2014 | Faculty of Business Economics

DOCTORAL DISSERTATION

Household risk balancing in European agriculture: an econometric approach

Doctoral dissertation is submitted to obtain the degree of
Doctor of Applied Economic Science

Yann de Mey

Promoter: Prof. Mark Vancauteren
Co-promoters: Prof. Steven Van Passel
Prof. Erwin Wauters

D/2014/2451/22

Members of the jury

Prof. dr. Mark Vancauteren (promoter)
KIZOK Research Center for Entrepreneurship and Innovation
Hasselt University

Prof. dr. Steven Van Passel (co-promoter)
Centre for Environmental Sciences
Hasselt University

Prof. dr. Erwin Wauters (co-promoter)
Institute for Agricultural and Fisheries Research – Social Sciences Unit
Department of Veterinary Sciences
University of Antwerp

Prof. dr. Piet Pauwels (chairman)
Faculty of Business Economics
Hasselt University

Prof. dr. Ludwig Lauwers
Institute for Agricultural and Fisheries Research – Social Sciences Unit
Department of Agricultural Economics
University of Ghent

Prof. dr. Ludo Peeters
KIZOK Research Center for Entrepreneurship and Innovation
Hasselt University

Prof. dr. Joshua Woodard
Dyson School of Applied Economics and Management
Cornell University

Prof. dr. Robert Finger
Institute for Food and Resource Economics, Production Economics Group
University of Bonn

Acknowledgements

After my fruitful MSc thesis research endeavors in Senegal, I decided to pursue a PhD in the field of agricultural economics. Little did I know at that time what an enormous undertaking it is in practice! However, I was also unaware of all the wonderful people I would meet along the way that make writing a PhD dissertation a very fulfilling endeavor. This first section is dedicated to everyone who contributed to the final version of this dissertation.

Eerst had ik graag mijn promotor prof. Mark Vancauteren en copromotor prof. Steven Van Passel willen bedanken om mij de kans te bieden om aan dit doctoraat te werken. Bedankt Mark voor de wetenschappelijke vrijheid die je me gaf, voor de vele interessante econometrische discussies die we hadden en voor de gemoedelijke samenwerking (meeting 1: *"laat die U maar vallen, on se tutoie!"*). Bedankt Steven voor de aangename treinritten samen naar Diepenbeek en om me steeds weer op het juiste spoor te zetten voor mijn doctoraat (en om na 4,5 jaar nog steeds te lachen met flauwe woordspelingen zoals deze). Ik heb enorm veel geleerd van jou, zowel op academisch vlak als daarbuiten en bewonder hoe enthousiast en persoonlijk jij de onderzoeksgroep milieueconomie leidt.

I would also like to express my gratitude to the jury members of my dissertation for the valuable time they have invested in reading my manuscript. Thanks to the Belgian members (prof. Ludwig Lauwers, prof. Erwin Wauters and prof. Ludo Peeters) to keep me on track along these 4.5 years. Also, a sincere thank you to the external jury members prof. Joshua Woodard and prof. Robert Finger. We met each other on AgEcon conferences across the globe and I hope our professional paths will cross again in the future. Furthermore, thank you Josh for presenting me with a post-doc opportunity at Cornell, I am very much looking forward to our collaboration this summer!

Een welgemeende merci ook aan team-ARAMIS a.k.a. de musketiers D'Artagnan en Athos a.k.a. team –win voor de ongelooflijk leuke samenwerking voor het IWT project. Gebruikerscommissies voorbereiden, ARAMIS voorstellen op Agribex, presentaties geven op conferenties en workshops, satellietwerken in Brussel, onze tool voorleggen aan landbouwers, … het kunnen saaie activiteiten klinken voor sommigen maar dat waren ze zeker niet door de super dynamiek die we hadden

en door de complementaire activiteiten die we samen op poten hebben gezet (burgers in Brussel, pintjes in Dublin, gebakken lucht verkopen, …)!

Merci liefste collega's aan de UHasselt om de momenten tussen het werken door en daarbuiten zo fijn te maken. Ik zal de Fitlink TD's, de lunchmeetings, de teamuitstap, de BOT'jes, de fratskes, de originele cadeaus, de koffiekletsen en nog zoveel meer zeker nooit vergeten!

Matty (en natuurlijk ook een beetje Pieter ;), merci om mijn interesse in het onderzoek aan te wakkeren in Senegal, mij vervolgens de kneepjes van het vak te leren en ook tijdens mijn PhD jaren nog steeds even enthousiast mijn onderzoek op te volgen! Hopelijk werken we spoedig nog eens samen!

Ik wil ook graag alle organisaties en externe collega's danken waar ik tijdens mijn doctoraatsonderzoek mee heb samengewerkt: ILVO L&M, Boerenbond, Landbouwkrediet, VAC, Boeren op een Kruispunt, AMS en de Afdeling Landbouw- en Visserijbeleid van het Departement Landbouw en Visserij en ART.

Bedankt ook beste vrienden om enerzijds mij ontspanning te bieden als dat nodig was (een speciale vermelding voor optredens met Joris, Mariokart met Mats en Toinne, loze PhD mails met Steven, de mannen Whats-App groep, post-nieuwjaarsfeestjes met de bio-bende, longboard sessies met de Crew ft. Possie en etentjes met Toto/Hendrik) en anderzijds begrip op te brengen als ik tijdens drukke momenten activiteiten heb afgezegd.

Beste ouders en schoonouders (en schoon-oma ;), bedankt voor al jullie steun en om steeds heel enthousiast te zijn als ik op conferentie mocht gaan of een paper aanvaard had. Liefste zusjes, bedankt om zo fier te zijn op de grote broer, leve de 'fantastic four' ☺

Last but not least, bedankt mijn allerliefste Astrid. Jij bent er altijd voor mij en hebt me steeds de steun gegeven die ik nodig had om mijn gedachten te verzetten als ik even in een PhD knoop zat. Bedankt^2 om zoveel begrip op te brengen dat ik de laatste maanden heel saai was, mezelf opsloot in mijn bureauke en steeds met mijn doctoraat in mijn hoofd zat. Bedankt^3 om vervolgens even enthousiast te zijn als ik over mijn post-doc in Cornell! Al 5 jaar zijn wij super samen en ik ben er van overtuigd dat dat er ook 5^2, 5^3, … samen gaan worden!

Abstract

In recent years, risk analysis and risk management have come to the fore of agricultural research and driven policy discussions regarding European agriculture. Indeed, numerous changes in the agricultural production chain such as increased globalization and liberalization, climatic changes and a growing awareness for environmental and animal welfare have made several types of risk increasingly important. A good understanding of farmers' risk behavior is essential in order to be able to predict sectorial responses to these changes in risk conditions and to anticipate the outcome of risk-related policies. Risk balancing behavior constitutes one potential unanticipated risk response as it involves making strategic financial risk adjustments in response to changes in business risk levels. European evidence on risk balancing behavior, however, was lacking to date leaving EU-policy makers partly in the dark with regards to the full impact of risk-altering policy measures of the CAP—*i.e.*, the existing decoupled income support and future risk management instruments currently considered in CAP reform discussions.

Another area that is gaining increased attention in European agricultural risk analysis is the importance of farm household risk exposure and management. Given that farmers have a broad range of family-related goals and values and that EU farm households increasingly earn a large part of their household income from non-agricultural sources, agricultural risk behavior could be better understood by also considering risk exposure and risk constraints at the household level. Therefore, the possibility of the simultaneous adoption and potential correlation between different on-farm and off-farm responses needs to be acknowledged when looking at risk balancing behavior. The central research objective of this PhD dissertation is therefore to examine risk balancing behavior in European agriculture and acknowledging the role of the farm household.

Chapter 2 presents a literature review that frames risk balancing research in the agricultural finance and decision making under risk literature and theoretically describes risk balancing behavior and the associated behavioral assumptions.

Chapter 3 presents the first European evidence on risk balancing behavior using the rich EU-15 FADN dataset for the period 1995–2008. By means of a correlation

relationship analysis and several fixed effects regressions, the results reject evidence of strong-form risk balancing (trade-offs between financial risk and business risk keeping total risk constant) but cannot reject weak-form risk balancing (trade-offs between financial risk and business risk with some observed changes in total risk). While previous empirical studies focused on one production typology within one country, the results in this chapter disclose inter-country and inter-typology differences in risk balancing behavior. Using the Flanders (Belgium) FADN dataset for the period 2005–2012 complemented with survey data from 2013, it is further found that the observed risk balancing behavior might be driven by the risk averse proportion of farm operators. To the best of my knowledge, this is the first study to empirically validate that risk aversion is a prerequisite for risk balancing behavior.

Chapter 4 discusses farm-level risk balancing measurement issues in greater detail and provides a deeper insight into the risk balancing behavior observed in Chapter 3. Risk balancing, in fact, involves two distinct risk responses depending on the direction of the strategic financial adjustment. When a farmer lowers financial risk in response to an increase in business risk, risk balancing entails a risk management strategy. Conversely, risk balancing behavior also involves an unanticipated entrepreneurship strategy where a farmer increases financial risk in response to lowered business risk conditions. To the best of my knowledge, this dissertation is the first study to explicitly consider both strategies and to empirically validate the occurrence of either strategy. Making use of correlation coefficients in the same EU-15 FADN dataset from Chapter 3, risk balancing is mostly observed as a risk coping strategy for farmers (42%) and to a lesser extent as an unanticipated risk response (26%). In the latter case, I observed rather low incidence figures for the paradoxical situation where the financial risk response is greater than the business risk decline (dubbed 'the paradox of risk balancing' in literature): only for 47% of the entrepreneurship risk balancers (12% of all risk balancers). By means of a multinomial Probit model, I further find that the determinants of a farmer's choice to adopt either of both risk balancing strategies had opposite effects. These results clearly put risk balancing into a broader perspective and contrast the focus that is put on entrepreneurship risk balancing in literature.

Chapter 5 of this dissertation theoretically extends the original Gabriel and Baker (1980) risk balancing framework to the household level. The novel concept of farm household risk balancing is introduced by means of a theoretical framework in which the farm household sets a constraint on the total household level risk and balances farm level and off-farm level risk. By taking farm household income and not just farm income as the focal point of the behavioral assumptions, a much wider variety of behavioral responses are considered in reaction to changes in the economic and policy environment. Besides altering the level of financial risk, farm households could just as well (i) attract off-farm income, (ii) smooth consumption levels, (iii) make off-farm investments or (iv) maintain liquidity buffers in response to exogenous changes in the level of business risk. Extensive empirical evidence from literature leading up to the model is presented and the implications for EU policy are discussed.

Chapter 6 presents empirical evidence on Chapter 5's novel household risk balancing framework using two distinct empirical approaches. First, based on 2013 survey information that complements the Flemish 2005–2012 FADN dataset, a psychometric household risk balancing scale is constructed. The results suggest that the average Flemish farm household exhibits household risk balancing behavior based on four underlying factors: (i) making decisions by the family as a whole, (ii) cutting private consumption in response to setbacks in business performance, (iii) mixing personal and business bank accounts to cover expenses and (iv) the necessity of off-farm income. Second, a system of equations was econometrically estimated using the Swiss 2003–2012 FADN dataset analyzing a farm household's joint decision of the level of debt, off-farm income and consumption. The evidence supports the notion that farm households make strategic farm and off-farm decisions in response to exogenous changes in expected business risk. Both approaches demonstrate that part of the behavioral risk response of farm households is ignored when focusing solely on the farm-level in the original risk balancing framework and thus illustrate the relevance of the extended household risk balancing framework from Chapter 5.

In summary, the findings of this dissertation provide a broader picture of risk balancing behavior in European agriculture. As the results reject evidence of strong-form risk balancing but cannot reject weak-form risk balancing, the

balancing effect might not be as strong as the theoretical risk balancing models put forward. The extent of the balancing effect is further found to differ between countries and typologies and risk aversion is empirically validated as a necessary prerequisite for risk balancing behavior. Focusing on the direction of the balancing behavior, it is mostly observed as a risk coping strategy (risk management risk balancing) for farmers and to a lesser extent as an unanticipated risk response (entrepreneurship risk balancing). Accordingly, rather low incidence figures for the 'Paradox of risk balancing' are observed, which contrasts the focus that is put on this unanticipated behavioral response in the risk balancing literature. By extending the original risk balancing framework to the household level, this dissertation considers a much wider variety of behavioral responses in reaction to risk changes in the economic and policy environment. The empirical results suggest the incidence of household risk balancing behavior in two case study regions (Flanders and Switzerland).

Samenvatting

De laatste jaren kwam risico in de landbouw meer dan ooit in beeld: veranderende teeltomstandigheden door klimaatsveranderingen, schommelende prijzen door geglobaliseerde markten en de onzekerheid omtrent de stelselmatige hervormingen van het Europese gemeenschappelijk landbouwbeleid (GLB). Het analyseren en beheren van deze risico's heeft de laatste jaren bijgevolg ook meer aandacht gekregen in het landbouweconomisch onderzoek en in beleidsdiscussies rond de Europese landbouw. Het is namelijk van belang voor EU beleidsmakers om de sectorale reactie op dit veranderende risicoklimaat en de potentiële impact van risico-gerelateerde beleidsinstrumenten juist in te kunnen schatten. In de landbouweconomische literatuur wordt 'risico balancerend' gedrag beschreven als een onverwachte reactie op een veranderend risicoklimaat, wat een juiste inschatting kan bemoeilijken. De theorie stelt dat landbouwers strategische veranderingen maken in hun schuldenstructuur als reactie op veranderingen in de graad van operationeel risico. Landbouwers balanceren zo als het ware hun operationeel en financieel risico opdat het totale bedrijfsrisico constant zou blijven. Europese studies rond risico balancerend gedrag bestaan echter niet, waardoor de volledige impact van risico-gerelateerde beleidsmaatregelen van het GLB (bv. ontkoppelde inkomenssteun of gesubsidieerde risicobeheersings-instrumenten) niet gekend is.

Een ander aspect dat meer en meer belicht wordt in de Europese landbouweconomische literatuur is de rol van het landbouwgezin in het beheersen van de risico's van het landbouwbedrijf. Steeds vaker verdienen Europese landbouwgezinnen een aanzienlijk deel van hun gezinsinkomen via niet-landbouw kanalen. Gezien de nauwe band tussen het landbouwbedrijf en –gezin nemen landbouwers naast bedrijfsgerichte doelen (bv. het maximaliseren van winst) ook gezinsaspecten in overweging bij het nemen van risicovolle beslissingen. Bijgevolg kan het nemen van risicovolle beslissingen door landbouwers beter begrepen worden indien zowel bedrijfsgerichte als gezinsstrategieën bekeken worden. Gegeven bovenstaande bevindingen is de centrale onderzoeksvraag van dit doctoraatsproefschrift het analyseren van risico balancerend gedrag bij Europese landbouwers en daarbij expliciet de rol van het landbouwgezin te erkennen. Meer informatie omtrent deze onderzoeksvraag is beschreven in hoofdstuk 1.

Hoofdstuk 2 beschrijft het theoretisch kader rond risico balancerend gedrag en geeft een literatuuroverzicht met de belangrijkste evoluties van deze theorie in de landbouweconomische literatuur, agrarisch financiële literatuur en literatuur rond besluitvorming onder risico.

Hoofdstuk 3 presenteert het eerste Europese bewijs van risico balancerend gedrag aan de hand van de EU-15 FADN dataset voor de periode 1995–2008. Een correlatieanalyse en verschillende 'fixed effects' regressiemodellen geven aan dat landbouwers inderdaad strategische financieringsaanpassingen gemaakt hebben in navolging van veranderingen in operationeel risico. De resultaten geven echter wel aan dat oorspronkelijke balans van bedrijfsrisico niet volledig wordt hersteld. Waar eerder onderzoek vooral keek naar specifieke Amerikaanse landbouwsystemen, geeft dit hoofdstuk verder aan dat de omvang van risico balancerend gedrag verschilt tussen de EU lidstaten en de diverse productierichtingen die er bestaan. Aan de hand van de Vlaamse FADN dataset voor de periode 2005–2012 gecomplementeerd met enquêtegegevens uit 2013 vinden we verder dat vooral risico-averse landbouwers risico balancerend gedrag vertonen.

Hoofdstuk 4 gaat dieper in op hoe risico balancerend gedrag op bedrijfsniveau kan gemeten worden en kijkt expliciet naar de richting waarin de strategische financieringsaanpassingen gebeuren. Indien een landbouwer minder schulden aangaat (of bestaande schulden herschikt) als hij een toename in operationeel risico verwacht, dan omvat risico balancerend gedrag een risicobeheersingsstrategie. Anderzijds omvat risico balancerend gedrag ook een ondernemerschapsstrategie indien een landbouwer meer schulden aangaat wanneer hij minder operationeel risico verwacht. Aan de hand van correlatiecoëfficiënten berekend in de EU-15 FADN dataset uit hoofdstuk 3, observeren we dat risico balancerend gedrag in Europa voornamelijk (42%) als risicobeheersingsinstrument gebruikt werd en in mindere mate als ondernemerschapsstrategie (26%). Een multinomiaal Probit model geeft verder aan dat de drijfveren om één van beide strategieën toe te passen tegengesteld zijn. Deze resultaten schetsen een breder perspectief van risico balancerend gedrag: het is voor Europese landbouwers eerder een risicobeheersingsstrategie dan een ondernemerschapsstrategie, daar waar in de Amerikaanse literatuur de focus omgekeerd ligt.

In hoofdstuk 5 wordt het theoretische model rond risico balancerend gedrag uitgebreid naar het gezinsniveau. Het model beschrijft hoe landbouwgezinnen een optimale hoeveelheid totaal gezinsrisico identificeren en vervolgens een balans zoeken tussen bedrijfsrisico en gezin-specifiek risico. Door niet alleen op bedrijfsstrategieën te focussen, maar ook naar het gezin te kijken, beschrijft het model hoe landbouwgezinnen naast strategische financieringsaanpassingen ook (i) inkomen buiten de landbouw kunnen verdienen, (ii) hun gezinsuitgaven kunnen beperken, (iii) niet landbouw gerelateerde investeringen kunnen maken en (iv) privé reserves kunnen opbouwen als gevolg van veranderingen in het operationeel risico van het landbouwbedrijf. Dit hoofdstuk bespreekt verder empirische studies in overeenstemming met het nieuwe model en de implicaties voor het EU landbouwbeleid (het GLB).

Hoofdstuk 6 presenteert bewijs voor het theoretische risico balancerend model op gezinsniveau van hoofdstuk 5 aan de hand van twee verschillende empirische methodes. Eerst wordt voor de Vlaamse 2005–2012 FADN dataset gecomplementeerd met enquêtegegevens uit 2013 een psychometrische meetschaal opgesteld gebaseerd op 4 factoren (i) beslissingen nemen in gezinsverband, (ii) gezinsuitgaven beperken als het bedrijf het minder doet, (iii) het mengen van privé- en bedrijfsrekeningen en (iv) het belang van niet-landbouwinkomen. Deze schaal geeft aan dat het gemiddelde Vlaamse landbouwgezin gedrag vertoont in lijn met het model uit hoofdstuk 5. Verder wordt een econometrisch systeem van drie vergelijkingen geschat voor de Zwitserse 2003–2012 FADN dataset. De vergelijkingen beschrijven hoe Zwitserse landbouwgezinnen simultaan het niveau van hun schulden, niet-landbouwinkomen en consumptie aanpassen als reactie op verwachte veranderingen in het risico van het landbouwbedrijf. Beide methodes onderlijnen het belang van het model uit hoofdstuk 5 en geven aan dat een deel van de risico-gerelateerde aanpassingen op gezinsniveau genegeerd worden indien men enkel naar risico balancerend op het bedrijf kijkt.

List of abbreviations

3SLS .... Three stage least squares

ANOVA .... Analysis of variance

ART .... Agroscope Reckenholz–Tänikon

BR .... Business risk

CAP.................. Common agricultural policy

CARRA .... Constant absolute risk aversion

CF.................... Cash flow

CHF .... Swiss franc

CONS .... Consumption

CRRA .... Constant relative risk aversion

CV .... Coefficient of variation

DARA .... Decreasing absolute risk aversion

EBITDA .... Earnings before interest, taxes, depreciation and amortization

EU-15 .... Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom

EU .... Expected utility

EU-MV.............. Expected utility mean-variance

FADN .... Farm accountancy data network

FE.................... Fixed effects

FR.................... Financial risk

GDP .... Gross domestic product

GMM .... Generalized method of moments

HHRB .... Household risk balancing

IRRA .... Increasing relative risk aversion

N .... Number of observations

NOI.................. Net operating income

OECD .... Organization for economic co-operation and development

OFI .... Off-farm income

OFR .... Off-farm risk

OLS .... Ordinary least squares

RA .... Risk aversion

RB .... Risk balancing

RE .... Random effects

ROA .... Rate of return on assets

SEU .... Subjective expected utility

SUR .... Seemingly unrelated regressions

TR .... Total risk

TR_f .... Total farm-level risk

TR_h .... Total household-level risk

UC .... Units of consumption

US .... United States of America

VIF .... Variance inflation factor

Table of contents

List of figures

Chapter 4

Chapter 6

Appendix

List of tables

Chapter 3

Chapter 4

Chapter 6

Appendix

Chapter 1

Introduction

1.1 Dealing with risk in agriculture

"Newsflash: Agriculture is risky"

(Dana Hoag, 2009: 3)

Since the 1970's, agricultural risk and uncertainty analysis has been one of the most distinctive contributions to the agricultural economics profession (Runge, 2008). In more recent years, risk analysis and risk management have also come to the fore of agricultural research and driven policy discussions regarding European agriculture (Vrolijk et al., 2009). This amplified attention can be attributed to several changes in the agricultural production chain that made several types of risk increasingly relevant to the European agricultural producer (discussed below). From a farmer's perspective, risk analysis is therefore important in order to evaluate risk exposure and assess potential coping strategies to sustain the viability of the farm.

Even in ancient times, agricultural production has faced much challenges related to the inherent uncertainty of the biological production process. In recent times, production risks due to the weather have become increasingly relevant as agriculture experiences the impact of climate change first hand (Howden et al., 2007; Ericksen et al., 2009; Nelson and Shively, 2014). Potential pest or disease epidemics in crop and livestock production is another venue that could induce additional production risks (Wilkinson et al., 2011).

The increased globalization and liberalization in agricultural trade is expected to increase the volatility in input and output markets (Eakin, 2005; Chavas and Kim, 2006). Given the limited control individual farmers have over input and output markets, this development does not only present them with more price (market) risks, but in turn also threatens global food security (Ericksen et al., 2009). The advent of biofuels has also altered the nature of the link between energy and agricultural markets, with biofuel prices potentially transmitting volatility to feedstock and food prices (Banse et al., 2008; Serra, 2013). The 2007–2008 world food price crisis and the slump during the succeeding years has further opened the debate regarding the role of speculative movements in organized commodity markets on the nervousness and volatility of agricultural markets (Headey and Fan, 2008; Sumner, 2009).

Growing awareness regarding environmental and animal welfare perspectives progressively puts more restrictions on input usage and directs production techniques in the EU (Brouwer et al., 2012). These restrictions can provoke additional production risks and the uncertainty regarding these standards and their implementation are experienced as considerable institutional (policy) risks. In the same vein, market stabilizing government programs such as import quota, price support or export subsidies have been gradually abolished in the EU over years in favor of alternative measures such as direct payments. EU policy makers have shifted from managing markets to emphasizing risk management and in doing so placed a share of the risk managing responsibility back into the hands of the farm operator (Varangis et al., 2002). In the recent Common Agricultural Policy (CAP) reform discussions, however, more focus is put on specific risk mitigation policies (Cafiero et al., 2007) and a new risk management toolkit is being proposed as part of the Pillar 2 rural development measures (Tangermann, 2011).

The aforementioned business risks forego the fact that the agricultural sector is in general a capital intensive industry with a heavy reliance on non-depreciable assets such as farmland (Barry and Ellinger, 2010). Combined with the increased specialization with linked scale enlargements of EU agricultural systems (Hill, 2006), the capital intensity implies liquidity challenges and a great need for debt usage which provokes additional financial risks related to the fixed debt servicing obligations associated with foreign capital (Barry and Robison, 2001). Furthermore, as agriculture is a self-employment business, there is often no clear distinction between farm capital and household capital; financial risks are thus often transferred and coped with at the household level. Studying the relationship between business risks and the level of financial risk acknowledging the role of the household will be a central theme of this dissertation; more specifically it will focus on risk balancing behavior.

Risk balancing behavior refers to farmers making strategic capital structure (*i.e.*, financial risk) decisions in response to exogenous changes in the level of business risk (Gabriel and Baker, 1980). The risk balancing hypothesis is a normative concept in agricultural finance (Barry and Ellinger, 2010), yet empirical applications predominantly originate from a US base, as evidenced by the literature review in Chapter 2. The first aim of this dissertation is therefore to evaluate and validate the first European evidence on risk balancing behavior (Chapter 3). Given the aforementioned changes in the EU agricultural risk environment and the ongoing discussion regarding the role of risk management in the new CAP towards 2020, this information is timely for EU policy makers.

Discerning risk balancing behavior from observed data is not an easy venture, however, as alternative factors could drive co-evolutions between changes in business risk and financial decisions. On the one hand, business risk is increasing in the EU (Vrolijk et al., 2009), while on the other hand the EU farming population is getting older on average (Hill, 2006) entailing that debts are getting repaid and hence financial risk decreases. However, theses aggregate changes hinting at an unintentional risk balancing phenomenon mask important dynamics that might be occurring at individual farms. Accordingly, it is important to underline the farm-level approach that is taken in this dissertation to analyze risk behavior (Kimura et al., 2010). Analyzing farm-level decision making is also challenging nonetheless, as alternative farm strategies might drive financial decision making and the capital structure of some farms might be locked-in due to historical investments. The farm-level econometric approach of this dissertation therefore aims at controlling for alternative strategies or other unobserved heterogeneity that might drive observed patterns of business risk and financial risk.

A central theme in dealing with risk in agriculture is investigating risk preferences using the expected utility framework (Meyer, 2010). Empirical evidence following different approaches indicates that most farmers exhibit risk averse behavior (e.g. Binswanger, 1981; Antle, 1987; Chavas and Holt, 1996; Lien, 2002; Gómez-Limón et al., 2003), yet some scholars have argued that the relevance of acknowledging its role in risk analysis is exaggerated (Pannell et al., 2000;

Hardaker et al., 2004) or that alternative explanations can be presented for seemingly risk averse behavior (Just and Pope, 2003). Although risk preferences are acknowledged in risk balancing models and have been theoretically shown to influence risk balancing responses (Ramirez et al., 1997; Escalante and Rejesus, 2008), empirical applications considering a measure of risk aversion are scarce (one application can be found in (Turvey and Kong, 2009)). Chapter 3 of this dissertation will therefore empirically evaluate the role of risk aversion in risk balancing behavior.

1.2 Risk management and policy analysis

"An efficient and effective policy approach to risk management in agriculture will pay attention to the interactions and trade-offs among different risks […]"

(OECD, 2011: 12)

Risk is an issue not only relevant for agricultural producers but also from a societal or policy maker's perspective. Explaining production uncertainty and understanding risk behavior in agriculture is important to be able to predict sectorial responses to changes in risk conditions (Just and Pope, 2003; Plà et al., 2013). The economic uncertainty in agriculture has played an important role in justifying policy intervention and many farm support programs are supported as risk safety nets for producers (Glauber and Collins, 2010). The current income support policy of the CAP has direct and indirect effects on the level of risk in the EU agricultural sector and equally important on the distribution within the sector (Meuwissen et al., 2008; Vrolijk et al., 2009).

In order to improve agricultural policy analysis, it is of fundamental importance to take into account the correct expected risk behavior and uncovering unexpected behavioral responses. History presents several examples of agricultural policies that failed to meet their well-intended target due to unanticipated market or producer responses. Risk-reducing or income enhancing government programs for instance have been found to (i) increase agricultural land rents redistributing the policy benefits between farmers and landowners (Roberts et al., 2003), (ii) induce risk-taking behavior by farmers, e.g. by growing more risky crops (Turvey, 2012) and (iii) crowd-out alternative risk management instruments, e.g. subsidized insurance schemes reducing farmers' participation in forward contracting opportunities (Coble et al., 2000). To illustrate the sometimes counter-intuitive risk-taking behavior of decision makers, Skees (1999) discusses an analogous case where risk-reducing policy measures missed their well-intended target due to unanticipated behavioral responses: tractor accidents. To reduce the number of fatal tractor accidents, steel reinforced roll bars over the driver's seat became mandatory in the US. After this policy measure came into effect, the serious injury and death rates remained roughly the same, however, as people in these reinforced tractors were found to drive faster and on steeper slopes—*i.e.*, they exhibited more risk-taking behavior.

Risk balancing is another venue through which agricultural policies could induce unanticipated or perverse effects. The risk balancing hypothesis contends that risk-reducing or income-enhancing policies induce farmers to increase their financial risk level hence keeping total farm-level risk at the same level (Gabriel and Baker, 1980). This notion was entitled the 'paradox of risk balancing' in literature (Featherstone et al., 1988). Risk balancing can also work the other way around, *i.e.*, farmers can lower financial risk in response to an increase in business risk as a risk management strategy. This duality in risk balancing responses has never been explicitly addressed in literature. Chapter 4 will therefore look deeper into the occurrence of both distinct strategies to provide a broader perspective on risk balancing. The US-based risk balancing literature has mainly focused on the risk increasing direction of risk balancing (increasing financial risk in response to a drop in business risk), which could be attributed to the widespread availability and adoption of risk management tools such as insurance in North America. As the insurance schemes are heavily subsidized in the US (58% of total premiums, or up to 72% also taking funds for administrative costs and re-insurance into account (Bielza Diaz-Caneja et al., 2009), it is natural for researchers to focus on the potential debt-usage increasing effect of subsidized insurance schemes (e.g. see: Ifft et al., 2013). In European agriculture, however, the focus of agriculture policy has been more on income support and less on (subsidized) risk management. Accordingly, the market penetration of agricultural insurance schemes differs greatly between member states and there is no widespread use of different insurance options such as farm revenue, yield, or index-based insurances (Bielza Diaz-Caneja et al., 2009). Therefore, the inverse risk balancing response to decrease debt usage when business risk increases that has been overlooked on literature might be equally relevant for European agriculture.

1.3 Farm household risk and management

"[…] reducing farm-related risk through public policies should be evaluated in so far as it contributes to the reduction of the overall risk of the entire agricultural household's enterprise"

(Cafiero et al., 2007: 423)

Another area that is gaining increasing attention in agricultural risk analysis is the importance of farm household risk exposure and management (Cafiero et al., 2007; OECD, 2011). Several studies have revealed that farmers have a broad range of goals and values of which farm income maximization is only one aspect that is complemented by family-related goals such as having time for the family and having a stable household income (Gasson, 1973; Sumpsi et al., 1996; Wallace and Moss, 2002; Lien et al., 2006). Accordingly, scholars are agreeing that agricultural research that focusses only on farm-level aspects misses out on part of what is really going on in the majority of farm households, even in developed countries (Offutt, 2002; Freshwater, 2007). In order to rationalize risk behavior and risk preference, it is therefore clear that results could differ greatly between measures based on farm income versus household income (Hardaker et al., 2004: 113) as farm households in the US (Mishra et al., 2002), Canada (Freshwater, 2007) and Europe (OECD, 2003; Vrolijk et al., 2009) increasingly earn a large part of their household income from non-agricultural sources. Accordingly, focusing only of farm income and the volatility thereof to assess farmers' well-being is flawed (United Nations, 2007). For EU agriculture, information regarding off-farm activities and/or income is limited, yet several studies point out that many farmers spend a significant share of their time working on non-farm activities (McNamara and Weiss, 2005; Benjamin and Kimhi, 2006; Hennessy and Rehman, 2008). As the objectives of the CAP are also clearly formulated with farm households as the social unit in mind, considering farm household-level income and household risk is relevant for EU agricultural policy.

Taking these elements into consideration, Chapter 5 of this dissertation extends the original risk balancing framework to the household level and argues that agricultural risk behavior is better understood by considering risk levels and risk constraints at the household level. By taking farm household income and not just farm income as the focal point of the behavioral assumptions, a much wider variety of behavioral responses are considered in reaction to changes in the economic and policy environment.

In order to provide an empirical underpinning of the novel household risk balancing framework, Chapter 6 will present empirical evidence using two complementary methodologies: (i) a psychometric household risk balancing scale constructed using qualitative survey data and (ii) an econometric system of equations estimated using quantitative accounting data. Both approaches present a unique view on the strategic decisions farm households make in response to changes in farm-level risk.

1.4 Objectives and outline

It is clear from the preceding sections that the EU agricultural risk environment has been subject to changes over the past years and further changes are to be expected in the future. EU agricultural policy is conjointly changing in order to support the agricultural sector to cope with these evolutions. In order to make policies with risk implications efficient and well-targeted, a good understanding of EU farmers' risk behavior is therefore essential. As risk balancing behavior constitutes potential unexpected behavioral responses, demonstrating the occurrence of risk balancing tradeoffs made by EU farmers could be central to evaluate future risk-related CAP measures. However, acknowledging that many farm households in the EU increasingly attract a substantial part of their income from non-agricultural sources, the possibility of the interaction between on-farm and off-farm responses also needs to be acknowledged. Given these problem statements, the central research objective of this dissertation can be summarized as:

Examining risk balancing behavior in European agriculture and acknowledging the role of the farm household.

Each chapter of this dissertation will look at distinct elements that contribute to a better understanding of European household risk balancing behavior by considering the following objectives:

- Providing empirical European evidence on risk balancing behavior
- Exploring differences in risk balancing across different countries and farm typologies
- Determining the drivers of the extent and direction of risk balancing behavior
- Covering farm-level risk balancing measurement issues
- Evaluating the role of risk aversion in risk balancing behavior
- Acknowledging the role of farm household's risk behavior in risk balancing
- Providing empirical evidence on household risk balancing behavior

This dissertation is structured as follows. After outlining the central research question and stating the research objectives of this dissertation's chapters in the introduction, the next section will review how risk is characterized in this dissertation.

Chapter 2 theoretically introduces risk balancing behavior and frames risk balancing research in the agricultural finance and decision making under risk literature. Two leading risk balancing models are discussed (the theoretical Gabriel and Baker (1980) model and the follow-up utility-centric Collins (1985) model) and the underlying behavioral assumptions are spelled out in detail. The chapter further presents an overview of the existing risk balancing literature and introduces the theoretical concepts of strong-form and weak-form risk balancing.

Chapter 3 and Chapter 4 will first focus on the original risk balancing framework and provide several empirical applications. The econometric analysis of Chapter 3 presents the first European (EU-15) evidence on risk balancing behavior, discusses inter-country and inter-typology differences and is also conducted at an unprecedented large scale. Using an additional accounting data source complemented with survey information, the impact of risk aversion in risk balancing is empirically analyzed for the first time. All empirical analyses in this dissertation follow a micro-level approach, since the individual risk (management) environment of a farmer can be significantly different from that in the aggregate (Just, 2003; OECD, 2008).

Chapter 4 discusses farm-level risk balancing measurement issues and provides a deeper insight into risk balancing behavior by explicitly focusing on the dual direction of the strategic balancing behavior. It introduces the concepts of risk management risk balancing (where a farmer lowers financial risk in response to an increase in business risk) and entrepreneurship risk balancing (where more financial risk is taken when the business risk position improves) in literature. Using several econometric models, the drivers of the extent and direction of risk balancing behavior of European farmers are discerned for the first time in literature.

Chapter 5 and Chapter 6 go beyond the original risk balancing framework by acknowledging the role of farm household's risk behavior. Chapter 5 presents a conceptual model that extends the original risk balancing framework to household level in which the farm household balances farm level and off-farm level risk. Extensive empirical evidence from literature leading up to the model are presented and implications for EU policy are discussed.

Chapter 6 presents empirical evidence on Chapter 5's novel household risk balancing framework using two diverse empirical approaches. First, combining accounting data with survey information, a psychometric household risk balancing scale is constructed and the differences between farm households are explored. Second, an econometric model is estimated that analyzes a farm household's joint decision of the levels of debt, off-farm income and consumption. Both approaches demonstrate that part of the behavioral risk response of farm households is ignored when focusing solely on the farm-level in the original risk balancing framework and thus illustrate the relevance of the extended household risk balancing framework.

1.5 Characterizing and measuring risk

"Risk is like love, we all know what it is, but we don't know how to define it"

(Joseph Stiglitz)

Dealing with risk in agriculture can be challenging because there is no general consensus about the definition of risk and much confusion exists on how it can be measured to begin with. Therefore, this section will present a brief overview of how risk is characterized and operationalized in this dissertation.

Agriculture can be seen as a textbook example of a sector that produces under inherent uncertainty. Uncertainty is a prerequisite for risk to occur, but uncertainty does not lead to a risky situation by default. Various authors have addressed the question what makes an uncertain situation risky, however, there is still no clear consensus. The seminal work by Knight (1921) distinguishes risk from uncertainty on the basis of information availability in the former and absence in the latter concept. Another school of thought draws no sharp distinction between risk and uncertainty and uses both terms interchangeably (Chavas, 2004). In this dissertation, risk will be clearly distinguished from uncertainty based on several other characteristics than information availability, as elaborated below.

Barring the presence of uncertainty as a prerequisite of risk, there are several other elements that I identify to characterize risk. Firstly, predictability plays an important role as expected variability can be taken into account by the decision maker hence making an uncertain situation less risky. For example, seasonal variation is pervasive in crop yields (e.g. Just and Weninger, 1999) and livestock prices (e.g. Parker and Shonkwiler, 2014) and can thus be predicted and managed up to some level by crop and livestock producers. Secondly, the uncertainty should have an impact on the decision maker, *i.e.*, risk is uncertainty that matters (Anderson et al., 1977; Robison and Barry, 1987; Harwood et al., 1999; Hardaker et al., 2004). One could clearly categorize climatic volatility as an uncertainty that matters (*i.e.*, risk) to an arable farmer, yet as uncertainty that does not matter to a specialized greenhouse grower that controls every climatic aspect of his/her production. Thirdly, the level of control a decision maker has—particularly is it within his/her locus of control—will influence his/her perception of how great the risk is. Fourthly, risk considerations should evaluate both the positive and negative side of the incurred variability, which are commonly distinguished as upside and downside risk respectively. Lastly, there is an important time aspect as short term volatility can easily smooth out in the medium run, whereas longer term serially correlated negative outcomes clearly present a very risky situation.

After characterizing risk, the next question is how risk can be measured. An important distinction can be made between "real risk" and "risk perception". Taking a realist perspective, real risk is seen as the objectively measurable risk obtained by applying a certain methodology to observed data. Risk perception, in contrast, is the level of risk that is perceived and subjectively assigned by the decision maker. One way of obtaining a proxy for real risk is taking a frequentist approach, *i.e.*, derived from the limit of a relative frequency ratio. Conversely, the subjectivist view to obtaining risk perceptions is based on the degree of belief in an uncertain proposition and is gaining more traction recently in literature (Hardaker and Lien, 2010). Although coping with risk is inherently a subjective business, measuring risk in practice to take into account this subjective perception is often impractical given the large geographical and/or temporal scale of the problem at hand. As the scope of this dissertation is scrutinizing risk balancing behavior for European agriculture, I will make use of a frequentist risk measure.

There are three common ways of quantifying risk using observed data, namely as (i) the distribution of outcomes, (ii) the chance of a bad outcome and (iii) variability of outcomes (Hardaker, 2000). Each of these definitions have their advantages and disadvantages (Aven, 2010). Considering risk by observing the whole distribution of outcomes (e.g. by a probability or cumulative density function) has the advantage that it tells the whole story by presenting both upside and downside risk. It has the clear disadvantage, however, that it does not present a single measure that can be used to compare the level of riskiness. This feature makes it an inconvenient measure for large-scale applied risk studies such as in this dissertation. The second notion is the preceding one's antagonist in the sense that it does reduce risk to a single measure (such as the probability of a bad outcome or analogously the threshold value corresponding to a certain probability frequently called the value-at-risk), yet only focuses on downside risk. The third notion of risk as variability combines best of both worlds as it allows summarizing risk by one measure of dispersion (e.g. variance, standard deviation or median absolute deviation) and by considering the dispersion in relation to a measure of central tendency (e.g. mean or median) it takes into account both upside and downside risk. Therefore, in this dissertation I will operationalize risk by means of coefficients of variation (*i.e.*, the standard deviation relative to the mean) which also have the added advantage of being unit-free.

Chapter 2

Risk balancing behavior: conceptual frameworks and related literature

2.1 Conceptual frameworks

The risk balancing hypothesis offers a perspective on how farmers make strategic capital structure decisions under risk. In the corporate finance literature, several alternative capital structure theories have been proposed such as agency theory (Jensen and Meckling, 1976), tradeoff theory (Miller, 1977), pecking order theory (Myers, 1984), transaction costs theory (Williamson, 1988) or market timing theory (Baker and Wurgler, 2002). However, as farm businesses differ from corporate firms (Zhengfei and Oude Lansink, 2006), these theories might not be directly applicable to an agricultural setting. In the agricultural finance literature, an alternative view on optimal capital structure gained a lot of traction: the expected utility model of Collins (1985) that builds on the seminal risk balancing paper by Gabriel and Baker (1980). The model identifies leverage (the debt over assets ratio) as a choice variable, of which the optimum is found when farmers maximize their expected utility.

The central paradigm of analyzing producer behavior under uncertainty is the subjective expected utility (SEU) theory that dates all the way back to Bernoulli's *'Exposition of a New Theory on the Measurement of Risk'* (1738) and was subsequently extended by Von Neumann and Morgenstern (1947) and Savage (1954). Based on four decision theory axioms (ordering, transitivity, continuity and independence), the SEU hypothesis describes the existence of a utility function *U* that associates a utility value $U(a_i)$ to any risky prospect a_i which allows risky prospects to be ranked as the one with the highest utility is the most preferred (Hardaker et al., 2004: 35). The elegance of SEU is that it aptly integrates a decision maker's subjective probability of the occurrence of a certain prospect and his/her risk preference (reflected by the shape of their utility function). The SEU theory has been criticized, however, as decision makers not always act consistently with the theory (Buschena, 2001). The main critique is the invalidity of the independence axiom (Allais, 1984). A number of alternative and more general decision theories have been formulated in literature such as prospect theory (Kahneman and Tversky, 1979) or rank-dependent utility (Quiggin, 1992). For agricultural decision analysis, however, the SEU is still widely accepted in literature making the assumption of rational preferences (Meyer, 2001; Just, 2003; Hardaker et al., 2004).

The two major risk balancing models that can be discerned in literature (the theoretical Gabriel and Baker (1980) model and the utility-centric Collins (1985) model) make alternative behavioral assumptions for the decision maker. Both models are based on SEU, but differ with regards to how utility is modeled: implicitly in the Gabriel and Baker model versus explicitly in Collins' model. Both models further differ on three grounds: (i) measuring risk with coefficients of variation versus variance, (ii) using an absolute or relative return measure and (iii) defining an additive or multiplicative relationship between business risk and financial risk. These conceptual choices lead up to analogous versions of the risk balancing model that end in essentially the same model differing only in their measurement concepts. The next sections will present both risk balancing models in detail and discuss the underlying concept of risk balancing.

2.1.1 The original Gabriel and Baker risk balancing model

The original Gabriel and Baker (1980) risk balancing model presents a conceptual framework that theoretically describes risk balancing behavior. The framework assumes that a farmer has farm survival (*i.e.*, avoiding bankruptcy) and profit maximization as behavioral goals with a focus on the former. Mention is made of a lexicographic utility function where the farmer maximizes profits (income) subject to a total risk constraint (Encarnación, 1964; Halter and Dean, 1971). Risk is defined in terms of the variability of outcomes and is measured using the coefficient of variation (CV).[1] Business risk (BR)—the inherent risk on a farm

[1] Alternatively, one could use standard deviations (Barry et al., 1981) or variances (Collins, 1985)

independent of the way it is financed—can be reflected in the variability of any operational return parameter such as the rate of return on assets, net cash flow or net operating income (NOI). Gabriel and Baker (1980) define BR in terms of NOI as:

$$BR = \frac{\sigma_{NOI}}{\mu_{NOI}}. \quad (2.1)$$

Analogously, the total risk (TR) of a farm is defined as:

$$TR = \frac{\sigma_{NOI,d}}{\mu_{NOI-I}}, \quad (2.2)$$

where I represents fixed debt servicing obligations[2] and $\sigma_{NOI,d}$ the standard deviation of NOI with debt financing (before the deduction of I). Financial risk (FR) is then specified as the difference between TR and BR[3]:

$$FR = \frac{\sigma_{NOI,d}}{\mu_{NOI-I}} - \frac{\sigma_{NOI}}{\mu_{NOI}}. \quad (2.3)$$

Rewriting equation 2.3 and assuming that debt usage does not induce a change in NOI variability, i.e., $\sigma_{NOI,d} = \sigma_{NOI}$ (Gabriel and Baker, 1980: 561), yields:

$$FR = \frac{\sigma_{NOI}}{\mu_{NOI}} \frac{I}{\mu_{NOI} - I}. \quad (2.4)$$

Equation 2.4 demonstrates that FR is composed of two factors: (i) the inherent level of BR, and (ii) the leverage factor $\frac{I}{\mu_{NOI} - I}$. Accordingly, financial risk is a function of the exogenous level of business risk and a leverage choice component (how much fixed debt servicing obligations can be sustained relative to the NOI earned after servicing debt).

The risk balancing effect can be best explained expressing TR as the sum of BR and FR, and by identifying the target maximum amount of TR that can be coped with by a farm. This risk constraint, denoted with β, depends on farm specific factors such as farm profitability or farm size, personal characteristics such as the age or level of risk aversion of a farm operator and also exogenous factors such

[2] Note that the fixed debt servicing obligations (I) only include interest payments, owing to our NOI-based definition of BR. Under a net cash flow based definition, both interest and principal payments would be involved (Gabriel and Baker, 1980).

[3] Note that here an additive relationship between TR, BR and FR is defined consistent with Gabriel and Baker (1980). Alternatively, a multiplicative relationship can be used (Barry, 1983; Collins, 1985; Barry and Robison, 1987; Featherstone et al., 1988). As noted by Barry and Robison (1987, p. 144): "The two approaches are essentially the same, differing only in their measurement concepts".

as general economic conditions. Following the preceding definitions, the TR constraint can thus be written as:

$$\alpha \leq TR = BR + FR = \frac{\sigma_{NOI}}{\mu_{NOI}} + \frac{\sigma_{NOI}}{\mu_{NOI}} \frac{I}{\mu_{NOI} - I} \leq \beta \qquad (2.5)$$

where α represents the minimum amount of TR that a farm can experience (this lower bound theoretically can be zero if BR is zero, e.g. in the very extreme position when borrowing at the risk free rate to buy risk free bonds). Starting in the case where TR is equal to its optimal level β, the risk balancing effect involves strategic adjustments in the business and financial risk components, following an exogenous shock in the total risk balance. These adjustments could be in the form of a production, (re)financing, or investment decision, or a combination of any of them. For example, if on the one hand a price support policy induces a decline in BR, FR would also lower, resulting in a slack in the total risk constraint (TR < β). A farmer would therefore be motivated to increase financial risk (e.g. increase leverage) or look for high risk—high return production opportunities, to restore the TR balance (TR = β). If a farmer maximizes profit subject to his risk constraint, he will look for opportunities that increase his objective function. On the other hand, if an exogenous shock increases BR (e.g. adverse weather conditions), FR and TR will rise as well, possibly exceeding the TR constraint (TR > β). In this case, a farmer is forced to make risk adjustments such as refinancing, reorganizing assets or shifting to less risky production possibilities to comply with the TR risk constraint. The risk balancing effect as described above assumes that decisions are taken in such a way that the level of β does not change while BR and FR move in opposite directions (*i.e.* a constant level of risk aversion is assumed). This form of risk balancing can be defined as *strong-form* risk balancing. However, in practice this is a strong assumption and there probably will be observed variation in the level of β due to varying levels of risk aversion (e.g. see illustration 3 at the bottom of p.149 by Barry and Robison, 1987) or due to time effects: changing FR in response to changes in BR will usually not take place within one year but over a longer time span (Ahrendsen et al., 1994). Therefore, *weak-form* risk balancing can be defined as a more realistic inverse tradeoff between FR and BR with some observed changes in β (in terms of equation 2.5, $\beta' < \beta$ would be introduced).

2.1.2 A perspective from decision theory: Collins' risk balancing model

Follow-on studies of the seminal Gabriel and Baker paper use utility-centric risk balancing models (Collins, 1985; Barry and Robison, 1987; Featherstone et al., 1988; Jensen and Langemeier, 1996; Turvey and Kong, 2009) that formalized the risk balancing hypothesis in the broader context of decision making. The optimal debt model of Collins (1985)—developed along the strong-form risk balancing form discussed above is the most popular in literature.

In the Collins model, risk is also conceptualized in terms of the variability of outcomes. Business risk is defined as the exogenous variance of the rate of return on assets (ROA) and total risk as the variance of the rate of return on equity (ROE). Financial risk is then defined as the leverage factor δ=debt/assets chosen by the farmer that makes total risk a multiple of business risk.[4]

As a behavioral assumption, the Collins model assumes that a farmer's objective is to maximize expected utility from a stochastic ROE:

$$Max\ EU(\widetilde{ROE}). \tag{2.6}$$

By choosing a negative exponential utility function $(1 - e^{-2\rho ROE})$ with leverage as a choice variable and assuming ROE is normally distributed as $\widetilde{ROE} \sim N(\overline{ROE}, \sigma^2_{ROE})$, a mean-variance approximation to expression 2.6 can be made:[5]

$$Max\ U(\delta) = \widetilde{ROE} - \left(\frac{\rho}{2}\right)\sigma^2_{ROE}, \tag{2.7}$$

where ρ represents the coefficient of risk aversion. Making use of the duPont identity (Mishra et al., 2009) and acknowledging the cost of debt K, Collins (1985: 628) then expresses ROE as:

$$ROE = (ROA - K\delta)\frac{1}{1-\delta}. \tag{2.8}$$

Combining expression 2.8 and expression 2.7, regarding ROA as stochastic and K as fixed yields:

---

[4] Note that Collins' definition of financial risk is presented in accounting terms (*i.e.*, the percentage of assets that is financed with debt), whereas the Gabriel and Baker definition focusses on liquidity (*i.e.*, the percentage of income that is spent on servicing debt)

[5] The mean-variance framework (Freund, 1956; Levy and Markowitz, 1979; Meyer, 1987) is restrictive, yet widely used in agricultural finance literature due to its intuitive economic interpretation and attractive properties for analytical purposes.

$$Max\ U(\delta) = (\overline{ROA} - K\delta)\frac{1}{1-\delta} - \left(\frac{\rho}{2}\right)\sigma^2_{ROA}\left(\frac{1}{1-\delta}\right)^2. \quad (2.9)$$

Solving the first order conditions of equation 2.9 ($\frac{\partial U(\delta)}{\partial \delta} = 0$) yields the optimal debt formulation:

$$\delta^* = 1 - \frac{\rho\sigma^2_{ROA}}{[\overline{ROA} - K]}, \quad (2.10)$$

which suggests that optimal financial risk (δ^*) decreases with the level of risk aversion (ρ), business risk (σ^2_{ROA}) and the cost of debt (K) and increases with expected asset profitability ($\overline{ROA}$). The second order conditions require that:

$$-\frac{\rho}{2}\sigma^2_{ROA} < 0, \quad (2.11)$$

which is met if a farmer is risk averse ($\rho > 0$). By differentiating equation 2.10 with respect to business risk (σ^2_{ROA}) we obtain:

$$\frac{\partial \delta^*}{\partial \sigma^2_{ROA}} = -\frac{\rho}{[\overline{ROA} - K]}. \quad (2.12)$$

Equation 2.12 asserts that for risk averse farmers ($\rho > 0$), the optimal level of financial risk (δ^*) *ceteris paribus* depends negatively on business risk as long as the interest rate on debt (K) does not exceed expected ROA. Equation 2.12 thus supports the risk balancing hypothesis for an expected utility maximizer, but also prescribes that non-risk balancing behavior can be theoretically expected for risk loving farmers or when a threshold level of expected income (ROA) is not met.

2.2 Literature review

Following the seminal 1980 paper by Gabriel and Baker, several theoretical models analyzing optimal debt structure have been developed that are compatible with the risk balancing hypothesis (under certain assumptions). This section will present an overview of the advancements that have been presented in literature. The risk balancing literature is embedded in farm finance research and has been analyzed predominantly in a US context. Although abundant literature is available on risk balancing, including recent conference papers and reports, in the following review we mainly focus on peer reviewed studies published in journals. Furthermore, only papers explicitly modeling the concept or developing a model that is consistent with the hypothesis are mentioned.

Barry et al. (1981) develop an expected utility mean-variance (EU-MV) portfolio model of credit risk and liquidity management compatible with risk balancing in the case where interest rates are non-stochastic; in the case where credit risks are introduced—*i.e.*, a stochastic interest rate—however, the sign of the effect of BR on FR is ambiguous *a priori.*

Barry and Robison (1987) integrate the financial concepts of risk balancing models into an applied framework. Using mathematical and graphical approaches, the authors illustrate the portfolio responses to changes in the operating environment and the operator's risk attitude.

The preceding models were extended by Featherstone et al. (1988) to evaluate the impact of agricultural policies on farm failures (negative rates of return to equity). Their theoretical model show that increased leveraging due to risk-reducing or income-augmenting policies may also increase the likelihood of farmers losing part of their equity or going bankrupt. They named this paradoxical aspect of well-intended policies the "risk balancing paradox".

In line with this paradoxical finding, a related study by Moss et al. (1989) concludes that the elimination of capital gains deductions in 1986 raised optimal leverage levels and the probability of farm failures (negative rates of return to equity) for all levels of risk aversion.

Turvey and Baker (1989) look at the relationship between business risk, financial risk, and hedging using a theoretical expected utility model of optimal hedging. Their main conclusion is that hedging increases with risk aversion and a higher leverage ratio, *i.e.* hedging is a valid instrument to lower business risk to offset increased financial risk in accordance with the risk balancing hypothesis (see also Turvey and Baker, 1990). Looking conversely at how hedging affects capital structure, they find that a business risk-reducing and expected return on assets increasing hedge may induce increased leverage that increases financial risk. However, in the case where a hedge lowers the return on assets, this decrease could outweigh the benefits of the anticipated risk reductions through hedging. In the specific case where this threshold decrease is realized, financial risk increases due to decreased returns, which would induce a decrease in financial leverage.

A methodological contribution to the risk balancing literature was provided by Featherstone et al. (1990), who discuss a discrete stochastic programming (DSP) model to model multiyear farm financial decisions. By substituting the optimal debt equation back into the expected utility function, their DSP model illustrates risk balancing in a normative way by examining utility using optimal debt.

Moss et al. (1990) use an autoregressive conditional heteroskedastic model to analyze aggregate agricultural debt. Their model provides empirical support for the risk balancing hypothesis; more specifically they find that the elasticity of real aggregate debt with respect to expected riskiness of agricultural returns is greater than one.

Ahrendsen et al. (1994) revisit the Collins (1985) expected utility model of farm capital structure by incorporating depreciation, taxes, investment tax credits, economies of scale, and wealth effects. Using US dairy farm micro data, they find evidence in favor of the risk balancing hypothesis, but note, however, that "the [strategic] adjustment process is likely to be slow" (p. 117).

An alternative dynamic model of farm capital structure has been proposed (1993) and preliminary examined (1995) by Collins and Karp. The previous models assumed risk aversion and were static (single period), whereas the Collins and Karp model is dynamic and assumes a risk neutral decision maker. Their model results suggest that in addition to the factors identified in the Collins (1985) model, leverage (and thus FR) is determined by the farm operator's age, wealth, and the opportunity cost of farming.

Jensen and Langemeier (1996) empirically test their unconstrained utility maximization model by estimating a Tobit regression on US panel data. Their results point out that leverage is affected by business risk—as measured by the variance in real operating profits—beside other factors such as profitability, tax policy, and the growth rate in the value of assets.

Ramirez et al. (1997) reformulate the Collins (1985) risk balancing model, incorporating the consumption/investment trade-off. A numerical example indicates that in their stochastic optimal control model, the debt over assets ratio is elastic with regards to both the expected rate of return on assets and variance of the rate of return on assets (*i.e.,* business risk).

In a simulation-optimization framework, Escalante and Barry (2001) look at interactions between risk balancing and alternative risk management strategies. The authors show that the preference of farmers for diversified risk management strategies might downplay the importance of the risk balancing effect.

Escalante and Barry (2003) follow an alternative approach to look at risk balancing, *i.e.,* rather than modeling the relationship between leverage and risk, they use simple correlation relationships to measure the strength and determinants of risk balancing behavior. Using longitudinal data and cross-sectional time series for the US, they report that over 50% of the 80 studied farms showed risk balancing behavior. Factors found to significantly influence risk balancing behavior include the amount of crop insurance coverage, the farm tenure position and crop diversification.

Using simulation-optimization techniques in a multi-period programming framework, Escalante and Rejesus (2008) explore risk balancing decisions for a representative US grain farm under alternative risk behavioral assumptions. In their most consistent model reflecting decreasing absolute risk aversion (DARA) and constant relative risk aversion (CRRA), risk balancing was occurring, whereas in the traditional constant absolute risk aversion (CARRA) – increasing relative risk aversion (IRRA) based model, the risk balancing concept was violated.

The most recent and sole non-US empirical evidence on risk balancing was, to the best of our knowledge, provided by Turvey and Kong (2009). In four linear regression models looking at rural credit use, the authors find strong evidence of risk balancing behavior by Chinese rural farm households.

Our review of the risk balancing literature above reveals that following the leading Gabriel and Baker paper, the concept has been expanded upon theoretically and has seen several empirical applications. Most content originates from a US base and consequently—barring one China-based exception—all applications are to the US agricultural sector. In general, the empirical evidence points in favor of the hypothesis, but depends on factors such as the level of risk aversion and furthermore, alternative risk management strategies were identified as downplaying the importance of the risk balancing effect.

Chapter 3

Farm-level evidence on risk balancing behavior in the EU-15

Abstract

This chapter presents empirical evidence of risk balancing behavior by European farmers and looks empirically at the role of risk aversion in risk balancing models. We conduct a correlation relationship analysis and run several regression models using the EU-15 FADN panel dataset for the period 1995–2008 and the regional Flemish FADN panel dataset for the period 2005–2012 extended with survey data from 2013. Overall, we find EU evidence of risk balancing. Our correlation relationship analysis suggests that just over half of the farm observations are compatible with risk balancing behavior whereas the other (smaller) half is not. The coefficient in our static fixed effects regression suggests that a 1% increase in business risk reduces financial risk by 0.042%, the long-run coefficient in a dynamic model suggests a longer run decrease of 0.21%. The results reject evidence of strong-form risk balancing—inverse trade-offs between financial risk and business risk keeping total risk constant—but cannot reject weak-form risk balancing –inverse trade-offs between financial risk and business risk with some observed changes in total risk. Furthermore, the extent of risk balancing behavior is found to differ between different European countries and across farm typologies and also to be driven by risk averse farmers.

Keywords

Risk balancing, business risk, financial risk, Europe, capital structure

Parts of this chapter have been published as: de Mey, Y., van Winsen, F., Wauters, E., Vancauteren, M., Lauwers, L. and Van Passel, S. (2014) Farm-level evidence on risk balancing behavior in the EU-15. Agricultural Finance Review 74(1): 17-37.

3.1 Introduction

Ever since there is consensus that the agricultural sector will face increased volatility in both economic markets (e.g. due to the dismantling of price support policies) and biophysical environments (e.g. owing to climate change effects) (Vrolijk et al., 2009), risk and risk management have come to the fore of policy discussion in European agriculture. To optimally assess the net impact of programs and policies related to risk and risk management in agriculture, sound knowledge about farm decision making is essential to reduce the possibility of unanticipated effects. This chapter deals with one such unanticipated effect, namely risk balancing behavior.

The risk balancing hypothesis is a popular theory put forward in literature by Gabriel and Baker (1980) that links the operating, financing and investment decisions that a farmer makes. More specifically, risk balancing behavior refers to a farmer aiming for an optimal level of total farm risk by balancing its constituents business risk and financial risk. Business risk is the inherent risk a farm faces due to biophysical influences and the market environment (e.g. production-, price-, institutional, and policy risk) and is independent from the financial risk, that is defined as the additional risk that arises from the usage of debt financing (and/or cash leasing). Financial risk is dependent on the level of business risk through the leverage effect and includes risks such as interest rate risk, default risk, or credit risk. The importance of risk balancing behavior lies in the fact that business risk-reducing policies might unintentionally miss their target to lower the total risk on a farm by inducing increased leveraging. In this chapter we will look for evidence on such risk balancing behavior in the EU-15 using historical data. Looking at interactions between different types of risk, our work complements the 'holistic approach' to risk management proposed by the OECD (2009) that looks at interactions between risk management strategies (e.g. government programs covering certain risks might reduce farmers' incentives adopt other risk management strategies).

The main contributions of this chapter are fourfold. First, to the best of our knowledge, this is the first study that provides European (EU-15) evidence on risk balancing behavior, whereas most previous risk balancing literature has mainly focused on US applications. Second, making use of the large and unique FADN database, our analysis not only allows us to observe inter-country differences, but is also conducted at an unprecedented large scale (using more than 124,000 farm observations). Third, our analysis provides risk balancing evidence across alternative farming systems; previous studies have focused solely on one production system. Fourth, by complementing regional Flemish FADN data with survey information, we empirically analyze the impact of risk aversion in risk balancing. We would also like to underline the importance of following a micro-level approach, since the individual risk (management) environment of a farmer can be significantly different from that in the aggregate (OECD, 2008).

This chapter is structured as follows. First, the next section presents the theoretical model underpinning our analysis. Section 3 elaborates our methodology and section 4 describes our dataset. In section 5 and section 6 we present and discuss our results, while section 7 summarizes and concludes.

3.2 Conceptual framework

We use the original risk balancing framework developed by Gabriel and Baker (1980) in this study (elaborated in section 2.1.1 of Chapter 2). Risk is defined in terms of the variability of outcomes and operationalized using the coefficient of variation (CV); alternatively one could use standard deviations (Barry et al., 1981) or variances (Collins, 1985). Business risk (BR)—the inherent risk on a farm independently of the way it is financed—can be reflected in the variability of any operational return parameter such as the rate of return on assets, net cash flow or net operating income (NOI). Following Gabriel and Baker (1980), we define BR in terms of NOI as:

$$BR = \frac{\sigma_{NOI}}{\mu_{NOI}}. \quad (3.1)$$

Analogously, the total risk (TR) of a farm is defined as:

$$TR = \frac{\sigma_{NOI,d}}{\mu_{NOI-I}}, \quad (3.2)$$

where I represents fixed debt servicing obligations[6] and $\sigma_{NOI,d}$ the standard deviation of NOI with debt financing (before the deduction of I). Financial risk (FR) is then specified as the difference between TR and BR[7]:

$$FR = \frac{\sigma_{NOI,d}}{\mu_{NOI-I}} - \frac{\sigma_{NOI}}{\mu_{NOI}}. \quad (3.3)$$

Rewriting equation 3.3 and assuming that debt usage does not induce a change in NOI variability, i.e., $\sigma_{NOI,d} = \sigma_{NOI}$ (Gabriel and Baker, 1980: 561), yields:

$$FR = \frac{\sigma_{NOI}}{\mu_{NOI}} \frac{I}{\mu_{NOI-I}}. \quad (3.4)$$

FR is thus determined by two factors: (i) the inherent level of BR, and (ii) the leverage decision which is reflected by $\frac{I}{\mu_{NOI-I}}$, the level of fixed debt servicing obligations relative to NOI after servicing debt.

The risk balancing model assumes that a farmer is risk averse and has farm survival and profit maximization as behavioral goals, with a focus on the former. The risk balancing effect can be best explained expressing TR as the sum of BR and FR, and by identifying the target maximum amount of TR that can be coped with by a farm. This risk constraint, denoted with β, depends on farm specific factors such as farm profitability or farm size, personal characteristics such as the age or level of risk aversion of a farm operator and also exogenous factors such as general economic conditions. Following the preceding definitions, the TR constraint can thus be written as:

$$\alpha \leq TR = BR + FR = \frac{\sigma_{NOI}}{\mu_{NOI}} + \frac{\sigma_{NOI}}{\mu_{NOI}} \frac{I}{\mu_{NOI-I}} \leq \beta \quad (3.5)$$

where α represents the minimum amount of TR that a farm can experience (this lower bound theoretically can be zero if BR is zero, e.g. in the very extreme position when borrowing at the risk free rate to buy risk free bonds). Starting in the case where TR is equal to its optimal level β, the risk balancing effect involves strategic adjustments in the business and financial risk components, following an

[6] Note that the fixed debt servicing obligations (I) only include interest payments, owing to our NOI-based definition of BR. Under a net cash flow based definition, both interest and principal payments would be involved (Gabriel and Baker, 1980).

[7] Note that we define an additive relationship between TR, BR and FR consistent with Gabriel and Baker (1980). Alternatively, a multiplicative relationship can be used (Barry, 1983; Collins, 1985; Barry and Robison, 1987; Featherstone et al., 1988). As noted by Barry and Robison (1987, p. 144): "The two approaches are essentially the same, differing only in their measurement concepts".

exogenous shock in the total risk balance. These adjustments could be in the form of a production, (re)financing, or investment decision, or a combination of any of them. For example, if on the one hand a price support policy induces a decline in BR, FR would also lower, resulting in a slack in the total risk constraint (TR < β). A farmer would therefore be motivated to increase financial risk (e.g. increase leverage) or look for high risk—high return production opportunities, to restore the TR balance (TR = β). On the other hand, if an exogenous shock increases BR (e.g. adverse weather conditions), FR and TR will rise as well, possibly exceeding the TR constraint (TR > β). In this case, a farmer is forced to make risk adjustments such as refinancing, reorganizing assets or shifting to less risky production possibilities to comply with the TR risk constraint. The risk balancing effect as described above assumes that decisions are taken in such a way that the level of β does not change while BR and FR move in opposite directions (*i.e.* a constant level of risk aversion is assumed). This form of risk balancing can be defined as *strong-form* risk balancing. However, in practice this is a strong assumption and there probably will be observed variation in the level of β due to varying levels of risk aversion (e.g. see illustration 3 at the bottom of p.149 by Barry and Robison, 1987) or due to time effects: changing FR in response to changes in BR will usually not take place within one year but over a longer time span (Ahrendsen et al., 1994). Therefore, *weak-form* risk balancing can be defined as a more realistic inverse tradeoff between FR and BR with some observed changes in β (in terms of equation 3.5, $\beta' < \beta$ would be introduced).

Follow-on studies of the Gabriel and Baker paper use utility-centric risk balancing models. For example, the optimal debt model of Collins (1985)—developed along the strong-form risk balancing form discussed above—derived the following optimum relationship between business risk and debt:

$$\delta^* = 1 - \frac{\rho\sigma_A^2}{[\bar{R}_A - K]} . \quad (3.6)$$

This relationship shows that as expected profits ($\bar{R}_A$) decrease or the cost of debt (K), risk aversion (ρ), or business risk (σ_A^2) increase, optimal debt (δ^*) will fall. As is evident from equation 3.6, risk aversion is endogenous in utility-centric models of this kind (Collins, 1985; Barry and Robison, 1987; Featherstone et al., 1988; Jensen and Langemeier, 1996; Turvey and Kong, 2009). However, because risk aversion is difficult or even impossible to measure from observed agricultural production data (Lence, 2009), for the large part of this chapter we base our empirical analysis on the original Gabriel and Baker risk balancing framework where risk aversion is reflected in the level of β. The last part our empirical application is based on the Collins model and will look deeper into the incorporation of risk aversion in risk balancing model using a survey-based risk aversion measure (Section 3.6).

The risk balancing effect is based on the presumption that the FR decision in the current period is based on a farmer's expectation of future BR developments. As is frequently done in literature, this chapter assumes that historical experiences are the basis for forming this expectation, so current period FR decisions can be presumed to be based on the previous period's level of BR. Note on the one hand that this frequentist approach is often criticized by the subjectivist approach, which makes use of subjective probabilities (Hardaker and Lien, 2010). In the present chapter, however, it is impossible to follow the subjectivist approach given the large geographical and temporal scale of the dataset. In addition, intra-year variations in the BR conditions might also have an influence on the FR decision. However, because farm accounts are reported on an annual basis, these effects cannot be accounted for.

3.3 Methodology

Several methodologies have been used to analyze the risk balancing hypothesis, such as looking at comparative statics in theoretical models (e.g. Collins, 1985), simulation/optimization models (e.g. Escalante and Barry, 2001), correlation relationship analysis (e.g. Escalante and Barry, 2003) and linear regression analysis (e.g. Turvey and Kong, 2009). Given our opportunity to work with the rich FADN dataset, in this chapter we will make use of the two latter empirical approaches to verify the risk-balancing behavior of farmers in the EU.

In both approaches, financial risk (*FR*) is defined as the right-hand factor in equation 3.4: the ratio of interest paid over NOI after interest has been paid. This factor reflects the strategic adjustments that are made in the level of financial risk. Business risk (*BR*) is defined as the coefficient of variation of NOI, calculated over a 3-year window. The span of 3 years was chosen in conformity with the findings of Escalante and Barry (2003) that: "farmers tend to adopt a myopic perspective when contemplating risk-balancing plans" (p. 67). Furthermore, increasing the window requires more data, which drastically lowers the available sample for estimation.

3.3.1 Correlation relationship analysis

A first method we will use to look at risk balancing consists of simply analyzing the correlation relationship between business and financial risk, analogous to the study by Escalante and Barry (2003). The proxy for farm-level risk balancing behavior is the correlation coefficient between the current period's level of *FR* and a 1-year lagged *BR* measure, calculated over a 5-year window.[8] A negative correlation coefficient indicates that the current *FR* position moves in the opposite direction than past levels of *BR*, thus providing simple descriptive evidence of risk balancing behavior. Using this correlation coefficient, the proportion of risk balancers in the sample can be calculated by counting those observations having a negative coefficient. The strength of the risk balancing effect can also be discerned by averaging the negative correlation coefficients. For those farm observations that do not balance risk, a positive correlation coefficient can be expected because in the absence of strategic adjustments, the level of financial risk is positively dependent on the level of business risk (see equation 3.4). Note that this correlation relationship approach ignores other potential influential factors influencing the FR decision. This weakness will be overcome in the regression approach elaborated in the next section.

3.3.2 Econometric design

Our main approach to analyze the risk balancing hypothesis consists of regressing our measure of financial risk on historical levels of business risk and several influential farm and farmer characteristics. The regression rationale follows from the equations of section 3.2.

Strategic adjustments in the level of financial risk are reflected in the right-hand factor in equation 3.4; this ratio will constitute the dependent variable in our regression, *FR*.

[8] For a practical illustration of how the risk balancing coefficient is constructed using time series data, we refer to Table 1 in Escalante and Barry (2003).

The risk balancing hypothesis prescribes that the amount of business risk in past negatively influences *FR* in the current period. Given the temporal aspect of this hypothesis, our regression model will make use of lagged variables, *i.e., FR* in the current period *t* will be explained by the one period lagged business risk variable, denoted BR_{t-1}.

Following equation 3.4, two other factors are assumed to motivate a farmer to make adjustments in the farm's financial risk position: (i) the cost of debt and (ii) profitability. The cost of debt of the previous period $(I/D)_{t-1}$, measured as interest paid (I) over total outstanding debt (D), is hypothesized to positively influence *FR* in the short run because a higher cost of debt leads, all things equal, to higher financial risk. In the longer run, when the cost of debt remains high over several periods, the effect might be negative since a farmer might be motivated to lower leverage or restructure his finances in response to costly debt (Moss et al., 1990).

Greater profitability $(NOI/A)_{t-1}$, measured as the ratio of NOI over total assets (A), should, *ceteris paribus*, lead to higher debt coverage and thus lower *FR* in the short run. In the longer run, a farmer might be motivated to increase debt to make use of the leverage effect, when his return on assets is consequently high over several periods (Moss et al., 1990).

Two structural factors, farm size and the farmer's age, are also considered to influence the *FR* decision. Farm size, measured in total hectares of utilized agricultural area and denoted with *Area*, is expected to be positively related to the choice of *FR* because, in general, large farms have more access to credit.

The farm operator's age (*Age*) is considered a proxy for the life cycle of the farm. The life cycle hypothesis posits that farmers prefer to pay off their debts as they become older and thus lower their financial risk. This could be due to increased levels of risk aversion with age, or other dynamic factors (Collins and Karp, 1993).

To observe differences in the *FR* decision and risk balancing between alternate farming systems, we also include farm typology dummies in our model, denoted with *Type*. To ease the interpretation of the regression coefficients, the regression model will be estimated in the natural logarithmic form (except for age). Given the definitions above, the following regression model will be estimated:

$$\ln(FR)_{i,t} = \alpha_i + \beta_1 \ln(BR)_{i,t-1} + \beta_2 \ln\left(\frac{I}{D}\right)_{i,t-1} + \beta_3 \ln\left(\frac{NOI}{A}\right)_{i,t-1} + \beta_4 \ln(Area)_{i,t}$$

$$+\beta_5 (Age)_{i,t} + \sum_{k=1}^{K-1} \delta_k Type_k + \sum_{t=1}^{T-1} \varphi_t Year_t + \varepsilon_{i,t} \quad (3.7)$$

where *i* and *t* are indexing farm and year; *K*, and *T* represent the total amount of typologies and years respectively, and α_i, β_{1-5}, δ_k and φ_t are parameters to be estimated. The error term $\varepsilon_{i,t}$ captures all stochastic events that are not accounted for in the specification. To account for unobserved heterogeneity due to the panel structure of the FADN dataset, the model is estimated as a fixed effects regression where farm effects—accounting for unobserved heterogeneity that varies across farms but does not change over time within one farm—are captured by the farm specific intercepts α_i and year effects—accounting for unobserved heterogeneity that evolves over time but is constant across farms—by the coefficients of the time dummies φ_t.

Model 3.7 has two potential limitations: (i) autocorrelation issues due to the persistency of FR and (ii) the assumption that BR is strictly exogenous. As adjustments to capital structure (financial risk) are not necessarily made in the short run (e.g. due to adjustment costs or sticky prices), model 3.7 can be extended with a lagged FR variable to control for the level of financial risk in t-1:

$$\ln(FR)_{i,t} = \alpha_i + \beta_0 \ln(FR)_{i,t-1} + \beta_1 \ln(BR)_{i,t-1} + \beta_2 \ln\left(\frac{I}{D}\right)_{i,t-1} + \beta_3 \ln\left(\frac{NOI}{A}\right)_{i,t-1}$$

$$+\beta_4 \ln(Area)_{i,t} + \beta_5 (Age)_{i,t} + \sum_{k=1}^{K-1} \delta_k Type_k + \sum_{t=1}^{T-1} \varphi_t Year_t + \varepsilon_{i,t} \quad (3.8)$$

The resulting model is a dynamic panel model, which is playing an increasingly important role in corporate finance research to not only look at short run, but also long run impacts on FR (Flannery and Hankins, 2013). As a robustness check, expression 3.8 models the persistency of the financial risk variable which allows us to infer short run from long run impacts. As model 3.8 also contains fixed effects α_i, estimating the model using OLS leads to biased and inconsistent estimates (the Nickell bias) because the error term is correlated with the lagged dependent variable by construction. To deal with this endogeneity problem, we use instrumental variables to estimate the coefficients. For panels with a limited number of years and a substantial number of observations (small T, large N), GMM estimators—Arellano-Bond's difference GMM or Arellano-Bover/Blundell-Bond's system GMM—are typically used to estimate dynamic panel models. We have implemented these estimators, yet refrained from using them as the Sargan/Hansen test of over-identifying restrictions rejected the exogeneity of all possible sets of lagged dependent variables as instruments.[9] Instead, model 3.8 was estimated with 2SLS using instrumental variables selected from the FADN dataset that are tested to be exogenous (elaborated in section 3.5.2).

A second issue is that farm households could have some influence on the level of BR by adopting risk management instruments. Therefore, BR might not be strictly exogenous as is stipulated in the theoretical risk balancing models (see Chapter 2). To overcome this potential shortcoming, we also instrument BR_{t-1} with exogenous instruments in model 3.8 and will formally test whether BR can be considered exogenous.

A final set of regression models will look at the inclusion of risk aversion in risk balancing models. This has been first considered by Jensen and Langemeier (1996), yet the authors excluded risk aversion in their empirical model in absence of risk aversion data. Ramirez et al. (1997) present a numerical example that shows that the risk balancing response appears to be fairly sensitive to changes in relative risk aversion. Using a simulation-optimization model, Escalante and Rejesus (2008) find that the occurrence of risk balancing depends on the risk behavioral assumptions. Risk balancing was occurring under decreasing absolute risk aversion (DARA) and constant relative risk aversion (CRRA) yet under constant absolute risk aversion (CARRA) and increasing relative risk aversion (IRRA) the risk balancing concept was violated.

As risk aversion is considered a stable personal trait in risk balancing models, it is time-invariant and hence cannot be included in a fixed effects model. Therefore, we will rerun model 3.7 as a random effects model (to take farm-specific effects into account) and include a measure of risk aversion as a regressor:

$$\ln(FR)_{i,t} = \mu + \beta_1 \ln(BR)_{i,t-1} + \beta_2 \ln\left(\frac{I}{D}\right)_{i,t-1} + \beta_3 \ln\left(\frac{NOI}{A}\right)_{i,t-1} + \beta_4 \ln(Area)_{i,t} + \beta_5 (Age)_{i,t}$$

$$+\beta_6 (Risk\ Aversion)_i + \sum_{k=1}^{K-1} \delta_k Type_k + \sum_{t=1}^{T-1} \varphi_t Year_t + \alpha_i + \varepsilon_{i,t} \quad (3.9)$$

[9] As suggested by (Roodman, 2009), different lag lengths and more distant lags were tested, to no avail.

were all symbols are defined as before, μ represents a common intercept and the farm effects α_i now represent independently and identically distributed random factors. In line with Collins' model (Collins, 1985), we expect to find that financial risk decreases with increasing levels of risk aversion (see equation 3.6 in section 3.2). A related study by Turvey and Kong (2009), however, did not find a significant impact.

To extend the empirical literature, model 3.7 will additionally be rerun for a group of farms with risk averse operators and compared to a group consisting only of risk loving farm operators. This comparison will allow us to observe differences in the risk balancing response related to alternative risk preferences. In line with the literature cited above, we expect to find that the response is sensitive to differences in risk attitude and potentially is greater for risk averse farmers.

A summary of the regression variables with their expected signs can be found below in Table 3.1.

Table 3.1 Definitions and expected signs of the regression variables

Variable	Abbreviation	Definition (unit)	Expected sign
Financial risk	*FR*	The ratio of interest paid over NOI after interest has been paid, *i.e.,* the proportion of net income that is spent on interest payments (ratio)	
Business risk	*BR*	Coefficient of variation of NOI, calculated over a 3 year window (ratio)	-
Cost of debt	*I/D*	The ratio of interest paid over total outstanding debt (ratio)	+
Asset profitability	*NOI/A*	The ratio of NOI over average Assets used (ratio)	-
Farm area	*Area*	Total utilized agricultural area (hectares)	+
Age	*Age*	Age of farm operator in 2012 (years)	-
Farm type	*Type*	1 = 'fieldcrops', 2 = 'horticulture', 3 = 'wine', 4 = 'other permanent crops', 5 = 'milk', 6 = 'other grazing livestock', 7 = 'granivores', 8 = 'mixed' (categorical, fieldcrops as reference)	+/-
Risk aversion	$RA_{continuous}$	Risk aversion scale (1 = risk loving to 5 = risk averse)	-
	RA_{dummy}	Risk aversion dummy (0 = risk loving and 1 = risk averse)	-
	Risk loving	Risk loving dummy (0 = risk neutral and 1 = risk averse)	+
	Risk averse	Risk averse dummy (0 = risk neutral and 1 = risk averse)	-

3.4 Data and descriptive statistics

3.4.1 Data sources

The main data source used in this chapter is the rich FADN (Farm Accounting Data Network) dataset, which is compiled by the European Commission. The FADN data is a micro-economic dataset based on harmonized bookkeeping principles across all EU member states and is representative for all agricultural farms in the EU which can be classified as commercial holdings. Farms are selected to take part in the survey on the basis of region wise stratified sampling. The panel is unbalanced and covers the period 1995–2008. About half of the original farm observations do not have debt; these observations are naturally excluded for analysis because no strategic balancing in the debt structure can occur in the absence of liabilities. Given the problems relating to calculating the logarithm or coefficient of variation of negative values, observations with a negative NOI, NOI/A, or FR are excluded for analysis. Given the data demanding design of this analysis—farms need to be in the panel for at least 4 consecutive periods to pair FR_t and BR_{t-1}—and the unbalanced character of the FADN dataset, farm observations with missing regression elements are also excluded for analysis. After these data requirements, the final main panel used in this chapter consists of 32,124 farms providing 124,132 observations.

Additionally, we make use of the Flemish (*i.e.*, the northern region of Belgium) regional version of the FADN dataset which is collected and analyzed by the Flemish government (De Becker, 2007). This panel is also unbalanced and covers the period 2005–2012. We selected the share of the farmers in this sample (79%) of which information regarding risk preferences is available from an elaborate 2013 survey on risk experience and behavior (see Appendix A2 for more details). Following the same data requirements discussed in the previous paragraph, the second panel used in this chapter consists of 418 farms providing 1,503 observations.

3.4.2 Variables definitions and descriptive statistics

The dependent variable considered in this chapter—FR—is the choice component in the financial risk specification by Gabriel and Baker (1980) (the right-hand factor in equation 3.4 of section 3.2). *FR* is calculated as: interest paid / (NOI –

interest paid). Interest paid is the total amount of interest paid on current loans (both short and long term). NOI is calculated as operating receipts – intermediate costs (specific and overheads) – depreciation + balance of subsidies and taxes – wages paid – rent paid for land. Note that this definition of NOI excludes imputed costs for family labor and land used under property. This choice was made to reduce the amount of problematic negative observations (see above). By including taxes and VAT in our NOI variable, we account for their influence on farmer's FR decision making behavior.

The main independent variable in this chapter, business risk (BR), comprises the coefficient of variation of NOI, calculated over a 3-year window (see equation 3.1 in section 3.2).

The cost of debt, *I/D*, is calculated as: interest paid / debt. Debt is the average of the opening and closing valuation of total debt. Averaging is carried out to rule out any differences in accounting principles used by the different accounting offices (e.g. whether investments appear in the opening or closing valuation).

Asset profitability, *NOI/A*, is measured as the ratio of NOI over total assets. The latter includes both fixed assets (agricultural land and farm buildings and forest capital + buildings + machinery and equipment + breeding livestock) and current assets (non-breeding livestock + circulating capital (stocks of agricultural products + other circulating capital).

Area is the total utilized agricultural area in hectares (excluding unused agricultural land, woodland and land occupied by buildings, farmyards, tracks, etc.).

The farm operator's age (*Age*) was calculated using the year of birth in the FADN dataset.

Farm type is a categorical variable that classifies farms into one of 8 broad farming types defined at the level of the European Union: 'fieldcrops', 'horticulture', 'wine', 'other permanent crops' (e.g. fruit, olives), 'milk', 'other grazing livestock', 'granivores' (e.g. pigs, poultry) or 'mixed' (*i.e.,* combination of crops and livestock). Note that this classification is based on the dominant output of a farm, therefore a farm classified into the ‘fieldcrops’ category, can also have a small animal-based enterprise.

Risk aversion is measured using a psychometric scale based on survey responses. Several specifications of risk aversion are included in our models: (i) a continuous risk aversion measure (ii) a risk aversion dummy and (iii) a categorical variable distinguishing risk averse, risk neutral and risk loving farm operators. Elaborate details regarding the construction of the risk aversion scale and derived variables is available in Appendix A2.

Given the outlier sensibility of OLS, extreme values in the dataset were dealt with by trimming the top and/or bottom 1% observations of the variables that showed extreme values that probably represent data errors. Note that all the variables in our model are either nonmonetary or defined as a ratio; hence there is no need for deflation. Panel descriptive statistics of the computed variables described above can be found in Table 3.2 for the EU-15 dataset and Table 3.3 for the Flemish FADN dataset.

Table 3.2 Descriptive statistics of EU-15 FADN panel dataset

Country	N Obs.	% Obs.	*FR*	*BR*	*I/D*	*NOI/A*	*Area*	*Age*
Austria	9,671	7.79	0.12 (0.26)	0.27 (0.18)	0.05 (0.04)	0.11 (0.07)	42.02 (30.80)	55.0 (9.31)
Belgium	6,251	5.04	0.24 (0.34)	0.26 (0.20)	0.07 (0.02)	0.18 (0.12)	50.65 (36.55)	54.7 (9.33)
Denmark	2,639	2.13	0.86 (0.81)	0.28 (0.23)	0.06 (0.02)	0.08 (0.06)	84.52 (76.82)	59.5 (10.07)
Finland	4,208	3.39	0.17 (0.34)	0.31 (0.21)	0.04 (0.03)	0.13 (0.08)	55.51 (36.65)	55.6 (9.16)
France	36,928	29.75	0.20 (0.33)	0.32 (0.22)	0.04 (0.02)	0.15 (0.11)	95.17 (71.79)	56.1 (8.78)
Germany	25,285	20.37	0.18 (0.34)	0.35 (0.22)	0.04 (0.03)	0.10 (0.10)	73.13 (66.32)	56.8 (9.57)
Greece	3,534	2.85	0.08 (0.21)	0.34 (0.23)	0.13 (0.08)	0.18 (0.15)	14.87 (14.81)	58.6 (10.39)
Ireland	3,612	2.91	0.14 (0.29)	0.29 (0.20)	0.08 (0.05)	0.04 (0.03)	61.82 (41.45)	57.9 (10.75)
Italy	5,542	4.46	0.15 (0.31)	0.38 (0.25)	0.08 (0.06)	0.09 (0.10)	38.38 (52.41)	56.6 (11.30)
Luxembourg	2,034	1.64	0.22 (0.34)	0.27 (0.20)	0.04 (0.02)	0.06 (0.04)	85.52 (47.51)	54.5 (9.67)
Portugal	1,227	0.99	0.18 (0.37)	0.38 (0.24)	0.10 (0.06)	0.21 (0.16)	38.42 (56.28)	56.2 (10.50)
Spain	11,257	9.07	0.07 (0.20)	0.38 (0.25)	0.07 (0.04)	0.13 (0.09)	49.70 (59.40)	58.0 (10.76)
Sweden	2,609	2.10	0.28 (0.46)	0.35 (0.22)	0.05 (0.03)	0.10 (0.09)	96.09 (68.26)	59.7 (9.01)
The Netherlands	4,379	3.53	0.45 (0.54)	0.31 (0.23)	0.05 (0.02)	0.08 (0.08)	43.39 (45.60)	57.3 (10.12)
United Kingdom	4,956	3.99	0.29 (0.47)	0.37 (0.24)	0.07 (0.04)	0.08 (0.08)	130.57 (94.95)	62.4 (10.62)
Overall	124,132	100.00	0.20 (0.37)	0.33 (0.22)	0.05 (0.04)	0.12 (0.11)	71.70 (66.99)	56.8 (9.77)

Notes: Standard deviations shown within brackets

Table 3.3 Descriptive statistics of Flemish FADN panel dataset

Variable	Mean	Stdev.
FR	0.14	0.16
BR	0.38	0.25
I/D	0.05	0.02
NOI/A	0.15	0.11
Area	38.79	30.64
Age	46.19	8.25
$RA_{continuous}$	3.24	0.58
RA_{dummy}[a]		
Risk loving	0.46	
Risk averse	0.54	
$RA_{categorical}$[a]		
Risk loving	0.29	
Risk neutral	0.39	
Risk averse	0.32	

Notes: [a] Mean represents percentage of sample. N = 1,503

3.5 Results and discussion

3.5.1 Correlation relationship analysis

Our first simple descriptive evidence of risk balancing behavior in the EU-15 is based on risk balancing correlation coefficients. Overall, the correlation coefficient between financial risk in the current period and business risk in the previous period is -0.0158, a significant (α = 0.05), but small correlation. The results of our farm level correlation analysis (see section 3.3.1) can be found in Table 3.4, where the proportion of risk balancers and the extent of the risk balancing effect are presented per country and typology. In general over all countries and typologies, more than half of the farm observations significantly (α = 0.05) are compatible with risk balancing behavior with an overall significant proportion of 54%. Accordingly, just under half of the observations show no evidence of risk balancing. Looking across countries, a small majority of farm observations also is compatible with risk balancing behavior, with Denmark, France, and Sweden having the highest proportions but Portugal and The Netherlands having a proportion below 50%. Differences over farm typology are also revealed: the 'other permanent crops' and 'other grazing livestock' farm types have below average proportions of risk balancers, while the ‘milk’ and ‘granivores’ types have the greatest proportions.

The strength of the risk balancing effect for those farm observations that were classified as risk balancers—measured by averaging the negative correlation coefficients—is presented in the second column of Table 3.4. In general, the risk balancing effect for the risk balancing class of farm observations is strong, with an overall correlation coefficient of almost -0.50. We further observe little variation across countries and typologies. The third column of Table 3.4 presents the average positive correlation coefficients, *i.e.,* for those farm observations that were identified as non-risk balancers. Because in the absence of strategic risk balancing adjustments, the level of financial risk depends positively on the level of business risk, we observe a strong positive relationship with an overall correlation coefficient of almost +0.50 and little variation across countries and typologies.

In summary, our correlation relationship analysis points out that just over half of the farm observations are compatible with risk balancing whereas the other (smaller) half is not. Combining both groups therefore leads to an overall significant but small negative correlation. Because our correlation relationship approach ignores other potential factors influencing the FR decision (besides BR), we will now discuss the results of our regression model that controls for these factors.

Table 3.4 Proportion of risk balancers and extent of risk balancing effect across the EU-15 countries and alternative farm typologies, based on risk balancing correlation coefficients

	Proportion (%)[a]	Average coefficient risk balancers[b]	Average coefficient non-risk balancers[c]
Country			
Belgium	54.8*	-0.47	0.47
Denmark	55.6*	-0.49	0.48
Germany	54.8*	-0.47	0.46
Greece	50.2	-0.46	0.50
Spain	54.3*	-0.47	0.49
France	56.9*	-0.47	0.46
Ireland	53.1*	-0.45	0.47
Italy	55.2*	-0.47	0.48
Luxembourg	52.7	-0.49	0.51
The Netherlands	49.5	-0.46	0.48
Austria	51.3*	-0.46	0.48
Portugal	48.6	-0.47	0.50
Finland	52.1*	-0.49	0.47
Sweden	55.5*	-0.47	0.48
United Kingdom	54.9*	-0.45	0.49
Farm type			
Fieldcrops	54.7*	-0.47	0.47
Horticulture	55.8*	-0.46	0.48
Wine	56.8*	-0.46	0.47
Other permanent crops	52.5*	-0.47	0.48
Milk	59.9*	-0.50	0.45
Other grazing livestock	53.6*	-0.47	0.48
Granivores	58.0*	-0.47	0.46
Mixed	55.0*	-0.46	0.46
Overall	54.2*	-0.47	0.47

Notes: [a] A farm observation is classified as risk-balancing when the 5-year correlation coefficient between financial $risk_t$ and business $risk_{t-1}$ shows a negative sign. * Denotes that the portion of risk balancers is greater than 50% at the 5% significance level. [b] The average of the negative coefficient. [c] The average of the positive coefficients. In every case, the mean risk balancing coefficient is significantly different for the risk balancers versus the non-risk balancing group of farmer observations at the 5% significance level.

3.5.2 EU-15 regression model results

The econometric analysis was carried out using the statistical package Stata for Windows (StataCorp, 2011). There was no indication of multicollinearity problems in the data, with variance inflation factors (VIF) of all regressors between 1 and 2. A modified Wald test for group wise heteroskedasticity in fixed effect regression models indicated the presence of heteroskedasticity for all models. Furthermore, Wooldridge's test for autocorrelation in panel data was conducted and the null hypothesis of no first order autocorrelation was rejected at the critical 5% significance level. Given these last two findings, we clustered our standard errors by farm to take heteroskedasticity and autocorrelation into account.

The parameter estimates from model 3.7 in section 3.2 are presented in the first column of Table 3.5. The within R-squared is rather low at 5.4%, but not deemed problematic since the purpose of this research is not prediction but revealing the direction and extent of relationships. The overall F-statistic of the model is high, indicating the overall significance of the regression model (α = 0.01). Furthermore, barring some dummy variables, all factors are found to have a significant influence on the financial risk decision at the critical 5% significance level and exhibit their expected signs.

The business risk$_{t-1}$ coefficient estimate of -0.0418 (±0.0055) is negative, thus providing evidence that overall, the EU-15 farmers made strategic financial risk adjustments in line with the risk balancing hypothesis.[10] Hence, after controlling for alternative FR determinants and fixed effects in our regression model (compared to our correlation measures) we find evidence of a negative relationship between business risk$_{t-1}$ and financial risk$_t$. The coefficient estimate suggests that a 1% increase in business risk reduces financial risk by 0.042%. Recall that under strong-form risk balancing a 1% increase in BR must reduce FR by 1% in order to keep TR at a constant level. Hence our results reject evidence of strong-form risk balancing, but we cannot reject weak-form risk balancing. One potential explanation of why we would expect weak-form risk balancing in practice was mentioned in section 3.2: the strategic capital adjustment process might be

[10] Note that by purging fixed effects in model 2.7, the time-invariant farm-specific component of business risk is controlled for in the regression and no longer reflected in the estimated coefficient of business risk on financial risk.

spanning more than three years. To test this last hypothesis, the regression was repeated using business risk measures calculated over a 5-year, 7-year and 9-year window, yielding respective risk balancing regression coefficients of -.0808***, -.1237***, and -.1537***.[11] These results hint at a slow adjustment process in concordance with Ahrendsen et al. (1994), but contrast the findings of Escalante and Barry (2003).

The cost of debt$_{t-1}$ and asset profitability$_{t-1}$ coefficients are positive and negative respectively, in line with our expectations that a higher cost of debt or lower profitability, all things equal, leads to a higher level of financial risk in the short run.

Our two structural factors, area$_t$ and age$_t$, also exhibit their expected positive and negative signs respectively, demonstrating that a smaller farm size and life cycle effects lower financial risk, *ceteris paribus*.[12]

Differences between farm types are captured by the farm type dummies and are presented with respect to fieldcrops as the reference farm type. A joint Wald test of these dummies shows significant overall typology effects (α = 0.01). Since 'fieldcrops' is a typology with average levels of financial risk, both positive and negative deviations are observed. The most notable result is that dairy farms have significantly higher levels of financial risk.

A joint Wald test of the year dummies shows the presence of significant year effects (α = 0.01). The coefficients capture any events that make a specific year particular with respect to the reference year 1998 in terms of financial risks. The magnitudes of the coefficients suggest an increasing trend in financial risk over the period under consideration (1998–2008).

As a robustness check, the remaining columns of Table 3.5 present the coefficient estimates of the dynamic model 3.8. In the 2SLS model 1, the lagged FR variable was instrumented with the two and three period lagged level of Debt. These instruments are found to be valid: they are relevant (the first stage regression's

[11] Note that the respective sample sizes are 70,642; 38,990 and 19,666 due to increasing data requirements.
[12] A nonlinear age specification was also tested by including the variable Age². Because the coefficient of this variable was not significant (α = 0.05) we found no evidence of a nonlinear relationship and hence excluded this term from our final model.

R^2 was high at 0.60 and an F-test of joint significance of both instruments yields a P-value of 0.00) and exogenous (Hansen J statistic yields a P-value of 0.2697). A Hausman test for endogeneity in the second stage IV regression yields a significant P-value of 0.000, indicating that as expected the lagged dependent variable should be treated as endogenous. The coefficient estimate of FR_{t-1} suggests an adjustment speed of 31%. The short run coefficient of BR_{t-1} is estimated at -0.0659***. The coefficient has the same sign and order of magnitude as in the static FE model, indicating that for our main variable of interest BR_{t-1}, our FE regression model did not suffer bias due to potential autocorrelation issues. The implied long run coefficient for BR_{t-1} is -0.21.[13] The signs of the cost of debt$_{t-1}$ and asset profitability$_{t-1}$ coefficients are opposite to the ones in the static model. This is in line with our long run expectations in section 3.3.2 that a higher cost of debt or lower profitability, all things equal, leads to a lower level of financial risk in the long run. The other coefficients are similar to the coefficients in the static model and will not be further discussed.

2SLS model 2 is an extension of 2SLS model 1 where BR_{t-1} is additionally treated as potentially endogenous. Because more distant lagged BR variables turned out to be unsuitable instruments, components of BR_{t-1} were used as instruments: lagged coefficients of variation of value added, wages, and rent.[14] These instruments are found to be relevant (the first stage regression's R^2 was high at 0.544 and an F-test of joint significance of the three instruments yields a P-value of 0.000) and exogenous (Hansen J statistic yielded a P-value of 0.6806). A Hausman test for endogeneity in the second stage IV regression yielded an insignificant P-value of 0.9744, leading us to accept the H_0 that BR_{t-1} can be considered an exogenous variable in our regression model. Accordingly, the results of 2SLS model 1 should be used as they are more efficient (note that the coefficient estimates of 2SLS model 2 overall did not change markedly compared to 2SLS model 1.

[13] $\frac{\beta_{BR_{t-1}}}{1-\beta_{FR_{t-1}}} = -0.0659/(1-0.6861)$

[14] Recall that BR is calculated as the 3-year coefficient of variation of NOI and NOI is calculated as value added – wages paid – rent paid.

Table 3.5 Static and dynamic fixed effects (FE) panel regression model results, explaining (ln) financial risk in the EU-15 over the period 1995-2008

	FE model (static)		2SLS model 1 (dynamic)		2SLS model 2 (dynamic)	
Variable	Coefficient	(SE)	Coefficient	(SE)	Coefficient	(SE)
Ln FR_{t-1}			0.6861***	(0.0233)	0.6814***	(0.0383)
Ln BR_{t-1}	-0.0418***	(0.0055)	-0.0659***	(0.0050)	-0.0606***	(0.0111)
Ln I/D_{t-1}	0.1353***	(0.0116)	-0.4612***	(0.0230)	-0.5116***	(0.0391)
Ln NOI/A_{t-1}	-0.0985***	(0.0083)	0.6528***	(0.0265)	0.7052***	(0.0431)
Ln $Area_t$	0.1417***	(0.0243)	0.0846***	(0.0206)	0.1235***	(0.0306)
Age_t	-0.0128***	(0.0013)	-0.0061***	(0.0010)	-0.0041**	(0.0016)
Farm *Type* Dummies						
Horticulture	0.1812*	(0.1002)	-0.0371	(0.0805)	0.0819	(0.1107)
Wine	-0.1884**	(0.0756)	-0.2044***	(0.0637)	-0.1229	(0.0851)
Other permanent crops	0.0745	(0.0524)	0.0550	(0.0442)	0.1252*	(0.0658)
Milk	0.2221***	(0.0691)	0.0886	(0.0588)	0.1156	(0.0873)
Other grazing livestock	-0.0402	(0.0456)	-0.0458	(0.0382)	-0.0176	(0.0537)
Granivores	0.1255**	(0.0594)	0.0680	(0.0497)	0.0673	(0.0728)
Mixed	-0.0047	(0.0398)	-0.0096	(0.0341)	0.0370	(0.0474)
Year Dummies						
1999	-0.0922***	(0.0116)	-0.0611***	(0.0119)	-0.0527***	(0.0185)
2000	-0.2029***	(0.0133)	-0.1291***	(0.0127)	-0.0975***	(0.0196)
2001	-0.2372***	(0.0150)	-0.1452***	(0.0139)	-0.1148***	(0.0209)
2002	-0.2820***	(0.0159)	-0.1612***	(0.0144)	-0.1112***	(0.0219)
2003	-0.3486***	(0.0171)	-0.2032***	(0.0154)	-0.1654***	(0.0230)
2004	-0.4613***	(0.0183)	-0.2843***	(0.0165)	-0.2473***	(0.0243)
2005	-0.5126***	(0.0189)	-0.3031***	(0.0172)	-0.2483***	(0.0249)
2006	-0.6097***	(0.0197)	-0.3666***	(0.0182)	-0.3119***	(0.0263)
2007	-0.8450***	(0.0207)	-0.5538***	(0.0195)	-0.5018***	(0.0283)
2008	-0.5996***	(0.0218)	-0.2642***	(0.0210)	-0.2006***	(0.0305)
Constant	-2.0283***	(0.1300)				
R^2 Within	0.0538					
F	110.0***		185.3***		59.0***	

Notes: Clustered standard errors are shown between brackets. Single, double, and triple asterisks (*) denote statistical significance at the 0.10, 0.05 and 0.01 levels, respectively. The dummy reference levels are 1998 and fieldcrops respectively, N = 124,132

3.5.3 Country and farm type specific results

Given the observed differences in risk balancing behavior between countries and farm types in section 3.5.1, our fixed effects regression model 3.7 was also rerun separately for each of the EU-15 countries and 8 farm typologies. Farm type dummies are still included in the country-specific model to capture typology specific fixed. These partial regressions allow us to look further into the risk balancing behavior in specific countries and for alternative farm types.

The results of the country-specific regressions can be found in Table 3.6.[15] In almost every country, the within R-squared measures are higher than in the overall regression and the F-statistics indicate the overall significance of every partial regression model ($\alpha = 0.01$). The business risk$_{t-1}$ coefficients are once again in line with the risk balancing hypothesis: farmers seem to make strategic financial risk adjustments in response to changes in business risk. The extent of the risk balancing effect differs between the different EU-15 countries, with the United Kingdom, Ireland, and Germany having the highest coefficients. Potential explanations for these differences include country-specific capital market imperfections (e.g. influencing the ease of access to credit), alternative policy environments, and differences in tenure ratios. For eight countries—Belgium, Greece, Italy, Luxemburg, Austria, Portugal, Finland and Sweden—the coefficient is insignificant and hence we do not find evidence on risk balancing. Also note that in no country a positive significant coefficient was observed, hence we do not find evidence that contradicts risk balancing behavior. Possible explanations for the insignificant coefficients can be found in Escalante and Barry (2003). The authors found that for Illinois grain farmers risk balancing behavior was significantly downplayed by having less crop insurance protection, higher tenure ratios (*i.e.* more land under property), and more diversified enterprise plans and furthermore observed that younger farmers resort less to risk balancing. The expected signs for the cost of debt$_{t-1}$ and asset profitability$_{t-1}$ coefficients are not confirmed for every country, whereas the expected coefficient signs for area$_t$ and age$_t$ are verified in the country-specific regressions with the exception of some insignificant results.

The results of the typology-specific regressions can be found in Table 3.7.[16] For almost every farm type, the within R-squared measure is higher than in the overall

[15] Note that this model assumes a full correlation between country and all regressors. As an intermediate result, another regression model was tested first where the country dummy was only interacted with the business risk$_{t-1}$ variable. The country × business risk$_{t-1}$ interaction terms were jointly different from 0 at the critical 5% significance level, hinting at alternate risk balancing behavior between countries.

[16] Note that this model assumes a full correlation between farm type and all regressors. As an intermediate result, another regression model was tested first where the typology dummy was only interacted with the business risk$_{t-1}$ variable. The farm type × business risk$_{t-1}$ interaction terms were jointly different from 0 at the critical 5% significance level, hinting at alternate risk balancing behavior between typologies.

regression and the F-statistics indicate the overall significance of every partial typology regression model ($\alpha = 0.01$). The business risk$_{t-1}$ coefficients are in line with the risk balancing hypothesis as before. The extent of this effect differs between the 8 different farm types in the EU-15, with the 'milk' and 'granivores' typologies having the greatest coefficients. Potential explanations for these differences include varying levels of EU support (CAP payments), the degree of specialization, and factors influencing the business risk environments such as dependencies on specific inputs that have prices fluctuating on world markets. The expected signs for the cost of debt$_{t-1}$, asset profitability$_{t-1}$, area$_{t}$, and age$_{t}$ coefficients are—barring a few insignificant coefficients—confirmed for each typology in concordance with the overall regression.

Table 3.6 Fixed effects panel regression model results, explaining (ln) financial risk over the period 1995-2008 individually for each EU-15 country

Variable	Coefficient (SE) by country						
	BEL	DAN	GER	GRE	SPA	FRA	IRE
Ln *BR* $_{t-1}$	-0.0210	-0.0598**	-0.0743***	-0.0385	-0.0584**	-0.0472***	-0.0794***
	(0.0180)	(0.0288)	(0.0119)	(0.0302)	(0.0231)	(0.0088)	(0.0263)
Ln *I/D* $_{t-1}$	-0.4296***	0.3385***	0.1620***	0.2881***	-0.1119***	0.3358***	-0.1225**
	(0.0703)	(0.1163)	(0.0218)	(0.0487)	(0.0292)	(0.0242)	(0.0504)
Ln *NOI/A* $_{t-1}$	-0.0508	0.0314	0.0252	-0.0453	-0.0763***	-0.2056***	-0.0072
	(0.0407)	(0.0618)	(0.0162)	(0.0448)	(0.0261)	(0.0143)	(0.0476)
Ln *Area* $_t$	0.0807	0.0690	0.2578***	-0.1701*	-0.0109	0.2497***	0.8924***
	(0.0820)	(0.1085)	(0.0733)	(0.0939)	(0.0519)	(0.0364)	(0.2031)
Age $_t$	-0.0386***	-0.0526***	-0.0018	-0.0130	-0.0171***	-0.0142***	-0.0009
	(0.0059)	(0.0162)	(0.0031)	(0.0143)	(0.0058)	(0.0017)	(0.0042)
Constant	-0.8258	2.9924***	-3.1124***	-1.4230*	-2.0802***	-1.9256***	-6.2458***
	(0.5149)	(1.0036)	(0.3661)	(0.8477)	(0.4274)	(0.2125)	(0.8571)
R^2 Within	0.1580	0.1340	0.0748	0.1500	0.1525	0.0774	0.1077
F	24.5***	5.2***	44.6***	11.0***	34.7***	50.1***	12.8***
N	6,251	2,639	25,285	3,534	11,257	36,928	3,612

	ITA	LUX	NET	AUS	POR	FIN	SWE	UNI
Ln *BR* $_{t-1}$	-0.0369	-0.0722	-0.0457*	0.0033	0.0098	0.0020	-0.0064	-0.1170***
	(0.0297)	(0.0468)	(0.0234)	(0.0194)	(0.0619)	(0.0281)	(0.0320)	(0.0367)
Ln *I/D* $_{t-1}$	0.1614	0.3732**	0.0981	0.0429	-0.3309***	-0.0118	0.2698***	0.0130
	(0.1125)	(0.1679)	(0.0656)	(0.0328)	(0.0966)	(0.0442)	(0.0832)	(0.0618)
Ln *NOI/A* $_{t-1}$	0.0586	-0.3487***	-0.0743	-0.2616***	0.1279	-0.1879***	-0.0637	0.1131**
	(0.0377)	(0.0774)	(0.0465)	(0.0363)	(0.0821)	(0.0434)	(0.0477)	(0.0450)
Ln *Area* $_t$	-0.0715	0.9180**	0.1729	0.1920	0.2629	0.2258	0.2921*	0.0040
	(0.1291)	(0.4658)	(0.1615)	(0.1351)	(0.2139)	(0.1416)	(0.1519)	(0.2474)
Age $_t$	0.0097	-0.0107	-0.0193***	-0.0038	-0.0991***	-0.0314***	-0.0127*	0.0001
	(0.0076)	(0.0083)	(0.0051)	(0.0037)	(0.0256)	(0.0062)	(0.0077)	(0.0068)
Constant	-2.5515***	-5.7107***	-1.1706*	-3.9470***	2.0980	-1.3662**	-1.1171	-0.9923
	(0.6061)	(2.1332)	(0.6571)	(0.5566)	(1.5824)	(0.6593)	(0.8896)	(1.2255)
R^2 Within	0.1430	0.0647	0.0476	0.0779	0.1615	0.1005	0.1332	0.0777
F	12.9***	3.2***	9.4***	12.8***	7.0***	12.1***	8.8***	6.5***
N	5,542	2,034	4,379	9,671	1,227	4,208	2,609	4,956

Notes: Robust standard errors are shown between brackets. "." Denotes dropped due to collinearity. Single, double, and triple asterisks (*) denote statistical significance at the 0.10, 0.05 and 0.01 levels, respectively. Year and farm type dummies omitted for brevity.

Table 3.7 Fixed effects panel regression model results, explaining (ln) financial risk in the EU-15 over the period 1995-2008 individually by farm type

	Fieldcrops	Horticulture	Wine	Other permanent crops	Milk	Other grazing livestock	Granivores	Mixed
Ln BR_{t-1}	-0.0327***	-0.0221	-0.0451**	-0.0316***	-0.1533***	-0.0554*	-0.1450***	-0.0553***
	(0.0122)	(0.0228)	(0.0188)	(0.0080)	(0.0391)	(0.0319)	(0.0295)	(0.0147)
Ln I/D_{t-1}	0.1485***	0.2440***	0.0879**	0.0741***	0.0452	0.0804	0.1676**	0.0792**
	(0.0230)	(0.0525)	(0.0355)	(0.0182)	(0.0641)	(0.0591)	(0.0717)	(0.0335)
Ln NOI/A_{t-1}	-0.1057***	-0.1281***	0.0057	-0.0979***	0.0293	0.0304	-0.0454	-0.0469**
	(0.0171)	(0.0359)	(0.0233)	(0.0142)	(0.0377)	(0.0441)	(0.0383)	(0.0224)
Ln $Area_{t}$	0.0991	0.0301	0.1543	0.3019***	0.1608	0.5198*	0.1077	0.1736
	(0.0704)	(0.0799)	(0.1127)	(0.0504)	(0.2013)	(0.2952)	(0.2404)	(0.1148)
Age_{t}	-0.0115***	-0.0179**	-0.0084*	-0.0099***	-0.0174**	-0.0021	-0.0073	-0.0069**
	(0.0028)	(0.0072)	(0.0044)	(0.0019)	(0.0076)	(0.0086)	(0.0047)	(0.0030)
Constant	-1.9826***	-0.6807	-2.4921***	-2.9063***	-1.2150	-4.1960***	-1.7826*	-2.5352***
	(0.3405)	(0.4591)	(0.4011)	(0.2364)	(0.8433)	(1.2069)	(0.9800)	(0.5237)
R^2 Within	0.0883	0.0619	0.0316	0.0569	0.1150	0.0819	0.0820	0.0436
F	81.5***	11.4***	8.8***	70.2***	15.9***	7.1***	11.6***	18.2***
Observations	27,988	6,287	11,129	51,770	3,783	4,068	4,185	14,922

Notes: Robust standard errors are shown between brackets. "." Denotes dropped due to collinearity. Single, double, and triple asterisks (*) denote statistical significance at the 0.10, 0.05 and 0.01 levels, respectively. Year dummies omitted for brevity.

3.6 Risk aversion and risk balancing

Table 3.8 presents the coefficient estimates of our random effects (RE) and fixed effects (FE) models that look at the inclusion of risk aversion in risk balancing models using the Flemish 2005–2012 FADN dataset.

First, models (a) through (d) are several RE models consistent with equation 3.9 in section 3.3.2. We find model coefficients of the same order of magnitude of those for the whole of Belgium (first column in Table 3.6). As expected, we find that (more) risk averse farm operators have lower levels of financial risk as evidenced by models (b) and (c). Comparing risk averse and loving farm operators with their risk neutral counterparts in model (d), we find no significantly higher financial risk levels for risk loving farm operators and anew significantly lower levels for risk averse operators. We further observe that upon including a measure of risk aversion, the coefficient of our main variable of interest does not change, which suggests that our previous models did not suffer from omitted variable bias by excluding risk aversion.

The fixed effects models in the second part of Table 3.8 are consistent with equation 3.7 in section 3.3.2. A Hausman test indicates a systematic difference in coefficients ($\alpha = 0.01$) between model (a) and (e), hence we prefer to use consistent fixed effects regression models over random effects models for the remainder of our analysis. By rerunning the basic FE regression model (e) for a subsample of risk averse and risk loving farm operators (based on a median split of the continuous risk aversions measure), we find no significant financial risk response for risk loving farm operators. This suggests that the overall risk balancing response in model (e) is driven by the risk averse proportion of the sample who do demonstrate a significant response of the same magnitude. The final three models of Table 3.8 that distinguish three classes of risk preferences—risk averse, risk neutral and risk loving—based on tertiles of the continuous risk aversion measure, lead to a similar conclusion. By splitting our sample into three equal categories, we only observe a significant response ($\alpha = 0.10$) for the risk neutral and risk averse farm operators and no risk balancing response for the risk loving class.

Table 3.8 Random effects (RE) and fixed effects (FE) panel regression model results looking at the inclusion of risk aversion in risk balancing models

	RE models				FE model					
						RA_{dummy}		$RA_{categorical}$		
	(a)	(b)	(c)	(d)	(e)	Risk Loving	Risk Averse	Risk Loving	Risk Neutral	Risk Averse
Ln BR_{t-1}	-0.0980^{**}	-0.0906^{**}	-0.0898^{**}	-0.0906^{**}	-0.1515^{***}	-0.0798	-0.1528^{**}	-0.0796	-0.1157^{*}	-0.1665^{*}
	(0.0382)	(0.0392)	(0.0392)	(0.0391)	(0.0393)	(0.0539)	(0.0610)	(0.0638)	(0.0612)	(0.0894)
Ln I/D_{t-1}	-0.1265^{*}	-0.1297^{*}	-0.1330^{*}	-0.1272^{*}	-0.2676^{***}	-0.3810^{***}	-0.1323	-0.2998^{***}	-0.4836^{***}	-0.0027
	(0.0746)	(0.0739)	(0.0747)	(0.0745)	(0.0838)	(0.0879)	(0.1266)	(0.1049)	(0.1492)	(0.1486)
Ln NOI/A_{t-1}	-0.1272^{***}	-0.1246^{***}	-0.1236^{***}	-0.1239^{***}	-0.0042	0.0326	0.0129	0.0582	0.0276	-0.0300
	(0.0378)	(0.0390)	(0.0387)	(0.0388)	(0.0418)	(0.0605)	(0.0593)	(0.0644)	(0.0658)	(0.0961)
Ln $Area_{t}$	-0.0673	-0.0991^{*}	-0.0730	-0.0849	0.4506^{*}	-0.0909	0.8130^{*}	-0.1815	0.0550	0.9282^{*}
	(0.0593)	(0.0587)	(0.0585)	(0.0583)	(0.2586)	(0.3447)	(0.4311)	(0.4141)	(0.5070)	(0.5532)
Age_{t}	-0.0329^{***}	-0.0310^{***}	-0.0330^{***}	-0.0322^{***}	-0.0186^{***}	-0.0082	-0.0527^{***}	-0.0051	-0.0118	-0.0591^{***}
	(0.0057)	(0.0058)	(0.0059)	(0.0058)	(0.0068)	(0.0078)	(0.0071)	(0.0107)	(0.0085)	(0.0104)
$RA_{continuous}$		-0.4069^{***}								
		(0.1093)								
RA_{dummy}			-0.3433^{***}							
			(0.1141)							
Risk Loving				0.2004						
				(0.1241)						
Risk Averse				-0.3455^{**}						
				(0.1469)						
Constant	-1.5648^{***}	-0.1732	-1.3224^{***}	-1.4149^{***}	-3.9698^{***}	-2.9816^{**}	-3.0226^{**}	-2.6048^{*}	-3.1549^{*}	-2.7241
	(0.4442)	(0.5635)	(0.4503)	(0.4497)	(0.9278)	(1.1810)	(1.4696)	(1.4101)	(1.7405)	(1.9344)
N	1,503	1,457	1,457	1,457	1,503	688	769	427	588	442
Chi^2	206.9^{***}	220.7^{***}	220.1^{***}	228.4^{***}						
R^2	0.1272	0.1621	0.1491	0.1570						
F test					10.7^{***}	8.0^{***}	100.1^{***}	42.7^{***}	8.6^{***}	688.3^{***}
R^2 Within					0.1833	0.1252	0.2810	0.1152	0.2121	0.3057

Notes: Robust standard errors are shown between brackets. Single, double, and triple asterisks (*) denote statistical significance at the 0.10, 0.05 and 0.01 levels, respectively.

3.7 Summary and conclusion

This chapter looks for European evidence of risk balancing behavior—making strategic adjustments in the level of financial risk in response to exogenous shocks in the level of business risk. Using the large and rich FADN dataset for the EU-15 over the period 1995–2008, we (i) follow the correlation relationship analysis proposed by Escalante and Barry (2003) and (ii) estimate an extended version of the original econometric model by Gabriel and Baker (1980). Using the regional FADN dataset for Flanders (Belgium) for the period 2005–2012 complemented with survey data from 2013 we further consider the role of risk aversion in risk balancing models. Overall, we find evidence on risk balancing. Our correlation relationship analysis points out that just over half of the farm observations are compatible with risk balancing whereas the other (smaller) half is not. Controlling for other determinants of financial risk and removing fixed effects, our regression analysis also provides on-average evidence in favor of the risk balancing hypothesis. The short-run coefficient estimate of our static model suggests that a 1% increase in business risk reduces financial risk by 0.043% and the long-run coefficient in the dynamic specification suggests a decrease of 0.21% in the long run. These results reject evidence of strong-form risk balancing (inverse trade-offs between financial risk and business risk keeping total risk constant) but cannot reject weak-form risk balancing (inverse trade-offs between financial risk and business risk with some observed changes in total risk). The extent of risk balancing behavior is also found to differ between different European countries and across alternative farm typologies. Using the Flemish dataset, we find that our results might be driven by the risk averse proportion of farm operators as we do not find a significant risk balancing response for farm operators classified as risk loving.

Given the EU evidence on risk balancing behavior, future research should look deeper into the drivers of the occurrence and extent of the effect. One interesting venue would be looking at the interaction between risk balancing and other risk management strategies, an interaction that was already revealed (Harwood et al., 1999) and analyzed (Escalante and Barry, 2001; 2003) for US agriculture. One potentially important risk management strategy could be household-level risk buffering (see also Turvey and Kong (2009)). On methodological grounds, future risk balancing research could further look at alternate definitions of business risk (e.g. making use of subjective probabilities of future risks instead of relying on historical data) and financial risk (e.g. see Morgan et al. (2012)).

The policy implications of our results are that risk-reducing (or analogously income-augmenting) agricultural policies might induce strategic upwards leverage adjustments. When these adjustments are great enough, they could downplay the intended positive policy effects and actually increase the total risk on a farm, increasing the likelihood of farm bankruptcy. If risk balancing is occurring, the effect should thus not be neglected in optimal policy design. This chapter provides EU policy makers a first insight into risk balancing behavior of the EU farmers. Further research is needed, however, looking into what drives risk balancing behavior.

Chapter 4

Risk management versus entrepreneurship: the dual direction of risk balancing

Abstract

Risk balancing, a normative concept in agricultural finance, embodies two distinct responses: (i) a risk management strategy where a farmer lowers financial risk in response to an increase in business risk and (ii) an entrepreneurship strategy, where more financial risk is taken when the business risk position improves. Using the EU-15 FADN dataset for 1995–2008, we provide a first empirical insight into this dual direction of risk balancing. On average, 52% of the EU-famers with debt are risk balancers and 42% of them followed a risk management strategy, 26% an entrepreneurship strategy. By means of a fixed effects model and a multinomial Probit model, we examine the impact of farm(er) related determinants of risk balancing behavior and find that the determinants of adopting either of both risk balancing strategies have opposite effects.

Keywords

Business risk, financial risk, risk balancing, correlation analysis, categorical dependent variable model

Parts of this chapter have been submitted as: de Mey, Y., van Winsen, F., Wauters, E., Vancauteren, M., Lauwers, L. and Van Passel, S. (2014) Risk management versus entrepreneurship: the dual direction of risk balancing.

4.1 Introduction

Risk balancing, a normative concept in agricultural finance, embodies strategic capital structure adjustments in response to exogenous shocks in a farm's business risk environment. That is, when the total risk incurred on a farm deviates from its target level due to a change in business risk, a farmer is theorized to make offsetting changes in his level of financial risk to restore the original balance (Gabriel and Baker, 1980). Business risk is the risk inherent to a farms' operating environment and is mainly determined by biophysical and market influences, e.g. the weather and world price volatility. It is assumed independent from financial risk, which is defined as the additional risk arising from debt usage (e.g. interest rate risk).

The risk balancing concept was originally hypothesized by Gabriel and Baker (1980). It has been theoretically expanded in literature and several empirical applications found evidence in favor of the hypothesis. Most studies were conducted in a U.S. context, to the best of our knowledge only two non-U.S. applications to Chinese (Turvey and Kong, 2009) and European agriculture (Chapter 3 of this dissertation) exist. The term 'risk balancing' is exclusively used in agricultural economics literature, yet the concept also appears in other strands of literature. For example, in corporate finance literature there is also wide acceptance that financial leverage is a function of business risk. Most studies assert a negative relationship (e.g. Booth et al., 2001), though evidence on a positive (Kim and Sorensen, 1986) or no relationship exists as well (Titman and Wessels, 1988).

Risk balancing involves two risk responses depending on the direction of the strategic adjustment. On the one hand, risk balancing constitutes a risk management response when a farmer lowers financial risk in response to an increase in business risk. On the other hand, we denote entrepreneurship risk balancing where a farmer increases financial risk in response to lowered business risk. To the best of our knowledge, this dual direction has not been explicit addressed in agricultural economics literature, nor have differentiating terms been previously defined. Most studies tend to focus on either risk management (Escalante and Barry, 2001) or entrepreneurship (Featherstone et al., 1988) under the common denominator term of risk balancing. Entrepreneurship risk balancing has an important policy dimension with regard to risk-reducing policies. In this case, the hypothesis prescribes unanticipated risk responses, *i.e.* farmers increase financial risk and hence restore original total risk levels. Although the risk-reducing policy attains an entrepreneurship-stimulating goal, it is attained through increased financial risk, making it miss its risk-reducing objective. Moreover, Featherstone et al. (1988) theoretically showed that risk-reducing (or income-enhancing) policies might trigger an increase in financial leverage large enough to increase total risk and the probability of financial failure increases. This contradictory observation was labeled the 'paradox of risk balancing' and has spurred research into the risk balancing implications of risk-reducing government programs (Skees, 1999; Ifft et al., 2013).

The main objective of this chapter is to increase insight into risk balancing behavior in the EU-15 by explicitly focusing on the direction of the strategic balancing behavior. By focusing on risk management versus entrepreneurship strategies and looking at the persistence of risk balancing behavior over time, we aim to provide EU policy makers a broader perspective on risk balancing that can be interesting for future policy design. Using fixed effects and multinomial Probit models, we look respectively at the determinants of the extent of risk balancing and at the adoption of both distinct risk balancing strategies. The main contributions of this chapter are (i) exploring the dual direction of EU-risk balancing behavior, (ii) discussing farm-level risk balancing measurement issues and (iii) providing the first European and large scale empirical evidence on the determinants of risk balancing behavior.

4.2 Risk balancing: concepts and measurement

4.2.1 Conceptual framework

Risk balancing has been analyzed in two frameworks that differ in their concepts, but lead to analogous versions of the risk balancing model (see section 2.1 in Chapter 2). The seminal conceptual framework based on equilibrium analysis was developed by Gabriel and Baker (1980) and was subsequently recast in terms of expected utility maximization using a mean-variance approach by Collins (1985).

The central risk balancing equation of Gabriel and Baker (1980) defines total risk (TR) as the sum of business risk (BR) and financial risk (FR):

$$TR = BR + FR = \frac{\sigma_{NOI}}{\mu_{NOI}} + \frac{\sigma_{NOI}}{\mu_{NOI}} \frac{I}{\mu_{NOI} - I} \leq \beta, \qquad (4.1)$$

where *NOI* represents net operating income, I interest payments, μ and σ mean and variance respectively and β the maximum tolerable level of TR identified by the decision maker. The latter is dependent on farm-specific factors such as farm size, personal characteristics such as the level of risk aversion and exogenous factors such as general economic conditions and in equilibrium is equal to TR (see below). Note that FR is defined as a multiple of BR, with the multiplier dependent on the financing decision. Equation 4.1 can be used to outline risk balancing behavior for a risk averse farmer based on the lexicographic preferences of farm survival and profit maximization (with a focus on the former). In equilibrium, TR is equal to the optimal level β, desired by the farmer. When an exogenous shock to BR disrupts this equilibrium, risk balancing entails two risk responses in the FR component to restore the balance depending on the direction of the adjustment: entrepreneurship versus risk management.

When BR is exogenously lowered (e.g. due to a price stabilization policy), FR would lower accordingly resulting in a slack in the total risk constraint ($TR < \beta$). The risk balancing hypothesis prescribes that a farmer, as an entrepreneur, would be motivated to increase FR (e.g. increase leverage) or look for high risk-high return production opportunities to restore the TR balance (*i.e.* until $TR = \beta$). When, however, the exogenous shock increases BR (e.g. adverse climatic changes) and accordingly FR, the TR constraint would be exceeded ($TR > \beta$). In this case, the risk balancing hypothesis contends that as a risk management strategy, a farmer is forced to make risk adjustments such as refinancing (longer maturity) or seeking less risky production possibilities to comply with his TR constraint.

Risk balancing decisions in which the level of β does not change (*i.e.* assuming a constant level of risk aversion) while BR and FR move in opposite directions are defined as *strong-form* risk balancing (as introduced in Chapter 2 of this dissertation). In practice, this is a strong assumption because probably the β level may vary due to either varying levels of risk aversion or due to time effects as changing FR in response to changes in BR will usually take place over a certain timespan (Ahrendsen et al., 1994). Accordingly, the inverse tradeoff between FR and BR with some observed changes in β is defined as *weak-form* risk balancing.

4.2.2 Measuring risk balancing at farm level

Evidence in favor of risk balancing has been presented in literature based on aggregate and farm-level data (see literature overview in Chapter 2). Both approaches suggest that in the aggregate or for the average farmer, risk balancing behavior can be expected (see also Chapter 3 of this dissertation). These aggregate conclusions might mask differences at the individual farm level, however, as some farmer might be exhibiting risk balancing behavior whereas others might not. In order to scrutinize the determinants of risk balancing behavior and the direction of risk balancing, farm-level measures of risk balancing are needed. However, measuring risk balancing behavior at the individual farm level is a difficult task given the limited number of observations typically available. One methodology was proposed by Escalante and Barry (2003): using correlation coefficients between a measure of financial risk and a lagged measure of business risk. This approach is imperfect as simple correlation coefficients only prove an estimate of (unconditional) association between variables. In order to acknowledge them as measures of risk balancing, one has to accept the assumption that the observed correlation mainly reflects changes in BR_{t-1} having an influence on FR_t. Although this is a strong assumption, we have to make it in order to work with farm-level risk balancing measures. Another justification is that this chapter uses the same dataset from Chapter 3 for which evidence of on-average risk balancing behavior was found.

Practically, farm-level risk balancing behavior is measured by the correlation coefficient (Pearson's r) between the current period's level of FR and a one-year lagged BR measure. The one year BR lag is based on the presumption that farmers form their expectation of future BR developments based on past levels of risk exposure.[17] Analogous to Gabriel and Baker (1980), we calculate BR as the coefficient of variation of net operating income (NOI) and FR as the choice component of financial risk that reflects the strategic financial adjustments: the ratio of interest payments to NOI minus interest payments.[18] A negative

[17] Note that by defining only a backward looking component of business risk ($E(BR) = BR_{t-1}$), we implicitly assume that business risk is exogenous. However, if business risk is not strictly exogenous (*i.e.*, farmers have some level of control over its level), there might also be a forward looking component of business risk which is reflected in FR_t.

[18] The financial risk measure reflects the level of risk chosen by the farmer, *i.e.*, when the share of income spent on interest payments is high, farmers choose to have more financial risk as the margin to pay off their debt is lower and they are also more exposed to interest rate risk.

correlation coefficient indicates that the current FR position moves in the opposite direction of past-year BR levels, indicating that a farmer made adjustments in his capital structure in response to deviations in his business risk environment. To facilitate the interpretation of our RB measure (and the model coefficients in the next section), the sign of the correlation coefficient is inverted, implying that a positive correlation coefficient indicates RB behavior and correlation coefficients closer to 1 suggest a larger RB extent. Accordingly, negative correlation coefficients designate non-risk balancing behavior, *i.e.*, matching BR changes with parallel FR adjustments.

The preceding definitions imply that when calculating risk balancing correlation coefficients, one needs to choose (i) a window of calculation of the BR measure (a coefficient of variation) and (ii) the evaluation period for the RB correlation coefficient. Increasing the window of calculation of BR, implicitly assumes that a farmer considers more past years when forming his expectation of future BR. Increasing the evaluation window of the RB correlation coefficient, extends the period over which RB behavior is determined. As calculating both risk and risk balancing measures is rather data-demanding[19], increasing the calculation windows presents a trade-off between conceptual design and data availability. In section 4.5.1 we will compare different risk balancing correlation coefficients based on alternative calculation windows.

When a long time series dimension is available for a farm and RB is calculated over short time periods, one can look at the persistence of risk balancing behavior, *i.e.,* how does RB behavior change over time. Theoretically, we would expect risk balancing behavior to be a stable personal trait for risk averse persons. The tolerable level of TR, β, can change over time or the direction of risk balancing can, but RB behavior should not. Therefore we would a-priori expect rather stable RB measures. Section 4.5.1 will compare the persistence of the risk balancing correlation coefficients.

The risk balancing correlation coefficients give an indication of risk balancing behavior, yet they do not tell anything about the direction in which its components

[19] A risk balancing correlation coefficient evaluated over 3 years and based on a 3-year BR measure requires 6 successive farm observations, whereas a 7-year correlation coefficient based on a 7-year BR measure requires 14.

moved over the evaluation period. Each period, a farmer has an expectation of the level of BR and has the opportunity to change his level of FR. Accordingly, focusing on a single period, there is clarity with regards which of both strategies was adopted (*i.e.*, either financial risk increased or decreased). As we evaluate risk balancing behavior over several consecutive periods, however, ambiguity can arise when the observed data presents a mix of both strategies (e.g., financial risk increased in response to an increase in business risk in the first period and the opposite happened the next period). Therefore, we will distinguish the dual risk balancing strategies by counting single period changes of FR and BR over the evaluation period. Focusing only on risk balancing farm observations, risk balancing as a risk management strategy is defined when over the RB calculation window, the number of years where FR decreases and BR increases is greater than the number of years where the opposite happens or FR and BR move in the same direction.[20] Analogously, risk balancing as an entrepreneurship strategy is defined when over the RB calculation window, the number of years where FR increases and BR decreases is greater than the number of years where the opposite happens or FR and BR move in the same direction. Those observations where the number of years is equal (or where in most years BR and FR move in the same direction), will be labelled as ambiguous.

Finally, we will examine the paradox of risk balancing, which occurs when (i) a farmer is targeted by a risk-reducing or income-augmenting policy, (ii) that farmer balances risk as an entrepreneurship strategy and (iii) by doing so increases total risk to a greater level than before. While (ii) and (iii) can be verified empirically, information regarding (i) is not always readily available at the farm level.

4.3 Methodology

To begin with, we will look at the occurrence of the dual direction of risk balancing in the aggregate by extending the dynamic model 3.8 from the previous chapter:

[20] e.g. Evaluating risk balancing over three years, we might classify an observation as presenting risk balancing behavior (*i.e.*, a negative correlation is observed between FR_t and BR_{t-1}). In order to attribute the direction of the response, we look at the yearly changes pattern of FR_t and BR_{t-1}: (1) $\Delta FR_t<0$, $\Delta BR_{t-1}>0$, (2) $\Delta FR_t<0$, $\Delta BR_{t-1}>0$ and (3) $\Delta FR_t>0$ $\Delta BR_{t-1}>0$. As we observe a risk management response in two years, this observation would be classified as 'risk management RB'

$$\ln(FR)_{i,t} = \alpha_i + \beta_0 \ln(FR)_{i,t-1} + \beta_{1,\text{up}} \ln\left(BR_{up}\right)_{i,t-1} + \beta_{1,\text{down}} \ln(BR_{down})_{i,t-1}$$
$$+\beta_2 \ln\left(\frac{I}{D}\right)_{i,t-1} + \beta_3 \ln\left(\frac{NOI}{A}\right)_{i,t-1} + \beta_4 \ln(Area)_{i,t} + \beta_5 (Age)_{i,t} + \sum_{k=1}^{K-1} \delta_k Type_k$$
$$+ \textstyle\sum_{t=1}^{T-1} \varphi_t Year_t + \varepsilon_{i,t} \qquad (4.2)$$

where all symbols are defined as before (see section 3.3.2) and the *BR* variable is split into two variables in order to distinguish the dual direction of risk balancing:

$$BR_{up} = \begin{cases} BR \text{ } if \text{ } \Delta BR > 0 \\ 0 \text{ } if \text{ } \Delta BR < 0 \end{cases} \quad \text{and} \quad BR_{down} = \begin{cases} 0 \text{ } if \text{ } \Delta BR > 0 \\ BR \text{ } if \text{ } \Delta BR < 0 \end{cases}.$$

If two negative β_1 coefficients are obtained, $\beta_{1,up}$ is an indicator of the average risk management risk balancing response (*i.e.*, how much does FR_t lower in response to an increase in BR_{t-1}) and $\beta_{1,down}$ an indicator of the average entrepreneurship risk balancing response (*i.e.*, how much does FR_t increase in response to a decrease in BR_{t-1}).

Next, we look at farm-level risk balancing behavior based on the definitions from the preceding section. First, we look at determinants of the strength of the risk balancing effect—why is risk balancing stronger on some farms than others—by fitting a linear fixed effects regression model on our risk balancing measure:

$$RB_{i,t} = \alpha_i + \overline{X_{i,t}}\beta + \varepsilon_{i,t}, \qquad (4.3)$$

where *i* and *t* are indexing farm and year, $RB_{i,t}$ represents an inverted risk balancing correlation coefficient (see section 4.2.2), $\overline{X_{i,t}}$ is a set of averaged covariates, α_i and β are set of parameters to be estimated. Note that as risk balancing behavior is evaluated over a number of years, it would be arbitrary to explain the resulting behavior based on a single period's covariates. Therefore, the covariates are averaged over the risk balancing evaluation period. Furthermore, equation 4.3 is expanded by incorporating fixed year and farm type dummies that control for unobserved heterogeneity that is constant within these two dimensions (e.g. respectively CAP policy changes and the inherent level of risk of a certain farming system). The error term $\varepsilon_{i,t}$ captures any stochastic event not accounted for in the specification. Estimating the model as a fixed effects regression, we are able to account for unobserved heterogeneity that is constant over time within one farm but which varies across farms (e.g. risk aversion).

Next, we analyze the determinants of adopting either of the strategic risk balancing adjustments—why are farmers increasing financial risk in response to a decrease in business risk or *vice versa*—by running a multinomial Probit model:

$$P(RBbehavior_{i,t} = j|\overline{X_{\iota,t}}) = \Phi(\overline{X_{\iota,t}}\beta_j), \qquad (4.4)$$

where $RBbehavior_{i,t}$ is a categorical variable indicating risk balancing behavior defined following the definitions in section 4.2.2 with j = risk management, entrepreneurship, ambiguous or non-risk balancer (reference level), $\overline{X_{\iota,t}}$ is a set of farm-specific averaged covariates and β_j a set of alternative-specific parameters to be estimated. Model 4.4 is further expanded by incorporating year and farm type dummies.

Several structural and socio–demographic variables with expected impact on risk balancing behavior are discussed below. In general, factors making a farm more financially flexible could have a positive influence on strategic capital structure adjustments.

Farm and farm operator related factors

The farm operator's *age* is considered a proxy for the life cycle of the farm. The life cycle hypothesis assumes farmers reduce leverage as they become older. This could be attributed to increasing levels of risk aversion with age (Lins et al., 1981) or other dynamic factors (Collins and Karp, 1993). Older farmers are thus expected to balance risk to a greater extent as a risk management strategy, but less as an entrepreneurship strategy.

If a farm copes with an increasing amount of *total risk*, we would expect more risk management risk balancing behavior for farmers with a low maximum tolerable level of total risk β and less entrepreneurship risk balancing for farmers with a high β.

Farm *size* is predicted to be positively related to risk balancing behavior as larger farms have more access to credit, can obtain more favorable loan terms and are more financially flexible (Barry and Robison, 2001). Intuitively, one can assume that smaller farms face larger fixed costs when refinancing and therefore will be slower to make changes in their capital structure. Larger farms are thus expected to more easily make use of strategic changes in financial risk to balance changes in business risk.

In the same vein, *land tenure* (ranging from pure tenant to full owner) is expected to exhibit a negative influence on entrepreneurship risk balancing behavior as evidence in literature suggests that farmland has a low debt carrying capacity, whereas leasing improves access to credit (Barry and Robison, 1986; Ellinger and Barry, 1987).

Having a high *operating productivity* could positively add to a farm's risk bearing capacity and hence reduce the need for risk balancing (Escalante and Barry, 2003). However, farms that are more productive at the operating level might also make use of risk balancing to prevent lowering productivity as a risk management risk strategy.

Financial variables

A farm that is more *leveraged* or has to pay high *costs for additional debt*, would be expected to be less inclined to resort to risk balancing as an entrepreneurship strategy. Because it is already highly leveraged and additional debt is expensive, it will not further increase leverage; rather it would be expected to use risk balancing as a risk management strategy to lower financial risk in response to increases in business risk.

Having higher *asset profitability* or receiving more *subsidies* increases a farm's liquidity buffer, which makes the farm more resilient to changes in risk. Hence, we would expect a decreased importance of risk balancing as a means of risk management. On the other hand, more entrepreneurship risk balancing could be expected given the leverage increasing effect of income-enhancing policies (Featherstone et al., 1988).

Risk management variables

Synergies between risk balancing and alternative risk management strategies such as *insurance* and *diversification* can exist as highly risk averse farmers prefer integrated, diverse risk management plans (Escalante and Barry, 2001). Hence, alternative risk management strategies might downplay the importance of risk balancing in the overall risk management plan.

Finally, we would like to disclose the conditions where the risk balancing hypothesis is not expected to hold: (i) a risk seeking farmer, (ii) when interest costs exceed NOI and (iii) when a farmer makes use of alternative strategies to cope with his risk constraint, e.g. by shifting production activities or reordering/investing in assets or a combination of both (Gabriel and Baker, 1980; Collins, 1985).

4.4 Data

4.4.1 Data source

This chapter uses the EU-15 FADN (Farm Accounting Data Network) dataset which contains micro-level data of commercial agricultural farms based on bookkeeping principles harmonized across all EU member states. An unbalanced panel dataset is compiled for the years 1995–2008 limited to farm observations with debt. This limitation is a requirement for analyzing strategic balancing in the debt structure. Given the problems related to calculating the coefficient of variation of negative values, observations with a negative NOI or NOI after interest are excluded for analysis. Observations with leverage ratios (debt/assets) or financial risk measures greater than one are considered outliers and also excluded for analysis. Furthermore, farms need to be in the panel for at least 6 consecutive periods to pair FR_t and BR_{t-1} over three years. The final panel that meets these data requirements consists of 16,611 farms providing 59,171 observations.

4.4.2 Variables definition

The two dependent variables of this chapter—*RB and RBbehavior*—have been previously defined in section 4.3.

The four farm(er) related independent variables are: age, total risk, area, land tenure and operating productivity. *Age* is derived from the farm operator's year of birth in the FADN dataset. *Total risk* is calculated as *σ(NOI)/μ(NOI-interest)* (Gabriel and Baker, 1980), where NOI is calculated as operating receipts - intermediate costs (specific and overheads) - depreciation + balance of subsidies and taxes - wages paid - rent paid for land[21], and interest represents total interest

[21] Note that this definition of NOI excludes imputed costs for family labor and privately owned land. This choice was made to reduce problematic negative observations. By including taxes and VAT in our NOI variable, we account for their influence on farmer's risk balancing decision making behavior.

paid on loans. *Area* is the total utilized agricultural area in hectares (excluding unused agricultural land, woodland and land occupied by buildings, farmyards, tracks, etc.). *Land tenure* is the ratio of owned hectares of land over total hectares of agricultural land used. *Operating productivity* is calculated as operational costs over gross revenue; lower ratios indicate a higher operating productivity.

The five financial independent variables are: leverage, cost of debt, asset profitability, uncoupled subsidies and decoupled subsidies. *Leverage* is the ratio of total outstanding debt (the average of the opening and closing valuation of total debt)[22] over total assets. The latter includes both fixed assets (agricultural land and farm buildings and forest capital + buildings + machinery and equipment + breeding livestock) and current assets (non-breeding livestock + circulating capital (stocks of agricultural products + other circulating capital). The *cost of debt* is calculated as: interest paid over total debt. *Asset profitability* is measured as the ratio of NOI over total assets. The *uncoupled subsidy ratio* is represented by the total amount of uncoupled subsidies received over total revenue including subsidies. Analogously, the *decoupled subsidy ratio* is calculated as the total amount of decoupled subsidies received over total revenue including subsidies.

The two risk management variables are insurance costs and enterprise diversification. *Insurance costs* are represented by the amount of insurance premium paid over total costs. *Enterprise diversification* is measured as (1 – a Herfindahl index based on revenue from crops, animals, and other sources), defined this way higher index values indicate a greater level of diversification.[23]

Note that all variables in our models are either defined as a ratio or nonmonetary and therefore do not need to be deflated. Summary statistics and a brief variable description can be found in Table 4.1. In addition, the table also presents summary statistics for the three risk-balancing categories (risk management, entrepreneurship and non-risk balancing). These presented differences indicate that these three groups are heterogeneous groups.

[22] Averaging is carried out to rule out any differences in accounting principles used by the different accounting offices (e.g. whether investments appear in the opening or the closing valuation).

[23] The general formula of a Herfindahl index is: $\sum_{i=1}^{N}\left(Revenue\ Share_i\right)^2$

Table 4.1 Variables definition and summary statistics

		Overall		By risk balancing category					
				Risk management		Entrepreneurship		Non-risk balancing	
Variables	Definition	Mean	Stdev.	Mean	Stdev.	Mean	Stdev.	Mean	Stdev.
Farm and farmer related									
Age	Age of farm operator in years	48.32	9.44	48.63^{***}	9.39	47.91^{***}	9.57	48.25	9.41
Total Risk	Coefficient of variation calculated as σ(*NOI*)/μ(*NOI*-interest)	0.33	0.22	0.37^{***}	0.24	0.30^{***}	0.20	0.31	0.22
Utilized Agricultural Area	Total utilized agricultural area in hectares	75.30	90.07	73.04^{**}	83.37	79.74^{***}	103.78	75.05	91.38
Land Tenure Ratio	Ratio of owned hectares of land over total hectares of agricultural land used	0.46	0.36	0.48^{***}	0.36	0.44^{***}	0.36	0.46	0.36
Operating Productivity Ratio	Ratio of operational costs over gross revenue	0.61	0.21	0.58^{***}	0.20	0.64^{***}	0.22	0.60	0.22
Financial									
Leverage	Total debt over total assets	0.19	0.19	0.17^{***}	0.17	0.23^{***}	0.20	0.19	0.19
Cost of Debt	Ratio of interest paid over total outstanding debt	0.05	0.05	0.05^{***}	0.05	0.05^{***}	0.05	0.05	0.05
Asset Profitability	Ratio of NOI over assets used	0.13	0.13	0.15^{***}	0.14	0.11^{***}	0.13	0.13	0.14
Uncoupled Subsidy Ratio	Ratio of uncoupled subsidies received divided by total revenue	0.15	0.14	0.15	0.14	0.16^{*}	0.14	0.15	0.14
Decoupled Subsidy Ratio	Ratio of decoupled subsidies received divided by total revenue	0.05	0.08	0.05	0.08	0.05^{*}	0.09	0.05	0.08
Risk management									
Insurance Costs Ratio	Ratio of insurance premium paid relative to total costs	0.04	0.03	0.04^{**}	0.03	0.04	0.03	0.04	0.03
Enterprise Diversification	1 - Herfindahl index for revenue diversification between crops, livestock and other revenue	0.23	0.19	0.23^{**}	0.19	0.23	0.19	0.23	0.19

Notes: N = 59,171; RB = Risk balancing, BR = Business risk, FR = Financial risk, NOI = Net operating income, σ = variance, μ = mean. Single, double, and triple asterisks (*) denote a statistical significant difference compared to non-risk balancing at the 0.10, 0.05 and 0.01 levels, respectively.

4.5 Results and discussion

4.5.1 Measuring farm-level risk balancing behavior

First, we compare the impact of choosing alternative calculation windows for business risk and risk balancing measures on the proportion of risk balancers within the EU-15.[24]

Table 4.2 Impact of the calculation windows of business risk and risk balancing measures on the proportion of risk balancers in 2008

Business risk window	Risk balancing window	% EU-15 risk balancers		
		Mean	Min	Max
3-year	3-year	49.8	28.6	56.9
	4-year	52.8	41.9	66.7
	5-year	51.2	41.9	65.7
	6-year	55.0	41.2	78.6
	7-year	55.4	42.1	85.7
4-year	3-year	50.5	41.2	59.3
	4-year	53.4	47.1	63.0
	5-year	54.9	41.2	71.4
	6-year	56.2	42.1	78.6
	7-year	56.8	31.6	78.6
5-year	3-year	50.3	44.4	64.3
	4-year	53.8	47.4	64.2
	5-year	56.0	42.1	71.4
	6-year	55.9	42.1	64.3
	7-year	55.8	36.8	64.3
6-year	3-year	50.1	41.2	60.0
	4-year	52.6	41.2	65.7
	5-year	55.2	50.6	71.4
	6-year	55.4	41.2	71.4
	7-year	55.9	42.1	71.4
7-year	3-year	47.6	33.3	58.8
	4-year	50.0	29.6	59.7
	5-year	52.7	42.1	64.3
	6-year	53.1	40.0	78.6
	7-year	54.2	40.0	64.3

Notes: N = 1,989

[24] Note that due to the data demanding calculation of the twofold 7-year RB measure (14 consecutive years are needed) and listwise deletion of observations to make a fair comparison, the full range of measures could only be calculated for 9% of the available farms.

Table 4.2 reveals that the impact of widening the RB calculation window happens in an orderly fashion: a higher proportion of risk balancers is found when increasing the interval of calculation. The presented minima and maxima reflect that there is variability across countries, hence for some EU member states the impact might be greater. The impact of considering more years when calculating BR is limited on the proportion of risk balancers obtained: we observe that the proportion slightly decreases after an initial increase.[25] This finding that farmers do not tend to base their expectations on historically remote business experiences is in line with literature (Escalante and Barry, 2003). Given the preceding findings, we will consider RB measures of different lengths in our subsequent results, and in order to retain as much observations as possible all of them based on a 3-year BR measure.

The time series dimension of our panel allows to look at how risk balancing behavior changes over time. Table 4.3 presents the amount of farms that are classified as risk balancing over two and three subsequent years.[26] We find that, as expected, RB is very persistent over two or three years, but that the result depends on how many years are used to evaluate RB (changing the calculation window of BR did not have a pronounced influence). Increasing the RB evaluation periods yields more persistent measures.

Table 4.3 Percentage of persistent risk balancers over 2 or 3 years

Risk balancing window	Persistence over # years (%)	
	2 years	3 years
3-year	64.5	37.5
4-year	83.4	56.7
5-year	89.5	73.1
6-year	91.8	81.6
7-year	92.8	85.1

Notes: N = 3,605

The results in Table 4.2 and Table 4.3 in general point out that measurement choices do have an impact on the obtained RB measures. This leaves researchers with a tradeoff between data availability (long panels with many consecutive

[25] Also, in our dataset, BR measures calculated over 3 to 7 years are strongly (60–95%) and significantly (α = 0.05) correlated with each other, suggesting that these measures do not differ that much in practice.
[26] Note that only 3.8% and 3.2% of the available farms respectively for the 2-year and 3-year results were used for this comparison due to listwise deletion and the data demanding calculation of the 7-year RB measure (12 consecutive years are needed).

observations are often difficult to obtain) and the required information value of the measure (e.g. with regards to persistence).

4.5.2 Exploring risk balancing behavior in the EU-15

To put risk balancing into a broader perspective, Figure 4.1 breaks down the prerequisites and constituents of risk balancing behavior based on a 3-year RB measure.[27] The first branch reveals that about half (48%) of the EU-15 farmers in our sample do not have any debt and hence cannot be risk balancers. A lot of variation between countries is masked by this average as in several countries nearly all commercial farmers have debt (e.g. Denmark, Germany, France, Luxembourg, The Netherlands and Sweden) whereas only 10% of Greek and Italian farmers have debt. About half of those farmers with debt (52%) can be classified as a risk balancer, the other half did not make strategic financial risk adjustments. A further distinction can be made with regards to the direction of the strategic adjustments. Of the risk balancing farmers, 42% decreased financial risk in response to an increase in business risk (labeled risk management) and 26% increased financial risk in response to a decrease in business risk (labelled entrepreneurship); the remaining 32% of farmers were labelled ambiguous as in one of the 3 years considered financial risk and business risk did not move in opposite directions. Focusing on changes over a single period (which rules out ambiguous observations, but which is likely to be an insufficiently long period to evaluate risk balancing behavior), the shares are 58% risk management versus 42% entrepreneurship. This evidence points out that risk balancing mostly constitutes a risk management response that aims at leveling off total risk at the farm, rather than an entrepreneur response to take more financial risk in light of improved business risk positions. In the latter case, the so-called 'paradox of risk balancing'—the situation where the level of total risk increases over the 3-year period under consideration for an entrepreneurship risk balancer—is observed in 47% of the cases, which is 12% of all risk balancers. Note furthermore that only when one assumes that these farmers were targeted by a risk-reducing policy that this result can be reasonably called paradoxical.

[27] Note that data-averaged proportions are presented. Calculating year-specific averages yields matching results, *i.e.*, no year-specific idiosyncrasies are identified.

These findings suggest that risk balancing should be mostly seen as a risk coping strategy for a farmer and to a lesser extent as an unanticipated risk response. Although part of the risk balancing literature tends to focus on the paradox of risk balancing as a justification for research, our rather low overall incidence figure indicates that for the EU-15 more focus should be put on risk management versus entrepreneurship risk balancing strategies.

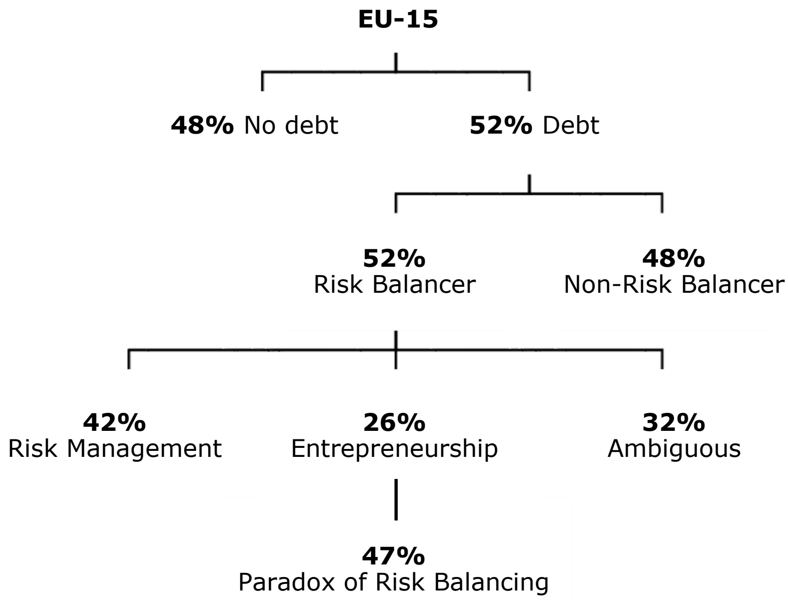

Figure 4.1 Breakdown of risk balancing behavior in the EU-15

4.5.3 The dual direction of risk balancing in the aggregate

This section presents aggregate evidence on the dual direction of risk balancing. Table 4.4 presents the coefficient estimates of the dynamic model 4.3 estimated using 2SLS (analogous to Chapter 3). The lagged FR variable was instrumented with the two and three period lagged level of debt. These instruments are found to be valid: they are relevant (the first stage regression's R^2 was high at 0.619 and an F-test of joint significance of both instruments yields a P-value of 0.000) and exogenous (Hansen J statistic yields a P-value of 0.4557). A Hausman test for endogeneity in the second stage IV regression yields a significant P-value of

0.000, indicating that as expected the lagged dependent variable should be treated as endogenous.

Table 4.4 Dual direction of risk balancing results based on a dynamic fixed effects (FE) panel regression model explaining (ln) financial risk in the EU-15 over the period 1995-2008

Variable	Coefficient	(SE)
Ln FR_{t-1}	0.6368***	(0.0294)
Ln $BR_{t-1,up}$	-0.0907***	(0.0081)
Ln $BR_{t-1,down}$	-0.0679***	(0.0058)
Ln I/D_{t-1}	-0.4359***	(0.0283)
Ln NOI/A_{t-1}	0.6183***	(0.0336)
Ln $Area_t$	0.0651***	(0.0245)
Age_t	-0.0061***	(0.0012)
Farm *Type* Dummies		
Horticulture	-0.1206	(0.0913)
Wine	-0.2451***	(0.0772)
Other permanent crops	0.0459	(0.0531)
Milk	0.1137*	(0.0664)
Other grazing livestock	-0.0655	(0.0462)
Granivores	0.0669	(0.0592)
Mixed	-0.0235	(0.0413)
Year Dummies		
1999	0.2568***	(0.0231)
2000	0.1794***	(0.0214)
2001	0.1440***	(0.0207)
2002	0.1189***	(0.0195)
2003	0.0758***	(0.0183)
2004	0.0052	(0.0172)
2005	-0.0135	(0.0161)
2006	-0.0822***	(0.0150)
2007	-0.2764***	(0.0140)
2008	.	.
F	126.3***	
N	86,902	

Notes: Clustered standard errors are shown between brackets. Single, double, and triple asterisks (*) denote statistical significance at the 0.10, 0.05 and 0.01 levels, respectively. '.' Denotes dropped due to collinearity. The dummy reference levels are 1998 and fieldcrops respectively.

We obtain two significant and negative coefficients for BR_{t-1}, indicating that the average farmer exhibits behavior consistent with both directions of risk balancing behavior. The coefficient of risk management risk balancing $\beta_{t-1,up}$ is more negative than the coefficient of entrepreneurship risk balancing $\beta_{t-1,down}$ and the difference between both coefficients 0.0228 is statistically significant at $\alpha = 0.01$. This finding suggests that the risk management risk balancing response—lowering

FR_t lower in response to an increase in BR_{t-1}—is stronger, on average, than the entrepreneurship risk balancing response—increasing FR_t in response to a decrease in BR_{t-1}.

4.5.4 Determinants of the extent of farm-level risk balancing behavior

In this section we will describe what determines the extent of risk balancing behavior in the EU-15. The fixed effects regression model from equation 4.3 was estimated using OLS. All statistical analyses were carried out using the statistical package Stata for Windows (StataCorp, 2011). Our data showed no indication of multicollinearity (VIF's of the regressors are between 1 and 2). Wooldridge's test for autocorrelation in panel data rejected the null hypothesis of no first-order autocorrelation ($\alpha = 5\%$). A modified Wald test for group-wise heteroskedasticity in fixed effect regression models indicated the presence of heteroskedasticity. The Pesaran (2004) test for cross-sectional dependence suggests that there is cross-sectional dependence in the disturbances that needs to be taken into account.[28] Given the preceding tests, we estimated Driscoll-Kraay standard errors that are robust to heteroscedasticity, autocorrelation and are assumed cross-sectionally dependent (Hoechle, 2007). The multinomial Probit model from equation 4.4 was estimated using maximum likelihood. The standard errors are heteroscedasticity and autocorrelation robust by means of clustering them by farm.

Table 4.5 presents the coefficient estimates and robust standard errors of our regression models based on a 3-year RB measure.[29] Tables A1.1 and A1.2 in Appendix A1 provide a supplementary robustness analysis by comparing the same regression models for risk balancing correlation coefficients evaluated over longer periods.

---

[28] As we have an unbalanced and very large sample, we tested different subsets as suggested by De Hoyos and Sarafidis (2006). The cross-sectional dependence tests rejected the null hypothesis of no cross-sectional dependence in all subsets with p-values ranging from 0.0208 to 0.0959.

[29] Note that alternative regression models were also tested. As an alternative to our fixed effects regression model, we also fit a random effects model. A subsequent Hausman test indicated a systematic difference in coefficients and hence our consistent fixed effects regression was preferred over the random effects model. A multinomial Logit model yielded similar results to our multinomial Probit model, but was not used because a Hausman-McFadden test indicated that the independence of irrelevant alternatives assumption (IIA) was violated.

Table 4.5 Parameter estimates for the determinants of the extent of 3-year risk balancing behavior in the EU-15 for the period 2000–2008

Variables[a]	FE model	Multinomial Probit model	
	RB[b]	Risk Management	Entrepreneurship
Age of Farmer	0.0022**	**0.0025**[**c]	**-0.0018**
	(0.0007)	(0.0010)	(0.0012)
Total Risk	0.2469***	**0.9946*****	**-0.2199*****
	(0.0245)	(0.0407)	(0.0516)
Utilized Agricultural Area	-0.0001	**-0.0001**	**0.0002**
	(0.0002)	(0.0001)	(0.0001)
Land Tenure Ratio	0.0974**	**0.0627***	**-0.1426*****
	(0.0370)	(0.0344)	(0.0428)
Operating Productivity Ratio	0.5492***	**-0.1792****	**0.4562*****
	(0.0661)	(0.0796)	(0.0968)
Leverage	-0.1534**	**-0.4029*****	**0.2492*****
	(0.0500)	(0.0665)	(0.0769)
Cost of Debt	-0.1175	-0.0761	-0.4737
	(0.0982)	(0.2383)	(0.3206)
Asset Profitability	-0.5817***	**0.1263**	**-0.9194*****
	(0.0961)	(0.0924)	(0.2751)
Uncoupled Subsidy Ratio	-0.1514	**0.2273****	**-0.1329**
	(0.1221)	(0.1119)	(0.1342)
Decoupled Subsidy Ratio	-0.2055*	**0.3883***	**-0.6023****
	(0.0948)	(0.2239)	(0.2631)
Insurance Costs Ratio	-0.0306	-0.1678	-0.7022
	(0.3375)	(0.4265)	(0.5450)
Enterprise Diversification	-0.0095	-0.1289*	-0.0816
	(0.0450)	(0.0670)	(0.0782)
Constant	0.5500**	-0.6780***	-1.0068***
	(0.1953)	(0.0901)	(0.1189)
Farm type and year dummies omitted for brevity			
F-test statistic	38.4***		
R^2 Within	0.0121		
Chi^2		1,466***	
Log-Likelihood		-73,569	

Notes: N = 59,171; Robust standard errors in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$; [a] All independent variables are averages over the last 3 periods (including the current period); [b] All dependent variables are based on a 3-year risk balancing measure; [c] **Bold** indicates that the Risk Management coefficients differ significantly from the Entrepreneurship coefficients (α = 0.05) in the Multinomial Probit model (reference level is non-risk balancing, category 'Ambiguous' omitted for brevity)

The first column in Table 4.5 presents the results of our fixed effects regression model looking at the determinants of the extent of risk balancing behavior. We find a significant (α = 0.05) coefficient for age[30], total risk, tenure ratio, operating

[30] A nonlinear specification was also tested for Age by including Age². Because the coefficient of this variable was not significant (α = 0.05) in any of our models, it was excluded from our final models.

productivity, leverage and asset profitability. These coefficients indicate that we observe risk balancing to greater extent (as measured by the size of the correlation coefficient) if a farmer (i) is older, (ii) has coped with more total risk over the preceding years, (iii) owns a larger percentage of his land, (iv) is less productive at the operating level, (v) is less leveraged and (vi) is less profitable. These findings are in line with our expectations. The robustness analysis presented in Appendix A1 (Table A1.1) reveals that these findings are consistent when evaluating risk balancing over a longer period (*i.e.* the significant coefficients exhibit the same sign and have comparable magnitudes).

Our multinomial Probit model looks at what determines a farmer's choice to adopt either of both distinct risk balancing strategies: risk management versus entrepreneurship.[31] The second and third column of Table 4.5 show the impact of our explanatory variables for both risk balancing strategies; bold figures indicate a significant ($\alpha = 0.05$) difference between both coefficients. We observe a significant difference in coefficients for several explanatory variables and furthermore that the effect is opposite between both strategies. These findings remain consistent when evaluating risk balancing over a longer period (see Table A1.2 in Appendix A1). We now focus our attention on those variables for which we observe a significant difference in coefficients between both strategies which persists in the longer period models, and where at least one of the coefficients is statistically significant. As hypothesized, we find that when risk balancing, older farmers and farms that coped with more total risk over the risk balancing evaluation period tend to do so more as a risk management strategy and less as an entrepreneurship strategy. Farmers that proportionally own more of their land also tend do make more use of risk balancing for risk management purposes whereas farmers who lease more land might have improved access to credit (Barry and Robison, 1986; Ellinger and Barry, 1987) and hence focus on the entrepreneurship strategy. This result corroborates with the findings of Sherrick et al. (2004) who determine that greater reliance on ownership reflects stronger risk bearing capacities and hence a greater reliance on self-insurance (in our case through risk balancing). Farms productive at the operating level are found to make

[31] The reference level in our multinomial Probit model is non-risk balancing behavior. The category 'ambiguous'—representing farmers that we were unable to classify under one of both risk balancing strategies—was also included in the model but the results were omitted in Table 4.5 for brevity yet are included in Table A1.2 in Appendix A1.

more use of risk management and less entrepreneurship risk balancing to prevent their productivity to lower. We observe that farms with greater leverage tend to focus on entrepreneurship and less on risk management. This results is opposing what we hypothesized in section 4.3, but can be explained assuming that leverage is an indicator of entrepreneurship. Contrary to our prior belief, we find that more profitable farms focus on risk management when risk balancing, and less on entrepreneurship. The influence of decoupled payments on risk balancing behavior is equivocal. In the 3-year model we observe a significant difference between a positive influence towards risk management and a negative influence towards entrepreneurship. This difference does not hold for the additional models, however, and positive coefficients for both strategies are observed.

4.6 Conclusions

Risk balancing, *i.e.* strategic adjustments in capital structure that offset reductions or mitigate increases in business risk, is a much researched concept in agricultural finance. It involves two distinct risk responses depending on the direction of the strategic adjustment. When a farmer lowers financial leverage in response to an increase in business risk, risk balancing entails a risk management strategy. Conversely, risk balancing behavior also involves an entrepreneurship strategy where a farmer increases leverage in response to lowered business risk conditions. Making use of the EU-15 FADN dataset, we look empirically at the determinants of risk balancing behavior while focusing on the direction of the strategic balancing behavior. Simple correlation coefficients between a financial risk measure and a lagged business risk measure are used as a proxy for farm-level risk balancing behavior. Although this is based on the strong assumption that the observed correlation mainly reflects changes in FR_t triggered by changes in BR_{t-1}, we have to make it in order to obtain farm-level risk balancing measures. Sensitivity analyses are conducted by varying the number of calculation years for business risk and the evaluation period of the risk balancing correlation measure. Our econometric analysis consists of fixed effects and multinomial Probit models to look respectively at determinants of the extent of the balancing effect and the adoption of both distinct risk balancing strategies.

Our results demonstrate that measurement choices have an impact on the obtained farm-level risk balancing measures. Evaluating risk balancing behavior over longer periods of time is found to have a more pronounced impact compared to considering more years when calculating business risk. This finding presents researchers with a tradeoff between data availability (long panels with many consecutive observations are often difficult to obtain) and the required information value of the measure (e.g. with regards to persistence of the observed behavior). By presenting a breakdown of the prerequisites and constituents of risk balancing behavior, we put risk balancing into a broader perspective. Only half of the EU farmers have debt (52%, but this proportion differs greatly between member states) and hence can make strategic capital structure adjustments; about half of them are risk balancers. Risk balancing is mostly observed as a risk coping strategy for a farmer (42%) and to a lesser extent as an unanticipated risk response (26%). The situation when in the latter case the financial risk response is greater than the business risk decline (and total risk increases), is called the 'Paradox of risk balancing' in literature (Featherstone et al., 1988). We observe rather low incidence figures for this potential paradoxical situation, however, only for 47% of entrepreneurship risk balancers, or 12% of all risk balancers. An aggregate dynamic fixed effects model suggests that the average EU-15 farmer exhibits behavior consistent with both directions of risk balancing behavior. Using farm-level risk balancing measures, our fixed effects regression models present several determinants of the extent of risk balancing behavior. We find that a farmer balances risk to a greater extent if he is older, has coped with more total risk over the preceding years, owns a larger percentage of his land, is less productive at the operating level, is less leveraged and is less profitable. By means of a multinomial Probit model, we find that the determinants of a farmer's choice to adopt either of both distinct risk balancing strategies have opposite effects. In contrast to the U.S findings of Escalante and Barry (2001; 2003), we do not find interactions with alternative risk management strategies for our EU-15 sample.

The results of our study provide a deeper insight into the dual aspect of the behavioral construct of risk balancing and indicate that it is mainly a ubiquitous risk management strategy. Future research could incorporate risk balancing behavior when modeling farms' risk management plans. Although risk balancing as an entrepreneurship strategy and the related 'paradox of risk balancing' were found to be of lesser importance, our results presents EU policy makers a first insight into what determines the adoption of the strategy.

Chapter 5

Farm household risk balancing: implications for policy

Abstract

This chapter theoretically introduces the concept of farm household risk balancing, a theoretical framework in which the farm household sets a constraint on the total household level risk and balances farm level and off-farm level risk. We argue that the risk behavior of farmers is better understood by considering risk at the household level and consider a wide variety of behavioral responses to changes in the policy and economic environment. Empirical evidence from previous literature that leads up to our model is presented and the implications for EU policy are discussed.

Keywords

Business risk, financial risk, farm risk, off-farm risk, risk balancing

Parts of this chapter have been submitted as: Wauters, E., de Mey, Y., van Winsen, F., Van Passel, S., Vancauteren, M. and Lauwers, L. (2014) Farm household risk balancing: implications for policy.

5.1 Introduction

Acknowledging that many farm households in the EU attract a substantial part of their income from non-agricultural sources, this chapter theoretically introduces the concept of farm household risk balancing, *i.e.*, the notion that changes in the policy and economic environment might lead to unanticipated behavioral responses at the farm household level. The chapter further describes the implications of this novel concept for policy makers and researchers. Risk analysis and risk management are since long issues that have sparked considerable interest among agricultural economists and policy makers. Today, risk management at the individual farm level is considered one of the greater challenges for the farming community (Richardson et al., 2000; Just, 2003). However, several authors assert that there is a strong case that the handling of risk in policymaking in the agricultural and resource sectors leaves scope for improvement (e.g., Just, 2003; Hardaker and Lien, 2010). One of the most important areas in this respect relates to the behavioral response of farmers in reaction to changes in the economic and policy environment. Farming systems theory views a farm as a unique, goal-setting purposeful system (Dillon, 1991). Farmers are active decision makers and changes in the environmental, policy and economic situation induce them to change certain aspects of their farming business. Depending on the behavioral response, policy measures aimed at obtaining one particular goal (e.g., income stabilization), may have adverse effects on alternative goals.

Another area is the measurement of income and the associated objectives of farmers and policy makers. Increasingly, scholars realize that the focus of agricultural policy and research on a measure of farm income goes beyond what is really going on in the majority of farm households, even in developed countries (Freshwater, 2007). In those countries where an adequate measurement of income at the household level exists, such as the U.S., evidence shows that only a minority of farm households earn the majority of their income from agricultural sources, such that the use of a measure of farm income to assess farmers' well-being is flawed (United Nations, 2007). While these issues are gaining considerable agreement, the majority of agricultural economics research is still focusing on a measure of farm income as its target variable and risk research in agriculture is no exception to this case. Yet, in farm households where a significant proportion of the overall household income is coming from non-agricultural sources, there might be an interaction between both the level and riskiness of the agricultural and the non-agricultural income.

This chapter presents a novel theoretical framework in which the farm household sets a constraint on the total household-level risk and balances farm and off-farm risk. We argue that the risk behavior of farmers is better understood by considering risk at the household level. By taking farm household income and not just farm income as the focal point of our behavioral assumptions, we consider a much wider variety of behavioral responses to changes in the policy and economic environment. The original risk balancing framework (Gabriel and Baker, 1980) describes how financial risk and business risk are trade-offs in the risk behavior of farmers. Our model shows that changes affecting the business risk at the farm level might just as well induce changes at the household level (e.g., changes in off-farm employment or non-farm investments) and not just changes in the farm financial position. The main contributions of this chapter are (i) presenting a novel theoretical framework describing a farm household's risk behavior, (ii) thus advancing the argument that the farm household is the preferred level of analysis for risk (management) research and (iii) extending the original risk balancing framework to the household level. Important implications for policy makers and researchers are discussed. Focusing on the role of liquidity in agricultural household risk management, our model presents a link between liquidity reserves and agricultural risk management policies which is very important, yet largely ignored in literature (Pedersen and Olsen, 2013).

This chapter is structured as follows. The second section reviews the existing literature on risk management policies and the measurement of farm household income, demonstrating the importance of considering the household level in risk (management) analysis. The third section introduces the conceptual and operational measures for household risk and its constituents. In the fourth section we show that, for a farm household with income from both within and outside agriculture that is optimizing household income risk, risk behavior may involve a trade-off between total farm risk and household-level risk and provide a behavioral equation with important implications. The fifth section discusses these implications and provides considerable evidence from literature in support of our model. The last section summarizes and concludes.

5.2 Household level policy and risk (management) analysis in agriculture

5.2.1 Risk management policies

Farm support policies in the EU have long been in place in several member states to provide income support for individual farmers depending on their size, production practices, output orientation and levels of market prices. Recently, risk management and income stabilization in agriculture have become a central point of European and national agricultural policies, induced by a growing consensus that the agricultural sector will face increased price and production volatility (OECD, 2011). Accordingly, the focus of farm support policies has recently shifted towards more specific risk mitigation policies (Cafiero et al., 2007), in addition to a remaining focus on farm-level support. Recent estimates show that this support is again on the rise in 2012, after an historically low in 2011 (OECD, 2013a). Also recently, the European Commission has suggested in its new proposed CAP reform a risk management toolkit as part of the Pillar 2 rural development measures that gives member states the opportunity to develop a mix of instruments (insurance, mutual funds, income stabilization tools) consistent with their current national insurance systems and laws (Tangermann, 2011).

In order to improve new policy measures directed towards risk and risk management, policy makers and researchers need to be able to predict how farmers will respond to changes in the institutional environment. Policy makers and researchers should look beyond intended effects and be especially concerned with unanticipated effects. As Freshwater (2002: 465) puts it: 'it is not appropriate to conclude that a program is successful if it has met its stated goals but has created significant harm in other areas'.

Several unanticipated responses with regards to risk management policies have already been identified. Previous studies reveal that risk-reducing or income stabilizing government programs could induce risk-taking behavior for farmers (e.g., growing more risky crops (Turvey, 2012)), have adverse environmental externalities (e.g., reduced biodiversity (Di Falco and Perrings, 2005)), or crowd-out other instruments (e.g., subsidized insurance schemes potentially reduce farmers' participation in forward contracting opportunities to hedge prices (Coble et al., 2000)). Another unanticipated effect is risk balancing, originally postulated by Gabriel and Baker (1980). Risk balancing refers to the fact that farmers strategically adjust the level of financial risk in response to exogenous changes in business risk. On the one hand risk balancing entails a rational risk management strategy when farmers lower financial risk in response to an increase in business risk; when on the other hand more financial risk is taken when the business risk position improves, it involves an unanticipated entrepreneurship strategy to restore the original total risk level (see Chapter 4 of this dissertation). The latter case led several authors to the notion of the paradox of risk balancing or the fact that when income-enhancing or business risk-reducing policies (e.g., price stabilization policies) induce farmers to increase their financial risk, their overall risk position is left unchanged or even worse off (Featherstone et al., 1988). The occurrence of risk balancing supports the policy goal of stimulating innovation and entrepreneurship, but the purpose of providing the farming population with a stable farm income, however, could be jeopardized by off-setting increases in the financial risk position.

5.2.2 Farm income as the focal point of agricultural policy

Initially, the focus of income support policy and research was the farm household, but in the 1970s it changed to the farm enterprise (Freshwater, 2007). As a result, the implicit assumption became that a farm household maximizes farm income. However, there is sufficient evidence that shows that the majority of farm households in the US and Canada, attract a significant part of their income from non-agricultural sources (Mishra et al., 2002; Freshwater, 2007). It is estimated that also in the EU many farm households attract a significant portion of their total household income from off-farm sources (OECD, 2003). In Ireland, off-farm income was voluntarily reported by 25% of the population (Hennessy and Rehman, 2008). Earlier data from Austria (McNamara and Weiss, 2005). and France (Benjamin and Kimhi, 2006) also showed that many farmers spent a significant share of their time working time on non-agricultural activities. Farmers are known to be able to adapt to unanticipated changes in farm income, by cutting down household expenses, or by using household liquidities and/or capitalizing household/farm assets. Hence, Freshwater (2007) argued that the behavioral assumption of farmers maximizing farm income is no longer tenable and that to assess the impact of income support policies on welfare, the focus should return to the farm household. Already in 1973, Gasson's seminal paper showed that farmers have a broad range of goals and values and that farm income maximization is only one of them. The relative priorities that are attached to each value explains farmers' economic behavior when confronted with a choice (Gasson et al., 1988). More recently, Lien et al. (2006) found that profit maximization as a goal was ranked rather low by both full-time and part-time crop and dairy farmers. Having a reliable and stable income, however, was ranked among the most important goals. Wallace and Moss (2002) also consider a series of alternative goals aside from conventional profit maximization and quantify the trade-off between family and farm goals. Profit maximization might be sound behavioral assumption for corporate/commercial farms, yet in 2010, 97% of all farms in the EU were considered family farms (European Commission, 2013). Their importance in the agricultural chain might increase over time (Schmitt, 1991; Brookfield, 2008) and they are found to remain operational according to the notion of the disappearing middle in the size distribution of farms (Weiss, 1999). In her AAEA presidential address, Offutt (2002) also emphasized the importance of understanding the microeconomic behavior at the household level in order to succeed in effective design and implementation of farm policies.

5.2.3 Risk analysis and management in agriculture: a new focus on the household level

Combining the findings of the two preceding sections, we advance the argument that the analysis of risk and risk management in agriculture should consider the farm household as the preferred level of analysis rather than focusing solely on the farm. This implies that measures of off-farm and total household-level risk are needed. The interdependence between the farm household and the farm is strong as they are intertwined both in terms of physical location and labor supply. There is also a financial dependency as farm and family accounts frequently coincide or are used for both purposes. The strong interaction between the farm and the farm household permits farm operational decisions to be influenced by and to have influence on a much broader range of alternative household-related factors than is assumed under the behavioral assumption of profit-maximization. For example, Jetté-Nantel et al. (2011) found that Canadian farmers' operational (production) decisions are influenced by off-farm income.

There is also a policy-related reason to start focusing more on household-level risk. The Agenda 2000 reform of the CAP still listed ensuring a fair standard of living for the agricultural community as an objective and further explicitly acknowledged the stability of farm incomes and the creation of abundant alternative income opportunities for farmers and their families as goals of the CAP. These objectives are clearly formulated with the farm household as the social unit in mind and hence in order to assess to what extent risk management policies succeed in realizing these objectives, a measure of household risk is warranted.

Whereas in the past, risk research mainly used aggregate datasets (Just, 2003), research and policy analysis on risk (management) is increasingly focusing on farm-level analyses (e.g., Kimura et al., 2010), which is important because averaging may substantially misrepresent the risk farmers are facing at the individual level (Just and Weninger, 1999). We argue, however, that a final step towards better risk research and policy analysis is considering the farm household as the decision making unit[32], not ignoring the household layer of risk. Although the notion that farm household risk exposure and management is not limited to simply farm-level aspects and thus the household-level should be considered has been previously discussed in US/Canada based research (e.g., Barnett and Coble, 2009; Freshwater and Jette-Nantel, 2011), EU-based research (e.g., Cafiero et al., 2007; Vrolijk et al., 2009) and has been pointed out by the OECD (2009; 2011), the fact that this notion has yet to permeate the agricultural risk management discipline in practice is quite surprising.

5.3 Conceptualizing and operationalizing household risk

This section will introduce the different risk concepts used in our extended risk balancing framework and present specifications to operationalize these concepts.

[32] Considering the farm household as the decision making unit is accomplished in household models that explicitly acknowledge that farm-level and household-level choices are endogenous and inseparable (Chayanov, 1966; Singh et al., 1986). Farm household models are commonly based on the behavioral assumption of the maximization of subjective expected household utility. In our framework, we further identify that farm households are risk-constrained by aiming for an optimal level of household-level risk (see section 5.4).

5.3.1 *Business risk*

Business risk is the risk inherent in the farming operation and is independent of the way the operation is financed (Gabriel and Baker, 1980). Business risk is generally operationalized using a measure of farm return that is not influenced by the financing decision (such as EBITDA, operational cash flow or the rate of return on assets). From a probability distribution of any of these result parameters, several measures of risk may be derived, such as the coefficient of variation, the value-at-risk or the probability of a predefined disastrous outcome. Each measurement concept results in an alternative, yet identical representation of business risk that leads up to analogous versions of the risk balancing model. For the remainder of this chapter we will work with cash-based definitions as this definition allows the transition to the household level (United Nations, 2007). Following Gabriel and Baker (1980), we define business risk (BR) in terms of a coefficient of variation:

$$BR = \frac{\sigma_{CF_O}}{\overline{CF_O}} \tag{5.1}$$

where $\overline{CF_O}$ represents expected operational cash flow and σ_{CF_O}its standard deviation. The two major causes of business risk in the farm are unexpected variability in production and in the prices of inputs and outputs. Whereas the level of business risk is mainly influenced by external sources (e.g., market conditions, policy changes, environmental circumstances, the weather, pests and diseases), internal factors such as productive efficiency and general management skills may also influence the level of business risk.

5.3.2 *Financial risk*

Financial risk is defined as the added variability on the return for owners of equity that results from the cash obligations associated with debt financing (Gabriel and Baker, 1980). Primarily, this risk results from the use of debt as leverage, which multiplies the potential business risk that will be generated (Boehlje, 2002). Of course, there are other risks involved in the use of debt, most notably risks arising from uncertainties in the cost (interest rate) and availability of debt (Boehlje, 2002). Financial risk (FR) can be specified as (Gabriel and Baker, 1980):

$$FR = \frac{\sigma_{CF_O^*}}{\overline{CF_O} - I_f} - \frac{\sigma_{CF_O}}{\overline{CF_O}} \tag{5.2}$$

where $\sigma_{CF_o^*}$ represents the standard deviation of operational cash flow with debt financing, but before the deduction of fixed debt servicing payments of the farm I_f. When working in cash flow terms, I_f involves both interest paid and principal, but only interest when using income-based definitions. Rewriting this expression and assuming no leverage-induced changes in the variability of cash flows yields[33]:

$$FR = \frac{\sigma_{CF_o}}{\overline{CF_o}} \frac{I_f}{\overline{CF_o} - I_f} \quad (5.3)$$

This equation demonstrates that FR can be regarded as a multiple of BR with the right-hand multiplier term reflecting the finance decision.

5.3.3 Total farm risk

Analogous to the definition of business risk, the total risk of the farm (TR_f) is generally reflected in the variability of cash flow after debt financing (or alternatively using accounting definitions in the rate of return to equity). More formally:

$$TR_f = \frac{\sigma_{CF_o - I_f}}{\overline{CF_o} - I_f} = \frac{\sigma_{CF_o}}{\overline{CF_o} - I_f} \quad (5.4)$$

where the second equation removes I_f from the standard deviation as it is assumed to be fixed.

5.3.4 Off-farm risk

We define off-farm risk as the change in the variability of household cash flow compared to the variability of farm cash flow. Several household-level activities or strategies might influence this change—both in the positive and negative sense—such as off-farm wages or private financial investments (see the next section for a full elaboration). Practically, we define off-farm risk (OFR) as:

$$OFR = \frac{\sigma_{CF_h}}{\overline{CF_h}} - \frac{\sigma_{CF_o}}{\overline{CF} - I_f} \quad (5.5)$$

[33] Gabriel and Baker (1980) assume, for most of their reasoning, that the standard deviation of cash flows with debt financing equals that without debt financing. This assumption may hold in practice, as debt financing is most often used to increase the scale of current operations, rather than removing some of the uncertainty inherent in current operations. Some farmers, however, take on additional new loans, thereby increasing debt to asset ratio, in order to decrease business risk. Indeed, many investments to decrease the risk inherent in normal farm operations require large funds, which most farmers can only acquire though debt financing. For these farmers, this assumption will be flawed.

where $\overline{CF_h}$ represents expected household cash flow and σ_{CF_h} its standard deviation. Household cash flow is defined as operational cash flow minus fixed debt servicing obligations plus off-farm cash flow:

$$CF_h = CF_o - I_f + CF_{of} \tag{5.6}$$

Using this equation and the assumption that I_f is fixed and hence can be removed from standard deviations, expression 5.5 can be rearranged as:

$$OFR = \frac{\sigma_{CF_o}}{\overline{CF} - I_f}\left(\frac{\sigma_{CF_o + CF_{of}}\left(\overline{CF_h} - \overline{CF_{of}}\right) - \overline{CF_h}\sigma_{CF_o}}{\overline{CF_h}\sigma_{CF_o}}\right) \tag{5.7}$$

This expression demonstrates that—analogous to FR—off-farm risk can be regarded as a multiple of total farm risk, where the multiplier now depends on both the share of off-farm cash flow in household cash flow and the variability of each cash flow.

5.3.5 Total household risk

Total household risk (TR_h) is the variability of household cash flow and is defined as:

$$TR_h = \frac{\sigma_{CF_h}}{\overline{CF_h}} = \frac{\sqrt{\sigma^2_{CF_o} + \sigma^2_{CF_{of}} + 2Cov\left(CF_o, CF_{of}\right)}}{\overline{CF_o} - I_f + \overline{CF_{of}}} \tag{5.8}$$

Total household risk thus depends positively on (i) the variability of operational cash flow; (ii) the variability of off-farm cash flow; (iii) the interdependency of operational and off-farm cash flow; (iv) the fixed debt servicing obligation and depends negatively on (v) expected operational cash flow and (vi) expected off-farm cash flow. An important implication of (iii) is that when farm cash flow and non-agricultural cash-flow are countercyclical, total household risk decreases, but increases when it is procyclical with operational cash flow.

A first special case of equation 5.8 is when there is no off-farm cash flow, *i.e.,* a farm focuses entirely on agricultural production. In this case $\overline{CF_{of}}$, $\sigma^2_{CF_{of}}$ and $Cov\left(CF_o, CF_{of}\right)$ are equal to zero, hence:

$$TR_h = \frac{\sigma_{CF_o}}{\overline{CF_o} - I_f} = TR_f. \tag{5.9}$$

This special case amounts to the Gabriel and Baker (1980) framework, and suggests that when a decision maker can identify a constraint on total household risk, risk balancing between business risk and financial risk may occur. Consider, for instance, that the decision maker identifies β as the maximum bearable total household risk.[34] Then equation 5.9 can be rewritten as:

$$TR_h = \frac{\sigma_{CF_o}}{\overline{CF_o}} \frac{\overline{CF_o}}{\overline{CF_o} - I_f} \leq \beta. \tag{5.10}$$

A shock in for instance price variability, causing σ_{CF_o} and hence BR to lower, can lead to an adjustment in the financing decision, with an equivalent increase in I_f. This decision may be a pure financing decision, an investment decision or both.

A second special case is when off-farm cash flow is non-zero but fixed, e.g., when a farmer (or his spouse) has a steady extra off-farm job. In that case, the variability of off-farm cash flow and its covariance with operational cash flow equals zero:

$$TR_h = \frac{\sigma_{CF_o}}{\overline{CF_o} - I_f + \overline{CF_{of}}} \tag{5.11}$$

Rewriting this equation and considering an equivalent risk constraint β yields:

$$TR_h = \frac{\sigma_{CF_o}}{\overline{CF_o}} \frac{\overline{CF_o}}{\overline{CF_o} - I_f} \frac{\overline{CF_o} - I_f}{\overline{CF_o} - I_f + \overline{CF_{of}}} \leq \beta \tag{5.12}$$

This equation shows that a decision maker that sets a constraint on total household risk can assume more business and/or financial risk when off-farm cash flow is positive and less when it is negative. This equation further shows that, in reaction to an exogenous shock that decreases σ_{CF_o} and hence BR, a decision maker with the objective of stabilizing household cash flow does not necessarily take on more financial risk (by changing I_F), he may also lower the household buffer he/she maintains by changing CF_{of}.

A third case is when off-farm cash flow is non-zero, variable but uncorrelated with operational cash flow, e.g., when a farmer receives a variable return from financial investments or he/his spouse has a flexible extra job. This is likely the most prevailing situation, as farmers are motivated to seek uncorrelated income

[34] The size of β depends on personal characteristics (e.g., the level of risk aversion of the farm operator), farm-level factors (e.g., profitability) and exogenous factors (e.g., general economic conditions).

streams when looking for off-farm opportunities. In this case, total household risk can be expressed as:

$$TR_h = \frac{\sigma_{CF_h}}{\overline{CF_h}} = \frac{\sqrt{\sigma^2_{CF_o} + \sigma^2_{CF_{of}}}}{\overline{CF_o} - I_f + \overline{CF_{of}}} \leq \beta. \tag{5.13}$$

In this case total household risk increases with the riskiness of off-farm cash-flow, but decreases with expected off-farm cash-flow.

5.4 Risk balancing and liquidity management: the role of household components

In order to gain a better insight into the role of business risk, financial risk and off-farm risk in the determination of total household risk, we move away from operationalizing risk in variability terms and now look at risk in a probabilistic sense. This will also shed light on one of the merits of considering total household income and the risk thereof as determinants of farm household risk behavior. We now define the total household risk in terms of the probability that household cash flow falls below a certain critical level *z*:

$$TR_h = P(CF_h \leq z) \tag{5.14}$$

Using Tchebycheff's theorem, an upper bound can be placed on this probability:

$$P(CF_h \leq z) \leq \frac{\sigma^2_{CF_h}}{(\overline{CF_h} - z)^2} \tag{5.15}$$

We can now identify a total household risk constraint *α* as the maximum tolerable level of total household risk:

$$P(CF_h \leq z) \leq \frac{\sigma^2_{CF_h}}{(\overline{CF_h} - z)^2} \leq \alpha \tag{5.16}$$

As previously defined, household cash flow is equal to operational cash flow minus fixed debt servicing obligation of the farm plus off-farm cash flow (see equation 5.6). We now further expand this definition by introducing the role of liquidity reserves, both belonging to the farm (R_f) and to the household (R_h). One might think of liquidity reserves in terms of cash deposits on a bank account, but also in terms of liquid assets. Further, we introduce the role of new loans, both for the farm business (L_f) and household (L_h). New loans also represent, in a way, a liquidity reserve and are dependent on the borrowing capacity of the farm household. New loans may be used to refinance existing loans and may also be used to reinvest in new farm or non-farm assets. We also introduce household debt servicing obligations (I_h), corresponding to the household loans. Hence, the total expression for household cash flow becomes:

$$CF_h = CF_o - I_f + R_f + L_f + CF_{of} - I_h + R_h + L_h \tag{5.17}$$

Introducing this expression into the risk constraint equation 5.16 and assuming that operational cash flow and off-farm cash flow are the only two stochastic yet uncorrelated elements in this equation we obtain:

$$\sqrt{\sigma^2_{CF_o} + \sigma^2_{CF_{of}}} \leq \sqrt{\alpha}\left(CF_o - I_f + R_f + L_f + CF_{of} - I_h + R_h + L_h - z\right) \tag{5.18}$$

Dividing each side by CF_o and rearranging yields:

$$\frac{\sqrt{\sigma^2_{CF_o}+\sigma^2_{CF_{of}}}}{CF_o} + \sqrt{\alpha}\left(\frac{I_f}{CF_o} - \frac{R_f}{CF_o} - \frac{L_f}{CF_o} - \frac{CF_{of}}{CF_o} + \frac{I_h}{CF_o} - \frac{R_h}{CF_o} - \frac{L_h}{CF_o} + \frac{z}{CF_o}\right) \leq \alpha \tag{5.19}$$

The conclusions from this equation are that a farm household can take a certain amount of business risk and off-farm risk, which are reflected in the first term on the left-hand side, and this tolerable amount of risk is increased by private and business liquidity reserves, private and business additional loans and off-farm cash flow and decreased by the amount of business and private debt servicing obligations and the size of the risk constraint. A farm household that wants to minimize the probability that household cash flow falls below a certain threshold, will have to adjust any of the elements in the numerators of the second element on the left-hand side equation.

5.5 Discussion

5.5.1 Evidence from previous literature

Our model shows that the Gabriel and Baker (1980) risk balancing hypothesis may be extended to include a trade-off between total farm risk and off-farm risk. The model of equation 5.19 suggests several possible trade-offs and interactions between components such as the level and variability of both farm and non-farm cash flow, farm loans, private loans, farm liquidity reserves, private liquidity reserves, farm and private debt servicing obligations and household expenditures. The model encompasses the well-covered topic of farm-level risk balancing and further allows consideration of a much broader pattern of farm-level responses and adjustments relating to household components which have been previously discerned in literature. Although not a formal proof of our model, the following findings in literature provide some empirical underpinning of our model.

A well-covered topic in literature is that of off-farm employment. Our model suggests that an increase in business risk may induce farmers to spend more time on off-farm work (given the other components in equation 5.19). Conversely, their engagement in an off-farm activity may explain why certain farmers pursue rather risky farm activities. Particularly in North-America (Canada and the U.S.), this has been an extensively studied topic in the agricultural economics profession. Gardner (2005) writes that small farms are flourishing to an extent no one would have guessed 30 or 40 years ago, and that the main contributor to this finding is off-farm income which has reduced the riskiness of the on-farm income stream. There have been many empirical confirmations of the existence of a relation between the level of farm income and off-farm income (e.g., Becker, 1965; Gronau, 1973; Weersink et al., 1998). Woldehanna et al. (2000) show that in the Netherlands the hours spent in off-farm labor and the expected off-farm wage are inversely related to the expected farm income. Lien et al. (2010) found similar results for Norwegian grain farms.

More importantly, many papers confirm the existence of a link between the variability of farm income and off-farm employment in the U.S. and Canada (e.g., Kyle, 1993; Mishra and Goodwin, 1997; Mishra and El-Osta, 2001; Mishra and Sandretto, 2002; Jetté-Nantel et al., 2011; Poon and Weersink, 2011). The main consensus in the US and Canada is that for risk averse farmers off-farm employment increases in response to greater farm income variability and has helped to lower the variability of total farm household income variability. Blank and Erickson describe how U.S. farm households use off-farm income to hedge against risky farm-level production and that this has enabled many risk averse farmers to remain in agriculture longer than they would without off-farm income (Blank and Erickson, 2007). In the EU, less studies have been conducted—or reported—on this topic. In Ireland, Hennessy and Rehman (2008) showed that decoupling, which has consequences for the level and variability of farm returns, is likely to increase both the probability and the amount of time spent on off-farm labor. In Austria, McNamara and Weiss (2005) showed that on-farm diversification, a strategy to reduce business risk from farming, had a negative impact on the probability of pursuing in part-time farming. The broader issue of pluriactivity of farm households has also been a topic well-covered in the sociological and rural development literature, both in the North Americas (e.g., Bessant, 2006) and especially in the EU (e.g., Shucksmith and Smith, 1991). Pluriactivity refers to the diversification of activities of farm households (both farm-centered and off-farm) where a potential motivator to start new non-agricultural businesses was found to be reducing risk (Hansson et al., 2013).

Another link suggested by our model is that between off-farm employment and farm financial risk. The existence of this link has empirically been shown in several studies looking at the determinants of debt usage (e.g., Collins and Karp, 1993; Collins and Karp, 1995; Katchova, 2005) and the results of Mishra and Goodwin (1997) also suggest that highly leveraged farms work more hours off-farm.

A final link related to off-farm employment is that with farm investments. The direction and sign of this interaction has been shown to be context specific, for instance depending on farm type, size, location and other factors (Andersson et al., 2005). Hennessy and O'Brien (2008) found that the probability of investing in the farm decreased in Ireland when the farm manager engaged in off-farm employment whereas the effect of off-farm employment by the spouse was less clear.

Our model also suggests a link between off-farm investments and the components of total farm risk: business risk and financial risk. Serra et al. (2004) found that higher fluctuations in farm income (*i.e.*, business risk) increase the share of non-farm assets in the farm household portfolio. Mishra and Morehart (2001) found that leverage (*i.e.*, financial risk) and farm diversification decreased the possibility of off-farm investments, whereas nonfarm aspects such as off-farm income and the household’s net worth along with a farm operator’s age, educational level, management skills increased the probability. Off-farm investments (e.g., in financial assets) can be an effective farm household income risk management tool similar to off-farm employment when the correlation between on-farm and off-farm investments is low (Serra et al., 2004; Nartea and Webster, 2008). Farm households are therefore motivated to diversify their portfolios and if changes in nonfarm capital have larger positive impacts on farm household wealth there might be economic incentives to shift resources out of agriculture (Blank et al., 2004; Blank et al., 2009).

As any other non-agricultural household, farm households will smooth their consumption to some extent in function of total household income variability (Langemeier and Patrick, 1990; Mishra et al., 2002). The smoothing response can also be linked to business risk, as most variability of total household income can be attributed to farm income variability (Mishra and El-Osta, 2001). The consumption changes also differ with regards to the source of income variability, as the marginal propensity to consume from off-farm income and government payments was found to be significantly greater than the propensity to consume from farm income (Carriker et al., 1993; Sand, 2002).

A final link suggested by our model is that between farm-level risk and liquidity reserves; farm families will also maintain liquidity reserves/savings as a risk management strategy (Remble et al., 2013). Facing higher future income uncertainty, farm households will—besides smoothing future income—accumulate more savings, called precautionary savings (Mishra and Chang, 2009). These savings were found to constitute about 8% of total household wealth for U.S. farm households (Mishra et al., 2013).

5.5.2 Implications

With ample empirical support for the different possible interactions suggested by our model, the household risk balancing hypothesis suggests some important implications for the future of agricultural policy and research.

First, in line with Offutt (2002) we advocate a micro-level, farm household approach to policy analysis. In the EU, this is particularly important, given the ongoing CAP reform discussions and challenging, given the continuing resistance to broaden the agricultural statistics collection with household income data (Hill, 2002; United Nations, 2007). There is a need for better data to analyses at a minimum the effects of changes in agricultural policy and the general economic conditions on the well-being and behavior of farm households, ideally a panel dataset of farm households is constructed that allows looking at volatility and robust analyses (Boisvert, 2002). Policy analyses that are only focused on the farm level ignore potentially important farm household responses that affect the achievement of the intended policy effects. The assumptions that underlie most of the agricultural policy measures are very much targeted towards those farm families with a small household buffer or low possibilities to increase this buffer. Empirical evidence shows that this is in many countries not the majority of farm households. As such, expectations about responses of farmers to agricultural policy instruments, remain unfulfilled. Furthermore, as many farmers stay in agriculture despite low farm profits by hedging with off-farm income, policies based on profit maximizing behavior are unsuitable and call for a household-centered policy perspective (Blank and Erickson, 2007).

Second, our model suggests that current EU risk management policy, which is gradually moving towards the World Bank approach (Freshwater, 2007), allowing for subsidies on insurance premiums, should encompass a more broad view on agricultural risk management. Currently, the focus of agricultural policy is on just one of the elements of the household risk balancing equation, business risk, since it is guided by a policy analysis framework that is focused at the farm level. Farm households, however, have created a new reality, one in which pluriactivity or part-time farming is the norm, rather than a marginal phenomenon restricted to small and less efficient farmers. In this new reality, farm households in the EU internalize the risks inherent in farming, by adjustments in off-farm risk stemming from consumption, off-farm employment, private liquidity reserves and private loans. Policies that aim to reallocate resources to more risky activities that provide larger benefits to society, in terms of resource efficiency and value creation, might consider targeting the other way around. More specifically, rural development policies that encourage multiple job holdings, or enable farm families to easily attract cash flow from non-agricultural sources may just as well induce them to engage in more risky farming activities, because it increases their total risk bearing capacity. In this respect, policies that enable farm households to maintain or even increase their household buffer, may be able to assume more business risk, thereby allocating resources to more efficient activities and increasing their resilience (Jetté-Nantel et al., 2011).

Third, the model also shows why, in certain sectors, some farm families persist even against all economic rationality, while others go bankrupt, or at least are in serious problems. Some farm families have built up a considerable household buffer or assume very low financial risk. These households are much less affected by variability in price and production than others. We believe that especially for such farm households, our model provides a valuable extension to the original Gabriel and Baker (1980) model. Our model suggests that the overreliance on price support policies in the past might have pushed farmers towards more financial risk and very low household buffers (Woldehanna et al., 2000; Kostov and Lingard, 2003). Recently, with the shift towards less distortive policies, coinciding with increased international trade, business risk may have increased well above the constraint set by financial and household risk. More specifically, the expectation that farmers may alter the allocation of resources, in response to price stabilization policies, to more efficient production systems might be jeopardized. Gabriel and Baker (1980) assert that as a reaction, farmers may assume more financial risk. Our model shows that farmers may also change their household strategies, decreasing their off-farm risk.

5.6 Conclusions

In this chapter, we extend the original Gabriel and Baker (1980) risk balancing framework to the household level. We analytically show that, confronted with an exogenous change in business risk, farm households may also respond by a change in household buffering strategies and not only by a change in their financial position, as posited by Gabriel and Baker (1980). Empirical evidence from previous literature regarding elements of our model is presented and important implications for policy makers and researchers are discussed. Future research could empirically validate our model for countries were data on both on-farm and off-farm activities of farm households are available. In the EU, however, this might prove difficult as only a few EU member states (e.g., The Netherlands (Vrolijk et al., 2009)) meet these data requirements; comparable data across EU member states is non-existent ruling out a cross-country analysis. Acknowledging that the farm household is the preferred level of analysis for risk (management) research, our model advocates broadening agricultural statistics collection with household income data. Another important implication of our model is that EU policy makers have an extended set of policy instruments at hand to ensure a stable income and enhance the well-being of farm households by also considering rural development programs that facilitate off-farm opportunities. Future policies should account for the increasing heterogeneity of the agricultural sector and acknowledge the multiple dimensions of farm households. As the household situation will influence a farmers' decision to diversify their farm, studies are needed in order to understand future farm sector developments as this a highly prioritized themes in EU rural development policy (Hansson et al., 2013).

Chapter 6

Empirical evidence on household risk balancing

Abstract

This chapter presents the first empirical evidence on farm household risk balancing behavior, *i.e.*, making strategic off-farm decisions in response to changes in expected business risk. Firstly, using survey data combined with Flemish FADN data, we construct a psychometric household risk balancing scale and explore what determines the differences in scores for different farm households. Secondly, using Swiss FADN data, we estimate an econometric model that analyzes how farm households jointly alter their levels of debt, off-farm income and consumption. The evidence suggests that in response to exogenous changes in expected business risk, farm households make strategic off-farm decisions. Our study demonstrates that part of the behavioral risk response of farm households is ignored when focusing solely on farm-level analyses and illustrates the relevance of the extended household risk balancing framework.

Keywords

Farm risk, off-farm risk, financial risk, off-farm income, consumption

Parts of this chapter have been submitted as: de Mey, Y., Wauters, E., Lips, M., Schmid, D., Vancauteren, M. and Van Passel, S. (2014) Farm household risk balancing: empirical evidence from Switzerland.

Parts of this chapter are accepted for publication as: Wauters, E., van Winsen, F., de Mey, Y. and Lauwers, L. (2014) Risk perception, attitudes towards risk and risk management: evidence and implications. Agricultural Economics - Zemědělská ekonomika.

6.1 Introduction

This chapter presents the first empirical evidence on farm household risk balancing behavior, *i.e.*, farm households making strategic off-farm decisions in response to exogenous changes in expected business risk (see Chapter 5 of this dissertation). The observed unanticipated behavioral responses demonstrate the relevance of the household extension to the original risk balancing framework by Gabriel and Baker (1980).

The original risk balancing framework describes the trade-off between financial risk and business risk in the risk behavior of farmers. Business risk comprises any risk that can be experienced (and managed) at the operational level (e.g., price risk, production risk, institutional risk) and is considered independent from the way the farm is financed. The financial structure of the farm implies additional financial risk stemming from the fixed financial debt obligations. The sum or product of business risk and financial risk constitutes the total farm-level risk. A farmer's risk balancing behavior is characterized by strategic choices of the level of financial risk in response to exogenous changes in expected business risk, keeping the level of total farm risk constant (strong-form risk balancing) or with some observed changes in optimal total farm risk (weak-form risk balancing).

The original risk balancing framework has had several theoretical extensions—most notably the utility-centric model by Collins (1985)—and empirical applications in predominantly US-based research. Chapter 5 of this dissertation extends the risk balancing framework to the household level by analytically showing that exogenous changes in the farm's business risk position might just as well induce changes in household buffering strategies aside from changes in the level of farm financial risk. It is widely recognized that farm households have several buffering strategies at their disposal that smooth the variation in total household income, including earning off-farm income (e.g. Jetté-Nantel et al., 2011), smoothing consumption levels (e.g. Mishra et al., 2002), seeking off-farm investments (e.g. Serra et al., 2004) or maintaining liquidity buffers (e.g. Remble et al., 2013). Household risk balancing thus involves strategic changes in any of these buffering strategies in response to exogenous changes in expected business risk while aiming to stabilize total household risk.

This chapter will present the first empirical application of the household risk balancing framework using two methodologies. Although many papers have acknowledged the importance of farm household risk exposure and management in European agricultural economics research (e.g. Cafiero et al., 2007; Vrolijk et al., 2009; OECD, 2011), empirical applications are limited which is not surprising given that only a few EU member states have the required data on both on-farm and off-farm activities of farm households. Our application analyzes the household risk balancing framework by explicitly recognizing the possibility of simultaneous adoption and the potential correlation between different on- and off-farm responses. This empirical application will make use of (i) data from an extensive survey on the risk experience and behavior of Flemish farmers and (ii) the Swiss farm accountancy data network (FADN) dataset which contains detailed information on farm households' off-farm employment, family composition and consumption levels. Adopting a survey approach for Flanders allowed us to circumvent the problem of data unavailability at the household level. Switzerland—where off-farm data is available—on the other hand is a very interesting case study because off-farm employment opportunities have been readily available to Swiss farmers in recent years and currently off-farm income thus constitutes nearly a third of total household income (FOAG, 2013).

This chapter is structured as follows. Section 2 introduces the agricultural production, risk exposure and related policies of our two sample regions. Section 3 discusses the model survey approach and econometric specification of our household risk balancing analysis. Section 4 describes the dataset used combined with the expected regression coefficient signs. The results are presented and discussed in section 5, while section 6 summarizes and concludes.

6.2 Agricultural production and risk exposure in Belgium/Flanders and Switzerland

6.2.1 Belgium/Flanders

The relative economic importance of agriculture is limited in Belgium as only 0.7% of the country's GDP in 2012 was provided by agriculture, forestry and fishing (OECD, 2013b). However, its importance in total exports was eight times higher (5.8%) and given future environmental and energy challenges its overall importance could increase over time (FOD Economie, 2013).The leading farm structure in Flanders is the small family farm, only 13.7% of the farms were organized as a partnership in 2012; most farms are classified as livestock farms (55%), followed by arable farms (19%), horticulture (13%) and mixed farms (13%) (Departement Landbouw en Visserij, 2013).

Overall income support—*i.e.,* direct payments and rural development schemes—constituted 35% on average over the period 2009–2011, however there were large disparities between farm typologies as support ranged from a low 10% in the fruits, vegetables and floricultural sector to a high 95% for livestock farms.

The availability of recent statistics regarding risk exposure in Flemish agriculture is limited. The volatility of farm income over the period 1990–2003 was found to be high compared to other European countries (Vrolijk et al., 2009: 39). Lauwers et al. (2009) compare the volatility of yields, prices and gross margins of Flemish farms over the period 1989–2003 and conclude that farm-level volatility is in most instances greater than the volatility measured at sector level. An overview of risk exposure and available risk management instruments in Flemish agriculture is given by (Deuninck et al., 2007). The authors conclude that income or revenue insurance is not a priority, yet new production insurances in the crop sector are needed.

6.2.2 Switzerland

Although the relative economic importance of agriculture is low in Switzerland—0.7% of Switzerland's GDP and below 4% of the employment rate was provided by agriculture in 2011—it is of great importance for the country's rural landscape as farming takes up nearly a quarter of the surface area (OECD, 2013c). The dominant farm structure is the small family farm and dairy farms constitute the most prevalent farm typology. Intensive forms of farming are present in the valley region, compared to more extensive systems in the hills and mountain regions.

Swiss agriculture is highly protected, due to several agricultural policy measures in place (e.g. market price support and border protection). Although Switzerland has progressively reduced its support to farmers over time, overall government support remains high. This can be reflected in the high OECD producer support estimates (PSE) at 55% in 2011, which is almost three times the OECD (19%) or

EU (17%) average (OECD, 2013c). Following a referendum in 1996, the policy objectives of a sustainable agricultural sector that safeguards the rural landscape, conserves resources and adopts environmentally friendly production methods have been anchored into the Swiss constitution (Mann, 2003). Accordingly, in order to be eligible for general direct payments, Swiss farmers have to comply with a set of ecological standards (cross-compliance). In addition, several alternative ecological and animal welfare direct payments are available on a voluntary (compensated) basis.

A consequence of the high level of government protection and support is that Swiss farmers are less exposed to market price risk than their colleagues in neighboring countries and also makes them less vulnerable to climate volatility (Lehmann et al., 2013). Accordingly, Swiss agricultural gross revenues and household incomes are rather stable (El Benni et al., 2012). Regardless of the high level of income support, however, Swiss farmers do earn a lower income compared to other industries. For the 2010-2012 period, agricultural incomes reached between 41% (mountainous region) to 66% (plain region) of the comparable income earned in the industry or service sectors (Schmid and Roesch, 2013). Lips et al. (2013) show for Swiss dairy farms that farmer's family members earn double the on-farm income per full-time employee when they work off-farm. The income composition of Swiss farm households has also changed over the last years: between 2003/04 and 2010/10 the agricultural income was almost stable at CHF 57,500, yet at the same time the off-farm income increased by 34% reaching CHF 20,000 (Lips and Schmid, 2013). The question arises, however, whether this increased reliance on off-farm income involves a risk-reduction strategy.

6.3 Methodology

6.3.1 Survey analysis approach

Our first approach to empirically assess household risk balancing behavior consist of constructing a psychometric scale based on survey questions. Details regarding the survey design will be discussed in section 6.4.1 and in Appendix A2. In order to elicit a proxy for household risk balancing behavior, we asked the following set of nine questions in a questionnaire survey:

Q1: My partner and/or I would like to obtain an off-farm income

Q2: We cut private expenses when the farm has a financially rough time

Q3: Important farm investments are always discussed with the whole family (spouse, children) and their opinion weighs in on the final decision

Q4: I am reluctant to make farm business decisions that might jeopardize our family income

Q5: I do not distinguish between a private and business bank accounts

Q6: Sometimes money from our private account is used to repay farm business loans

Q7: In times of low farm income, private expenses are postponed

Q8: Off-farm income is essential for the farm household to make ends meet

Q9: Sometimes money from our private account is used to pay farm business bills

Farmers were asked to indicate their level of agreement with these statements, on a scale ranging from 1 (totally disagree) to 5 (totally agree). The psychometric household risk balancing scale was constructed using a formative scale, accordingly a change in the construct is not necessarily associated by an equivalent change in each sub-dimension of the construct (Podsakoff et al., 2003). Based on the theoretical model from Chapter 5, household risk balancing is defined as a behavior that is characterized by four sub-dimensions: (i) making decisions by the family as a whole, (ii) cutting private consumption in response to setbacks in business performance, (iii) the necessity of off-farm income and (iv) mixing personal and business bank accounts to cover expenses. The first three dimensions were measured using two items (respectively: Q3 and Q4; Q2 and Q7; Q1 and Q8), the latter using three items (Q5, Q6 and Q9). Each of these subscales were considered reflective measurement scales, meaning that the items are manifestations of the underlying construct and a change in the construct is believed to cause a change in all items of the measurement scale (Edwards and Bagozzi, 2000). The reliability of each separate dimension (*i.e.*, whether they measure the same concept) was assessed with confirmatory factor analysis using maximum likelihood and varimax rotation and validated using Cronbach alpha values. The values of each sub-dimension were calculated as the mean of the individual item scores. Because each dimension was considered equally important in defining the overall household risk balancing construct, the composite index was calculated as the mean of all sub-dimensions.

To investigate the differences in our household risk balancing behavior scale, we estimate a simple cross-sectional linear regression model:

$$HHRB_i = \alpha + \beta X_i + \varepsilon_i \qquad (6.1)$$

where *i* indexes farms, *HHRB* represents our household risk balancing scale, *X* is a set of off-farm, farm operator and farm related covariates, *α* represents the intercept, *β* is a vector of coefficients to be estimated and *ε* is the idiosyncratic error term. Model 6.1 can be readily estimated using OLS.

6.3.2 Econometric model specification

Our second approach to evaluate household risk balancing behavior is based on estimating an econometric model using observed farm and off-farm data from the Swiss FADN dataset. Risk balancing behavior entails strategic decisions in response to exogenous changes in the expected level of business risk. The original Gabriel and Baker (1980) risk balancing framework focusses solely on financial responses (*i.e.*, changes in the level of debt), whereas the extended household risk balancing framework goes beyond the original framework by also considering strategic off-farm responses. These responses include changes in off-farm income, consumption levels, off-farm investments or liquidity buffers that determine the level of off-farm risk. Given the unavailability of data for the latter two responses in the Swiss FADN dataset, we will focus on off-farm income and consumption. We further assume that farmers form their expectations of future business risk based on past exposure to business risk (Hardaker et al., 2004: 62).

Our overall regression rationale to analyze household risk balancing is thus regressing changes in past levels of business risk on three strategic decisions made by the farm household: (i) the level of financial risk, (ii) the amount of off-farm income earned and (iii) farm household consumption. We expect to find a negative relationship for financial risk in line with the original risk balancing hypothesis (increased expected business risk results in lowered financial risk). Consistent with household risk balancing, we would expect farm households to lower off-farm risk in response to an increase in expected business risk by acquiring more off-farm income (positive relationship) and smoothing consumption levels (negative relationship). We further control for several additional risk balancing, farm(er) and household related characteristics based on literature. The definitions and expected signs of these regressors will be discussed in section 6.4.2.

First, we look at the original risk balancing hypothesis and estimate the following two-way fixed effects model (analogous to Chapter 3 of this dissertation):

$$FR_{i,t} = \beta_{BR}(BR)_{i,t-1} + \beta x_{i,t} + \mu_i + \lambda_t + \varepsilon_{i,t} \tag{6.2}$$

where *i* and *t* are indexing farm and year, *FR* represents our dependent variable financial risk, *BR* characterizes our main variable of interest business risk and its β_{BR} associated coefficient, β represents the coefficient vector of the explanatory variables x elaborated above and μ, λ and ε symbolize the farm-specific, year-specific and idiosyncratic error terms respectively. By estimating a fixed effects regression model, we make use of the panel structure of our dataset to account for unobserved heterogeneity that varies across farms but does not change over time and vice versa. Note that due to using lagged values of business risk (to represent expectations) it is considered purely exogenous.

Next, we look at household risk balancing by considering the three following equations that reflect strategic responses to exogenous changes in business risk:

$$FR_{i,t} = \beta_{BR,1}(BR)_{i,t-1} + \beta_1 X_{i,t,1} + \mu_{i,1} + \lambda_{t,1} + \varepsilon_{i,t,1} \tag{6.3}$$

$$OFI_{i,t} = \beta_{BR,2}(BR)_{i,t-1} + \beta_2 X_{i,t,2} + \mu_{i,2} + \lambda_{t,2} + \varepsilon_{i,t,2} \tag{6.4}$$

$$CONS_{i,t} = \beta_{BR,3}(BR)_{i,t-1} + \beta_3 X_{i,t,3} + \mu_{i,3} + \lambda_{t,3} + \varepsilon_{i,t,3} \tag{6.5}$$

where *OFI* and *CONS* represent our dependent variables off-farm income and consumption, all other symbols are defined as before and the subscripts 1, 2 and 3 are introduced to refer to the financial risk, off-farm income and consumption equations respectively.

Although these three equations can be estimated separately and consistently by OLS, there are gains in efficiency (*i.e.*, lower standard errors) to be obtained if they are estimated jointly using SUR—seemingly unrelated regressions (Zellner, 1962)—or 3SLS–three stage least squares (Zellner and Theil, 1962)—methods. Additionally, these methods allow for testing of cross-equation restrictions. The

SUR model corrects for contemporaneous correlation of the error terms, while in the case of 3SLS the dependent variables also appears as endogenous regressors in the other equations. As our three equations represent decisions made by the same entity (the farm household), they cannot be considered autonomous and hence 3SLS estimates would not make sense and SUR is the most appropriate system estimation methodology (Wooldridge, 2010: 239). Indeed, the *ceteris paribus* parameter estimates of business risk in a three-equation system modeling one strategic decision in terms of the others and vice versa would have no sensible economic meaning. Household risk balancing prescribes that a farm household simultaneously changes financial risk, off-farm income and consumption levels, hence we have no reason to hold any of the other responses fixed. Given the preceding arguments, we will estimate equations 6.2 to 6.4 in a system of seemingly unrelated regressions (SUR) which captures the efficiency by modeling the correlation of the disturbances across equations. We account for the panel structure of the dataset by manually applying a within transformation to the data (*i.e.,* subtracting the within-farm mean from each variable).

One potential problem when following a SUR approach is the presence of heteroskedasticity, which leads to inconsistent estimates. Therefore, we will also estimate our system of equations using what Wooldridge (2010: 219) calls the 'GMM 3SLS' estimator that extends the traditional 3SLS system estimator by taking heteroskedasticity into account using an optimal weight matrix. Furthermore, the estimator allows different instruments for different equations to be specified. As all the regressors in our model are exogenous, we specify the equation-specific regressors X_1, X_2 and X_3 as instruments, hence reducing the 3SLS estimator to the SUR estimator.

Note that the relationships expressed by equations 6.3, 6.4 and 6.5 are static models that assume that adjustments are made in the short run. However, adjustments to the financial risk position or to off-farm income streams are not necessarily made in the short run and consumption could be smoothed over longer periods of time. Capturing these effects would require a dynamic model formulation of this system of three equations where lagged dependent variables are included on the right hand side of the equations. To the best of our knowledge, however, a dynamic panel estimator (e.g. difference GMM or system GMM) allowing the simultaneous estimation of three equations does not exist. Therefore, in order to make use of a system estimator (to gain efficiency and test cross-equation restrictions) we focus on a static formulation ignoring potential dynamic or long run effects.

6.4 Data and descriptive statistics

6.4.1 Survey analysis approach

First, we make use of survey data from an extended 2013 questionnaire survey that was aimed at understanding the risk perception, attitudes towards risk and perceived effectiveness of alternative risk management strategies of Flemish farmers (n = 614). Details regarding survey design and data collection can be found in Appendix A2. The respondents were the farmers from the Flemish regional version of the FADN dataset which is collected and analyzed by the Flemish government (De Becker, 2007). This connection allows us to complement the information from our 2013 survey with farm and farm operator related variables of the 2012 FADN sample (2013 data was not yet available at the time this study was conducted) to estimate model 6.1 from section 6.3.1.

The construction of the dependent variable *household risk balancing* was previously discussed in section 6.3.1. A set of off-farm, farm operator and farm characteristics was selected as independent variables to investigate differences in household risk balancing behavior.

Off-farm activity is a dummy variable from the FADN dataset indicating whether the farm operator or his/her spouse spend time on an off-farm activity for at least one day per week. As information regarding *off-farm income* is not present in the Flemish FADN dataset, farmers were asked to indicate the percentage of total household income that is gained from off-farm sources. Another survey question inquired how variable total household income was over the past five years, which was termed *total household risk*. To distinguish smaller family farms from larger commercial farms, we constructed the dummy variable *employees* that takes the value of one when a farm has paid employees.

To characterize the risk attitude of the farm operator, we constructed a psychometric *risk aversion* scale based on nine survey questions. Detailed information regarding its construction can be found in the Appendix A2. *Age* is the age of the farm operator as reported in the 2013 survey. Two educational categorical dummies indicate the *education type* (none = reference level, agricultural, non-agricultural) and *educational level* (middle school or none = reference level, high school, undergraduate, graduate or other) of the farm operator as indicated in the FADN dataset.

To characterize the financial situation of the farm, the rate of return on assets (*ROA*), the share of subsidies received in total revenue (*subsidy ratio*) and solvability (*debt/assets*) were calculated from the FADN data. *Partnership* is a dummy variable indicating the legal status of the farm and takes the value of one when the farm business is organized in a formal partnership. We further account for differences in *farm typology* based on the 8 broad farming types defined in the FADN dataset. Farm cycle is a categorical survey variable indicating whether a farm is (i) starting out, (ii) established and growing, (iii) established and stable (reference level), (iv) preparing a takeover or (v) is winding down for retirement. Size class is a categorical dummy distinguishing small, medium and large farms based on standard output (a criterion of the economic size of a holding).

The final sample of farms available for analysis—*i.e.*, that does not have missing values for any of the variables elaborated above—consists of 441 observations, which is 72% of all surveyed farmers. Summary statistics of the variables used in the survey approach of this chapter can be found below in Table 6.1.

Table 6.1 Summary statistics for the Flemish FADN dataset complemented with survey data

Variable	Mean	Stdev.	Unit
Dependent variable			
Household risk balancing	3.36	0.65	Scale
Off-farm elements			
Off-farm activity operator[a]	0.07	0.26	Dummy
Off-farm activity spouse[a]	0.29	0.46	Dummy
Off-farm income	0.22	0.24	%
Total household risk	3.58	1.13	Scale
Employees[a]	0.34	0.48	FTE
Farmer related			
Risk aversion	3.22	0.59	Scale
Age	48.54	8.39	Years
Education type[a]			Categorical
None	0.00		
Agricultural	0.61		
Non-agricultural	0.38		
Educational level[a]			Categorical
Middle school or none	0.02		
High school	0.82		
Undergraduate	0.12		
Graduate	0.03		
Other	0.01		
Farm related			
ROA[a]	0.15	0.13	%
Subsidy ratio[a]	0.07	0.06	%
Debt/Assets[a]	0.28	0.22	%
Partnership[a]	0.16	0.36	Dummy
Farm typology			Categorical
Specialist field crops	0.09		
Specialist horticulture	0.17		
Specialist permanent crops	0.09		
Specialist grazing livestock	0.28		
Specialist granivore	0.17		
Mixed cropping	0.02		
Mixed livestock	0.09		
Mixed crops-livestock	0.10		
Farm cycle			Categorical
Starting out	0.02		
Established and growing	0.27		
Established and stable	0.60		
Preparing takeover	0.03		
Winding down for retirement	0.07		
Size Class			Categorical
Small	0.26		
Medium	0.36		
Large	0.39		

Notes: [a] Data from the 2012 FADN dataset, all other variables were collected in a 2013 survey; N = 441

6.4.2 Econometric approach

Our econometric approach makes use of the Swiss farm accountancy data network (FADN) dataset, which is collected and analyzed by Agroscope Reckenholz–Tänikon Research Station ART (Schmid and Roesch, 2013). The comprehensive database includes detailed information based on cost accounting and covers 10 years from 2003 to 2012. An unbalanced panel dataset is compiled from this source by selecting those farms that (i) do not have missing values for the key variables needed for estimation (ii) are present in the dataset at least four consecutive years (to calculate the lagged value of business risk, which in turn is calculated over 3 years), (iii) have a positive farm income (given the problematic calculation of the coefficient of variation of negative values) and (iv) do not present outlying values. The following observations were considered as outliers: financial risk measures greater than one, implausible consumption levels (*i.e.*, negative or extravagant (for 2 observations 10-fold higher compared to the previous period)), negative values of interest paid or ROA and extreme level of farm income (for 1 observation 10-fold higher compared to the previous period). Our final regression sample contains 12,827 observations (41% of the original data) covering 3,184 farms (55% of the original farms), 23.4% of which are present the entire period.

The three main dependent variables in the econometric analysis of this chapter are financial risk, off-farm income and consumption. In line with Gabriel and Baker (1980), *Financial risk* is measured as the ratio of interest paid over farm income. Farm income represents the remuneration of family owned capital, labor and land and is calculated by subtracting intermediate costs, depreciation, wages paid, rent paid for land and interest paid from gross revenue including subsidies and taxes. Financial risk reflects the level of risk chosen by the farm household, *i.e.,* when the share of income spent on interest payments is high, farm households choose to have more financial risk as the margin to pay off their debt is lower and they are also more exposed to interest rate risk. *Off-farm income* comprises all income sources earned off-farm that are actively chosen by the farm household: wages earned by self-employment, wages earned by employment and income from investments. These income sources account for 60% of total reported off-farm income on average and exclude sources such as social transfers, pensions or inheritances that farm households do not actively choose themselves. *Consumption* measures the total monetary level of consumption of the family members living on the farm (it includes the categories insurance costs, car costs, housing costs, social contributions and other consumption including food expenditures).

Our main independent variable of interest, *business risk* (BR), is represented by the coefficient of variation of farm income before interest payments. We thus define risk in terms of the variability of outcomes and assume that farmers form their expectations of future business risk based on past levels of variation in income. Note that observed past level of variation only represent part of the potential risk that farmers faced. Furthermore, by taking risk management actions, they potentially reduced risk, creating an additional difference between potential and observed variation. The coefficient of variation is calculated over a moving 3-year window. The 3-year period was chosen because business risk measures calculated over 4-year and 5-year periods were highly correlated (80%) with the 3-year measure. Hence, in order to retain as much observations as possible (recall that our dataset is unbalanced), we only considered 3-year measures. For our descriptive results in section 6.5.2, we additionally calculated *total farm risk* (TR_f) as the 3-year coefficient of variation of farm income and total household risk (TR_h) as the 3-year coefficient of variation of household income, which is simply the sum of farm income and off-farm income.

The original risk balancing related independent variables are past values of the cost of debt, profitability and liquidity. The cost of debt is represented by the *interest percentage* paid on loans (interest paid over total outstanding debt). Profitability is measured by the rate of return on assets (ROA), calculated as the ratio of farm income over total assets. Liquidity is characterized by the monetary value of *current assets*. In our financial risk equation, we expect to find a negative relationship with past levels of profitability and a positive relationship with past levels of debt costs and liquidity (Gabriel and Baker, 1980).

The off-farm elements considered in this chapter are the existence of extra off-farm income, the units of consumption, the amount of children and the educational level of the farm operator.

OFI incomplete is a dummy variable indicating whether additional off-farm income earned by the farm household was not completely reported under off-farm income. This variable mainly acts as a control variable, it should clearly be positively related to off-farm income and consumption.

The amount of *consumption units* (UC) represents the standardized number of family members in the farm household. The householder accounts for one UC, other family members of 14 years or older account for 0.5 UC and 0.3 UC for children below the age of 14. Aside from an obvious positive influence on consumption, we would also expect a positive influence of household size on off-farm income as larger farm families can more easily share the on-farm work—making more time available for off-farm work—and potentially have some family members willing to fully work off-farm (Mishra and Goodwin, 1997; Goodwin and Mishra, 2004). The variable *children -16* additionally counts the number of children below the age of 16 that are part of the farm household. This variable captures the effect of having a higher composition of children in the household as we also control for the amount of UC. Accordingly, we expect a negative influence on off-farm income as children below the age of 16 are considered too young to work and a positive influence on consumption as having more children tends to increase the required household budget.

An educational dummy represents whether the farm operator has had some form of household-related or nonagricultural *education* (e.g. an apprenticeship, a professional training, a mastercraftship or training at a technical college or university) or is currently in education. Having a formal education increases the amount of off-farm jobs available and hence potentially increases the amount of off-farm income that can be earned (Woldehanna et al., 2000; Alasia et al., 2009).

The farm(er) related variables considered in this study are direct payments, farm size, land tenure, age, farm income, liquidity and equity.

In our financial risk model, *% Direct payments* represents the share of direct payments received in total gross revenue. This alternative formulation was chosen to prevent multicollinearity problems with farm size as direct payments are tied to farm area. This form of government support can be considered as a stable and thus low-risk income source. In that sense, they would allow farmers to increase debt usage in line with the original risk balancing hypothesis. In the off-farm income and consumption regression, *direct payments* simply represent the monetary amount of direct payments received. Previous research has suggested that government subsidies (coupled or decoupled) reduce off-farm labor participation (Serra et al., 2005; Ahearn et al., 2006). Therefore we would expect a negative influence of direct payments on off-farm income obtained in addition to a logical positive influence on consumption levels.

Farm size measures the total *area* of the farm used for production in hectares. Previous research has suggested a positive relationship with debt usage (see Chapter 3 of this dissertation) and negative with off-farm income (Fernandez-Cornejo, 2007; Alasia et al., 2009). Larger farms potentially have higher consumption levels due to economies of scale allowing for increased income per family member.

Land *tenure* represents the percentage of land under tenure of the farm household and is measured as the ratio of owned land over total farm size. As agricultural land prices are generally high in Switzerland (e.g. Giuliani and Rieder, 2003), we expect farm households who own a larger percentage of their land to have higher debt usage and would be motivated to gain more off-farm income.

Age is the age of the farm operator and age² was also included in our models to account for potential second-order effects. We expect younger farmers to have larger levels of financial risk, yet also that they prefer to decrease investments and pay off their debts as they become older. Accordingly, we expect a concave down function and hence a positive age and negative relationship age² coefficient. The relation with off-farm income is less clear to predict a-priori, however, as older farmers might have more difficulties finding an off-farm job (Goodwin and Mishra, 2004), but this potential decrease in hours worked off-farm might be compensated by increased hours worked on-farm and therefore complemented with off-farm income gained by the other household members.

We anticipate that farm households with low amounts of *farm income* compensate by gaining more off-farm income (and vice-versa) and that getting more farm income has a positive influence on consumption levels.

To take the typical consumption-saving tradeoff into account, we include the monetary amount of current assets as a proxy for savings in absence of more detailed information regarding the savings behavior of the farm households (assuming that part of the yearly amount saved ends up under current assets in the balance sheet as cash on a checking or savings account).

Finally, we include equity as a proxy measure to take differences regarding household wealth into account. *Equity* represents the monetary amount of assets owned privately by the farm household (note that no clear distinction is made in the dataset between farm equity and farm household equity) and is expected to have a positive influence on consumption levels.

Note that all monetary variables are deflated using the CPI constructed by the Swiss Federal Statistical Office (available online at http://www.bfs.admin.ch). Summary statistics of the variables used in the econometric approach can be found in Table 6.2.

Table 6.2 Summary statistics for the Swiss FADN dataset

Variable	Mean	Std. Dev.	Unit
Dependent variables			
Financial risk (FR)	0.13	0.15	Ratio
Off-farm income (OFI)	1.42	2.26	10^4 CHF
Consumption (CONS)	7.34	2.64	10^4 CHF
Risk balancing			
Business risk (BR)	0.21	0.15	Coefficient of variation
Interest%	1.93	2.18	%
Return on Assets (ROA)	0.09	0.07	Ratio
Current Assets	1.22	0.93	10^5 CHF
Off-farm elements			
OFI Incomplete	0.25	0.43	Dummy
Consumption Units (UC)	3.52	1.46	UC
Children -16	1.05	1.35	Children
Education	0.10	0.30	Dummy
Farm(er) related			
Direct Payments	6.06	2.76	10^4 CHF
% Direct Payments	0.26	0.13	Ratio
Area	25.61	12.83	Ha
Tenure	0.64	0.28	Ratio
Age	48.21	8.37	Years
Farm Income	6.91	4.03	10^4 CHF
Equity	5.33	3.51	10^5 CHF

Notes: All monetary values deflated to 2012 values using the Swiss Federal Statistical Office CPI (http://www.bfs.admin.ch), N = 12,827

6.5 Results and discussion

6.5.1 Survey evidence on household risk balancing behavior

First, using confirmatory factor analysis, we find that the reflective measurement scales for the four household risk balancing sub-dimensions show adequate reliability. Taking decisions as a family, adjusting private expenses and adjusting off-farm income streams had 2 items each, with no items having a lower factor loading than 0.5. Mixing the private and business account had 3 items, all with factor loadings above 0.50. Second, the value of the sub-dimensions were calculated as the mean of all items for each sub-construct. Third, we calculated the composite household risk balancing construct as the average of each of these four sub-constructs. The mean value is 3.36 on a scale ranging from 1 (absolutely no household risk balancing behavior) to 5 (substantial household risk balancing behavior), suggesting that the average Flemish farm household exhibits household risk balancing behavior (Table 6.3). About two thirds of the sample (64%) has a value greater than the neutral level 3.

Table 6.3 Survey construct of household risk balancing behavior

(Sub-)Factor	Average (Std. Dev.)
Aggregate construct	3.36 (0.647)
Sub-dimensions	
Decisions in family	3.80 (0.781)
Delay/reduction in private spending	3.77 (0.923)
Mixing farm and private accounts	3.13 (1.174)
Necessity of non-farm income	2.73 (1.236)

Notes: N = 441

Table 6.4 presents the parameter estimates of model 6.1 that investigates the differences in the household risk balancing behavior scale from Table 6.3. There is no indication of multicollinearity problems in the data (variance inflation factors (VIF) of all regressors are between 1 and 2), nor is heteroskedasticity present (insignificant Breusch-Pagan/Cook-Weisberg heteroskedasticity test at $\alpha = 0.01$).

We find that farm operators that have an off-farm activity for at least one day per week and farm household where a larger proportion of total household income is earned off-farm, score greater on our household risk balancing scale; a sensible result as pursuing off-farm activities is part of our scale construction. Interestingly, farm households that indicate to have experienced high volatility in their household income over the past five years have greater household risk balancing scores. This finding suggests that for those families, households risk balancing could be a viable risk management option. We do not find a significant difference in household risk balancing behavior between small scale family farms versus larger scale commercial holdings.

Table 6.4 Parameter estimates for the determinants of the household risk balancing decisions made by Flemish farm households in 2013

Variable	Coefficient	(SE)
Off-farm aspects		
Off-farm activity operator[a]	0.2405**	(0.1049)
Off-farm activity spouse[a]	0.0549	(0.0642)
Off-farm income	0.5810***	(0.1283)
Total household risk	0.1718***	(0.0238)
Employees[a]	0.0231	(0.0737)
Farm operator		
Risk aversion	0.3365***	(0.0466)
Age	0.0038	(0.0040)
Education type[a]		
Agricultural	-0.5741	(0.5867)
Non-agricultural	-0.5270	(0.5855)
Educational level[a]		
High school	0.0551	(0.2270)
Undergraduate	-0.0069	(0.2401)
Graduate	-0.0936	(0.2668)
Other	-0.2645	(0.3281)
Farm		
ROA[a]	-0.5141**	(0.2396)
Subsidy ratio[a]	0.4802	(0.6816)
Debt/Assets[a]	0.3046**	(0.1410)
Partnership[a]	0.0390	(0.0737)
Farm typology		
Specialist field crops	-0.1731	(0.1072)
Specialist horticulture	-0.1193	(0.1149)
Specialist permanent crops	0.0224	(0.1438)
Specialist granivore	-0.0564	(0.1044)
Mixed cropping	-0.0302	(0.2136)
Mixed livestock	-0.0767	(0.1086)
Mixed crops-livestock	0.0318	(0.0972)
Farm cycle		
Starting out	-0.0278	(0.1899)
Established and growing	0.0593	(0.0659)
Preparing takeover	-0.0184	(0.1471)
Winging down for retirement	0.0714	(0.1080)
Size Class		
Small	0.0061	(0.0725)
Large	-0.0179	(0.0677)
Constant	1.7802***	(0.6091)
F	7.9***	
R^2 adjusted	0.3230	

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$; reference levels for the categorical variables are specialist grazing livestock, established and stable and medium respectively; N = 441

In the group of farm operator related variables, we find that more risk averse operators exhibit significantly greater household risk balancing behavior. This finding corroborates with our conclusions from Chapter 3 that farm-level risk balancing behavior is driven by the risk averse proportion of farmers.

We observe that less profitable and more leveraged farms—as measured by the rate of return on assets and the debt over assets ratio—perform more household risk balancing. Having low profitability and high levels of financial risk leads to higher farm-level risk. Our finding is thus in line with theory that in this case we would expect (more) household risk balancing behavior to buffer the elevated farm-level risk. Finally, we do not find any significant differences with regard to the farm's legal structure, typology, farm cycle or size class.

6.5.2 Risk exposure in Swiss agriculture over time, region and farm typology

Figure 6.1 presents the volatility of the average levels of total farm risk, business risk and total household risk over the period 2005–2012. The general risk exposure—as measured by coefficients of variation between 0.20 and 0.25—in Swiss agriculture is low compared to other countries. Chapter 3 of this dissertation reports the EU-15 average farm-level business risk at 0.33 (1995–2008), while Poon and Weersink (2011) report average levels of total farm risk of as high as 3.8 for Canada (2001–2006). Overall, there is little year-to-year variation in the average levels of risk, barring a small surge in the year 2010. The later can be explained by recalling that we calculate risk over three-year periods, hence the 2010 risk measure spans the years 2008–2010, a period characterized by elevated prices for arable crops and milk, followed by a marked drop (Schmid and Roesch, 2013). The difference between business risk and total farm risk represents financial risk and the difference between total farm risk and total household risk represents off-farm risk. Whereas financial risk increases total farm risk relative to business by definition, off-farm risk can either stabilize or increase total household risk compared to total farm risk. On average, the relationship is a stabilizing one (average total household risk is lower than total farm risk), yet for 24% of the observations household-level risk is higher than farm-level risk.

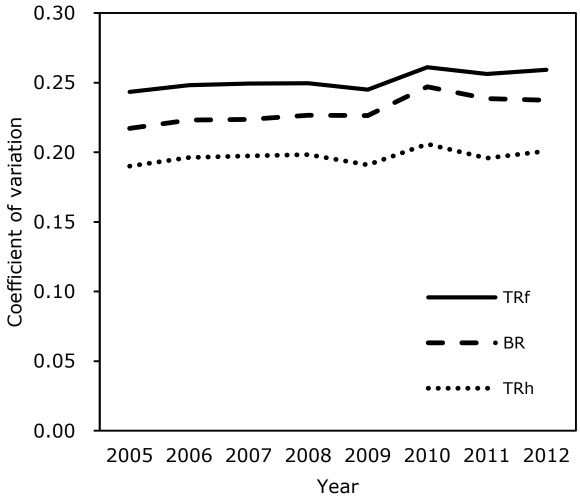

Figure 6.1 Comparison over time of average total risk at the farm level (TR_f), business risk (BR) and total risk at the household level (TR_h)

Table 6.5 compares the same risk measures from Figure 6.1 over farm typology and across the three distinct production regions in Switzerland. Four typologies were considered; dairy farms as these constitute the predominant farm type in Switzerland, and three general classes: mixed farms, crop based and animal based farms (other than dairy). We observe that the crop and animal based production types have above average levels of risk. A closer inspection of the data revealed that this is mainly accounted for by arable farms and pig farms, which are particularly susceptible to production risk (weather influences) and price risk (the hog cycle), respectively. Conversely, dairy farms have below average risk levels, which could be attributed to relatively stable milk prices—compared to the price volatility for crops and pork—and a higher share of direct payments. Differences across the production regions are less pronounced. One noticeable result is that the valley region has above average risk levels, as this is the region with most arable and pig farms and furthermore the share of direct payments in the farm's turnover increases with the altitude.

Table 6.5 Comparison over farm typology and region of average total risk at the farm level (TR_f), business risk (BR) and total risk at the household level (TR_h)

	TR_f	BR	TR_h	N
Farm Type				
Dairy	0.217	0.193	0.168	5,109
Mixed	0.247	0.221	0.199	5,008
Crops	0.268	0.234	0.190	1,784
Animals	0.253	0.234	0.200	926
Region				
Valley	0.244	0.219	0.199	5,639
Hill	0.232	0.205	0.178	3,985
Mountain	0.237	0.210	0.171	3,203
Total	0.239	0.213	0.185	12,827

Notes: The Swiss FADN distinguishes 11 types of farms (Hoop and Schmid, 2013). These types were classified as follows: dairy (21), mixed (51 to 54), crops (11 and 12) and animal (22, 23, 31 and 41)

6.5.3 Econometric evidence on farm-level and household-level risk balancing behavior

Table 6.6 presents the parameter estimates of our fixed effects (FE), seemingly unrelated regression (SUR) and generalized method of moments (GMM) models. All econometric models were estimated using the statistical package Stata (StataCorp, 2011). There is no indication of multicollinearity problems in the data, the variance inflation factors (VIF) of all regressors are between 1 and 2. We have reason to assume heteroskedasticity is present, as a modified Wald test for groupwise heteroskedasticity in fixed effects models (Greene, 2003: 598) for each individual equation indicated the presence of farm-specific error variances (α = 1%). We therefore clustered our standard errors by farm in the FE model and will compare our SUR model results with the heteroskedasticity robust GMM model results.

Table 6.6 Parameter estimates for the determinants of the financial risk (FR), off-farm income (OFI) and consumption (CONS) decisions made by Swiss farm households for the period 2006–2012 using fixed effects (FE), seemingly unrelated regression (SUR) and generalized method of moments (GMM) models

	FE	SUR			GMM		
	FR	FR	OFI	CONS	FR	OFI	CONS
Risk balancing							
BR_{t-1}	-0.0131	-0.0133**	0.2184***	-0.2107**	-0.0130	0.2191***	-0.2083**
	(0.0103)	(0.0061)	(0.0674)	(0.0913)	(0.0085)	(0.0689)	(0.0991)
Interest% $_{t-1}$	-0.0314	-0.0003			-0.0003		
	(0.0231)	(0.0004)			(0.0002)		
ROA $_{t-1}$	-0.1897***	-0.1964***			-0.1897***		
	(0.0307)	(0.0242)			(0.0247)		
Current Assets $_{t-1}$	0.0060*	0.0055***			0.0060**		
	(0.0031)	(0.0017)			(0.0024)		
Off-farm elements							
OFI Incomplete			0.2161**	0.2294*		0.2159***	0.2236**
			(0.0885)	(0.1198)		(0.0816)	(0.1015)
UC			0.0143	0.1720***		0.0143	0.1725***
			(0.0152)	(0.0205)		(0.0135)	(0.0230)
Children -16			-0.0719***	0.0494**		-0.0718***	0.0502**
			(0.0162)	(0.0219)		(0.0194)	(0.0228)
Education			-0.1087			-0.1277	
			(0.1201)			(0.1236)	
Farm(er) related							
% Direct Paym.	0.5055***	0.5128***			0.5055***		
	(0.0435)	(0.0252)			(0.0336)		
Area	-0.0012**	-0.0012***			-0.0012**		
	(0.0006)	(0.0004)			(0.0005)		
Tenure	0.1305***	0.1303***	0.1882	0.2035	0.1305***	0.1876	0.1937
	(0.0211)	(0.0137)	(0.1491)	(0.2020)	(0.0160)	(0.1249)	(0.2314)
Age	0.0056*	0.0055**	0.1161***	0.2262***	0.0056**	0.1161***	0.2272***
	(0.0034)	(0.0024)	(0.0278)	(0.0376)	(0.0025)	(0.0312)	(0.0445)
Age²	-0.0001	-0.0001**	-0.0013***	-0.0023***	-0.0001**	-0.0013***	-0.0024***
	(0.0000)	(0.0000)	(0.0003)	(0.0004)	(0.0000)	(0.0003)	(0.0004)
Direct Payments			-0.0623***	0.0673***		-0.0625***	0.0657***
			(0.0133)	(0.0180)		(0.0158)	(0.0236)
Farm Income			-0.0268***	0.0874***		-0.0275***	0.0818***
			(0.0040)	(0.0054)		(0.0051)	(0.0088)
Current Assets			0.1083***	-0.0708***		0.1083***	-0.0710*
			(0.0185)	(0.0250)		(0.0284)	(0.0417)
Equity			0.0082	0.0183		0.0081	0.0179
			(0.0099)	(0.0134)		(0.0148)	(0.0190)
Constant	-0.1643*						
	(0.0921)						
F test statistic	19.3***						
R² within	0.0489						
Chi² test statistic		674***	398***	548***			
R²		0.0489	0.0303	0.0383			
Wald test BR_{t-1}= 0			χ²(3) = 21.46***			χ²(3) = 18.2***	

Notes: Year dummies were included in each model but not reported for brevity, Standard errors in parentheses (clustered by farm for the FE model and robust for the GMM model), * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$, N = 12,827

The first column in Table 6.6 presents the results of our original risk balancing FE regression model based on equation 6.2. We find no significant evidence that *ceteris paribus* Swiss farmers made strategic changes in financial risk in response to changes in expected business risk. A potential explanation for this finding is that interest rates have been low and stable in Switzerland over the period under consideration (1.93% on average, Table 6.2). Debt was therefore easily available to Swiss farmers and hence the decision to change the level of financial risk was less driven by changes in business risk as it was not constrained. In line with our expectations from section 6.4.2, we find a negative relationship with past levels of profitability and a positive relationship with the share of direct payments, land tenure and past levels of liquidity. For area we find a significant negative yet small effect, where we would have expected a positive relationship as larger farmers generally have more access to credit. This suggests that the larger farms in terms of area in our sample are potentially less capital-intensive and hence have lower debt requirements.[35] For age, we find the expected signs for the coefficients that indicate a concave down function, yet the coefficients are low and only significant at 10%.

The second column in Table 6.6 presents the results of our SUR regression models from equation 6.3 to 6.5. The correlation coefficients between the regression errors are low (0.0036, 0.0223 and 0.0702), yet the Breusch-Pagan Lagrange Multiplier test of independence rejects the H_0 that the disturbance covariance matrix is diagonal ($\chi^2(3) = 69.8^{***}$). Hence, our three equations cannot be considered independent and our SUR approach is appropriate as opposed to single equation estimation. Estimating the three equations in a system of regressions on the one hand offers us a gain in efficiency (accordingly, we observe smaller standard errors in the FR equation compared to the estimates of the FE model) and on the other hand allows us to test cross-equation restrictions. We find that expected business risk has a significant influence of the expected direction in each of the three equations and a joint Wald test furthermore confirms that the effect is also jointly significant ($\alpha = 0.01$) across the three equations. However, as we have indications of the presence of heteroskedasticity, we will not further discuss our SUR results and turn to our heteroskedasticity robust GMM estimation results.

The coefficient estimates of our GMM model—presented in the last column of Table 6.6—are nearly identical to the SUR model estimates (as they should be, the slight differences are due to the different estimation approach of the SUR and GMM methods) yet the standard errors differ as we now take heteroskedasticity into account. A joint Wald test indicates that expected business risk still has a significant ($\alpha = 0.01$) influence across all three equations. However, our GMM results now indicate that expected business risk does not significantly influence

[35] Larger farms in terms of area have more arable land and usually less animals; making them less capital intensive compared to their smaller counterparts (in terms of area).

financial risk decisions. We do find a significant positive influence on the level of off-farm income attained and a negative influence on consumption levels. The effects are small, however, as the model coefficients suggest that for an increase of 0.10 in expected business risk (a change of one within standard deviation), *ceteris paribus*, off-farm income increases with CHF 219 and consumption decreases with CHF 208.

Although the other explanatory variables in our model are mainly added as control variables and are of secondary interest, we will briefly discuss their role in explaining changes in the dependent variables. In the financial risk equation, we obtain the same coefficients for the additional control variables compared to the FE model and hence will not further discuss them.

In the off-farm income equation we find that having a greater proportion of children (below the age of 16) in the household decreases off-farm income as hypothesized. In the category of farm(er) related control variables, we observe that farm households that have an older farm operator and that have more liquid assets have greater levels of off-farm income. Conversely, farms receiving more direct payments and that have greater levels of farm income attract lower levels of off-farm income, which is in line with literature (Serra et al., 2005; Ahearn et al., 2006).

Consumption levels are evidently greater in larger farm families and when the proportion of children below the age of 16 is higher. The farm operator's age, the level of farm income earned and the amount of direct payments received are furthermore found to have a positive impact on changes in consumption.

As a robustness check, the GMM model was rerun for each of the three distinct production regions in Switzerland—valley, hill and mountain—to check whether our results differ between regions. These extra models yielded highly similar results, *i.e.*, coefficients with identical signs and of the same order of magnitude and hence are not reported for brevity. Our main variable of interest, business risk, was only significant in the valley-specific models, however, which most likely pertains to differences in sample size (see Table 6.5).

6.6 Conclusions

Farm households have several off-farm buffering strategies at their disposal that allow them to influence the variation in total household income, such as earning off-farm income, smoothing consumption levels, seeking off-farm investments or maintaining liquidity buffers. In this light, household risk balancing behavior refers to strategic changes in household buffering in response to exogenous changes in the expected business risk of the farm. This household-level behavior complements original risk balancing behavior which comprises strategic changes in farm-level financial risk in response to the same exogenous changes in business risk (Gabriel and Baker, 1980).

The main objective of this chapter is presenting the first empirical evidence on farm household risk balancing behavior using two methodological approaches. Firstly, we use Flemish FADN data complemented with survey data to construct a psychometric household risk balancing scale and explore what determines the differences in scores for different farm households. We find that the average Flemish farm household tends to exhibit household risk balancing behavior based on four underlying factors: (i) making decisions by the family as a whole, (ii) cutting private consumption in response to setbacks in business performance, (iii) mixing personal and business bank accounts to cover expenses and (iv) the necessity of off-farm income. Factors driving differences in household risk balancing behavior are found to be off-farm activity of the farm operator, the level of household income risk, the percentage of household income gained from off-farm sources, the farm operator's level of risk aversion and the farm's profitability and solvability. Secondly, we use Swiss FADN data to estimate a fixed effects seemingly unrelated regression (SUR) model to analyze how farm households jointly alter their levels of financial risk, off-farm income and consumption. The evidence supports the notion that farm households make strategic farm and off-farm decisions in response to the exogenous changes in expected business risk. The econometric model coefficients suggest that for an increase of 0.10 in expected business risk (a change of one within standard deviation), *ceteris paribus*, off-farm income increases with CHF 219 and consumption decreases with CHF 208.

The results of our empirical study demonstrate that when focusing solely on farm-level analyses, an interesting part of the behavioral risk response of farm households is largely ignored. As important farm household responses are not revealed, the full impact of risk-related policies in the EU (e.g. price stabilization, subsidized insurance schemes, direct payments) cannot be assessed. Therefore, a farm household approach to policy analysis is of great importance (Offutt, 2002), and calls for a broadening of the agricultural statistics collection with household income data (Hill, 2002).

Future research could analyze household risk balancing behavior econometrically in those member states of the EU that collect reliable information on off-farm aspects (e.g. The Netherlands, Vrolijk et al., 2009). It would be valuable to compare results across countries as there surely are marked differences in off-farm opportunities, risk exposure and the level of government support. Our descriptive results indicate that for most farms, off-farm elements stabilize total household risk by buffering the variation in farm income. However, household risk balancing could potentially work in dual directions (analogous to Chapter 4 of this dissertation) as for one quarter of our observations the variation of total household income was greater than the variation in farm income. Future research could therefore look deeper into the incidence of both directions.

Chapter 7

Conclusions and perspectives

7.1 General synopsis

The main problem statement of this dissertation is that a good understanding of farmers' risk behavior is essential in order to anticipate risk-related policy outcomes and to uncover unexpected behavioral responses. Risk balancing behavior was presented as one potential unanticipated response as it involves making strategic financial adjustments in response to exogenous shocks in the level of business risk. The literature review in Chapter 2 disclosed that European evidence on risk balancing behavior was lacking to date, leaving EU-policy makers partly in the dark with regards to the impact of risk-altering policy measures of the CAP. It was further argued that the possibility of the simultaneous adoption and potential correlation between different on-farm and off-farm responses also needs to be acknowledged when looking at risk balancing behavior. The central research objective of this dissertation is therefore to examine risk balancing behavior in European agriculture and acknowledging the role of the farm household.

The remainder of this chapter will present the empirically-oriented and methodological conclusions and perspectives of each of the proposed sub-objectives of this dissertation. These conclusions will unite the relevant findings across each dissertation chapter. The perspectives will present the implications for farm management, farm extension and policy makers and outline suggestions for further research to the academic literature. Then, a general conclusion will be formulated and the last section will critically discuss the limitations to the dissertation's work.

7.2 Empirical conclusions and perspectives

The first set of objectives of this dissertation focus on empirical aspects that provide conclusions and perspectives that are mainly of interest to farm management, farm extension and EU policy makers.

7.2.1 Providing empirical European evidence on risk balancing behavior

Using the rich EU-15 FADN dataset for the period 1995–2008, overall I found evidence on risk balancing behavior in Chapter 3. A basic correlation relationship analysis pointed out that just over half of the farm observations (54%) are compatible with risk balancing. Taking the size of the correlation coefficient as an indicator of the strength of the balancing behavior, I found that when risk balancing behavior does occur, the effect is strong with an average correlation coefficient of -0.50. Controlling for other determinants of financial risk and removing fixed effects in a regression analysis further provided on-average evidence in favor of risk balancing behavior of European farmers. The short-run coefficient estimate of our static model suggests that a 10% increase in business risk reduces financial risk by 0.43% and the long-run coefficient in the dynamic specification suggests a decrease of 2.1% in the long run. The results rejected evidence of strong-form risk balancing (inverse trade-offs between financial risk and business risk keeping total risk constant) but could not reject weak-form risk balancing (inverse trade-offs between financial risk and business risk with some observed changes in total risk).

The corroboration of risk balancing behavior could be of interest to farm management and extension services as the mechanism allows for balanced business growth. Being aware of and taking risk balancing behavior into account improves farm management support for European farmers by selecting an optimal capital structure. In the context of limited resource farmers in developing economies, Shee and Turvey (2012) describe how risk-contingent loans can be designed to balance business and financial risk. They conclude that growth achieved by balanced business and financial risk could potentially aid farm households to exit a poverty trap.

It would be interesting to look deeper into the differences between these European results and the previous findings from the USA as both regions differ in their financial, policy and risk management environment. An important distinction between both regions is that US agricultural policy (based on farm bills) focuses more on safety nets, countercyclical payments and subsidized insurance schemes, whereas the common agricultural policy (CAP) of the EU mainly uses fixed decoupled payments (single farm payments). This distinction has an important impact on farmers' risk decision environment as much more market-based instruments or government risk management programs are adopted by US farmers. In the EU, the adoption is much lower and accordingly risk managing responsibility are more in the hands of the farm operator. Comparing empirical risk balancing results is not straightforward, however, as most studies in literature differ greatly with regards to variable definitions (e.g. defining financial risk as debt/assets versus interest paid/farm income), scope of the datasets (e.g. aggregate versus farm-level data) and methodologies used (e.g. simulation-optimization models versus a regression approach).

Given the evidence on risk balancing behavior, I advocate that policy models regarding decision making under uncertainty should account for risk balancing behavior. The broad field of decision making and optimization under uncertainty has known many recent advances (Krokhmal et al., 2011) and has several applications to agricultural systems with their specific modeling features (Mayer et al., 1998). Programming models have been widely adopted in agricultural finance and farm management (Turvey et al., 2005), modelling the agri-food supply chain (Ahumada and Villalobos, 2009) or modelling the impact of agricultural policy reforms on investment behavior (Heikkinen and Pietola, 2009; Viaggi et al., 2010). In spite of the technical accommodation of risk (or uncertainty) in these agricultural optimization models, they have not been given serious attention in supporting farm-level decision making (Musshoff and Hirschauer, 2007). Furthermore, the results of this dissertation propose that in order to adequately model farmers' responses to policy change, that not only risk should be appropriately taken into account (Arriaza and Gómez-Limón, 2003), but also the trade-offs between different types of risk.

7.2.2 Exploring differences in risk balancing across different countries and farm typologies

Combining several elaborate data sources in this dissertation allows me to compare the extent of risk balancing behavior across 16 different countries and 8 farm typologies, whereas previous studies have focused solely on one production type within one country.

The results from Chapter 3 and Chapter 4 demonstrated that some countries exhibit a much stronger risk balancing response than the EU-15 average (Germany, Ireland and the United Kingdom). Conversely, other countries displayed no significant response (Belgium, Greece, Italy, Luxemburg, Austria, Portugal, Switzerland, Finland and Sweden) but in none of these countries a positive significant coefficient was observed hence not providing evidence contradicting risk balancing behavior. Analogously, the response was found to differ to between farm typologies, with the 'dairy' and 'granivores' typologies having the greatest responses and no significant response for the 'horticulture' typology. Further research could look deeper into what drives the differences in response, such as country-specific capital market imperfections (e.g. influencing the ease of access to credit) or alternative policy environments and varying levels of EU support (CAP payments) or specialization for different farm typologies. The potential explanations for overall differences in risk balancing responses from Chapter 4 suggest that increased risk balancing behavior could be expected for countries/farm typologies that (i) have older farm operators, (ii) have coped with more total risk over the preceding years, (iii) have higher tenure ratios, (iv) have lower operating productivity, (v) have low leverage levels or (vi) are less profitable.

7.2.3 Determining the drivers of the extent and direction of risk balancing behavior

Risk balancing involves two distinct risk responses depending on the direction of the strategic financial adjustment. When a farmer lowers financial leverage in response to an increase in business risk, risk balancing entails a risk management strategy. Conversely, risk balancing behavior also involves an entrepreneurship strategy where a farmer increases leverage in response to lowered business risk conditions. To the best of my knowledge, no study before has explicitly focused on the occurrence of either strategy nor has their occurrence been empirically validated. Most studies tend to focus on either risk management (Escalante and Barry, 2001) or entrepreneurship (Featherstone et al., 1988) under the common denominator term of risk balancing.

Making use of correlation coefficients for the EU-15 FADN dataset, Chapter 4 presented a breakdown of the prerequisites and constituents of risk balancing behavior. Only half of the EU farmers had debt (52%, but this proportion differs greatly between member states) and hence could have made strategic capital structure adjustments; about half of them were classified as risk balancers. Risk balancing was mostly observed as a risk coping strategy for farmers (42%) and to a lesser extent as an unanticipated risk response (26%). The situation when in the latter case the financial risk response was greater than the business risk decline (and total risk increased), was called the 'Paradox of risk balancing' in literature (Featherstone et al., 1988). I observed rather low incidence figures for this potential paradoxical situation, only for 47% of the entrepreneurship risk balancers, which constitutes 12% of all risk balancers. By means of a multinomial Probit model, I further found that the determinants of a farmer's choice to adopt either of both risk balancing strategies had opposite effects. These results clearly put risk balancing into a broader perspective as each of both distinct risk balancing strategies has different policy implications.

Entrepreneurship risk balancing has an important policy dimension with regard to risk-reducing policies. In this case, the hypothesis prescribes unanticipated risk responses, *i.e.*, farmers increase financial risk and hence restore original total risk levels. Although the risk-reducing policy attains an entrepreneurship-stimulating goal, it is attained through increased financial risk, making it miss its risk-reducing objective. This notion is frequently cited as the rationale for risk balancing research and has spurred research into the risk balancing implications of specific risk-reducing government programs in the US such as federal crop insurance schemes (Skees, 1999; Ifft et al., 2013). The results from Chapter 4 show, however, that the paradox of risk balancing only concerns 12% of the risk balancing observations hence its importance for EU policy makers dwindles with regards to the risk management strategy.

As the majority of risk balancing behavior was attributed to risk management objectives, a more important focus for EU policy makers is looking at the interaction with other risk management instruments. Risk balancing—being an innate risk management strategy—could potentially crowd-out other available risk management instruments (OECD, 2009; 2011) as highly risk averse farmers prefer integrated, diverse risk management plans (Escalante and Barry, 2001). Hence, risk balancing might downplay the importance of alternative external (e.g. insurance) or internal (e.g. diversification) risk management strategies in the overall risk management plan. Such risk balancing interactions have already been revealed (Harwood et al., 1999) and analyzed (Escalante and Barry, 2001; 2003) for US agriculture. The analysis of Chapter 4, however, did not find any significant interactions for EU agriculture. As the data regarding the adoption of risk management strategies was limited in this dissertation, however, more research could be done collecting additional risk management data to explore the interactions with risk balancing more deeply.

7.2.4 Providing empirical evidence on household risk balancing behavior

Chapter 5 extended the original Gabriel and Baker (1980) risk balancing framework to the household level and presented extensive empirical evidence from previous literature regarding elements of the novel conceptual model. Chapter 6 then presented the first empirical evidence on Chapter 5's novel household risk balancing framework using two diverse empirical approaches.

First, complementing the Flemish regional FADN dataset with survey information, a psychometric household risk balancing scale was constructed. The results suggested that the average Flemish farm household exhibits household risk balancing behavior based on four underlying factors: (i) making decisions by the family as a whole, (ii) cutting private consumption in response to setbacks in business performance, (iii) mixing personal and business bank accounts to cover expenses and (iv) the necessity of off-farm income.

Second, an econometric model was estimated using the Swiss FADN dataset that analyzes a farm household's joint decision of the levels of debt, off-farm income and consumption. The evidence supported the notion that farm households make strategic farm and off-farm decisions in response to exogenous changes in expected business risk. The econometric model coefficients suggested that for an increase of 0.10 in expected business risk (a change of one within standard deviation), *ceteris paribus*, off-farm income increases with CHF 219 and consumption decreases with CHF 208. Both approaches demonstrated that part of the behavioral risk response of farm households is ignored when focusing solely on the farm-level in the original risk balancing framework and thus illustrate the relevance of the extended household risk balancing framework from Chapter 5.

Future qualitative research (e.g. using focus groups) might explore the motivations of farm households to implement household risk balancing behavior, *i.e.*, does it constitute an active behavior or is it rather an unconscious decision making pattern based on underlying goals such as family farm survival. As farmers and farm households have a broad range of goals and values (Gasson, 1973; Lien et al., 2006), it will certainly be no easy task to unravel the role of household risk balancing. Another interesting venue for future research is to econometrically analyze household risk balancing behavior in those member states of the EU that collect reliable information on off-farm aspects (e.g. the Netherlands or the UK). It would be valuable to compare results across countries as there surely are marked differences in off-farm opportunities, risk exposure and the level of government support. Descriptive results for Switzerland indicate that for most farms, off-farm elements stabilize total household risk by buffering the variation in farm income. However, analogous to the main thesis of Chapter 4, household risk balancing could potentially work in dual directions as for one quarter of the observations the variation of total household income was greater than the variation in farm income. Future research could therefore look deeper into the incidence of both directions.

7.3 Methodological conclusions and perspectives

The second set of objectives focus on methodological results and provide conclusions that are mainly of interest to an academic audience.

7.3.1 Covering farm-level risk balancing measurement issues

Several methodologies have been used in literature to analyze risk balancing behavior. This dissertation mainly makes use of econometric regression analysis to present aggregate evidence and in addition uses correlation relationship analysis and a survey-based psychometric scale construction to scrutinize farm-level evidence. These empirically-oriented methods complement the more theoretically-oriented methods in literature such as looking at comparative statics in theoretical models (e.g. Collins, 1985) or constructing simulation/optimization models (e.g. Escalante and Barry, 2001).

Chapter 2 introduced the concepts of strong-form and weak-form risk balancing in literature. The risk balancing literature has never explicitly pointed out the theoretical model assumption that the preferred level of total risk does not change while business risk and financial risk move in opposite directions (strong-form risk balancing). In reality, there probably will be observed variation in the level of preferred total risk due to varying levels of risk aversion (e.g. see illustration 3 at the bottom of p.149 by Barry and Robison, 1987) or due to time effects (Ahrendsen et al., 1994). Therefore, defining weak-form risk balancing as the inverse trade-off between financial risk and business risk with some observed changes in total risk is a welcome addition to literature as the empirical evidence in this dissertation suggest this behavior is more realistic.

The results from Chapter 3 and Chapter 4 demonstrated that measurement choices in a correlation relationship analysis have an impact on the obtained farm-level risk balancing measures as one needs to choose (i) a window of calculation of the business risk measure and (ii) the evaluation period for the risk balancing correlation coefficient. Evaluating risk balancing behavior over longer periods of time was found to have a more pronounced impact on the results compared to considering more years when calculating business risk. This finding presents researchers with a tradeoff between data availability (long panels with many consecutive observations are often difficult to obtain) and the required information value of the measure (e.g. with regards to persistence of the observed behavior as increasing the evaluation periods yields more persistent measures).

On household risk balancing methodological grounds, this dissertation contributes to literature by presenting an econometric approach to estimate how farm households jointly alter their levels of financial risk, off-farm income and consumption in response to farm-level changes in business risk. A GMM estimation of a system of seemingly unrelated regressions (SUR) was estimated to account for the simultaneity and non-autonomy of the three decisions made by the farm household. The choice of a SUR model over alternative system estimators was explicitly based on the autonomy requirement, as erroneous system estimators that do not satisfy autonomy requirement are prevalent in applied econometric work (Wooldridge, 2010: 241).

7.3.2 Evaluating the role of risk aversion in risk balancing behavior

Theoretically, risk preferences are reflected in the original risk balancing framework (Gabriel and Baker, 1980), are endogenous in the follow-up utility-centric risk balancing models (Collins, 1985) and have been theoretically shown to influence risk balancing responses (Barry and Robison, 1987; Ramirez et al., 1997; Escalante and Rejesus, 2008). Empirical applications considering a measure of risk aversion are scarce, however, to the best of my knowledge one application can be found in Turvey and Kong (2009). This scarcity probably relates to the difficulty of obtaining a reliable qualitative risk aversion measure in a large scale study or the dearth of deriving a quantitative measure of risk aversion from observed agricultural production data (Lence, 2009). Therefore, Chapter 3 of this dissertation empirically considered the role of risk aversion in risk balancing models using a reliable survey-based measure of risk aversion.

Using the regional FADN dataset for Flanders (Belgium) for the period 2005–2012 complemented with survey data from 2013, I found that observed risk balancing behavior might be driven by the risk averse proportion of farm operators as no significant risk balancing response was found for farm operators classified as risk loving. Distinguishing three classes of risk preferences—risk averse, risk neutral and risk loving—I similarly observed only a significant response for the risk neutral and risk averse farm operators and no significant risk balancing response for the risk loving farm operators. This empirical finding corroborates with literature, as non-risk balancing behavior is attributed to risk loving conditions (*i.e.*, the second order conditions are not met in Collins' (1985) equation 10). To the best of my knowledge, this is the first study to empirically validate that risk aversion is a prerequisite for risk balancing behavior (note that the sole previous study by Turvey and Kong (2009) did not find a significant result).

7.3.3 Acknowledging the role of farm household's risk behavior in risk balancing

Taking into account that several studies have revealed the broad range of family-related goals and values farm operators have (besides profit maximization) and that farm households earn a large part of their household income from non-agricultural sources, Chapter 5 of this dissertation theoretically extended the original risk balancing framework to the household level. The novel concept of farm household risk balancing was introduced by means of a theoretical framework in which the farm household sets a constraint on the total household level risk and balances farm level and off-farm level risk. By taking farm household income and not just farm income as the focal point of the behavioral assumptions, a much wider variety of behavioral responses are considered in reaction to changes in the economic and policy environment.

The novel household risk balancing model demonstrates that policy analyses that are only focused on the farm level ignore potentially important farm household responses that affect the achievement of the intended policy effects. Therefore, it advocates a farm household approach to policy analysis (Offutt, 2002) which is particularly important in the EU given the ongoing CAP reform discussions. To further assess the household-level responses there is a need for extended data collection in the EU. This might not prove easy, given the continuing resistance to broaden the agricultural statistics collection with household income data (Hill, 2002; United Nations, 2007).

Another important implication of the model is that it presents EU policy makers with an extended set of policy instruments to ensure a stable income and enhance the well-being of farm households by adopting a broader view on agricultural risk management. Currently, the focus of agricultural policy is on just one of the elements of the household risk balancing equation—business risk—as it is guided by a policy analysis framework that is focused at the farm level. The extended household risk balancing model describes, however, how farm households in the EU internalize risks by adopting off-farm strategies such as smoothing consumption, attracting off-farm income or maintaining private liquidity reserves. In this respect, policies that enable farm households to maintain or even increase their household-level risk buffering (e.g. rural development programs that facilitate off-farm opportunities), may be able to assume more business risk, thereby allocating resources to more efficient activities and increasing their resilience (Jetté-Nantel et al., 2011).

7.4 General conclusions

The findings of this dissertation paint a broader picture of risk balancing behavior in European agriculture. Overall, I find evidence on risk balancing behavior, yet present several additional elements that put the balancing behavior into a larger perspective. As the results reject evidence of strong-form risk balancing but cannot reject weak-form risk balancing, the balancing effect might not be as strong as the theoretical risk balancing models contend. The extent of the balancing effect is further found to differ between countries and typologies and risk aversion is empirically validated as a necessary prerequisite for risk balancing behavior. Focusing on the direction of the balancing behavior, it is mostly observed as a risk coping strategy (risk management risk balancing) for farmers and to a lesser extent as an unanticipated risk response (entrepreneurship risk balancing). Accordingly, rather low incidence figures for the 'Paradox of risk balancing' are observed, which contrasts the focus that is put on this unanticipated behavioral response in the risk balancing literature. By extending the original risk balancing framework to the household level, this dissertation considers a much wider variety of behavioral responses in reaction to changes in the economic and policy environment. The empirical results suggest the incidence of household risk balancing behavior in two case study regions (Flanders and Switzerland).

7.5 Limitations to the work

This final section will present and critically discuss the most important limitations to the dissertation's work. Most limitations pertain to data availability or methodological issues. They will be discussed in order of appearance in the text.

The foremost limitation to the dissertation is the difficulty of discerning active choice behavior from observed (accounting) data. The empirical setup is aimed at measuring risk balancing behavior and controls for confounding effects in order to provide evidence that business risk variations caused strategic financial risk choices. Although the observed effects are consistent with the theoretical expectations elaborated in Chapter 2, the empirical approach has the limitation that observed data cannot confirm active choices. In order to provide empirical evidence on risk balancing as an active behavior versus a subconscious balancing mechanism one approach could be having focus group discussions with farmers discussing their financial decision making. Alternatively, methods from experimental economics could be adopted (Roe and Randall, 2010) making use of the output from the focus groups. For example, an experimental setup could involve presenting farmers with hypothetical business risk environments and asking them to make financial decisions accordingly. The operationalization could be in the form of basic survey-based choice experiments to elaborate hypothetical computer simulations that present multiyear scenarios. As these methodologies allow for an experimental setup, bolder statements regarding active risk balancing behavior could be made.

Another limitation is that, throughout this dissertation, risk is operationalized using coefficients of variation (see section 1.5). Using the coefficient of variation as a risk measure is linked to decision theory by adopting the mean-variance (MV) approximation of the expected utility model. The MV analysis model has been derived under different assumptions such as: (i) normality of the decision variable and constant absolute risk aversion (CARA) preferences by the decision maker, (ii) based on a quadratic utility function which implies increasing absolute risk aversion (IARA) preferences or (iii) under more general conditions (Chavas, 2004: 69). Despite the reasonable flexibility of the MV specification in risk analysis, there are situations where the model—and consequently using the coefficient of variation—may be flawed. By only focusing on the first two moments—*i.e.*, mean and variance—the coefficient of variation has its limitations in representing (i) downside risk and (ii) rare events.

Firstly, the coefficient of variation does not distinguish between 'upside risk' (variation above the mean) and 'downside risk' (variation below the mean). Most decision-makers, however, treat upside risk and downside risk differently: they are strongly averse to downside risk, yet only mildly averse (or even risk loving) with respect to upside risk. This behavior is called decreasing absolute risk aversion (DARA). An increase in business risk as measured by a higher coefficient of variation could be due to more downside risk (negative skew) or due to more upside risk (positive skew). Assuming DARA risk preferences, a farmer is expected to exhibit a stronger risk balancing response in the former case compared to the latter; differences that are masked by using the coefficient of variation.

Secondly, the coefficient of variation does not properly address rare events, *i.e.*, events that occur with a very low probability and far from the mean outcome. Under DARA, a famer might be concerned about his exposure to rare downside events, yet their management involves changes in small probabilities. As the coefficient of variation does not adequately reflect these changes, the full risk balancing response might not be observed.

Alternative measures for business risk (e.g. Ma and Wong, 2010; Ahmadi-Javid, 2012) and financial risk (e.g. Morgan et al., 2012) have been formulated in literature. Despite the aforementioned shortcomings, the coefficient of variation was chosen as a risk measure due to its ease of interpretation (it is unit-free, expressed in percentages) and computational tractability given the large datasets used in this dissertation where only a limited number of observations were available per farm. Recent behavioral and neuroscience evidence has also been presented in support of the coefficient of variation as a predictor of risk taking behavior (Weber, 2010). Alternative measures of volatility such as the mean absolute deviation (MAD) could also have been considered as this measure is potentially more precise for shorter time spans and less volatile that using standard deviations.

By following a frequentist approach, the dissertation also presents a partial view on decision making under risk, as coping with risk is inherently a subjective business and using a subjectivist approach is becoming more widespread in literature (Hardaker and Lien, 2010). Making use of subjective probabilities of future risks instead of relying on historical data would be an interesting venue for future research, yet was considered impossible given the goal of this dissertation to scrutinize risk balancing behavior on a large geographical and broad temporal scale.

Chapter 3 looked at the role of risk aversion in risk balancing models and empirically validated it as a prerequisite for risk balancing behavior. Therefore, ideally, any risk balancing model should account for differences in risk preferences or pre-select the risk averse proportion of farm operators prior to analysis. Given the unavailability of a reliable measure of risk preference in most datasets used in this dissertation, however, this aspiration was not achieved. The risk balancing response observed in Chapter 3 could potentially be greater if the analysis could have focused on risk averse operators only. The last model results in Chapter 3 based on the Flemish regional FADN dataset did indicate, however, that the exclusion of a measure of risk aversion did not lead to omitted variable bias. Overall, not knowing the true impact of ignoring risk preferences remains a caveat to this study.

As stressed in Chapter 4, risk balancing involves two distinct risk responses depending on the direction of the strategic financial adjustment. It is not evident, however, to disentangle both approaches from observed time series data. When focusing on data from a single period, there is clarity with regards which of both strategies was adopted (*i.e.*, either financial risk increased or decreased). When observing risk balancing behavior over several consecutive periods, however, ambiguity can arise when the observed data presents a mix of both strategies (e.g., financial risk increased in response to an increase in business risk in the first period and the opposite happened the next). Chapter 4 classified a farm adopting risk management risk balancing based on the simple rule that when the number of years where financial risk decreased and business risk increased is greater than the number of years where the opposite happens or where non-risk balancing behavior is observed (and conversely for entrepreneurship risk balancing). This method is clearly a second-best solution, however, as 32% of the risk balancing observations ended up being labelled as 'ambiguous'. This loss of observations is certainly unfortunate, yet I do not deem that the attrition has an influence of the results obtained as these observations present peculiar cases that rightly should be filtered from the two clear-cut risk balancing samples.

Another data-related constraint for Chapter 4 is the availability of information regarding the adoption of alternative risk management strategies. As concluded above, it would have been interesting to compare the trade-off between risk balancing and several alternative risk management strategies such as contracting, hedging, buying insurance, diversification or investing in risk-reducing technologies. In the present analysis, only information regarding insurance and diversification were available. Future research could therefore focus on datasets with more elaborate information regarding the adoption of risk management instruments to fully explore the potential interactions with risk balancing. Furthermore, elaborate risk management information would allow a more rigorous test of the exogeneity of business risk. In the theoretical and empirical risk balancing models of this dissertation business risk is assumed to be exogenous because in general a farmer has limited control over the variation in prices or the biological uncertainty of his production process. Financial risk, on the other hand is treated as endogenous as it stems from a clear decision made by the farmer to use foreign capital which exposes him to the risk of having to meet monthly fixed debt servicing obligations. A farmer can take risk management measures, however, in order to influence his business risk. The impact of these measures on his level of business risk is not clear-cut, however. Only in the extreme case where a farmer insures his production against losses and also uses futures markets to hedge against price volatility he is certain about his level of business risk. As the adoption of both instruments is limited in the EU (Bielza Diaz-Caneja et al., 2009), farmers are assumed not to have extensive control on the level of business risk (making it an endogenous variable). With more information regarding the adoption of risk management instruments, the impact of the adoption thereof on the level of business risk could be modelled.

In order to empirically assess the extended household risk balancing framework formulated in Chapter 5, detailed information on both on-farm and off-farm activities of farm households were necessary. I was limited in my choice of case study countries as only selected countries in the European region such as the Netherlands, the UK or Switzerland meet these data requirements. Comparable data across EU member states is non-existent, ruling out a cross-country analysis *a priori*. I chose Switzerland because it constituted a very interesting case study (off-farm employment opportunities have been readily available to Swiss farmers in recent years) and given the already established connections with the research station ART. In the context of the research project ‘business-oriented monitoring and analysis of risk in agriculture’, the opportunity was presented to evaluate risk balancing behavior using a second, alternative, approach by means of conducting a representative questionnaire survey. I would argue that the limited geographical scope of the household risk balancing analysis is offset by the adoption of two empirically diverse approaches.

The final limitation to this dissertation pertains to the data availability in the Swiss FADN dataset for the econometric analysis in Chapter 6. The theoretical framework formulated in Chapter 5 identifies a set of off-farm responses that farm households could make in response to exogenous changes in business risk: (i) seeking off-farm income, (ii) smoothing consumption levels, (iii) making off-farm investments or (iv) maintaining liquidity buffers. Given the unavailability of data for the latter two responses in the Swiss FADN dataset, I had to focus on off-farm income and consumption in my empirical analysis. Information regarding off-farm investments or liquidity reserves is seldom available in datasets, however, hence it will remain a challenge for future empirical household risk balancing research to properly account for both responses.

Appendix

Appendix A1: Supplementary robustness analysis to Chapter 4 by comparing the econometric models for risk balancing correlation coefficients evaluated over longer periods.

Table A1.1 Fixed effects regression results with varying calculation window of our risk balancing measure

	Risk balancing correlation coefficient window				
	3-year	4-year	5-year	6-year	7-year
Age of Farmer	0.0022**	0.0012	0.0005	0.0012*	0.0026*
	(0.0007)	(0.0007)	(0.0004)	(0.0006)	(0.0010)
Total Risk	0.2469***	0.3815***	0.3955***	0.3076***	0.2037***
	(0.0245)	(0.0203)	(0.0264)	(0.0276)	(0.0299)
Utilized Agricultural Area	-0.0001	0.0001	0.0000	-0.0000	-0.0003***
	(0.0002)	(0.0002)	(0.0002)	(0.0001)	(0.0001)
Land Tenure Ratio	0.0974**	0.0682**	0.1778***	0.2158***	0.2963***
	(0.0370)	(0.0279)	(0.0251)	(0.0473)	(0.0362)
Operating Productivity Ratio	0.5492***	0.4705***	0.4199***	0.3514**	0.2849*
	(0.0661)	(0.0800)	(0.0758)	(0.0992)	(0.1234)
Leverage	-0.1534**	-0.2934***	-0.3241***	-0.3831**	-0.2951
	(0.0500)	(0.0575)	(0.0791)	(0.0959)	(0.1427)
Cost of Debt	-0.1175	-0.2342	-0.0872	0.0665	0.4029**
	(0.0982)	(0.2161)	(0.1698)	(0.1159)	(0.1180)
Asset Profitability	-0.5817***	-0.2473**	0.2387***	0.1591	0.2710
	(0.0961)	(0.0807)	(0.0413)	(0.1316)	(0.2225)
Uncoupled Subsidy Ratio	-0.1514	-0.1960	-0.0932	-0.1191	-0.0933
	(0.1221)	(0.1420)	(0.1503)	(0.1158)	(0.0647)
Decoupled Subsidy Ratio	-0.2055*	-0.0571	0.0992	0.0056	0.0168
	(0.0948)	(0.1237)	(0.1219)	(0.0989)	(0.1389)
Insurance Costs Ratio	-0.0306	-0.2265	-0.8183*	-0.7540	-0.9031
	(0.3375)	(0.3317)	(0.3675)	(0.8273)	(1.2761)
Enterprise Diversification	-0.0095	-0.0146	0.0399	0.0978	0.1240
	(0.0450)	(0.0704)	(0.1073)	(0.1085)	(0.1528)
Constant	0.5500**	0.2037***	-0.3495***	0.0087	-0.4329***
	(0.1953)	(0.0463)	(0.0384)	(0.0719)	(0.0792)
Farm Type and Year dummies omitted for brevity					
F-test statistic	38.4***	44.8***	525.5***	4.1*	18.3***
R^2 Within	0.0121	0.0161	0.0175	0.0137	0.0109
N	59,171	42,762	30,763	21,510	14,677

Notes: Robust standard errors in parentheses, * p<0.1, ** p<0.05, *** p<0.01

Table A1.2 Multinomial Probit regression results comparing risk management versus entrepreneurship with varying calculation window of our risk balancing measure

	Risk balancing correlation coefficient window								
	3-year			5-year			7-year		
	RM	EN	AM	RM	EN	AM	RM	EN	AM
Age of Farmer	**0.0025****	**-0.0018**	0.0025**	**0.0025**	**-0.0030**	0.0015	0.0022	-0.0038	0.0008
	(0.0010)	(0.0012)	(0.0011)	(0.0018)	(0.0021)	(0.0019)	(0.0028)	(0.0033)	(0.0030)
Total Risk	**0.9946*****	**-0.2199*****	0.7558***	**1.2026*****	**-0.1768***	0.7342***	**0.8785*****	**0.0741**	0.6564***
	(0.0407)	(0.0516)	(0.0435)	(0.0794)	(0.1008)	(0.0813)	(0.1243)	(0.1621)	(0.1273)
Utilized Agricultural Area	**-0.0001**	**0.0002**	-0.0001	-0.0002	0.0003	0.0001	**-0.0006***	**0.0004**	0.0004
	(0.0001)	(0.0001)	(0.0002)	(0.0002)	(0.0003)	(0.0002)	(0.0003)	(0.0003)	(0.0003)
Land Tenure Ratio	**0.0627***	**-0.1426*****	-0.0668*	**0.0929**	**-0.2181*****	-0.1368**	**-0.0003**	**-0.2417****	-0.1633*
	(0.0344)	(0.0428)	(0.0377)	(0.0593)	(0.0698)	(0.0614)	(0.0836)	(0.0990)	(0.0898)
Operating Productivity Ratio	**-0.1792****	**0.4562*****	0.1759**	**0.0097**	**0.5536*****	0.2726*	**0.0796**	**0.8653*****	0.3531*
	(0.0796)	(0.0968)	(0.0778)	(0.1337)	(0.1579)	(0.1400)	(0.1950)	(0.2270)	(0.2098)
Leverage	**-0.4029*****	**0.2492*****	0.1911***	**-0.5521*****	**0.1366**	-0.1001	-0.4240**	-0.1091	-0.1611
	(0.0665)	(0.0769)	(0.0688)	(0.1138)	(0.1286)	(0.1167)	(0.1673)	(0.1949)	(0.1758)
Cost of Debt	-0.0761	-0.4737	0.4445*	0.3017	-0.1065	0.4550	0.1416	1.3350	0.2351
	(0.2383)	(0.3206)	(0.2595)	(0.4711)	(0.6635)	(0.5061)	(0.7417)	(1.0069)	(0.8058)
Asset Profitability	**0.1263**	**-0.9194*****	-0.7610***	**0.4805****	**-0.8382****	-0.3772	0.0016	-0.3355	-0.5989**
	(0.0924)	(0.2751)	(0.1745)	(0.2157)	(0.3756)	(0.2466)	(0.1951)	(0.4083)	(0.2731)
Uncoupled Subsidy Ratio	**0.2273****	**-0.1329**	0.0910	-0.0363	-0.4560*	-0.0563	**-0.1622**	**-1.0657*****	-0.4272
	(0.1119)	(0.1342)	(0.1169)	(0.1938)	(0.2333)	(0.2028)	(0.2508)	(0.2985)	(0.2722)
Decoupled Subsidy Ratio	**0.3883***	**-0.6023****	-0.3651	0.5340	0.9168	-0.3158	2.1053**	1.8511*	1.1118
	(0.2239)	(0.2631)	(0.2403)	(0.5057)	(0.5645)	(0.5248)	(0.9026)	(1.0529)	(0.9993)
Insurance Costs Ratio	-0.1678	-0.7022	0.2196	-0.8488	-1.5200*	-1.1429	0.1806	-1.7728*	-0.0987
	(0.4265)	(0.5450)	(0.4334)	(0.6993)	(0.8792)	(0.7876)	(0.8465)	(1.0384)	(0.9781)
Enterprise Diversification	-0.1289*	-0.0816	-0.1125	-0.0687	0.0736	-0.0897	-0.2095	-0.1664	-0.1362
	(0.0670)	(0.0782)	(0.0712)	(0.1114)	(0.1293)	(0.1163)	(0.1579)	(0.1869)	(0.1708)
Constant	-0.6780***	-1.0068***	-1.1429***	-0.8102***	-1.0804***	-1.0614***	-0.5229***	-0.8314***	-0.9658***
	(0.0901)	(0.1189)	(0.0985)	(0.1520)	(0.1867)	(0.1587)	(0.1996)	(0.2371)	(0.2176)
Farm Type and Year dummies omitted for brevity									
Chi²	1,466***			627***			223***		
Log-Likelihood	-73,569			-38,482			-18,411		
N	59,171			30,763			14,677		

Notes: RM = Risk management, EN = Entrepreneurship, AM = Ambiguous; Robust standard errors in parentheses; * p<0.1, ** p<0.05, *** p<0.01

Appendix A2: Risk attitude and risk behavior survey in Flanders

In the context of the research project 'business-oriented monitoring and analysis of risk in agriculture', a questionnaire survey was conducted aimed at understanding the risk perception, attitudes towards risk and perceived effectiveness of alternative risk management strategies of Flemish farmers. This appendix will elaborate on the design of the survey and elaborate on one survey element that is highly relevant for this dissertation: risk attitude.

Research procedure and survey design

A sequential mixed methodology was adopted to conduct this survey (Cameron, 2009). Mixed methods are aimed at taking advantage of the interplay of qualitative phases (usually in the first stage) and quantitative techniques (e.g. data collection in subsequent stages) and are gaining increased momentum in rural sociology research where personal or psychosocial variables are of interest (e.g. Haque et al., 2010; Wauters and Mathijs, 2013).

In our first—qualitative—research stage, in-depth interviews were conducted with a sample of Flemish farmers (n = 35) aimed at understanding their perception of uncertainty and shocks in addition to their experience of coping with these shocks. As representativeness was not vital at this phase, we used purposive sampling, a non-random sampling method in which individuals who are expected to present the most useful information are selected (Teddlie and Yu, 2007). The in-depth interviews were structured in order to get an exhaustive overview of their risk experience, yet the use of the word 'risk' was avoided as much as possible to avoid confounding due to the different notion farmers have of the concept of risk (van Winsen et al., 2013). Instead, questions made reference to 'uncertainties' and 'shocks' occurring on the farm and we further asked them about 'difficulties' for farm management and their 'worries' about the future. Detailed results from this primary qualitative research stage are presented in van Winsen et al. (2013). The relevance of these results for the next quantitative stage is that they allowed us to calibrate the next-stage survey and prevented us from posing overly researcher-driven questions.

The second—quantitative—research stage consisted of a postal questionnaire survey, gauging the risk perception, attitudes towards risk and perceived effectiveness of alternative risk management strategies of a large sample of Flemish farmers (n = 614). Only two aspects of the survey are relevant for this dissertation: (i) the elicitation of risk attitude and (ii) exploring household-level risk management approaches. An elaborate description of the additional survey elements (farmers' risk perception, vision on farming and perceived usefulness of additional risk management strategies) and an analysis thereof is presented in Wauters et al. (2014). Several farmer and farm household characteristics relevant for this dissertation were additionally obtained in the second-phase survey, these variables are discussed in Chapter 6.

The survey was sent out to the whole Flemish FADN sample (759 farms) in March 2013 in collaboration with the Flemish government. 624 surveys were returned, yet after a first data inspection, 10 surveys were excluded for further analysis due to unreliable scores or more than 25% missing data. The final sample available for analysis thus consists of 614 surveys (response rate 81%) and is considered representative for Flanders.

Risk attitude

Risk attitude was elicited in two ways, namely by (i) direct measurement and (ii) constructing a psychometric measurement scale. The former method involved a simple question where farmers could indicate the extent to which they are willing to take risk on a 5-point scale ranging from 1 (very risk taking) to 5 (very risk averse) (Bard and Barry, 2000). The average score was 3.35 (see Table A2.1), suggesting that the average Flemish farmer is slightly risk averse.

The second method involved constructing a psychometric risk aversion scale based on nine questions that asked farmers to what extent they agree with statements about risk taking in general. A Likert scale was used ranging from 1 (strongly disagree) to 5 (strongly agree). The following questions were adapted from previous applications in literature (e.g. Bard and Barry, 2000; Pennings and Garcia, 2001; McCarthy and Thompson, 2007):

I do not like taking risky decisions

I able to cope well with financial risk and uncertainty on my farm

I cannot afford to take business risk

I am able to experiment with novel ideas (e.g. new varieties or alternative marketing channel), even though this implies additional risk

I am willing to take financial risks if they increase potential profit

I experience sleepless nights when I did not do my utter best to limit my risk exposure

I postpone investments until they are absolutely crucial

I am usually prudent with regards to taking farm financial decisions (e.g. loans and investments)

I am not afraid to lend a lot of money in order to make a profit-increasing investment

As the items are Likert-type variables, most parametric techniques can be used even in the case of serious deviation from normality (Norman, 2010). All nine items were checked for outliers and found to satisfy normality conditions (skewness and kurtosis statistics between -1 and +1). Based on theoretical foundations, a reflective measurement scale was used as these items are manifestations of the underlying construct 'risk aversion' and a change in risk aversion is believed to cause a change in all nine items of the measurement scale (Edwards and Bagozzi, 2000). The internal consistency of the scale constructed using these questions was considered good with a Chronbach alpha value of 0.73. This allows us to calculate a measure for the latent concept 'risk aversion' as the (unweighted) arithmetic mean of the nine items. The sample average of this scale equals 3.24, which is similar to our direct measure (see Table A2.1). Both risk aversion measures are significantly and positively correlated with $\rho = 0.48$, which is higher than comparable correlation coefficients in literature comparing alternative measurement methods (Hansson and Lagerkvist, 2012; Maart-Noelck and Musshoff, 2013; Nielsen et al., 2013).

Table A2.1 Risk attitude measurement

	Direct measure	Psychometric scale
All farms	3.35 (1.01)	3.24 (0.58)
Size class small	3.60 (0.94)***	3.40 (0.55)***
Size class medium	3.40 (0.70)***	3.26 (0.58)***
Size class large	3.12 (1.04)***	3.12 (0.58)***

Notes: *** denotes significance at 1%

A one-way ANOVA analysis indicated that risk aversion is uniform across different production typologies and hence these differences are not reported here. This is in line with our expectations as risk attitude is a personal trait which gives no reason to assume any differences across production typology *a priori*. We do find a significant difference in risk attitude with regards to different farm size classes (defined based on standard output): small farms are found to be more risk averse than medium sized farms, which in turn are still more risk averse than large farms.

Lastly, two risk aversion variables were derived from the continuous psychometric risk aversion scale: (i) a risk aversion dummy and (iii) a categorical variable. The risk aversion dummy—equal to 1 for risk averse individuals—was constructed by splitting the sample into two equal parts, *i.e.*, a median split (observations equal to the median were classified as risk averse). The risk aversion categorical dummy distinguishes risk loving, risk neutral and risk averse individuals and was analogously defined by splitting the sample into three equal parts, i.e., a tertile split (observations equal to the first and second tertiles were classified as risk neutral). Figure A2.1 presents the histogram of the continuous risk aversion scale and indicates the median cutoff point of the dummy variable (vertical line) and color codes the three risk attitude classes.

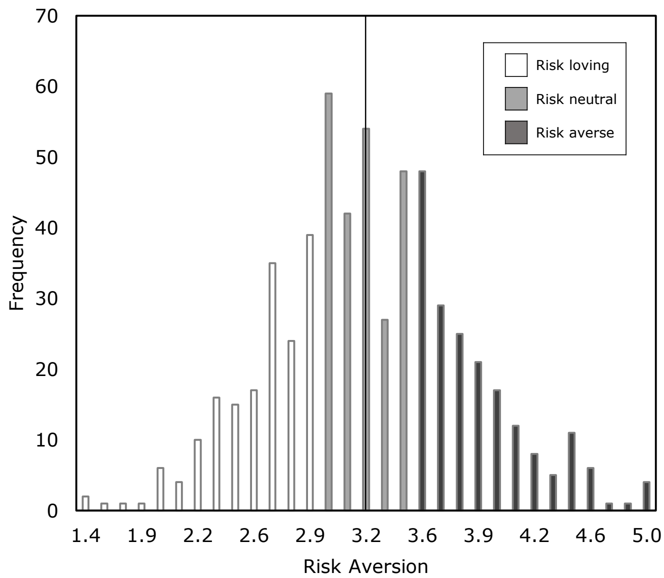

Figure A2.1 Risk aversion histogram and derived risk aversion categories

Bibliography

Ahearn, M. C., El-Osta, H., Dewbre, J. (2006) The impact of coupled and decoupled government subsidies on off-farm labor participation of U.S. farm operators. *American Journal of Agricultural Economics* 88 (2): 393-408.

Ahmadi-Javid, A. (2012) Entropic value-at-risk: a new coherent risk measure. *Journal of Optimization Theory and Applications* 155 (3): 1105-1123.

Ahrendsen, B. L., Collender, R. N., Dixon, B. L. (1994) An empirical analysis of optimal capital structure decisions. *Agricultural Finance Review* 54 (1): 108-119.

Ahumada, O., Villalobos, J. R. (2009) Application of planning models in the agri-food supply chain: a review. *European Journal of Operational Research* 196 (1): 1-20.

Alasia, A., Weersink, A., Bollman, R. D., Cranfield, J. (2009) Off-farm labour decision of Canadian farm operators: urbanization effects and rural labour market linkages. *Journal of Rural Studies* 25 (1): 12-24.

Allais, M. (1984) The foundations of the theory of utility and risk. In *Progress in utility and risk theory*, (eds.) O. Hargen and F. Wenstrop, 3-131. Dordrecht, The Netherlands: Reidel Publishing.

Anderson, J. R., Dillon, J. L., Hardaker, J. B. (1977) *Agricultural decision analysis*. Ames, USA: Iowa State University Press.

Andersson, H., Ramaswami, B., Moss, C. B., Erickson, K. W., Hallahan, C. B., Nehring, R. F. (2005) Off-farm income and risky investments: what happens to farm and nonfarm assets? Paper presented at the American Agricultural Economics Association annual meeting, July 24-27, Providence, USA.

Antle, J. M. (1987) Econometric estimation of producers' risk attitudes. *American Journal of Agricultural Economics* 69 (3): 509-522.

Arriaza, M., Gómez-Limón, J. A. (2003) Comparative performance of selected mathematical programming models. *Agricultural Systems* 77 (2): 155-171.

Aven, T. (2010) *Misconceptions of risk*. Chichester, United Kingdom: John Wiley & Sons Ltd.

Baker, M., Wurgler, J. (2002) Market timing and capital structure. *The Journal of Finance* 57 (1): 1-32.

Banse, M., van Meijl, H., Tabeau, A., Woltjer, G. (2008) Will EU biofuel policies affect global agricultural markets? *European Review of Agricultural Economics* 35 (2): 117-141.

Bard, S. K., Barry, P. J. (2000) Developing a scale for assessing risk attitudes of agricultural decision makers. *The International Food and Agribusiness Management Review* 3 (1): 9-25.

Barnett, B. J., Coble, K. H. (2009) Are our agricultural risk management tools adequate for a new era? *Choices* 24 (1): 36-39.

Barry, P. J. (1983) Financing growth and adjustment of farm firms under risk and inflation. In *Modeling farm decisions for policy analysis*, (eds.) K. H. Baum and L. P. Schertz, 111-134. Boulder, USA: Westview Press.

Barry, P. J., Baker, C. B., Sanint, L. R. (1981) Farmers' credit risks and liquidity management. *American Journal of Agricultural Economics* 63 (2): 216-227.

Barry, P. J., Ellinger, P. N. (2010) *Financial management in agriculture*. Upper Saddle River, USA: Prentice Hall.

Barry, P. J., Robison, L. J. (1986) Economic versus accounting rates of return for farm land. *Land Economics* 62 (4): 388-401.

Barry, P. J., Robison, L. J. (1987) Portfolio theory and financial structure: an application of equilibrium analysis. *Agricultural Finance Review* 47 (1): 142-151.

Barry, P. J., Robison, L. J. (2001) Agricultural Finance: credit, credit constraints, and consequences. In *Handbook of agricultural economics. Volume 1A Agricultural production*, (eds.) B. Gardner and G. Rausser, 513-571. Amsterdam, The Netherlands: Elsevier.

Becker, G. S. (1965) A theory of the allocation of time. *The Economic Journal* 75 (299): 493-517.

Benjamin, C., Kimhi, A. (2006) Farm work, off-farm work, and hired farm labour: estimating a discrete-choice model of French farm couples' labour decisions. *European Review of Agricultural Economics* 33 (2): 149-171.

Bernoulli, D. (1738) Specimen theoriae novae de mensura sortis. Translated by Somer, L. (1954) Exposition of a new theory on the measurement of risk *Econometrica* 22: 23-36.

Bessant, K. C. (2006) A farm household conception of pluriactivity in Canadian agriculture: motivation, diversification and livelihood. *Canadian Review of Sociology/Revue canadienne de sociologie* 43 (1): 51-72.

Bielza Diaz-Caneja, M., Conte, C. G., Gallego Pinilla, F. J., Stroblmair, J., Catenaro, R., Dittmann, C. (2009) Risk management and agricultural insurance schemes in Europe. Report EUR 23943 EN. Luxembourg: European Communities.

Binswanger, H. P. (1981) Attitudes toward risk: theoretical implications of an experiment in rural India. *The Economic Journal* 91 (364): 867-890.

Blank, S. C., Erickson, K. W. (2007) Agricultural household hedging with off-farm income. *Western Economics Forum* Spring: 1-13.

Blank, S. C., Erickson, K. W., Moss, C. B., Nehring, R. (2004) Agricultural profits and farm household wealth. *American Journal of Agricultural Economics* 86 (5): 1299-1307.

Blank, S. C., Erickson, K. W., Nehring, R., Hallahan, C. (2009) Agricultural profits and farm household wealth: a farm-level analysis using repeated cros sections. *Journal of Agricultural and Applied Economics* 41 (1): 207-225.

Boehlje, M. D. (2002) Risk in U.S. agriculture: new challenges and new approaches. Staff Paper #02-07. West Lafayette, USA: Purdue University.

Boisvert, R. N. (2002) Analysis of a re-focused agricultural policy within a farm-household framework. Some data requirements. Paper presented at the Workshop on the farm household-firm unit: its importance in agriculture and implications for statistics, April 12-13, London, UK.

Booth, L., Aivazian, V., Demirguc-Kunt, A., Maksimovic, V. (2001) Capital structures in developing countries. *Journal of Finance* 56 (1): 87-130.

Brookfield, H. (2008) Family farms are still around: time to invert the old agrarian question. *Geography Compass* 2 (1): 108-126.

Brouwer, F., Fox, G., Jongeneel, R. (2012) *The economics of regulation in agriculture. Compliance with public and private standards*. Oxforshire, UK: CABI Publishing.

Buschena, D. E. (2001) Non-expected utility: what do the anomalies mean for risk in agriculture. In *A comprehensive assessment of the role of risk in U.S.*

agriculture, (eds.) R. E. Just and R. D. Pope, 21-40. Dordrecht, The Netherlands: Kluwer Academic Publishers.

Cafiero, C., Capitanio, F., Cioffi, A., Coppola, A. (2007) Risk and crisis management in the reformed European agricultural policy. *Canadian Journal of Agricultural Economics/Revue canadienne d'agroeconomie* 55 (4): 419-441.

Cameron, R. (2009) A sequential mixed model research design: design, analytical and display issues. *International Journal of Multiple Research Approaches* 3 (2): 140-152.

Carriker, G. L., Langemeier, M. R., Schroeder, T. C., Featherstone, A. M. (1993) Propensity to consume farm family disposable income from separate sources. *American Journal of Agricultural Economics* 75 (3): 739.

Chavas, J.-P., Holt, M. T. (1996) Economic behavior under uncertainty: a joint analysis of risk preferences and technology. *The Review of Economics and Statistics* 78 (2): 329-335.

Chavas, J.-P., Kim, K. (2006) An econometric analysis of the effects of market liberalization on price dynamics and price volatility. *Empirical Economics* 31 (1): 65-82.

Chavas, J. P. (2004) *Risk analysis in theory and practice*. London, UK: Elsevier Academic Press.

Chayanov, A. V. (1966) *The theory of peasant economy*. Illinois, USA: Irwin Press.

Coble, K. H., Heifner, R. G., Zuniga, M. (2000) Implications of crop yield and revenue insurance for producer hedging. *Journal of Agricultural and Resource Economics* 25 (2): 432-452.

Collins, R. A. (1985) Expected utility, debt-equity structure, and risk balancing. *American Journal of Agricultural Economics* 67 (3): 627-629.

Collins, R. A., Karp, L. S. (1993) Lifetime leverage choice for proprietary farmers in a dynamic-stochastic environment. *Journal of Agricultural and Resource Economics* 18 (2): 225-238.

Collins, R. A., Karp, L. S. (1995) Static vs. dynamic models of proprietary capital structure: discussion and preliminary empirical evidence. *Agricultural Finance Review* 55: 1-9.

De Becker, R. (2007) Het Vlaamse LandbouwMonitoringsNetwerk: wat en hoe? Brussels, Belgium: Afdeling Monitoring en Studie.

De Hoyos, R. E., Sarafidis, V. (2006) Testing for cross-sectional dependence in panel-data models. *Stata Journal* 6 (4): 482-496.

de Lauwere, C. C. (2005) The role of agricultural entrepreneurship in Dutch agriculture of today. *Agricultural Economics* 33 (2): 229-238.

Departement Landbouw en Visserij. (2013) Landbouw Tuinbouw Vlaanderen 2013. Brussels, Belgium: Vlaamse overheid, Departement Landbouw en Visserij.

Deuninck, J., Koen, C., Bas, L., Van Gijseghem, D. (2007) Risicobeheersing in de land- en tuinbouw met focus op verzekeringen. Brussels, Belgium: Beleidsdomein Landbouw en Visserij, Afdeling Monitoring en Studie.

Di Falco, S., Perrings, C. (2005) Crop biodiversity, risk management and the implications of agricultural assistance. *Ecological Economics* 55 (4): 459-466.

Dillon, J. L. (1991) The farm as a purposeful system. Amidale, Australia: Department of Agricultural Economics and Business Management, University of New England.

Eakin, H. (2005) Institutional change, climate risk, and rural vulnerability: cases from Central Mexico. *World Development* 33 (11): 1923-1938.
Edwards, J. R., Bagozzi, R. P. (2000) On the nature and direction of relationships between constructs and measures. *Psychological Methods* 5 (2): 155-174.
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 (3): 301-324.
Ellinger, P. N., Barry, P. J. (1987) The effects of tenure position on farm profitability and solvency: an application to Illinois farms. *Agricultural Finance Review* 47: 106-118.
Encarnación, J., Jr. (1964) Constraints and the firm's utility function. *The Review of Economic Studies* 31 (2): 113-120.
Ericksen, P. J., Ingram, J. S. I., Liverman, D. M. (2009) Food security and global environmental change: emerging challenges. *Environmental Science & Policy* 12 (4): 373-377.
Escalante, C. L., Barry, P. J. (2001) Risk balancing in an integrated farm risk management plan. *Journal of Agricultural and Applied Economics* 33 (3): 413-429.
Escalante, C. L., Barry, P. J. (2003) Determinants of the strength of strategic adjustments in farm capital structure. *Journal of Agricultural and Applied Economics* 35 (1): 67-78.
Escalante, C. L., Rejesus, R. M. (2008) Risk balancing decisions under constant absolute and relative risk aversion. *Review of Business Research* 8 (1): 1-8.
European Commission. (2013) Structure and dynamics of EU farms: changes, trends and policy relevance. EU agricultural economics briefs 9. Brussels, Belgium: European Commission.
Featherstone, A. M., Moss, C. B., Baker, T. G., Preckel, P. V. (1988) The theoretical effects of farm policies on optimal leverage and the probability of equity losses. *American Journal of Agricultural Economics* 70 (3): 572-579.
Featherstone, A. M., Preckel, P. V., Baker, T. G. (1990) Modelling farm financial decisions in a dynamic and stochastic environment. *Agricultural Finance Review* 50 (1): 80-99.
Fernandez-Cornejo, J. (2007) Off-farm income, technology adoption, and farm economic performance. USDA Economic Research Report Number 36. Washington DC, USA: USDA.
Flannery, M. J., Hankins, K. W. (2013) Estimating dynamic panel models in corporate finance. *Journal of Corporate Finance* 19: 1-19.
FOAG. (2013) Agricultural Report 2013. Summary. Berne, Switzerland: Federal Office for Agriculture.
FOD Economie. (2013) Kerncijfers landbouw. De landbouw in België in cijfers. Brussels, Belgium: Algemene Directie Statistiek en Economische Informatie van de FOD Economie.
Freshwater, D. (2002) Economics of farm support and canada's safety net: discussion. *Canadian Journal of Agricultural Economics/Revue canadienne d'agroeconomie* 50 (4): 465-471.
Freshwater, D. (2007) Measuring farm net income to better achieve policy objectives. Agricultural economics staff paper # 466. Lexington, USA: University of Kentucky.
Freshwater, D., Jette-Nantel, S. (2011) Risk management and the role of off-farm income. Version 2.1. Lexington, USA: University of Kentucky.

Freund, R. J. (1956) An introduction of risk into a programming model. *Econometrica* 24 (3): 253-263.

Gabriel, S. C., Baker, C. B. (1980) Concepts of business and financial risk. *American Journal of Agricultural Economics* 62 (3): 560-564.

Gardner, B. (2005) The little guys are O.K. *The New York Times* OP-ED Monday, March 7: A21-A22.

Gasson, R. (1973) Goals and values of farmers. *Journal of Agricultural Economics* 24 (3): 521-542.

Gasson, R., Crow, G., Errington, A., Hutson, J., Marsden, T., Winter, D. M. (1988) The farm as a family business: a review. *Journal of Agricultural Economics* 39 (1): 1-41.

Giuliani, G., Rieder, P. (2003) Bodenmarkt zwischen Land- und Wirtschaft [Determinants of farmland prices]. *Agrarforschung* 10 (7): 258-263.

Glauber, J. W., Collins, K. J. (2010) Risk management and the role of the federal government. In *A comprehensive assessment of the role of risk in U.S. agriculture*, (eds.) D. R. Just and R. D. Pope, 469-488. Dordrecht, The Netherlands: Kluwer Academic Publishers Group.

Gómez-Limón, J. A., Arriaza, M., Riesgo, L. (2003) An MCDM analysis of agricultural risk aversion. *European Journal of Operational Research* 151 (3): 569-585.

Goodwin, B. K., Mishra, A. K. (2004) Farming efficiency and the determinants of multiple job holding by farm operators. *American Journal of Agricultural Economics* 86 (3): 722-729.

Greene, W. H. (2003) *Econometric Analysis. 5th edition*. Upper Saddle River, USA: Prentice Hall.

Gronau, R. (1973) The intrafamily allocation of time: the value of the housewives' time. *The American Economic Review* 63 (4): 634-651.

Halter, A. N., Dean, G. W. (1971) *Decisions under uncertainty*. Cincinnati, USA: South-Western Publishing Co.

Hansson, H., Ferguson, R., Olofsson, C., Rantamäki-Lahtinen, L. (2013) Farmers' motives for diversifying their farm business – The influence of family. *Journal of Rural Studies* 32 (0): 240-250.

Hansson, H., Lagerkvist, C. J. (2012) Measuring farmers' preferences for risk: a domain-specific risk preference scale. *Journal of Risk Research* 15 (7): 737-753.

Haque, M. M., Little, D. C., Barman, B. K., Wahab, M. A. (2010) The adoption process of ricefield-based fish seed production in northwest Bangladesh: an understanding through quantitative and qualitative investigation. *The Journal of Agricultural Education and Extension* 16 (2): 161-177.

Hardaker, J. B. (2000) Some issues in dealing with risk in agriculture. Working paper. New England, Australia.

Hardaker, J. B., Huirne, R., Anderson, J. R., Lien, G. (2004) *Coping with risk in agriculture*. Oxfordshire, UK: CABI Publishing.

Hardaker, J. B., Lien, G. (2010) Probabilities for decision analysis in agriculture and rural resource economics: the need for a paradigm change. *Agricultural Systems* 103 (6): 345-350.

Harwood, J., Heifner, R., Coble, K., Perry, J., Somwaru, A. (1999) Managing risk in farming: concepts, research, and analysis. Agricultural economic report no. 774. Washington DC, USA: U.S. Department of Agriculture.

Headey, D., Fan, S. (2008) Anatomy of a crisis: the causes and consequences of surging food prices. *Agricultural Economics* 39 (supplement): 375-391.

Heikkinen, T., Pietola, K. (2009) Investment and the dynamic cost of income uncertainty: the case of diminishing expectations in agriculture. *European Journal of Operational Research* 192 (2): 634-646.
Hennessy, T., O'Brien, M. (2008) Is off-farm income driving on-farm investment? *Journal of Farm Management* 13 (4): 235-246.
Hennessy, T. C., Rehman, T. (2008) Assessing the impact of the 'decoupling' reform of the common agricultural policy on Irish farmers' off-farm labour market participation decisions. *Journal of Agricultural Economics* 59 (1): 41-56.
Hill, B. (2002) Policy requirements in the EU and the existing array of indicators problem definition, policy performance and the implications of reform. Paper presented at the Workshop on the Farm Household-Firm Unit: Its Importance in Agriculture and Implications for Statistics, April 12-13, Wye Campus, Imperial College, London, UK.
Hill, B. (2006) Structural change in European agriculture. In *Policy reform and adjustment in the agricultural sectors of developed countries*, (eds.) D. Blandford and B. Hill, 5-21. Oxfordshire, UK: CABI publishing.
Hoag, D. L. (2009) *Applied risk management in agriculture*. Boca Rotan, USA: CRC Press - Taylor & Francis Group.
Hoechle, D. (2007) Robust standard errors for panel regressions with cross-sectional dependence. *Stata Journal* 7 (3): 281-312.
Hoop, D., Schmid, D. (2013) Grundlagenbericht 2012 [Baseline report of the Swiss FADN 2012]. Ettenhausen, Switzerland: Agroscope Reckenholz-Tänikon Research Station ART.
Howden, S. M., Soussana, J.-F., Tubiello, F. N., Chhetri, N., Dunlop, M., Meinke, H. (2007) Adapting agriculture to climate change. *Proceedings of the National Academy of Sciences* 104 (50): 19691-19696.
Ifft, J., Kuethe, T., Morehart, M. (2013) Farm debt use by farms with crop insurance. *Choices* 28 (3): 1-5.
Jensen, F. E., Langemeier, L. N. (1996) Optimal leverage with risk aversion: empirical evidence. *Agricultural Finance Review* 56 (1): 85-97.
Jensen, M. C., Meckling, W. H. (1976) Theory of the firm: managerial behavior, agency costs and ownership structure. *Journal of Financial Economics* 3 (4): 305-360.
Jetté-Nantel, S., Freshwater, D., Katchova, A. L., Beaulieu, M. S. (2011) Farm income variability and off-farm diversification in canadian agriculture. *Agricultural Finance Review* 71 (3): 329-364.
Just, R. E. (2003) Risk research in agricultural economics: opportunities and challenges for the next twenty-five years. *Agricultural Systems* 75 (2–3): 123-159.
Just, R. E., Pope, R. D. (2003) Agricultural risk analysis: adequacy of models, data, and issues. *American Journal of Agricultural Economics* 85 (5): 1249-1256.
Just, R. E., Weninger, Q. (1999) Are crop yields normally distributed? *American Journal of Agricultural Economics* 81 (2): 287-304.
Kahneman, D., Tversky, A. (1979) Prospect theory: an analysis of decision under risk. *Econometrica* 47 (2): 263-291.
Katchova, A. L. (2005) Factors affecting farm credit use. *Agricultural Finance Review* 65 (2): 17-29.

Kim, W. S., Sorensen, E. H. (1986) Evidence on the impact of the agency costs of debt on corporate debt policy. *Journal of Financial and Quantitative Analysis* 21 (02): 131-144.

Kimura, S., Antón, J., Le Thi, C. (2010) Farm level analysis of risk and risk management strategies and policies: cross country analysis. OECD Food, Agriculture and Fisheries Working Papers, No. 26. Paris, France.

Knight, F. (1921) *Risk, uncertainty and profit*. Boston, USA: Houghton-Mifflin Company.

Kostov, P., Lingard, J. (2003) Risk management: a general framework for rural development. *Journal of Rural Studies* 19 (4): 463-476.

Krokhmal, P., Zabarankin, M., Uryasev, S. (2011) Modeling and optimization of risk. *Surveys in Operations Research and Management Science* 16 (2): 49-66.

Kyle, S. (1993) The relation between farm production risk and off-farm income. *Agricultural and Resource Economics Review* 22: 179-188.

Langemeier, M. R., Patrick, G. F. (1990) Farmers' marginal propensity to consume: an application to Illinois grain farms. *American Journal of Agricultural Economics* 72 (2): 309-316.

Lauwers, L., de Mey, Y., Wauters, E., Van Meensel, J., Van Passel, S., Vancauteren, M. (2009) De volatiliteit van het landbouwinkomen. ILVO mededeling 68. Merelbeke, Belgium.

Lehmann, N., Briner, S., Finger, R. (2013) The impact of climate and price risks on agricultural land use and crop management decisions. *Land Use Policy* 35: 119-130.

Lence, S. H. (2009) Joint estimation of risk preferences and technology: flexible utility or futility? *American Journal of Agricultural Economics* 91 (3): 581-598.

Levy, H., Markowitz, H. M. (1979) Approximating expected utility by a function of mean and variance. *The American Economic Review* 69 (3): 308-317.

Lien, G. (2002) Non-parametric estimation of decision makers' risk aversion. *Agricultural Economics* 27 (1): 75-83.

Lien, G., Flaten, O., Jervell, A. M., Ebbesvik, M., Koesling, M., Valle, P. S. (2006) Management and risk characteristics of part-time and full-time farmers in Norway. *Applied Economic Perspectives and Policy* 28 (1): 111-131.

Lien, G., Kumbhakar, S. C., Hardaker, J. B. (2010) Determinants of off-farm work and its effects on farm performance: the case of Norwegian grain farmers. *Agricultural Economics* 41 (6): 577-586.

Lins, D. A., Gabriel, S. C., Sonka, S. T. (1981) An analysis of the risk aversion of farm operators: an asset portfolio approach. *Western Journal of Agricultural Economics* 6 (1): 15-29.

Lips, M., Schmid, D. (2013) Agrarische Diversifikation aus ökonomischer Sicht: Entwicklung auf den schweizerischen Landwirtschaftsbetrieben [Diversification from an economic persepctive: the development on Swiss farms]. In *Agrarische Diversifkation- rechtliche Aspekte von Agrotourismus bis Energieerzeugung. Tagungsband der 3. Luzerner Agrarrechtstagung 2012*, (eds.) R. Norer, 19-29. Zürich, Switzerland: Dike verlag.

Lips, M., Schmid, D., Jan, P. (2013) Labour-use pattern on Swiss dairy farms. *Agricultural Economics (Zemědělská ekonomika)* 59 (4): 149-159.

Ma, C., Wong, W.-K. (2010) Stochastic dominance and risk measure: a decision-theoretic foundation for VaR and C-VaR. *European Journal of Operational Research* 207 (2): 927-935.

Maart-Noelck, S. C., Musshoff, O. (2013) Measuring the risk attitude of decision-makers: are there differences between groups of methods and persons? *Australian Journal of Agricultural and Resource Economics* 57 (1): 1-17.

Mann, S. (2003) Doing it the Swiss way. *EuroChoices* 2 (3): 32-35.

Mayer, D. G., Belward, J. A., Burrage, K. (1998) Optimizing simulation models of agricultural systems. *Annals of Operations Research* 82 (0): 219-232.

McCarthy, M., Thompson, D. (2007) Risk management and farming families. Perceptions and practices. RIRDC Publication No 06/040. Kingston, Australia: RIRDC.

McNamara, K. T., Weiss, C. R. (2005) Farm household income and on- and off-farm diversification. *Journal of Agricultural and Applied Economics* 37 (1): 37-48.

Meuwissen, M. P. M., van Asseldonk, M. A. P. M., Huirne, R. B. M. (2008) *Income stabilization in European agriculture: design and economic impact of risk management tools*. Wageningen, The Netherlands: Wageningen Academic Publishers.

Meyer, J. (1987) Two-moment decision models and expected utility maximization. *The American Economic Review* 77 (3): 421-430.

Meyer, J. (2001) Expected utility as a paradigm for decision making in agriculture. In *A comprehensive assessment of the role of risk in U.S. agriculture*, (eds.) R. E. Just and R. D. Pope, 3-19. Dordrecht, The Netherlands: Kluwer Academic Publishers.

Meyer, J. (2010) Representing risk preferences in expected utility based decision models. *Annals of Operations Research* 176 (1): 179-190.

Miller, M. H. (1977) Debt and taxes. *The Journal of Finance* 32 (2): 261-275.

Mishra, A. K., Chang, H.-H. (2009) Factors affecting precautionary savings of self-employed farm households. *Agricultural Finance Review* 69 (3): 300-313.

Mishra, A. K., El-Osta, H. S. (2001) A temporal comparison of sources of variability in farm household income. *Agricultural Finance Review* 61 (2): 181-198.

Mishra, A. K., El-Osta, H. S., Morehart, M. J., D., J. J., W., H. J. (2002) Income, wealth, and the economic well-being of farm households. USDA agricultural economic report no. 812. Washington, USA: Department of Agriculture, Economic Research Service.

Mishra, A. K., Goodwin, B. K. (1997) Farm income variability and the supply of off-farm labor. *American Journal of Agricultural Economics* 79 (3): 880-887.

Mishra, A. K., Morehart, M. (2001) Off-farm investment of farm households: a Logit analysis. *Agricultural Finance Review* 61 (1): 87-101.

Mishra, A. K., Moss, C. B., erickson, K. W. (2009) Regional differences in agricultural profitability, government payments, and farmland values. Implications of DuPont expansion. *Agricultural Finance Review* 69 (1): 49-66.

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 (1): 208-221.

Mishra, A. K., Uematsu, H., Fannin, J. M. (2013) Measuring precautionary wealth using cross-sectional data: the case of farm households. *Review of Economics of the Household* 11 (1): 131-141.

Morgan, W., Cotter, J., Dowd, K. (2012) Extreme measures of agricultural financial risk. *Journal of Agricultural Economics* 63 (1): 65-82.

Moss, C. B., Ford, S. A., Boggess, W. G. (1989) Capital gains, optimal leverage, and the probability of equity loss: a theoretical model. *Agricultural Finance Review* 49 (1): 447-56.

Moss, C. B., Shonkwiler, J. S., Ford, S. A. (1990) A risk endogenous model of aggregate agricultural debt. *Agricultural Finance Review* 50 (1): 73-79.

Musshoff, O., Hirschauer, N. (2007) What benefits are to be derived from improved farm program planning approaches? The role of time series models and stochastic optimization. *Agricultural Systems* 95 (1–3): 11-27.

Myers, S. C. (1984) The capital structure puzzle. *The Journal of Finance* 39 (3): 574-592.

Nartea, G., Webster, P. (2008) Should farmers invest in financial assets as a risk management strategy? Some evidence from New Zealand. *Australian Journal of Agricultural and Resource Economics* 52 (2): 183-202.

Nelson, G. C., Shively, G. E. (2014) Modeling climate change and agriculture: an introduction to the special issue. *Agricultural Economics* 45 (1): 1-2.

Nielsen, T., Keil, A., Zeller, M. (2013) Assessing farmers' risk preferences and their determinants in a marginal upland area of Vietnam: a comparison of multiple elicitation techniques. *Agricultural Economics* 44 (3): 255-273.

Norman, G. (2010) Likert scales, levels of measurement and the "laws" of statistics. *Advances in Health Sciences Education* 15 (5): 625-632.

OECD. (2003) *Farm household income. Issues and policy response*. Paris, France: OECD Publishing.

OECD. (2008) An assessment of risk exposure in agriculture. A literature review. Paris, France.

OECD. (2009) *Managing risk in agriculture. A holistic approach*. Paris, France: OECD Publishing.

OECD. (2011) *Managing risk in agriculture: policy assessment and design*. Paris, France: OECD Publishing.

OECD. (2013a) *Agricultural policy monitoring and evaluation 2013: OECD countries and emerging economies*. Paris, France: OECD Publishing.

OECD. (2013b) Country statistical profile: Belgium 2013/2. Paris, France: OECD.

OECD. (2013c) Switzerland. In *Agricultural policy monitoring and evaluation 2013: OECD countries and emerging economies*, (eds.) OECD. Paris, France: OECD Publishing.

Offutt, S. (2002) The future of farm policy analysis: a household perspective. *American Journal of Agricultural Economics* 84 (5): 1189-1200.

Pannell, D. J., Malcolm, B., Kingwell, R. S. (2000) Are we risking too much? Perspectives on risk in farm modeling. *Agricultural Economics* 23 (1): 69-78.

Parker, P. S., Shonkwiler, J. S. (2014) On the centenary of the German hog cycle: new findings. *European Review of Agricultural Economics* 41 (1): 47-61.

Pedersen, M. F., Olsen, J. V. (2013) Measuring credit capacity on Danish farms using DEA. *Agricultural Finance Review* 73 (3).

Pennings, J. M. E., Garcia, P. (2001) Measuring producers' risk preferences: a global risk-attitude construct. *American Journal of Agricultural Economics* 83 (4): 993.

Pesaran, M. H. (2004) General diagnostic tests for cross section dependence in panels. Cambridge Working Papers in Economics No. 0435. Cambridge, UK: University of Cambridge, Faculty of Economics.

Plà, L. M., Sandars, D. L., Higgins, A. J. (2013) A perspective on operational research prospects for agriculture. *Journal of the Operational Research Society* doi:10.1057/jors.2013.45.

Podsakoff, P. M., MacKenzie, S. B., Podsakoff, N. P., Yeon Lee, J. (2003) The mismeasure of man(agement) and its implications for leadership research. *The Leadership Quarterly* 14 (6): 615–656.

Poon, K., Weersink, A. (2011) Factors affecting variability in farm and off-farm income. *Agricultural Finance Review* 71 (3): 379-397.

Quiggin, J. (1992) *Generalized expected utility theory: the rank-dependent model* Dordrecht, The Netherlands: Kluwer Academic Publishers.

Ramirez, O. A., Moss, C. B., Boggess, W. G. (1997) A stochastic optimal control formulation of the consumption/debt decision. *Agricultural Finance Review* 57 (1): 29-38.

Remble, A., Marshall, M., Keeney, R. (2013) Household saving behavior and the influence of family-owned business. *Journal of Family and Economic Issues* doi:10.1007/s10834-013-9372-1.

Richardson, J. W., Klose, S. L., Gray, A. W. (2000) An applied procedure for estimating and simulating multivariate empirical (MVE) probability distributions in farm-level risk assessment and policy analysis. *Journal of Agricultural and Applied Economics* 32 (2): 299-315.

Roberts, M. J., Kirwan, B., Hopkins, J. (2003) The incidence of government program payments on agricultural land rents: the challenges of identification. *American Journal of Agricultural Economics* 85 (3): 762-769.

Robison, L. J., Barry, P. J. (1987) *The competitive firm's response to risk*. New York, USA: Macmillan.

Roe, B., Randall, A. (2010) Survey and experimental techniques as an approach for agricultural risk analysis. In *A comprehensive assessment of the role of risk in U.S. agriculture*, (eds.) D. R. Just and R. D. Pope, 265-285. Dordrecht, The Netherlands: Kluwer Academic Publishers Group.

Roodman, D. (2009) How to do xtabond2: an introduction to difference and system GMM in Stata. *Stata Journal* 9 (1): 86.

Runge, C. F. (2008) Agricultural Economics. In *The new palgrave dictionary of economics*, (eds.) S. N. Durlauf and L. E. Blume: Palgrave Macmillan.

Sand, R. (2002) The propensity to consume income from different sources and implications for saving: an application to Norwegian farm households. Paper presented at the Workshop on the Farm Household-Firm Unit: Its importance in agriculture and implications for statistics, 12-13 April, London, U.K.

Savage, L. J. (1954) *Foundations of statistics*. New York, USA: John Wiley & Sons.

Schmid, D., Roesch, A. (2013) Die wirtschaftliche Entwicklung der schweizerischen Landwirtschaft 2012. Hauptbericht Nr. 36 der Zentralen Auswertung von Buchhaltungsdaten (Zeitreihe 2003-2012). ART-Bericht 768 [The economic development of Swiss agriculture 2012: Main report no. 35 of the Swiss FADN (time series 2003-2012)]. Ettenhausen, Switzerland: Agroscope Reckenholz-Tänikon ART.

Schmitt, G. (1991) Plenary paper 2: Why is the agriculture of advanced Western economies still organized by family farms? Will this continue to be so in the future? *European Review of Agricultural Economics* 18 (3-4): 443-458.
Serra, T. (2013) Time-series econometric analyses of biofuel-related price volatility. *Agricultural Economics* 44 (s1): 53-62.
Serra, T., Goodwin, B. K., Featherstone, A. M. (2004) Determinants of investments in non-farm assets by farm households. *Agricultural Finance Review* 64 (1): 17-32.
Serra, T., Goodwin, B. K., Featherstone, A. M. (2005) Agricultural policy reform and off-farm labour decisions. *Journal of Agricultural Economics* 56 (2): 271-285.
Shee, A., Turvey, C. G. (2012) Collateral-free lending with risk-contingent credit for agricultural development: indemnifying loans against pulse crop price risk in India. *Agricultural Economics* 43 (5): 561-574.
Sherrick, B. J., Barry, P. J., Ellinger, P. N., Schnitkey, G. D. (2004) Factors influencing farmers' crop insurance decisions. *American Journal of Agricultural Economics* 86 (1): 103-114.
Shucksmith, D. M., Smith, R. (1991) Farm household strategies and pluriactivity in upland Scotland. *Journal of Agricultural Economics* 42 (3): 340-353.
Singh, I., Squire, L., Strauss, J. (1986) *Agricultural household models: extensions, applications, and policy*. Baltimore, USA: Johns Hopkins University Press.
Skees, J. R. (1999) Agricultural risk management or income enhancement. *Regulation* 22 (1): 35-43.
StataCorp. (2011) Stata statistical software: release 12. College Station, Texas, USA: StataCorp LP.
Sumner, D. A. (2009) Recent commodity price movements in historical perspective. *American Journal of Agricultural Economics* 91 (5): 1250-1256.
Sumpsi, J. M., Amador, F., Romero, C. (1996) On farmers' objectives: a multi-criteria approach. *European Journal of Operational Research* 96 (1): 64-71.
Tangermann, S. (2011) Risk management in agriculture and the future of the EU's Common Agricultural Policy. ICTSD Issue Paper No. 34. Geneva, Switzerland: ICTSD.
Teddlie, C., Yu, F. (2007) Mixed methods sampling: a typology with examples. *Journal of Mixed Methods Research* 1 (1): 77-100.
Titman, S., Wessels, R. (1988) The determinants of capital structure choice. *Journal of Finance* 43 (1): 1-19.
Turvey, C. G. (2012) Whole farm income insurance. *Journal of Risk and Insurance* 79 (2): 515-540.
Turvey, C. G., Baker, T. G. (1989) Optimal hedging under alternative capital structures and risk aversion. *Canadian Journal of Agricultural Economics/Revue canadienne d'agroeconomie* 37 (1): 135-143.
Turvey, C. G., Baker, T. G. (1990) A farm-level financial analysis of farmers' use of futures and options under alternative farm programs. *American Journal of Agricultural Economics* 72 (4): 946-957.
Turvey, C. G., Escalante, C. L., Nganje, W. (2005) Developments in portfolio management and risk programming techniques for agriculture. *Agricultural Finance Review* 65 (2): 219-245.

Turvey, C. G., Kong, R. (2009) Business and financial risks of small farm households in China. *China Agricultural Economic Review* 1 (2): 155-172.

United Nations. (2007) *The Wye group handbook. Rural households' livelihood and well-being. Statistics on rural development and agriculture household income*. New York, USA and Geneva, Zwitserland: United Nations Publications.

van Winsen, F., de Mey, Y., Lauwers, L., Van Passel, S., Vancauteren, M., Wauters, E. (2013) Cognitive mapping: a method to elucidate and present farmers' risk perception. *Agricultural Systems* 122: 42-52.

Varangis, P., Larson, D., Anderson, J. R. (2002) Agricultural markets and risks: management of the latter, not the former. World Bank policy research working paper. Washington DC, USA: World Bank.

Viaggi, D., Raggi, M., Gomez y Paloma, S. (2010) An integer programming dynamic farm-household model to evaluate the impact of agricultural policy reforms on farm investment behaviour. *European Journal of Operational Research* 207 (2): 1130-1139.

Von Neumann, J., Morgenstern, O. (1947) *Theory of games and economic behavior (2nd edition)*. Princeton, USA: Princeton University Press.

Vrolijk, H. C. J., de Bont, C. J. A. M., van der Veen, H. B., Wisman, J. H., Poppe, K. J. (2009) Volatility of farm incomes, prices and yields in the European Union. The Hague, The Netherlands: LEI Wageningen UR.

Wallace, M. T., Moss, J. E. (2002) Farmer decision-making with conflicting goals: a recursive strategic programming analysis. *Journal of Agricultural Economics* 53 (1): 82-100.

Wauters, E., Mathijs, E. (2013) An investigation into the socio-psychological determinants of farmers' conservation decisions: method and implications for policy, extension and research. *The Journal of Agricultural Education and Extension* 19 (1): 53-72.

Wauters, E., van Winsen, F., de Mey, Y., Lauwers, L. (2014) Risk perception, attitudes towards risk and risk management in agriculture: evidence and implications (working paper). Merelbeke, Belgium: ILVO.

Weber, E. U. (2010) On the coefficient of variation as a predictor of risk sensitivity: behavioral and neural evidence for the relative encoding of outcome variability. *Journal of Mathematical Psychology* 54 (4): 395-399.

Weersink, A., Nicholson, C., Weerhewa, J. (1998) Multiple job holdings among dairy farm families in New York and Ontario. *Agricultural Economics* 18 (2): 127-143.

Weiss, C. R. (1999) Farm growth and survival: econometric evidence for individual farms in upper Austria. *American Journal of Agricultural Economics* 81 (1): 103-116.

Wilkinson, K., Grant, W. P., Green, L. E., Hunter, S., Jeger, M. J., Lowe, P., Medley, G. F., Mills, P., Phillipson, J., Poppy, G. M., Waage, J. (2011) Infectious diseases of animals and plants: an interdisciplinary approach. *Philosophical Transactions of the Royal Society B: Biological Sciences* 366 (1573): 1933-1942.

Williamson, O. E. (1988) Corporate finance and corporate governance. *The Journal of Finance* 43 (3): 567-591.

Woldehanna, T., Oude Lansink, A., Peerlings, J. (2000) Off-farm work decisions on Dutch cash crop farms and the 1992 and Agenda 2000 CAP reforms. *Agricultural Economics* 22 (2): 163-171.

Wooldridge, J. M. (2010) *Econometric analysis of cross section and panel data*. London, England: MIT Press.

Zellner, A. (1962) An efficient method of estimating seemingly unrelated regressions and tests for aggregation bias. *Journal of the American Statistical Association* 57 (298): 348-368.

Zellner, A., Theil, H. (1962) Three-stage least squares: simultaneous estimation of simultaneous equations. *Econometrica* 30 (1): 54-78.

Zhengfei, G., Oude Lansink, A. (2006) The source of productivity growth in Dutch agriculture: a perspective from finance. *American Journal of Agricultural Economics* 88 (3): 644-656.

Curriculum vitae

Personal details

Name	Yann de Mey
Address	Antoon van Dyckstraat 21/3, 2018 Antwerpen, Belgium
Mobile	+32(0)472208217
E-mail	yann_de_mey@hotmail.com
Place of birth	Bonheiden
Date of birth	24 October 1986
Nationality	Belgian
Marital status	unmarried
Webpage	http://www.linkedin.com/in/yanndemey

Education

2014	PhD in business economics at Hasselt University, Centre for Environmental Sciences
2009	MSc biosciences engineering: agricultural science (*Magna cum laude*) at KU Leuven. Major: crop production, minor: agricultural economics
2007	BSc biosciences engineering: agricultural science (*Cum laude*) at KU Leuven. Major: agriculture
2004	Secondary education science math 8 hours at Koninklijk Atheneum Keerbergen

Profile

Personality	positive – organized – enthusiastic
Professional interests	Agricultural economics, development economics, econometrics, risk analysis, risk management, productivity and efficiency analysis
Personal interests	Music, guitar, cooking, traveling, science, technology

Experience

Research abroad	June–Sept 2014 Post Doc at Cornell University Nov 2013 at ART Agroscope, Switzerland Aug–Oct 2008 at AfricaRice, Senegal July 2007 at Cecodri, Togo
Teaching	2012–2013 PC-labs for the course "Econometrics" and "Applied Econometrics", Hasselt University
MSc supervising	2009–2010 Stefanie Graulus 2010–2011 Eline Smeets 2011–2012 Lore de Jong 2012–2013 Gunther Damen, Martijn Vanherk
Conference organizing	Member of the local organizing committee of the 2013 EAAE PhD Workshop, Leuven, Belgium
Grant proposal writing	EU FP7 consortium proposal (2013)
Refereeing	Agricultural Economics Applied Economic Perspectives and Policy AgBioForum

Skills

Languages	Dutch	Mother tongue
	English	Excellent
	French	Excellent
	German	Notion
Software	STATA, SPSS, R, @Risk, Reference Manager, Endnote, Microsoft Office 2013, Adobe Photoshop	Excellent knowledge
Driver's license	B	

Awards

2014	Best paper award at the 15th PhD Symposium of the Belgian Association of Agricultural Economists for the paper: Farm household risk balancing: empirical evidence from Switzerland.
2010	Best paper award at the Africa Rice Congress for the paper: Estimated versus perceived damage control productivity: impact of birds on irrigated rice in the Senegal River Valley.

List of publications

Peer reviewed journal articles

de Mey, Y., Demont, M. and Diagne, M. (2012). Estimating bird damage to rice in Africa: Evidence from the Senegal River Valley. *Journal of Agricultural Economics* 63(1): 175-200.

de Mey, Y., van Winsen, F., Wauters, E., Vancauteren, M., Lauwers, L. and Van Passel, S. (2014). Farm-level evidence on risk balancing behavior in the EU-15. *Agricultural Finance Review* 74(1): 17-37.

van Winsen, F., de Mey, Y., Lauwers, L., Van Passel, S., Vancauteren, M. and Wauters, E. (2013). Cognitive mapping: a method to elucidate and present farmers' risk perception. *Agricultural Systems* 122: 42-52.

Wauters, E., van Winsen, F., de Mey, Y. and Lauwers, L. (2014). Risk perception, attitudes towards risk and risk management: evidence and implications. *Agricultural Economics - Zemědělská ekonomika* (accepted).

Peer reviewed book chapters

de Mey, Y. and Demont, M. (2013). Bird damage incidence and control in rice in Africa. In: Wopereis, M., Johnson, D., Horie, T., Tollens, E. and Jalloh, A. (eds.), *Realizing Africa's Rice Promise*. CABI, Wallingford, UK.

Submitted manuscripts under review

de Mey, Y., Vancauteren, M., van Winsen, F., Wauters, E., Lauwers, L. and Van Passel, S. (2014). Measuring productivity change using alternative input–output concepts: a farm level application using FADN data.

de Mey, Y., van Winsen, F., Wauters, E., Vancauteren, M., Lauwers, L. and Van Passel, S. (2014). Risk management versus entrepreneurship: the dual direction of risk balancing.

de Mey, Y., Wauters, E., Schmidt, D., Lips, M. (2014) Farm household risk balancing: empirical evidence from Switzerland.

van Winsen F., de Mey Y., Lauwers L., Van Passel S., Vancauteren M., Wauters E. (2014). Determinants of risk behaviour: effects of perceived risks and risk attitude on farmer's adoption of risk management strategies.

Wauters, E., de Mey, Y., van Winsen, F., Van Passel, S., Vancauteren, M. and Lauwers, L. (2014). Farm household risk balancing: implications for policy.

Presentations at international conferences and seminars

de Mey, Y., Demont, M. and Diagne, M. (2010). Estimated versus perceived damage control productivity: Impact of birds on irrigated rice in the Senegal River Valley. Paper presented at the Africa Rice Congress 2010: Innovation and Partnerships to Realize Africa's Rice Potential, 22-26 March, Bamako, Mali.

de Mey, Y., Vancauteren, M., Van Passel, S., van Winsen, F., Wauters, E. and Lauwers, L. (2011). Input-output concepts, profits and productivity growth: An application using Flemish farm level data. Paper presented at the EAAE 2011 Congress, August 30 - September 2, Zürich, Switzerland.

de Mey, Y., Vancauteren, M., van Winsen, F., Wauters, E., Lauwers, L. and Van Passel, S. (2013) Measuring productivity change using alternative input–output concepts: a farm level application using FADN data. Paper presented at the International Agricultural Trade Research Consortium (IATRC) Symposium, June 2-4, Seville, Spain.

de Mey, Y., van Winsen, F., Wauters, E., Vancauteren, M., Lauwers, L. and Van Passel, S. (2013). Drivers of risk balancing behavior in the EU–15. Paper presented at the SCC-76 Information Exchange Group: Economics and Management of Risk in Agriculture and Natural Resources, 14–16 March, Pensacola, USA.

de Mey, Y., Wauters, E., van Winsen, F., Vancauteren, M., Van Passel, S. and Lauwers, L. (2012). From total farm to household risk: Implication for risk management. Paper presented at the 123rd EAAE Seminar on Price Volatility and Farm Income Stabilisation, February 23-24, Dublin, Ireland.

de Mey, Y., Wauters, E., van Winsen, F., Van Passel, S., Vancauteren, M. and Lauwers, L. (2012). Risk balancing at the household level: Implications for policy and risk management. Paper presented at the International Agricultural Risk, Finance, and Insurance Conference (IARFIC), June 20-21, Beijing, China.

Research reports in Dutch

Lauwers, L., de Mey, Y., Wauters, E., Vancauteren, M., Vanmeensel, J., and Van Passel, S. (2009). De volatiliteit van het landbouwinkomen. ILVO mededeling nr. 68.

van Winsen, F., de Mey, Y., Wauters, E., Lauwers, L., Van Passel, S. and Vancauteren, M. (2011). Een volatiele melkprijs: het effect op het risicoprofiel van melkveebedrijven. ILVO-mededeling nr. 84.

Wauters, E., de Mey, Y., van Winsen, F., Van Passel, S., Vancauteren, M. and Lauwers, L. (2011). Van bedrijfsrisico naar sociaal-economisch risico bij landbouwgezinnen. ILVO-mededeling nr. 104.

Wauters, E., van Winsen, F., de Mey, Y., Van Passel, S., Vancauteren, M., Lauwers, L. and Deuninck, J. (2013). Risicoperceptie, attitude ten opzichte van risico en risicomanagement in de Vlaamse landbouw. Resultaten op basis van het LandbouwMonitoringsNetwerk. ILVO-mededeling nr. 145.