Can rent adjustment clauses reduce the income risk of farms?

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ABSTRACT

Risk management is gaining importance in agriculture. In addition to traditional instruments, new risk management instruments are increasingly being proposed. These proposals include the rent adjustment clauses (RACs), which seem to be an unusual instrument at first sight. In contrast with conventional instruments, RACs intentionally allow fixed-cost 'rent payments' to fluctuate. We investigate the whole-farm risk reduction potential of different types of RACs via a historical simulation. The change in standard deviation and the value at risk (VaR) of the total gross margin (TGM) measure risk reduction potential. Our results revealed that RACs contribute to farm risk management. However, the trade-off between moral hazard and basis risk must be considered. Our proposal of weather index-based RAC seems to be a 'good compromise': the problem of moral hazard is completely eliminated by objectively measuring weather data. At the same time, the risk reduction potential of precipitation-based clauses, for example, is comparatively high.

KEYWORDS: Risk management; rent adjustment clause; moral hazard; basis risk; weather index; value at risk

1. Introduction

Farms must face various types of risk. Agricultural enterprise risks are expected to continue to increase due to the elimination of subsidies, the liberalisation of the European market (Serra et al., 2006) and global climate change (Olesen and Bindi, 2002). Moreover, the proportion of external production factors in general and rented land in particular has recently increased in agricultural enterprises creating financial risk. For example, only 54% of the total agricultural area in Germany was rented in 1991; this proportion rose to 62% in 2007. In some parts of Eastern Germany, the rent share was approximately 80% in 2007 (Federal Statistical Office of Germany, 2011). Given these increasing risks, the relevance of risk management has increased.

In recent years, so-called rent adjustment clauses (RACs) have been proposed as an interesting alternative risk management instrument (Langemeier, 1997; Fukunaga and Huffman, 2009; Breustedt et al., 2010). At first glance, RAC are unusual risk management instruments. They adjust the cost factor 'rent' based on the economic situation of the farm. In contrast with traditional risk management instruments, a usually fixed cost factor is intentionally brought to vary. In this context, the crucial question is how these fluctuations affect the distribution of farm income.

On the one hand, there is empirical evidence that there is a very pronounced potential for RAC acceptance among farmers (Breustedt et al., 2010; Plumeyer et al., 2010). On the other hand, RACs are not common practice in many nations (e.g., in Germany). This contradiction may be due to farmers still not being familiar with these clauses. Furthermore, it is still unknown whether and to what extent RACs reduce the income risk of farms. Various types of RACs have been discussed in the literature that couple rent payments with the development of national price indices or operationally realised income, prices, or both. The choice of indicators underlying an RAC determines its risk-reducing effect. Thus far, studies have focused on the change in the expected rent payment for using various clauses (Plumeyer et al., 2010). Breustedt et al. (2010) investigate the change in the distribution of rent-adjusted revenue for using clauses based on different farm-specific price data. To the best of our knowledge, investigations that determine the risk reduction potential of RACs that account for cost risk have not been conducted. Therefore, the suggested risk reduction potential of RACs may be too low to cover all the costs associated with it. Moreover, there has been no systematic comparison of the risk reduction potential of different RACs.

This paper aims to determine how different RACs reduce the income risk of farms. Furthermore, we propose and examine an RAC based on the objectively and easily measurable weather indices that weather index insurances, which has been intensively discussed in recent years, are based on (Turvey, 2005; Chen et al., 2006; Berg and Schmitz, 2008; Norton et al., 2010). The calculations are conducted using a historical simulation of an exemplary German farm. To our knowledge, we are the first who quantify the overall operational risk reduction potential of different types of RACs in general and an RAC based on a weather index in

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particular. The results allow us to conclude as to whether a risk-reducing effect explains the low acceptance of RACs. We do not investigate whether landowners and farmers will accept RACs.

2. Rent adjustment clauses (RACs)

Systematisation of RACs

There are two major types of compensation for rented land: natural and monetary rent payments. Today, the fixed-rent payment is the most common type of monetary rent payment in Germany and in many other countries (Otsuka et al., 1992; Barry et al., 2000; Fukunaga and Huffman, 2009). 'Fixed rent' denotes that a fixed payment must be made to the landowner independent of the farm's performance. However, crop-yield-dependent rent payment systems are still widespread in many developing countries, such as Ethiopia and Madagascar (Kassie and Holden, 2007; Bellemare, 2009). Moreover, this method of payment still plays an important role in the agricultural sector of the USA (Allen and Lueck, 1999).

The RAC recently discussed therefore are not based on a completely 'new' idea. With an RAC, the annual rent payment is contractually linked to the development of a particular indicator. The contracting parties can freely decide on these indicators and the design of the contract. Some types of RACs that use on-farm indicators are similar to sharecropping contracts in the USA (Langemeier, 1996) and contract farming in the UK (Stockdale et al., 1996). Figure 1 classifies various types of RACs.

In principle, RACs can be divided into two groups of clauses: performance and sliding. Performance clauses allow the landowner and the farmer to renegotiate the rent when a measurable event (e.g., under- or above-average yields in crop production) occurs before the end of the regular lifetime of the contract. The possible rent adjustment, upon which the landowner and farmer agree, must be communicated to the respective parties. In addition, new negotiations must be scheduled and conducted. Therefore, this type of RAC is relatively expensive. In addition to renegotiations, the relationship between landowners and farmers can be negatively influenced. Accordingly, the practical applications of performance clauses appear to be limited.

Sliding clauses do not necessitate renegotiations after the conclusion of the contract; rather, the rent payment is adjusted automatically depending on the performance of a predetermined indicator (Langemeier, 1997; Plumeyer et al., 2010). The indicator upon which the sliding clause is based is measured either externally or internally (Langemeier, 1996; Breustedt et al., 2010). For example, the external group includes the 'price index clause' in which the rent adjustment is based on national and objectively measured price indices. The internal group includes a clause in which the rent adjustment depends upon the on-farm revenue generated from crop production.

One can expect that the clauses based on external indicators have smaller risk-reducing effects than clauses based on internal indicators. The indices applied in the price index clause aggregate data at a national or regional level and the overall success of an individual farm makes only a small impact. In addition, price indices are only available with a certain time delay; therefore, the rent may be based on data from a previous period. Thus, situations emerge in which rent payments increase due to developments in aggregated product price indices, although the success of single farm may have deteriorated. The remaining risk for the farmer that an RAC cannot eliminate is referred to as 'basis risk'. On the cost side, the RACs based on external indicators have a relative advantage over internal indicators.

The price index clause only determines small costs for information and control because the Federal Statistical Office transparently and objectively set external price indices. Furthermore, in most cases, these indices are freely available. However, the risk of rent adjustment operator manipulation emerges in clauses based on internal indicators. The key term here is 'moral hazard' (Ghatak and Pandey, 2000; Allen and Lueck, 1999). Moral hazard describes a situation in which the landowner cannot be sure that the farmer has not manipulated the rent-adjustment-relevant indicator.

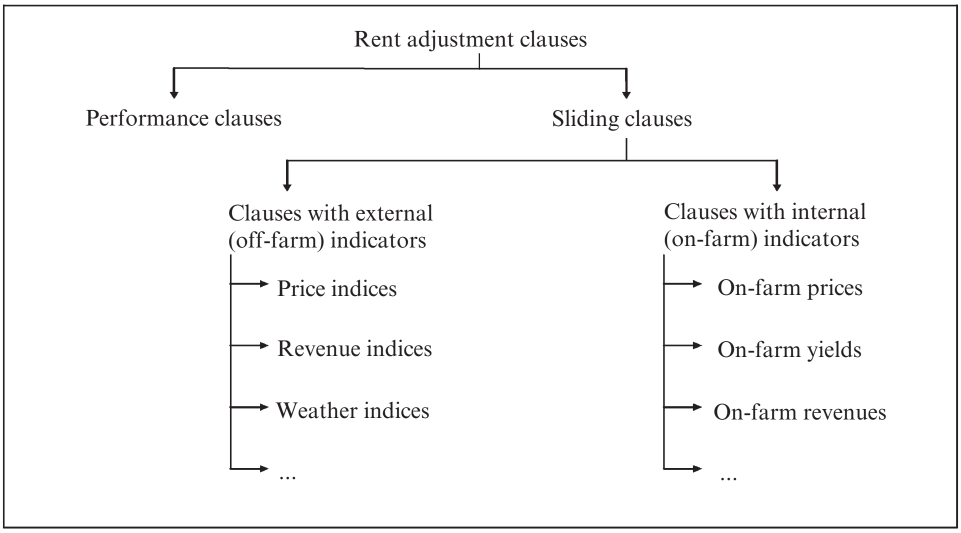

Figure 1: Classification of RACs

Instead, the landowner must either trust that the farmer has not manipulated the indicator values used for the RAC (Allen and Lueck, 1999) or he or she must conduct a high control effort. The costs of moral hazard include increased monitoring costs for the landowner and the farmer's unavoidable self-serving manipulation of his or her success.

A promising alternative to the aforementioned RAC is the use of a weather index as an external indicator for an RAC. For example, weather indices are used to underlie so-called weather derivatives (Turvey, 2005; Musshoff et al., 2011). In this situation, the total precipitation of the main growing season measured at an official weather station affects rent adjustment. When comparing the weather index clause with the previously discussed RAC, the following picture emerges. First, a weather index clause is advantageous because there is no risk of tampering with data (in contrast to internal indicators). Second, the required weather data can be obtained without a time delay, especially compared with the price index clause. Third, the risk reduction potential should be higher than the price index clause because the national indices are 'further away' from single-farm success than weather events such as rainfall. In summary, the cost of a weather index clause should be lower than that of clauses with internal indicators. The expected risk reduction potential, however, is higher in weather index clauses compared with clauses including external indicators (e.g., a price index clause).

The basis risk is the residual risk that remains with the farmer when an RAC is used. Three different sources can be distinguished from each other:

- The geographical basis risk arises when there is a geographical difference between the location at which the externally measured value and the corresponding indicator value on the farm are measured. This risk results in an imperfect correlation (Vedenov and Barnett, 2004; Xu et al., 2008). With regard to weather index clauses, an imperfect correlation means that weather patterns can vary between the reference weather station and the location of agricultural production. In terms of the revenue index clause, the rent adjustment will be determined based on average prices and the returns of several farms in a region. Depending on the size of the reference region, the economic success of an individual farm may differ greatly from the average success of the other farms in the region.
- The basis risk of production emerges when one indicator measured at the place of production is not perfectly correlated with the overall success of the farm (Musshoff et al., 2011). For example, wheat revenue may represent the economic success of a farm depending on the actual production of wheat and the correlation of the individual gross margins of different production methods.
- Another basis risk arises when the indicators of a previous period are used to determine rent adjustment due to a lag in data availability. Therefore, the RAC may be based on external revenues that require the actual production period data that is not available at the time of the rent payment determination. If the yield data of a previous period has a lower correlation to the current farm success than to that of the current production season, then a loss in the risk reduction potential may emerge.

The implementation of an RAC comes with a trade-off between risk reduction potential, on one hand, and moral hazard as well as information and monitoring costs, on the other.

Description of the analysed RAC

No rent adjustment (fixed rent)

A fixed rent does not require a rent adjustment. A payment at time t (R_t) is defined in the rent contract as the basic rent (R_B) and remains constant over time:

$$R_t = R_B \tag{1}$$

The fixed rent is generally widespread and occurs in Germany in particular because the rent payment is easy to administer and communicate (Stockdale et al., 1996; Sanjuán et al., 2009; Plumeyer et al., 2010).

RAC based on revenues

A rent adjustment in the amount of the percentage of change in the observed value of a revenue index (RI_t) compared with the base value of the revenue index (RI_B) is made for the RACs based on revenues. The observed revenue index value is the product of current crop prices (p_t) and yields (y_t) and moreover is derived from a contractually agreed base crop price (p_B) and a base yield (y_B), which may correspond with the long-term average values (Langemeier, 1996; 1997). The annual rent is calculated as follows:

$$R_t = R_B \cdot \frac{RI_t}{RI_B} = R_B \cdot \frac{(p_t \cdot y_t)}{(p_B \cdot y_B)} \tag{2}$$

Many design variants are conceivable for revenue-based rent adjustment. In addition to the choice of the revenue index base value, the following fundamental questions must be answered:

- Should the revenue relate to a particular crop or a mix of crops?
- Should the database be measured internally or externally?
- If the internally measured revenues are relevant, then should the RAC include a deductible?
- If the externally measured revenues are relevant, then which data aggregation level should be used?

To achieve the highest possible risk reduction, first it is reasonable to weight the revenue of each production process with its respective share in the production program. However, individual components of the production program may change over time. Such an RAC would involve a corresponding adjustment effort and could possibly be more difficult to communicate to (non-agricultural) landowners. Therefore, implementing an RAC that is based purely on the revenue of a dominant reference crop would be easier than using a RAC based on a crop mix.

The use of internally measured revenues is connected with the problem of moral hazard, which can be counteracted in two ways: by implementing a deductible or with externally measured revenues. A deductible means that a margin is set within which the indicator value may fluctuate without a rent adjustment. Because the portion of risk that is passed on to landowners decreases, incentives exist such that the farmer must seek to maintain a successful farm despite the RAC. Moral hazard can be completely avoided with external revenues. The risk reduction potential of the RAC is expected to decrease as the aggregation level increases. Note that the receipt of external relevant data can be delayed.

Thus far, we have focused on RACs based on revenues. Note that rent adjustments can be coupled with the development of a more disaggregated variable such as prices or yields (Langemeier, 1997). This coupling makes a clause easier to communicate and reduces the problem of delayed data availability. At the same time, however, the risk reduction potential is negatively affected (Langemeier, 1996).

Price index clauses

The price index clause uses national indices to derive rent adjustments. In this case, the determination of the RAC is based on three external indices (Plumeyer et al., 2010) published by the Federal Statistical Office of Germany. These include a Consumer Price Index (CPI), a Producer Price Index (PPI) and an Input Price Index (IPI). The percentage change in the indices with respect to the previous year (ΔCPI_t; ΔPPI_t; ΔIPI_t) is required to determine the rent adjustment. The annual rent is calculated as follows:

$$R_t = R_B \cdot \left(1 + \frac{\Delta CPI_t + \Delta PPI_t - 0{,}5 \cdot \Delta IPI_t}{2}\right) \qquad (3)$$

It is necessary to individually clarify to which index one refers. For example, it is possible to revert to the national producer price index for industrial products but the national producer price index for agricultural products (which is specific to agriculture). Moreover, it would be conceivable to use regional-specific indices rather than national-specific ones (Plumeyer et al., 2010). When using price indices, the problem of delayed data availability is particularly relevant.

Weather index clauses

In a weather index clause, the rent is linked to one or more weather variables. The rent adjustment is calculated as the percentage deviation of the measured weather index (WI_t) in the respective production season from the contractual base weather index (WI_B). The annual rent payment is calculated as follows:

$$R_t = R_B \cdot \frac{WI_t}{WI_B} \qquad (4)$$

There are various design options for weather index clauses. In addition to the choice of the base weather index, the following fundamental questions must be answered:

- Which weather variable is the base of the rent adjustment?
- Which weather station is the reference weather station?

The average temperature, precipitation, or both during a specific period of time is a plausible choice for a weather variable. A composite index derived from various weather variables can account for the small amounts of precipitation that lead to higher yield losses at high temperatures compared with low temperatures. Therefore, a composite index is expected to have a greater risk reduction potential than a weather index that only refers to the total precipitation of the main growing season. At the same time, a composite index is more difficult to communicate to contract partners because its calculation is more complex (Turvey, 2005). For this reason, it is reasonable to remain with a single index.

Initially, the farm's weather station, which is in close proximity to its agricultural land, is an interesting choice for a reference weather station. The weather data measured from the land should correlate with the success of the farm better than the weather stations that collect data from a distance. However, moral hazard accompanies the use of internally measured weather data. This problem can be avoided by using externally and objectively measured weather data from commercial weather stations.

3. Database and methodological approach

Gross margin time series for the sample farm

We investigated the risk-reducing effect of various RACs for an exemplary arable farm using the research farm at the University of Goettingen. The research farm is interesting for several reasons. First, the percentage of the rented area that comprises the arable land is relatively high (98%); thus, financial risk is particularly relevant. Second, it is a purely arable farm; therefore, its success is entirely dependent on fluctuations in cash crop production because land-based production is its only source of income. Other farming systems (e.g., animal husbandry or pasture farming) generate additional income that is not directly associated with land management. These systems might create a 'natural hedge' through the diversification of production that would reduce the risk of the farm. In addition, the relevant data is well documented. The farm has 420 hectares (ha) of arable land with an average of 69 soil quality points[2]. The soil types range from chalk to clayey loams. The farm's primary crops are winter wheat, winter barley, winter canola and sugar beet. On average, they are grown on 55%, 15%, 10% and 20%, respectively, of the arable area. Our analysis does not consider crops grown on an area of less than 5 ha and those grown on experimental areas. The long-term average annual rent paid is $351[3] per ha. The rent payments account for approximately 20% of the total operating costs.

The total gross margin (TGM) is the relevant business performance indicator whose volatility is reduced. No differences arise with respect to the risk reduction potential of the RAC when we use a profit or cash flow instead of the TGM because the difference is located

[2] According to the relative German soil quality classification scheme, which ranges from zero to 100 points.

[3] At the time of writing (late 2011) €1 was approximately equivalent to £0.88 (pound sterling) and US$1.40 (European Central Bank).

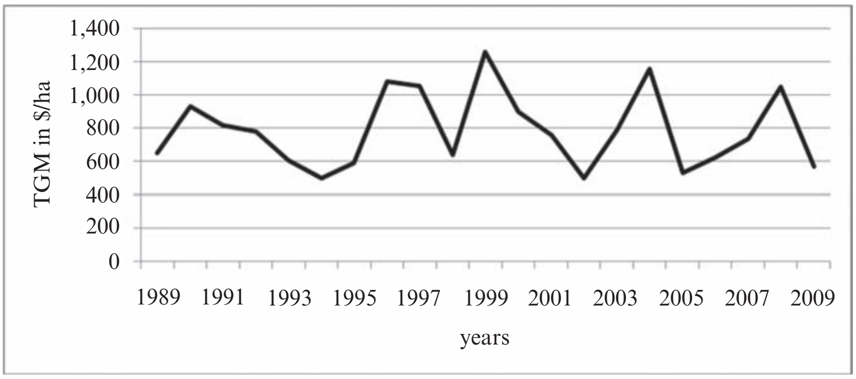

Figure 2: Time series of the TGM

only in constant fixed-costs or constant depreciation. Therefore, we determine a TGM time series for the sample farm (see Figure 2). The market prices and physical yield of the main crops were obtained from the appendix of the balance sheet from 1989 to 2009. Because research projects might distort the cost sections of these balance sheets, we used the variable costs that are published in the annual benchmark gross margins (Chamber of Agriculture, Lower Saxony (FID), different volumes) by the Agricultural Chamber of Lower Saxony, the federal state where the farm is located. The costs include expenses for fertiliser, pesticides, and machinery costs; rent costs are not included. The mean annual TGM before considering the rent payments was approximately $427,214 or $1,017 per ha. With regard to Figure 2, it becomes clear that TGM is subject to significant fluctuations over time.

The time series of the TGM without rent payment has a minimum of $570 per ha and a maximum of $1,490 per ha.

Relevant data for implementing an RAC

This section focuses on the data necessary to determine the risk-reducing effect of the following types of RACs:

The fixed-rent payment provides a reference. In the following section, we describe the data used to calculate RACs. The data were collected for a period corresponding with the considered gross margins.

Internal price and yield time series

For the RAC based on product prices and crop yields (see Equation 2), each of the grown cultures can be considered as base. We linked the rent adjustment to the prices and yields of winter wheat because it was grown in each of the past years and has the largest share of cultivated cropland on the research farm (on average 55%). Furthermore, winter wheat is very common in many parts of Germany. In 2010, approximately 28% of German agricultural land was used for its cultivation (Federal Statistical Office of Germany, 2011). The long-term average sales price of wheat was $20.88 per decitonne (dt), which formed the base crop price (p_B). The base yield (y_B) was the long-term average yield of wheat, which was 80.3 dt/ha.

External price and yield time series

Externally measured product prices and yields are needed for RACs based on external revenues. As in the case of the RAC with internal data, we used wheat prices and yields because of the aforementioned advantages and the easy access to the necessary long-term off-farm product prices and yield data.

To show the effects of the geographical basis risk associated with the revenue index clause, the required off-farm data was analysed using two aggregation levels. State-level data (Food and Agriculture Organization of the United Nations (FAOSTAT), 2011; Federal Statistical Office of Germany, 2011) as well as the federal state level data of Lower Saxony are used (FID, different volumes; Lower Saxony Statistical and Communication Technology Centre (LSKN), 2011). An additional reduction of the data aggregation level is not practical for several reasons. First, such data is not often published on the community level. Second, arrangements between farmers can occur on community level. Therefore, moral hazard cannot be excluded. In contrast, the data on the state and federal state levels are not related to moral hazard and are often accessible free of charge. However, they are only available after a time delay.

We considered two situations with regard to this time delay. First, if there is no time lag, then the rent adjustment is based on the price and yield data of the same year. Second, the price and yield data of the previous year must be used. Therefore, we revert to the external price and yield data of 1988 to 2009.

Price index time series

In accordance with Plumeyer et al. (2010), we chose the time series for three indices calculated by the German Federal Statistical Office (see Equation 3) to determine the risk-reducing effect of the price index clause. Specifically, we chose the following indices:

- The consumer price index for Germany (CPI);
- The index of producer prices for vegetable agricultural products (PPI);
- The index of purchase prices for agricultural inputs (IPI).

The CPI measures the trends of prices for German goods and services annually (Federal Statistical Office of Germany, 2011). The CPI should account for the landowner's perspective. Not all goods and services in this price index are directly related to agriculture (e.g., the cost of movie tickets). The PPI describes the development of the prices of vegetable products (Federal Statistical Office of Germany, 2011). In addition, we used the IPI index to indicate the development of the purchase prices of agricultural inputs such as fuel or fertiliser (Federal Statistical Office of Germany, 2011). The PPI and IPI should display the farmer's situation.

Weather time series

Weather data was required to determine the hedging effectiveness associated with weather-related index RACs (see Equation 4). At a weather station in Goettingen, 5 km away from the farm, average daily temperature and daily precipitation were measured. Data are available for the period from 1988 to 2009 (Institute of Soil Science, 2011). Average temperatures were calculated monthly, whereas rainfall sums were calculated for periods of one and two months (Itoh et al., 2009). Subsequently, we examined whether the weather variables are strongly correlated with the operational TGM.

The highest correlations between TGM and single-month precipitation were 0.30 for the 'February of the harvest year' and 0.28 for the 'October of the sowing year'. The two-month total precipitation of these months combined has the strongest positive correlation with the TGM (0.36). This strong correlation is because the arable land has soil with a high capacity for holding water. Thus, the rainfall in the aforementioned months is needed for soil 'water storage' and replenishes the plants in the spring. Only March had a monthly average temperature that was positively correlated with the TGM (0.26). This finding may be because the early warming of the soil extends the growing season and positively affects plant growth.

We compared the single-month precipitation of October and February with their sum to examine the basis risk of production. Furthermore, we used the average temperature of March as a weather index clause indicator.

We examined data from different weather stations to investigate the geographical basis risk. In addition to data from Goettingen, we used data from weather stations in Hanover and Magdeburg (German Meteorological Service (DWD), 2011) that are located 104 linear km and 135 linear km away, respectively. The correlation between the TGM and the rainfall in October and February was 0.22 for the weather station in Hanover and 0.17 for the weather station in Magdeburg.

Historical simulation

A historical simulation was performed to determine the risk reduction potential of the RAC in the sample farm (Dowd, 2002; Turvey, 2005). This simulation is a numerical, non-parametric method that uses historical data rather than estimated distributions. We sought to determine the values that target variable would have had in the past based on a particular decision (e.g., implementation vs. non-implementation of an RAC). The two crucial questions were

- How high was the risk of the TGM from 1989 to 2009, during which a fixed rent was paid?
- How high would the risk of the TGM have been if the farm had used an RAC?

The variation in the TGM risk triggered by the RAC is the risk reduction potential. The historical simulation included the following procedural steps:

1) The starting point was the TGM time series before rent payments, from 1989 to 2009 (see Figure 2). The historical simulation results are distorted when the stochastic variables include trends (Goodwin and Ker, 1998). A linear regression with a constant shows that the historical TGM had a significant trend (coefficient of time variable = 16.43, p-value = 0.0131, R^2 = 0.28). Therefore, we conducted a trend adjustment to the year 2009. The average trend-adjusted TGM before the consideration of rent payments was approximately $330,120 for the farm or $786 per ha.
2) The TGM time series after rent was determined by accounting for the trend-adjusted TGM time series using a fixed-rent payment of $351 per ha. The average trend-adjusted TGM after accounting for the fixed rent was approximately $182,700 or $435 per ha.
3) Statistical parameters were calculated that allowed us to quantify the TGM risk associated with the payment of a fixed rent.
4) To determine the risk-reducing effect of a RAC, the amount of rent payment from 1989 to 2009 was calculated under consideration of the development of the indicator of the relevant clause.
5) The TGM time series after rent payment was determined by accounting for the trend-adjusted TGM time series (see Step 1) and the rent according to the RAC (see Step 4).
6) Statistical parameters were calculated that allowed us to quantify the TGM risk associated with the rent payment derived by an RAC.
7) The comparison of statistical parameters calculated in Step 6 (with an RAC) and Step 3 (with fixed rent) allowed us to examine the risk-reducing effect of an RAC.

Furthermore, the following must be considered: We assumed that the percentage of rented land is 100% (not 98% as in the case of the real farm). Because we are solely concerned about analysing the risk-reducing effect of the RAC, we took a suitable precaution with our calculations such that the average annual rent payment was equal for all RAC. Therefore, we assumed that the implementation of an RAC does not cause an additional cost for the farmer (e.g., setup costs for contracts) or the landowner (e.g., cost control). Furthermore, we assumed that landowners are risk-neutral and that they would not demand a risk premium for receiving time varying rent payments rather than fixed ones. Any tax implication resulting from the introduction of the RAC, such as the potential impact on the marginal tax rate or the co-entrepreneurship of the landowner, was ignored.

Risk measures

Various risk measures were used to calculate the whole-farm risk reduction potential of the RAC. We determined the percentage of change in the standard deviation of the TGM time series caused by the RAC. The assumption of a normally distributed TGM cannot be rejected based on the Anderson-Darling or the Kolmogorov-Smirnov test. However, there are parametric distributions (e.g., the Weibull distribution) that describe our empirical TGM data distribution better than the normal distribution.

Because the standard deviation is of limited use for asymmetrical distributions (see Dowd, 2002), we calculated the percentage of change in the value at risk (VaR) compared with the reference scenario 'fixed-rent payment' to describe the risk reduction potential of the RAC. The VaR describes the loss of a particular risk position not exceeded by a given probability (confidence level) and within a given time horizon (Jorion, 2002). Although the VaR is often applied in the financial sector (see Jorion, 2002), it is increasingly used to measure agricultural risk (Odening and Hinrichs, 2003; Chen et al., 2006, Berg and Schmitz, 2008). Our calculations focused on the 90% confidence level (i.e., the expected loss at a maximum probability level of 90%). A VaR with a higher confidence level was less meaningful because we had annual data only and, therefore, a limited number of observations. We denote the VaR with 90% confidence level '90%-VaR'. The standard deviation provides information regarding the 'general variations' of the TGM. The VaR provides information regarding the left tail of the distribution.

Furthermore, we indicated the probabilities by which a TGM of less than $295 per ha (approximately 50% of the expected TGM) and TGM of less than $224 per ha (approximately 33% of the expected TGM) was achieved.

4. Results

Table 1 shows the risk reduction potential of various RACs compared with a fixed rent payment.

Line 1 refers to the reference scenario 'fixed-rent payment'. An average TGM of $435 per ha has a standard deviation of $227 per ha. The 90%-VaR of $254 per ha denotes that there is a 90% probability that the maximum expected reduction in annual TGM is not more than $254 per ha and not less than ($435–$254) $181 per ha. In the last two columns for fixed-rent payments, we see in 38% of all cases the TGM was below $295 per ha and there was a 19% probability of being below $224 per ha.

Line 2 shows that the standard deviation decreases by 12% (and the 90%-VaR decreases by 25%) with the introduction of an RAC based on internal revenues from winter wheat compared with the 'fixed-rent payment' reference scenario. The probabilities of a

Table 1: Risk-reducing effects of different RACs

RACs			Standard deviation of TGM after rent in USD/ha[b]	90%-VaR of TGM after rent in USD/ha[b]	Probability in % of loss higher than...	
					50% of the mean of TGM	66% of the mean of TGM
1	Fixed-rent payment	(Reference scenario)	227	254	38	19
2	Clause based on the internal revenues from winter wheat	Without deductible	201 (−12%)	189 (−25%)	29	10
3		With deductible	208 (−9%)	189 (−25%)	33	10
4	Clause based on the national average of winter wheat revenues	Without time lag	229 (0%)	208 (−18%)	33	10
5		One-year time lag	255 (+12%)	274 (+8%)	29	24
6	Clause based on the regional average of winter wheat revenue	Without time lag	215 (−6%)	213 (−16%)	29	10
7	Price index clause	Without time lag	223 (−2%)	229 (−10%)	38	14
8	Weather index clause based on the weather station in Goettingen	Sum of precipitation for October and February	203 (−11%)	212 (−17%)	29	14
9		Average monthly temperature of March	244 (+7%)	219 (−14%)	33	19
10		Monthly sum of precipitation for October	213 (−6%)	213 (−16%)	33	10
11		Monthly sum of precipitation for February	210 (−7%)	226 (−11%)	24	14
12	Weather index clause based on the weather station in Hanover	Sum of precipitation for October and February	213 (−6%)	257 (+1%)	29	24
13	Weather index clause based on the weather station in Magdeburg	Sum of precipitation for October and February	222 (−3%)	239 (−6%)	33	39

Notes: a. The expected TGM value after the rent payment was $435 per ha, independent of the respective RAC.
b. The percentage of change in the respective risk measure compared with the fixed rent (Line 1) is displayed in parentheses.

TGM less than $295 per ha and less than $224 per ha are decreasing by 24% and 47% in relative terms and by 9% in absolute terms. The percentage of change in risk measurement is different in each case, but the RAC based on internal revenues from winter wheat shows independent of the considered risk measure a substantial risk reduction potential. However, this RAC is associated with moral hazard.

One could try to mitigate this problem by introducing a deductible. With a deductible of 25% (Line 3), the risk reduction potential tends to decrease compared with Line 2. The 90%-VaR and the probability of the TGM below $224 per ha do not change. This finding is because these assessments are downside risk measures and because a deductible does not influence the rent adjustment when the TGM is low.

The clause based on the national average of wheat revenues represents a method of entirely avoiding moral hazard. Line 4 shows that this clause still reduces the 90%-VaR and the percentiles compared with the reference scenario. However, one also sees that the risk reduction potential is reduced considerably compared with the RAC based on internal wheat revenue (Line 2).

When one attempts to implement an RAC based on external average wheat revenues, the following must be mentioned with regard to the expected time lag in data availability and data aggregation level:

- The price and yield data from e.g. 2008 (Line 5) must be used to account for the one-year lag in data availability in the clause based on the national average of winter wheat revenues used to determine the rent adjustment in 2009. By doing so, the risk reduction potential will decrease substantially. The standard deviation and the VaR will increase compared with the reference scenario.
- When the RAC is based on a specific federal state average of wheat revenues, the risk reduction potential is slightly higher compared with the RAC based on national data (e.g., the change in the TGM standard deviation compared with the reference scenario is 6% in Line 6 and 0% in Line 4). Because only the aggregation level changed for the rent-adjustment-related data, an improvement in the risk reduction potential may be due to the smaller geographical basis risk when using small-area data.

The price index clause (Line 7) is clearly inferior (in parts) to the clauses based on internal or external wheat revenues. The standard deviation was reduced by 2% compared with the reference scenario; the 90%-VaR was reduced by 10%. The probability of a TGM lower than $295 per ha has not changed.

Line 8 displays the results concerning the RAC based on a precipitation index of 'October of the sowing year' and 'February of the harvest year'. By comparing all risk measurements with the reference scenario, one can notice a reduction in risk. Although this RAC was based on an external indicator, the standard deviation was reduced to $203 per ha (11%), and the 90%-VaR was reduced to $212 per ha (17%).

Lines 9 to 13 display the results for the alternative RACs; thus, they are not well-suited weather indices for the TGM. The results can be summarised as follows:

- In Line 9, the risk reduction potential of the RAC refers to the average temperature of March in Goettingen. Despite the fact that March has the highest positive correlation with temperature and the TGM, this clause has a lower risk reduction potential than the clause based on rainfall data in October and February (Line 8). The standard deviation of the TGM increases compared with the reference scenario. The risk reduction potential of the weather index clause in Line 8 and Line 9 is different due to a different basis risk of production because both rainfall and temperature are measured at the same distance from the place of production.
- Lines 10 and 11 refer to the RAC based on the total precipitation in October and February in Goettingen. They illustrate the basis risk of production and these results are similar to the temperature index clauses (Line 9). After comparing the one-month precipitation clauses with the two-month precipitation clause (Line 8), it becomes clear that combining the two months creates a greater risk reduction potential.

Lines 12 and 13 refer to the RAC based on the total precipitation in October and February measured at the weather stations in Hanover and Magdeburg. These data demonstrate the effect of the geographical basis risk. As the distance from the point of production in Goettingen (Line 8) increases from Hanover (Line 12) to Magdeburg (Line 13), the risk reduction potential of the respective RAC significantly decreases because the correlation with precipitation decreases as distance increases. The results of the temperature index clauses based on the weather data from Hanover and Magdeburg that are structured like those in Line 9 are not listed in Table 1. A similar pattern is observed with variations in the rainfall index: as the distance increases, the RAC risk reduction potential decreases. However, this decrease in the risk reduction potential is smaller because temperatures are more strongly spatially correlated with the agricultural production than precipitation (Norton et al., 2010).

5. Conclusion

The proportion of rented land has recently increased in the agricultural sector in general and in Germany in particular. Consequently, farm risk, especially financial risks, has also increased, which makes innovative risk management tools such as RACs more interesting. This paper aimed to determine the risk reduction potential of various RACs at the farm level.

Our calculations showed that the risk reduction potential of various RACs differ considerably from each other. In all, the achieved risk reduction level for all investigated clauses was not high. This result might explain why RACs have not been widely used thus far. However, RACs induce the fluctuation of only one cost factor. The much debated clauses based on internal prices or revenues are connected with moral hazard. Therefore, they are associated with high control and monitoring costs. The implementation of an RAC based on external and objectively measurable indicators is cost-effective. However, it is apparent that clauses based on national price indices are virtually ineffective. The weather index clause suggested in the present paper (which was based on rainfall data measured outside the farm) was many times more effective than the other clauses examined using external indicators. We conclude from our results that implementing RACs makes sense when they feature off-site measured weather-indices.

This paper is based on the data of one farm (i.e., the risk reduction potential was examined using an exemplary analysis). Investigating the extent to which our results can be replicated would be interesting, especially using farms in other countries or other types of farms to calculate the risk reduction potential. However, we would not expect qualitative differences because the nature of the RAC we examined does not change when other operational data are used.

Following an advice of a reviewer it is important to note that, in times of changing weather patterns due to global climate change, some farmland might become difficult to rent, if the landowner does not agree to an RAC. In addition, some landowners may find it beneficial to agree to an RAC to improve their risk management (e.g., when the RAC is negatively correlated with other income sources).

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