0.00	1.00	1.00
Hilly area (base category: city)	0.23	0.42	0.00	0.00	1.00
Mountainous area (base category: city)	0.07	0.25	0.00	0.00	1.00

Note: CV of TRI means the coefficient of variation of total rice income, TDP is the sum of the two direct payment types considered, DPr is the predetermined fixed-rate direct payment for rice production, and DPu is the direct payment for the utilisation of paddy fields for non-staple rice products. All monetary values are deflated by the GDP deflator (2011 = 100).

In this paper, we specify three regression models. We use the TDP per ha of cultivated paddy area in model (1) and disaggregate the TDP into two types of payments (DPr and DPu) in model (2). This is because different payments may play different roles in stabilising income. The originality of this paper compared with El Benni et al.(2012) and Severini et al. (2017) is that the effects of different types of payments are disaggregated. Further, to assess whether the effects of direct payments could differ by geographical locations, we developed model (3), which includes interaction terms generated by multiplying the direct payment variables with the dummy variables referring to the three types of geographical areas.

Although it is very useful for comparisons, CV is not suitable when the mean of the variable is close to zero or negative (Bojnec & Fertő, 2019; Severini et al., 2016a). In the considered sample, MRI and TRI take negative values in many farms. To address this problem, we calculate the CVs of TRI at farm level only for those farms that have a positive mean value for TRI, following Severini et al. (2016a) and Bojnec and Fertő (2019). This restricts the analysis to a balanced subsample of 514 farms (i.e. 77.8% of the whole balanced panel data).[7] Despite this, some of the remaining farms display a very large value for the CV of TRI because of having an average TRI that is close to zero. This causes the large difference between mean and median CV values (Table 2). Thus, there is a need to use estimation methods that reduce the role of such observations, which otherwise will bias the estimation results.

[7] Although the farms with negative mean values for TRI account for 22.2% of the entire sample, they receive only 2.11–3.42% of total TDP. In future research, such farms with negative income should be taken into account in measuring the effects of direct payments on income variability.

Table 3 Sources of variability of total rice income (TRI) for the full balanced sample

Sample size	Variance decomposition					
	Direct effects			Indirect effects		
	Var(REV)	Var(TDP)	Var(EC)	Cov(REV, TDP)	Cov(REV, EC)	Cov(TDP, EC)
661	0.596	0.042	0.362	0.124	0.254	0.036

Note: All values are sample averages of each effect calculated for each farm using the full balanced sample. Var( ) indicates the variance of each income component. Cov( ) indicates the covariance between income components. REV is the gross revenue from rice, TDP is the sum of the two direct payment types considered, and EC is the costs for external (i.e. non-family owned) factors.

Consequently, we used a robust regression method that is suitable for addressing this issue (Li, 1985)[8].

4. Results

4.1 Contribution of income components to rice income variability

In this section, the research question—do direct payments decrease Japanese rice income variability?—is addressed based on the empirical results of the variance decomposition (Table 3).

The results show that most of the variance in TRI is due to REV (59.6%) and EC (36.2%) for the whole balanced sample (Table 3). TDP accounts for only 4.2% of variability even though, on average, it accounts for 20–30% of TRI, as shown in Table 1. These results suggest that direct payments reduce Japanese rice income variability because TDP is a less variable income component than MRI.

The covariance effect between REV and TDP is positive (12.4%). The large covariance effect between REV and TDP in this paper can be interpreted as a result of the DPr being halved in the year (2014) when the REV decreased sharply, which makes the covariance between REV and TDP larger. A positive indirect effect between REV and EC (25.4%) suggests that, as expected, high levels of REV are associated with high levels of EC. Finally, a very small indirect effect between TDP and EC (3.6%) suggests that there is no relevant correlation between TDP and EC.

4.2 Effects of direct payments and farm characteristics on rice income variability

In this section, the answer to the research question presented in the previous section is confirmed quantitatively based on a regression analysis (Table 4).

[8] Using robust standard errors is not sufficient because we need to reduce the impact of unusual anomalous observations on the estimated coefficients. This is made possible by the robust regression (Li, 1985).

Table 4 Regression results for the effect of direct payments on rice income variability

	(1)	(2)	(3)
TDP per ha	–0.0011***		
	(0.0004)		
DPr per ha		–0.0017***	–0.0006
		(0.0006)	(0.0012)
DPu per ha		–0.0008	–0.0030*
		(0.0005)	(0.0015)
DPr per ha * plains			–0.0025*
			(0.0015)
DPr per ha * hilly area			–0.0006
			(0.0017)
DPr per ha * mountainous area			0.0020
			(0.0025)
DPu per ha * plains			0.0017
			(0.0017)
DPu per ha * hilly area			0.0046**
			(0.0019)
DPu per ha * mountainous area			0.0021
			(0.0035)
Rice planted area	–0.0064***	–0.0066***	–0.0063***
	(0.0020)	(0.0020)	(0.0020)
Fixed costs over total costs	1.0008***	1.0121***	1.0085***
	(0.1632)	(0.1641)	(0.1678)
Work time over rice planted area	0.0003**	0.0002*	0.0003***
	(0.0001)	(0.0001)	(0.0001)
Diversion area ratio over rice planted area	0.0430	0.0401	0.0312
	(0.0319)	(0.0320)	(0.0330)
Plains (base category: city)	–0.0324	–0.0298	0.0932
	(0.0389)	(0.0391)	(0.0826)
Hilly area (base category: city)	–0.0121	–0.0056	–0.0538
	(0.0447)	(0.0451)	(0.1016)
Mountainous area (base category: city)	–0.0919	–0.0858	–0.2541
	(0.0642)	(0.0649)	(0.1543)
Constant	0.4344***	0.4668***	0.4180***
	(0.0654)	(0.0689)	(0.0834)
Observations	514	514	514
Adjusted R-squared	0.1265	0.1289	0.1411

Note: Standard errors are shown in parentheses. The symbols ***, ** and * denote that $P < 0.01$, $P < 0.05$ and $P < 0.1$, respectively. TDP is the sum of the two types of direct payments considered. DPr is the predetermined fixed-rate direct payment for rice production. DPu is the direct payment for the utilisation of paddy fields for non-staple rice products.

Given the cross-sectional nature of the analysis, the overall goodness of fit is not high, but a non-negligible number of coefficients are significant and have the expected signs. For example, farm size (in terms of the rice planted area) and fixity of resources (in terms of fixed costs over total costs) are negatively and positively correlated, respectively, with income variability, as found in previous similar analyses (Barry et al., 2001; Bojnec & Fertő, 2018; El Benni et al., 2012; Severini et al., 2017).

Table 4 shows the estimated coefficients. The estimated coefficient for TDP (the sum of DPr and DPu) in model (1) is negative (–0.0011) and significant at the 1% level (see TDP per ha in Table 4). A comparison of model (1), which uses TDP per ha of cultivated paddy area, and model (2), which disaggregates TDP into the two payment types, indicates that only DPr reduces TRI variability significantly and the estimated coefficient for DPu is not significant (see DPr and DPu per ha in Table 4).

These results confirm the answer to our research question, namely that direct payments reduce rice income variability[9]. This result is consistent with previous studies. However, a significant negative relationship between the amount of direct payments per ha of cultivated paddy area and TRI variability is found only for DPr.

Regarding the interaction terms in model (3), only the interaction terms of DPr per ha with the plains dummy and of DPu per ha with the hilly dummy are significant at the 10% and 5% levels, respectively.[10] Therefore, in areas characterised by plains, DPr decreases TRI variability more than it does in city areas, but the effects of DPr in the hilly and mountainous areas are not significantly different from those in the city areas. The significant positive coefficient for the interaction term of DPu with the hilly dummy means that the extent to which DPu decreases TRI variability in the hilly areas is significantly reduced compared with the effect in the city areas.

Other variables in Table 4 affect TRI variability. Consistent with previous studies, farm size (rice planted area, shown in Table 4) decreases TRI variability. This suggests that compared with smaller farms, larger farms are more capable of withstanding extreme events, have more room to manoeuvre in terms of production diversification and apply a more comprehensive set of risk management strategies and tools (Barry et al., 2001; El Benni et al., 2012; Severini et al., 2017).

Fixity of resources (measured as fixed costs over total costs in Table 4) significantly increases TRI variability. Again, this is consistent with the literature and suggests that fixed costs cannot be adjusted in the short run to allow farm management to adapt to changes such as a drop in the rice price (Bojnec & Fertő, 2018; El Benni et al., 2012; Severini et al., 2017).

The estimated coefficient for labour intensity (shown as work time over rice planted area in Table 4) is positive and significant at the 5% level in model (1), significant only at the 10% level in model (2) and significant at the 1%

[9] Several robustness checks and the results of an additional estimation considering variability for the different components of rice income are presented in the online supporting information.

[10] The interaction terms contained in model (3) may correlate with direct payment variables and dummy variables indicating plains and hilly and mountainous areas, which can lead to multicollinearity. Therefore, we also estimated a model that removes the dummy variables indicating these geographical areas. However, the estimated coefficients in model (3) and the model without the dummies for various geographical areas showed the same tendencies. Further, in models with interaction terms, the coefficient estimates do not represent the marginal effects of the variables of interest. Thus, for DPr and DPu per ha, we estimated marginal effects evaluated at the mean of independent variables. Consistent with the results of model (2), only the marginal effect for DPr is significantly negative and that for DPu is not significant.

level in model (3). Finally, the estimated coefficients for the diversion ratio (diverted area over rice planted area in Table 4) and for the geographical characteristics (plains, hilly and mountainous areas in Table 4) are not significant in any of the models.

5. Discussion

First, comparing the variance decomposition results with the literature (Bojnec & Fertő, 2019; Severini et al., 2016a) indicates that the results of this paper are consistent with previous studies in that the REV effect is the largest and the TDP effect is the smallest among the direct effects. However, the covariance effect between REV and TDP (12.4%) is larger than that reported in the existing literature. Using data for Italy, Severini et al. (2016a) report that the covariance effect between REV and TDP is –2.2% on average, while Bojnec and Fertő (2019) report covariance effects of 0.02% and 0.0% for Hungary and Slovenia, respectively. The large covariance effect between REV and TDP in this paper can be interpreted as a result of the DPr being halved in 2014, the year when the REV decreased sharply, which increases the covariance between REV and TDP. This result suggests that reducing direct payments when the rice price is falling would increase rice income variability.

Second, we compare the regression analysis results with the literature (Bojnec & Fertő, 2018; El Benni et al., 2012; Enjolras et al., 2014; Knapp & Loughrey, 2017; Severini et al., 2017). The results of this paper are consistent with the results reported by El Benni et al. (2012) and Severini et al. (2017), indicating that TDP could decrease income variability. The results of both the variance decomposition and the regression analysis suggest that direct payments might affect farmer behaviour (Enjolras et al., 2014; Hennessy, 1998). Furthermore, the results suggest that direct payments decrease rice income variability in Japan because direct payments are less variable than the remaining part of income, as was also the case in Italy (Severini et al., 2016a, 2017).[11] In addition, the results confirm some of the findings of previous studies that farm size and fixity of resources appear to affect income variability.

These results have some policy implications. First, the direct payments contributed to the achievement of one of the policy objectives, that is ensuring farm viability by stabilising farm income, thus validating their introduction. This is shown by the results indicating that direct payments are less variable than the other components of rice income (Var(TDP) in Table 3) and that direct payments are negatively correlated with the CV of rice income (TDP per ha in Table 4). These results are consistent with the results reported by El Benni et al. (2012) and Severini et al. (2016a, 2017). Second, the results show that a significant negative relationship between the amount of direct

[11] However, this paper cannot identify the mechanism by which direct payments reduce income variability. This issue should be addressed in future research.

payments per ha and variability in TRI is found only in the case of DPr, but not in the case of the payments for non-staple rice crop production (DPu). Accordingly, the results suggest that to reduce the income variability from a particular crop, direct payments linked to that crop are effective. Third, the estimated coefficients for the interaction terms of direct payments with geographical areas in model (3) suggest that the effects of direct payments can differ among geographical areas, as discussed by Bojnec and Fertő (2018). Therefore, in designing policies, the geographical locations of the beneficiary farms should be taken into account. Fourth, the appropriate time for reductions in direct payments should be carefully determined because a reduction in direct payments that occurs at the same time as a fall in the rice price increases rice income variability significantly. Fifth, recently, the CAP has been shifting resources from farms with relatively high levels of direct payments to those with relatively low levels of direct payments (European Commission 2018a). If similar reforms were to occur in Japan, farms that face a larger reduction of direct payment levels would experience an increase in their income variability, ceteris paribus, as pointed out by Severini et al. (2016a).

6. Summary and policy recommendations

This paper investigates the effects of direct payments on rice income variability in Japan by asking the following research question: Do direct payments decrease Japanese rice income variability?

The analysis, using balanced individual farm data for a five-year period, reveals that the answer to this question is 'yes'. First, aggregated direct payments decrease Japanese rice income variability as a whole because TDP is less variable than the remaining part of income. Second, after controlling for various farm characteristics, we find a negative relationship between the amount of direct payments for rice production (DPr) and rice income variability. Third, the variance decomposition analysis suggests that making a direct payment reduction at the same time as a falling rice price would increase rice income variability.

Some relevant policy recommendations arise from this analysis. We highlight three that should be carefully considered in shaping future direct payment policies in Japan and other countries, especially Asian countries. First, the results of this paper suggest that in the case of exceptionally negative market conditions, the amount of direct payments could be increased to balance the resulting reduction in market income, as Severini et al. (2016a) argue. Second, as El Benni et al. (2012) conclude, the result that direct payments decrease income variability indicates that direct payments have an insurance effect and therefore affect optimum planning strategies (Hennessy, 1998). Thus, policymakers in Japan should formally recognise that direct payments have some effect on production decisions. Third, the timing of reductions in direct payments should be flexible and take volatility in agricultural prices into consideration.

There are limitations to this study that should be addressed in future research. First, the farms in our sample could produce agricultural products other than rice. If farmers have a diversified product mix, this may result in a limited increase in income variability overall. Furthermore, the effects of direct payments, especially DPu, on total farm income could differ from the effects on rice income. The variability of overall farm income in Japan should be considered in future research when relevant data are available. Second, it should be noted that because this paper excludes farms with negative incomes from the regression analysis due to the use of CVs, the results cannot necessarily be generalised to such farms. Analyses using a full sample (by considering farms with and without negative incomes) should be undertaken in future research. Third, the fact that DPr was halved during the analysis period may have affected our estimates. However, at the time of the analysis, data on each payment were only available for the period 2012–2016, making it difficult to focus the analysis only on the period before (or after) the halving of the DPr implemented in 2014. When a longer data series becomes available, it will be feasible to conduct an analysis of a period that excludes the halving of DPr. Fourth, although this paper focuses on income variability, a direct payment reduction results in downside risks to farm income (Majewski et al., 2008; Vrolijk et al., 2010). The effect of direct payments on low-income risk should be addressed in future work. Fifth, the results of this paper suggest that the effects of the direct payments could differ depending on the geographical location of farms. However, the results should be taken with caution given the limited number of available observations. More definitive results could be obtained in future research with a larger sample.

References

Barry, P.J., Escalante, C.L. & Bard, S.K. (2001) Economic risk and the structural characteristics of farm businesses. *Agricultural Finance Review*, 61, 73–86. https://doi.org/10.1108/00214760180001117

Bojnec, Š. & Fertő, I. (2018) Assessing and understanding the drivers of farm income risk: Evidence from Slovenia. *New Medit*, 17, 23–35. https://doi.org/10.30682/nm1803c

Bojnec, Š. & Fertő, I. (2019) Do CAP subsidies stabilise farm income in Hungary and Slovenia? *Agricultural Economics (Czech Republic)*, 65, 103–111. https://doi.org/10.17221/190/2018-AGRICECON

Burt, O.R. & Finley, R.M. (1968) Statistical analysis of identities in random variables. *American Journal of Agricultural Economics*, 50, 734–744. https://doi.org/10.2307/1238271

de Carvalho, M.L. & Godinho, M.L.F. (2006) Will farm income risk change under the new CAP reform? In: Cafiero, C. & Cioffi, A. (Eds.) *Income stabilization in agriculture. The role of public policies*. Naples: Edizioni Scientifiche Italiane, pp. 303–312.

Castañeda-Vera, A. & Garrido, A. (2017) Evaluation of risk management tools for stabilising farm income under CAP 2014–2020. *Economia Agraria y Recursos Naturales*, 17, 3–23. https://doi.org/10.7201/earn.2017.01.01

El Benni, N., Finger, R. & Mann, S. (2012) Effects of agricultural policy reforms and farm characteristics on income risk in Swiss agriculture. *Agricultural Finance Review*, 72, 301–324. https://doi.org/10.1108/00021461211277204

El Benni, N. & Finger, R. (2013) Gross revenue risk in Swiss dairy farming. *Journal of Dairy Science*, 96, 936–948. https://doi.org/10.3168/jds.2012-5695

Enjolras, G., Fabian, C., Magali, A. & Felice, A. (2014) Direct payments, crop insurance and the volatility of farm income: some evidence in France and in Italy. *New Medit*, 13, 31–40.

European Commission (2018a). *CAP explained: Direct payments for farmers 2015-2020*. Brussels: European Commission. Available from URL: https://euroalert.net/publication/610/cap-explained-direct-payments-for-farmers-2015-2020 [accessed 16 September 2020].

European Commission (2018b). *The common agricultural policy, legal texts and factsheets on the EU budget for the future*. Brussels: European Commission. Available from URL: https://ec.europa.eu/commission/publications/factsheets-long-term-budget-proposals_en.pdf [accessed 30 July 2019].

Feil, J.-H., Musshoff, O. & Roeren-Wiemers, T. (2014) Farm level effects of policy reforms in Germany: First empirical evidence. *Journal of Policy Modeling*, 36, 1036–1047. https://doi.org/10.1016/J.JPOLMOD.2014.11.003

Fujibayashi, K. (2015). *Japan: Grain and feed update - January 2015. GAIN report, JA5001*. Washington, D.C.: USDA Foreign Agricultural Service. Available from URL: https://www.fas.usda.gov/data/japan-grain-and-feed-update-0 [accessed 10 June 2019].

Hadrich, J.C. (2013) Quantifying the sources of revenue variation in the Northern Great Plains. *Agricultural Finance Review*, 73, 493–506. https://doi.org/10.1108/AFR-09-2012-0046

Hattori, S. (2012) *Not participating in TPP, keeping income compensation policies on farm-households: Prospects of Japan's agriculture and Japanese society depend upon them*. Tokyo: Agriculture and Forestry Statistics Publishing (in Japanese).

Hennessy, D.A. (1998) The production effects of agricultural income support policies under uncertainty. *American Journal of Agricultural Economics*, 80, 46–57. https://doi.org/10.2307/3180267

Ito, J., Feuer, H.N., Kitano, S. & Komiyama, M. (2018) A policy evaluation of the direct payment scheme for collective stewardship of common property resources in Japan. *Ecological Economics*, 152, 141–151. https://doi.org/10.1016/J.ECOLECON.2018.05.029

Ito, J., Feuer, H.N., Kitano, S. & Asahi, H. (2019) Assessing the effectiveness of Japan's community-based direct payment scheme for hilly and mountainous areas. *Ecological Economics*, 160, 62–75. https://doi.org/10.1016/J.ECOLECON.2019.01.036

Jones, R.B. (1969) Stability in farm incomes. *Journal of Agricultural Economics*, 20, 111–124. https://doi.org/10.1111/j.1477-9552.1969.tb02322.x

Kastens, T.L. & Featherstone, A.M. (1997) Federal agricultural improvement and reform act of 1996: A Kansas perspective. *Review of Agricultural Economics*, 19, 326–349. https://doi.org/10.2307/1349745

Kimura, S., Antón, J. & LeThi, C. (2010) *Farm level analysis of risk and risk management strategies and policies: Cross country analysis*. Paris: OECD Publishing. Available from URL: https://doi.org/10.1787/18156797 [accessed 17 July 2019].

Knapp, E. & Loughrey, J. (2017) The single farm payment and income risk in Irish farms 2005–2013. *Agricultural and Food Economics*, 5, 9. https://doi.org/10.1186/s40100-017-0078-9

Kobari, M. (2018). *Changes in Japan's rice policies: looking back on 15 years since the Principle and Outline of Rice Policy Reform in 2002*. Tokyo: Norinchukin Research Institute Co., Ltd. Available from URL: https://www.nochuri.co.jp/english/reports.html [accessed 10 June 2019].

Lee, Y.K. (2006) Production and income effects of direct payments program for rice industry. *The Korean Journal of Agricultural Economics*, 47, 51–68 (in Korean).

Li, G. (1985) Robust regression. In: Hoaglin, D.C., Mosteller, F. & Tukey, J.W. (Eds.) *Exploring data tables, trends, and shapes*. Hoboken: John Wiley & Sons, pp. 281–343.

Lim, C.-R., Jeong, H.-J., Lim, S.-S. & Chung, W.-H. (2018) An analysis of the effects of direct rice income compensation payment program on farm income by farm typology. *Korean Journal of Agricultural Management and Policy*, 45, 567–588 (in Korean).

MAFF (2011) *Implementation guidelines for income support direct payment program for farmers*. Tokyo: Ministry of Agriculture, Forestry and Fisheries. Available from URL: https://www.maff.go.jp/j/seisaku/kobetu_hosyo/pdf/h23_seido_jissiyioukou.pdf [accessed 21 December 2019]. (in Japanese).

Majewski, E., Was, A., Guba, W., Dalton, G. & Landmesser, J. (2008) Risk of low incomes under different policy scenarios. In: Meuwissen, M.P.M., van Asseldonk, A.P.M.M. & Huirne, R.B.M. (Eds.) *Income Stabilization in European Agriculture: Design and Economic Impact of Risk Management Tools*. Wageningen: Wageningen Academic Publishers, pp. 55–77.

Meuwissen, M.P.M., van Asseldonk, M.A.P. & Huirne, R.B.M. (Eds) (2008) *Income Stabilisation in European Agriculture: Design and Economic Impact of Risk Management Tools*. Wageningen: Wageningen Academic Publishers.

Mishra, A.K. & Sandretto, C.L. (2002) Stability of farm income and the role of nonfarm income in U.S. Agriculture. *Review of Agricultural Economics*, 24, 208–221. https://doi.org/10.1111/1058-7195.00014

Nitta, A., Yamamoto, Y., Kondo, K. & Sawauchi, D. (2020) Direct payments to Japanese farmers: Do they reduce rice income inequality? Lessons for other Asian countries. *Journal of Policy Modeling*, 42, 968–981. https://doi.org/10.1016/j.jpolmod.2020.02.006

OECD (1994) *Agricultural policy reform: New approaches. The role of direct income payments*. Paris: OECD Publications.

OECD (2000) *Agricultural policies in OECD countries: Monitoring and evaluation 2000*. Paris: OECD Publishing. Available from URL: https://doi.org/10.1787/agr_oecd-2000-en [accessed 7 January 2020].

OECD (2009) *Managing risk in agriculture: A holistic approach*. Paris: OECD Publishing. Available from URL: https://doi.org/10.1787/9789264075313-en [accessed 7 January 2020].

OECD (2011). *Agricultural policy monitoring and evaluation 2011: OECD countries and emerging economies*. Paris: OECD Publishing. Available from URL: https://doi.org/10.1787/agr_pol-2011-en [accessed 7 January 2020].

OECD (2014). *Agricultural policy monitoring and evaluation 2014: OECD countries*. Paris: OECD Publishing. Available from URL: https://doi.org/10.1787/agr_pol-2014-en [accessed 7 January 2020].

OECD (2019). *Innovation, agricultural productivity and sustainability in Japan, OECD food and agricultural reviews*. Paris: OECD Publications. Available from URL: https://doi.org/10.1787/92b8dff7-en [accessed 7 January 2020].

Severini, S., Tantari, A. & Di Tommaso, G. (2016a) Do CAP direct payments stabilise farm income? Empirical evidences from a constant sample of Italian farms. *Agricultural and Food Economics*, 4, 6. https://doi.org/10.1186/s40100-016-0050-0

Severini, S., Tantari, A. & Di Tommaso, G. (2016b) The instability of farm income. Empirical evidences on aggregation bias and heterogeneity among farm groups. *Bio-based and Applied Economics*, 5, 63–81. https://doi.org/10.13128/BAE-16367

Severini, S., Tantari, A. & Di Tommaso, G. (2017) Effect of agricultural policy on income and revenue risks in Italian farms. *Agricultural Finance Review*, 77, 295–311. https://doi.org/10.1108/afr-07-2016-0067

Takayama, T., Hashizume, N. & Nakatani, T. (2020) Impact of direct payments on agricultural land use in less-favoured areas: evidence from Japan. *European Review of Agricultural Economics*, 47, 157–177. https://doi.org/10.1093/erae/jbz008

Tobias, A., Molina, I., Valera, H.G., Mottaleb, K.A. & Mohanty, S. (2012) *Handbook on rice policy for Asia*. Los Baños, Philippines: International Rice Research Institute. https://doi.org/10.22004/ag.econ.281810

Vrolijk, H.C.J., De Bont, C.J.A.M., Blokland, P.W. & Soboh, R.A.M.E. (2010). Farm viability in the European Union: Assessment of the impact of changes in farm payments.

LEI report 2010-011, Project code 31964, LEI, The Hague. Available from URL: https://research.wur.nl/en/publications/farm-viability-in-the-european-union-assessment-of-the-impact-of-changes-in-farm-payments [accessed 5 August 2019].

Zulauf, C. & Orden, D. (2014). *The US Agricultural Act of 2014: overview and analysis*. IFPRI Discussion Paper 01393. Washington, D.C: IFPRI. Available from URL: https://www.ifpri.org/publication/us-agricultural-act-2014-overview-and-analysis [accessed 17 September 2020].

Supporting Information

Additional Supporting Information may be found in the online version of this article:

Appendix S1 Robustness checks.

Appendix S2 Estimation with the coefficients of variation for unit price, unit yield, planted area and cost.