Research Papers
Issue RP0242
December 2014

CIP - Climate Impacts and Policy Division

What role for income stabilisation insurance in EU agriculture? The case of the Regione Emilia Romagna in Italy

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This report represents the Deliverable P81 developed within the framework of Work Package 6.2.15 of the GEMINA project. The research leading to these results has received funding from the Italian Ministry of Education, University and Research and the Italian Ministry of Environment, Land and Sea under the GEMINA project and from the EU's Seventh Framework Program (FP7/2007-2013) under grant agreement n° 308438 (ENHANCE). We thank Mattia Amadio for drawing figures 1 and 3.

SUMMARY The steep upward-rising damage trend incurred by natural hazard risk as a result of climate change is already inflating economic losses in agriculture, as well as the costs of protection and recovery instruments. This is aggravated by the unprecedented economic crises the EU has faced since the summer 2007, which sparks further concerns about the solvency of the instruments used by states and insurers to finance the increasing costs of natural disasters. In this context, collaboration of public and insurance sectors through Public-Private Partnerships (PPPs) for crop insurance provision has been increasingly advocated. PPPs are a means to balance out the traditional solvency concerns of the insurance industry and society's affordability and equity targets, while reducing the overall financial burden of natural disasters and other risks. Most recently the EU has encouraged the development of income insurance in the context of the new CAP 2014-2020. While additional public funds have been made available for its implementation, a more in-depth knowledge of insurance demand dynamics is still necessary to make the most out of income insurance. This paper explores the viability of income insurance schemes in the framework of the CAP reform, developing a case study in the Regione Emilia Romagna (RER) in Italy. First, insurance supply costs are assessed using most recent actuarial data. The paper then develops and applies a methodology to estimate income insurance demand for the Agricultural Districts in the RER, based on Revealed Preferences Models and the Certainty Equivalent Theory. Results show that WTP for income insurance is close to the average risk premium, supporting in principle the development of income insurance.

Keywords: Crop insurance, Income insurance, Insurance demand, Revealed preferences, Italy.

JEL: Q14, Q17, Q18, Q20

1. INTRODUCTION

EU agriculture is a particularly vulnerable sector to the prospects of climate change: with *high confidence*, the Intergovernmental Panel on Climate Change (IPCC) portrays a climate change scenario for Europe marked by decreasing average annual and seasonal rainfall, intensified by more sudden heatwaves and droughts. Storms and floods will also increase their frequency and intensity. In some areas, higher temperatures combined with humidity could create conditions for increased pressure from fungal diseases and other pests. Also, weeds are likely to compete even more than now against crops such as corn. The combined effect of these impacts will affect international markets and distort the prices of agricultural inputs and outputs. Some climate changes may be positive for some northern European regions, but most of them will be negative, affecting areas already suffering from environmental or other changes, particularly southern and south-eastern European regions (IPCC, 2014). Although the bulk of these impacts may not be felt until 2050, the steep upward-rising damage trend incurred by natural hazard risk as a result of climate change is already inflating economic losses in agriculture, as well as the costs of protection and recovery instruments, and this will be aggravated even in the short term (IPCC, 2014; UNISDR, 2012).

The *unprecedented* (EC, 2009a) economic crises the EU has faced since the summer 2007 has sparked further concerns about the states' ability to co-finance the increasing costs of disaster protection, and the extent to which *ex-post* emergency funds can compensate the private damage even in countries where this is a regular practice. Furthermore, many have suggested that while the extreme events' probability distribution is getting progressively more fat-tailed, the private insurance businesses alone will not be able to keep the pace (Bielza et al., 2009; Capitanio et al., 2011a; Pérez-Blanco and Gómez, 2014a; Warner et al., 2013). Hence the collaboration of public and insurance sectors in meeting the great societal challenges posed by climate change has been increasingly advocated not only as an opportunity but as a sheer necessity.

In this context, Public-Private Partnerships (PPPs) have gained on importance for the provision of crop insurance, notably in some Member States such as France, Spain or Italy (Bielza et al., 2009; CEA, 2011). Public involvement in insurance provision expands the scope of this instrument from profitability and solvency concerns, to include also affordability and equity issues. Apart from their intrinsic societal value (OJ, 2012, chap. 174–175, 196 and 222), *equitability* and *affordability* in the context of crop insurance expand risk coverage and market penetration and facilitate a wide and stable supply of the valuable *public services* produced by the agricultural sector[1]. Given the current and aggravating climate change context, affordability and equity increasingly conflict with solvency, raising a tradeoff that is typically addressed through different degrees of public subsidization. But realizing the potential of subsidies to balance affordability, equity and solvency without bringing unbearable constraints to the public budget is not an easy task. The technical difficulties to make it happen are many.

Even assuming that insurers may accurately identify agents' risk and price them accordingly, this only guarantees solvency, not affordability (Mills et al., 2006). Subsidization may enhance affordability, but not necessarily equity: some agents may be over-subsidized while others may not be able to achieve sufficient risk coverage (O'Neill and O'Neill, 2012). Further increasing affordability through additional subsidies may generate a severe budgetary burden (Miranda and Glauber, 1997). An equitable, affordable and solvent solution within the limits of budgetary discipline demands a more selective subsidizing mechanism that localizes subsidies on highly exposed and low income areas/farmers, and transfers a larger share of their insurance costs to the areas/farmers with the capacity to afford it (Bielza et al., 2009). This welfare redistribution is only implementable with information on both insurer's and insured's surplus, which makes in turn necessary an in depth knowledge of both insurance *supply* and farmers' actual Willingness To Pay (WTP) for agricultural insurance (*demand*). There is a large research body that focuses on the former need and estimates insurance costs (Collier et al., 2009; Maestro et al., 2013; Mahul and Stutley, 2010; Martin et al., 2001; Pérez-Blanco and Gómez, 2014b; Skees et al., 1997). As for

[1] I.e. food supply independence, habitat and landscape protection, soil conservation, river basins management, carbon dioxide sequestration, biodiversity conservation and food security (Gómez-Limón and Riesgo, 2004; Kampas et al., 2012; Meuwissen et al., 2003; Pérez-Blanco and Gómez, 2013; Quiroga and Iglesias, 2009). These services, of particular importance to citizens, would be supplied in different conditions and lower quantities if not for a public intervention.

the latter, research on insurance demand is scarce and mostly focused on *ex-post* assessments in the North-American area (Cabas et al., 2008; Capitanio et al., 2011b). Consequently, the agreements on subsidization reached within EU PPPs for insurance provision are largely driven by the transaction costs raised by the relevant stakeholders that conform them (Gómez et al., 2013). Furthermore, insurers pooling and monopolistic supply may capture most of these subsidies as rents, eliminating the potential incentives for farmers to enter the market (Capitanio et al., 2011a). All these factors explain the differences in the subsidies to premium ratio among countries with similar agricultural insurance schemes such as Spain (49%) or Austria (46%), and Italy[2] (80%) (Bielza et al., 2009, 2008).

Despite this major technical barrier, EU authorities have consistently encouraged and actively underpinned the advancement towards increasingly comprehensive crop insurance systems (EC, 2014, 2010; OJ, 2009, 2004), eventually supporting the development of *income insurance* in the EU and, most importantly, providing *ad-hoc* financial instruments for its subsidization in the context of the new CAP 2014-2020 (EC, 2011). The CAP reform conceives income insurance as a substitute for previously used income stabilization tools in agriculture, including price stabilization tools and agricultural input subsidies (EC, 2003; OECD, 2013). To make the most out of this new instrument and avoid the reproduction of harmful strategic behaviours, research on both the costs of income insurance (supply), and especially on the determinants of income insurance demand, is necessary.

This paper explores the viability of income insurance schemes in the framework of the CAP reform, assessing insurance supply and demand for the case of the Regione Emilia Romagna (RER) in Italy. In Section 2, the paper reviews crop insurance in the EU and assesses the opportunities that the new CAP 2014-2020 offers for the introduction of income insurance. Section 3 assesses the legal framework of insurance markets in Italy. Section 4 presents the case study area (RER) and assesses the evolution of the most relevant variables in crop insurance *supply* (i.e. insured value, risk coverage, risk premium and solvency) in this region. Section 5 introduces a

[2] Most recent data for Italy is only available for *ex-ante* premium subsidization and still displays a high subsidy to premium ratio of 70% (ISMEA, 2014a).

methodology to estimate income insurance *demand*, based on Revealed Preferences Models and the Certainty Equivalent concept. Section 6 applies this methodology to each Agricultural District (AD, in Italian: *Regione Agraria*) in the RER. Section 7 concludes the paper.

2. CROP INSURANCE IN THE EU AND THE CAP 2014-2020

2.1 CROP INSURANCE IN THE EU

The EU has witnessed an expansion of crop insurance during the last years. Available systems are largely heterogeneous and may adopt several forms (Pérez-Blanco and Gómez, 2013). Overall, it is possible to classify insurance products attending to the risk sharing strategy, risk coverage, risk liability and the loss assessment mechanism.

Risk sharing strategies in the EU comprise mutual funds (non-profit, cooperation and self-help organizations that gather groups of farmers who assume responsibility for their own risk management), mutual insurance schemes (similar to mutual funds, but offering a legal title of compensation and following insurance legal requirements), and individual insurance schemes. Among these three risk sharing schemes, the latter is probably the best known and certainly the most common instrument in the EU (Bielza et al., 2009; Meuwissen et al., 2003).

From the point of view of the risks covered, crop insurance may cover volatility in the following agricultural outputs (as compared to their historical value, or the average of the last years): i) yields, valued at constant prices; ii) revenue, including yields and prices volatility; and iii) income, including yields, prices and costs volatility. Revenue and income insurance operate at a farm scale, being common in the US and Canada (Agriculture and Agri-Food Canada - Government of Canada, 2011; FCIC, 2014). Yield insurance is the only crop insurance available in the EU (EC, 2011), the few exceptions being some pilot insurance products developed in southern EU (AGROSEGURO, 2012). Yield insurance can be divided in turn in four categories offering different degrees of coverage: i) *single risk insurance* covers against one peril or risk, or even two as long as they do not have a systemic nature (most often hail, or hail and fire); ii) *combined insurance* (also known as multi-peril insurance) offers protection against two or more risks, mostly with hail as basic cover, that may include systemic risks such as drought insurance; iii) *integral insurance* covers against all natural hazards for a single crop; and iv) *whole-farm integral insurance* covers against all natural hazards for the whole farm.

From the point of view of risk liability, the following insurance systems may be differentiated: i) private systems without public support; ii) private partially subsidized systems, either *ex-ante* (through premium subsidization), *ex-post* (through quota-share reinsurance that provides for the proportional co-participation of insurer and reinsurer for all the insured risks within a given contract, or through stop-loss reinsurance that directly protects the company budget) or both; and iii) public insurance, which can be subsidized or not subsidized (in the former case, it may also be compulsory) and is only present in Greece and Cyprus.

Another relevant feature of insurance systems is the loss assessment mechanism. In the EU, losses are usually appraised on site by experts, with index insurance having little relevance[3] (Bielza et al., 2008).

The heterogeneous structure of insurance schemes results in different degrees of crop insurance penetration and coverage in the EU. While some MS offer combined and even integral insurance in partially subsidized systems (e.g., Austria, France, Italy, Luxembourg and Spain), others have a limited coverage that only comprises single risk insurance for non-systemic events and public support is not available[4] (Belgium,

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[3] Index-based insurance products are an alternative form of insurance that make payments based not on measures of farm yields, but rather on indexes measured by government agencies or other third parties. Index-based products are best suited for homogeneous areas where all farms have highly correlated yields (for example, in the Corn Belt in the USA). Given the heterogeneity of climates, geography and production systems in many EU countries, the efficiency of index-based products is lower here. In addition, time series of yield losses in the EU are often only available at a regional level, comprising relatively large regions. Some of these regions are big and heterogeneous, making difficult to create an index that can be useful for all farmers in the region; in these cases, the use of yield data at a more disaggregated level would be advisable or even necessary. Finally, there are also some regulatory problems that may make index-based products incompatible with the Community directives (Bielza et al., 2008a).

[4] Private schemes are adequate for single risk insurance, though when systemic risks are involved they may be regarded as an unfair mechanism due to the high premiums involved and the resultant exclusion of many farmers from the insurance market. As a result, the countries with a wider risk coverage usually rely on mixed (private partially subsidized) insurance.

Denmark, Estonia, Germany, Ireland, Netherlands and UK) (Bielza et al., 2009). What is common to all these systems is that income (or revenue) insurance is rarely found.

There are many MS in which agricultural systems have already reached a maturity that permits the progressive introduction of income insurance (AGROSEGURO, 2012; ISMEA, 2011). Italy, Austria, France and Spain have crop insurance systems in which combined insurance schemes prevail, comprising an increasing variety of risks (Bielza et al., 2009). In addition, these MS have precautionary clauses that demand a progressive implementation and recurrent testing of novel insurance systems, avoiding a large negative chain reaction if design problems are made evident[5].

2.2 CROP INSURANCE IN THE FRAMEWORK OF THE CAP 2014-2020

EU policy guidelines on agricultural risk management focus on insurance, and particularly *ex-ante* subsidization (EC, 2001, 1999). Apart from some additional insurance policies on wine grapes' crops (EC, 2007a) and fruit and vegetable production (EC, 2007b), EU support to crop insurance is based on the articles 68 and 70 of the regulation n. 73/09 (EC, 2009b). This regulation defines the preconditions to grant support to farmers in the form of Community contributions to insurance premiums (*ex-ante* subsidization). The EC shall co-finance 75% of the financial contribution by the MS to farmers if the following prerequisites are met: i) there is a natural catastrophe formally recognized as such; ii) *losses* represent more than 30% of the average annual output of the farmer in the preceding three-year period or a three-year average based on the preceding five-year period, excluding the highest and lowest entry; iii) the financial contribution granted per farmer does not exceed 65% of the insurance premium due; iv) there is no overcompensation from cross-subsidization; and v) the insurance payments do not compensate for more than the total cost of replacing the losses (EC, 2009b).

Noteworthy, with 'losses', the EU refers to "any additional cost incurred by a farmer as a result of exceptional measures taken by the farmer with the objective of reducing supply on the market concerned or any substantial loss of production" (EC, 2009b).

[5] In the case of Spain, for example, this clause has been embodied in a law enforced for over 30 years (BOE, 1978).

Therefore, this definition may comprise yield, revenue and income insurance: all of them would be eligible to receive *ex-ante* subsidization from the EU.

The principles of Regulation n. 73/09 (EC, 2009b) were incorporated in the CAP 2014-2020. Within its Pillar II, the new CAP focuses on the development of instruments (mostly subsidies) that encourage the adoption of risk sharing schemes with an extended coverage (EC, 2011). More specifically, the CAP 2014-2020 gives a central role to risk management procedures and explicitly suggests that CAP funds are to be used to reduce the variability of farms' earnings (thus, comprising again income security), which are mainly threatened by the "growing volatility of prices and the adverse weather conditions" (EC, 2011). The new CAP also comprises for the first time a Community income stabilization tool based on risk sharing schemes, which is firstly proposed for mutual funds[6] (EC, 2011).

The Community income stabilization tool shall be adopted "in the form of financial contributions to mutual funds, providing compensation to farmers who experience a severe drop in their income" (EC, 2011). Mutual funds are also eligible for *ex-ante* subsidization (EC, 2011, 2009b). As a result, mutual funds have been recently promoted in different MS to complement predominant insurance systems.

2.3 CROP INSURANCE IN ITALY: CURRENT SITUATION AND OPPORTUNITIES FOR REFORM

Conventional individual insurance is the prevailing risk sharing instrument in Italy (ISMEA, 2011). Recently, the financial support envisaged by the EU for mutual funds within the framework of the CAP 2014-2020 has resulted in Italian institutions encouraging the implementation of this instrument (ISMEA, 2014a). Mutual funds are not new in Italy, though: the decree 102/2004 (GU, 2004a) and the law 388/2000 (GU, 2000) already established that mutual funds constituted by the so-called *Comisioni di Difesa* were to be eligible to receive public funding. However, the law project that advanced public support to these funds did not receive the approval from the EC. In spite of this setback, mutual funds sprung up in Italy even without public support in

[6] In the EC definition, the legal nature of these institutions is not clear, and they could include also insurance mutuals (Bielza et al., 2009).

different agricultural spheres[7]. In any case, these mutual funds still have a marginal relevance in the wider agricultural risk management system.

The current Italian crop insurance system formally starts after the introduction of the National Solidarity Fund (NSF) (GU, 1970). The NSF institutionalized the coverage of agricultural losses due to uncontrollable variables through *ex-post* public compensation and included *ex-ante* interventions providing for active collective protection and subsidized insurance. During its first 30 years of activity, 70% of the budget of the NSF was aimed at *ex-post* compensation, with *ex-ante* subsidization playing a marginal role (ISMEA, 2011).

Following the EU policy guidelines on agricultural risk management (EC, 2001, 1999), the Legislative Decree 102/2004 amended the NSF priorities and gave a prominent role to the *ex-ante* tools for the promotion of insurance coverage through public subsidies for the payment of premiums (GU, 2004b). This law also established that insurable crops and premises would be excluded from *ex-post* compensation (GU, 2004b), causing a reduction in *ex-post* expenses and giving a more relevant role to agricultural insurance. The agricultural insured value grew by 38.5% in the period 2004-2012, reverting the previous trend that had reduced the insured value by 15.3% in the period 1998-2004[8] (ISMEA, 2014a).

Premium subsidization in Italy has a maximum threshold of 80% of the premium cost for insurance contracts against catastrophic natural disasters, in case the deductible amounts to at least 30% of the insured production (20% in the so called *disadvantaged areas* –comprising mountain and hill farming and other less favoured areas). The maximum threshold for premium subsidization falls to 50% in case the insurance contract also covers other damages outside the range of catastrophic natural disasters

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[7] This is the case of the *Fondo Multirischio Pomodoro da Industria Alessandria*, the *Fondo Mutualistico – difesa dale epizoozie del CODIPRA Parma, the Fondo di mutualità consortile*, the *Fondo commune Danni causati da avversità atmosferiche a frutta di Trento*, the *Fondo mutualistico consortile del CODIPRA Toscana* and the *Agrifondo Mutualistico Veneto e Friuli* (Pontrandolfi and Nizza, 2011).

[8] In the 1998 campaign the indemnity to premium ratio was above 150% due to catastrophic losses. Insurance companies reacted applying more restrictive selection criteria (reducing the insured value and the indemnities paid) and increasing the risk premium. As a result, the insured value experienced a reduction (ISMEA, 2014a).

(e.g., due to non-catastrophic adverse weather events or pests) (ISMEA, 2011). The latter would be the case for income stabilization insurance. Noteworthy, the former premium subsidization system would not be eligible for EU support, where the maximum threshold for premium subsidization is set at 65% (EC, 2009b).

In spite of its decreasing relevance, *ex-post* public support still play a fundamental role in the post-reform Italian insurance system, where the state acts as a re-insurer. There are two re-insurance systems available:

Non proportional reinsurance for combined risk policies, through a *stop-loss treaty* that protects the company budget when the indemnity to premium ratio of the insurance policy is between 90% and a maximum of 160%. The reinsurance fund is funded through a levy over the premium paid by insured agents that ranges between 8% and 14%. The fund may cover a maximum of 70% of the insured value. This system is applied for the *pluririschio* insurance, a type of combined insurance in Italy (GU, 2003).

Proportional reinsurance for other insurance systems through the *quota share system*, where insurer and re-insurer share premiums and risk. The insurance companies have to pay the reinsurance fund at least 80% of the premiums that fall under the fund's share. The fund may cover a maximum of 50% of the insured value. This system is applied for the *multirischio* insurance, another type of combined insurance in Italy (GU, 2003).

In addition, the Co-Reinsurance consortium against natural disasters in agriculture was also founded in 2007, with the objective of promoting the introduction of innovative insurance products through the apportionment of risks among the private agents that constitute the consortium (ISMEA, 2011).

The collaboration between private insurers and the public sector for the provision of crop insurance has made possible that premiums remain at stable and affordable levels to farmers, both through *ex-ante* subsidization and *ex-post* public re-insurance. At present, the Italian system is one of the most advanced agricultural insurance systems in the EU (Bielza et al., 2009). The system is adapted to the EU legislation (EC, 2009b) and largely compatible with CAP requirements (EC, 2011). However, some problems still persist. For example, there is an imbalance in the development of agricultural insurance: while the system is highly developed in areas to the north of

Italy (e.g., the PRBD), in the south agricultural insurance remains largely underdeveloped. Also, current policies only cover yield variability due to pests, adverse weather events and natural disasters but do not address market risks, of increasing concern among farmers and EU and national institutions. Closely connected to the latter, the generous Italian subsidization mechanism has resulted in one of the highest subsidies to premium ratios in the EU, and this is regarded as a budgetary burden preventing the adoption of a more comprehensive risk coverage (EC, 2011; ISMEA, 2011; Meuwissen et al., 2003).

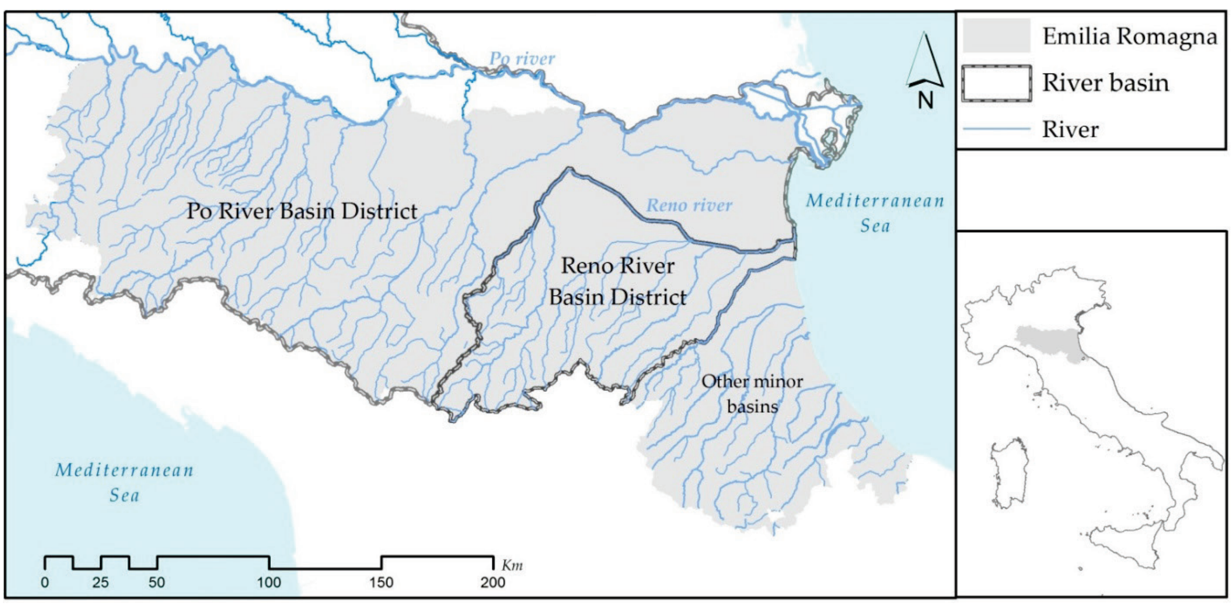
3. CASE STUDY AREA: THE REGIONE EMILIA ROMAGNA

The Regione Emilia Romagna (RER) is a region (NUTS 2) to the north east of Italy, with a total surface of 22 447 km^2 and a population of 4 429 766 inhabitants (Eurostat, 2014). RER is the third Italian region by GDP per capita, most of which is produced in the tertiary sector (66.5% of Gross Value Added, GVA, and 65.4% of employment). RER also harbours a thriving and varied manufacturing industry (24.1% of GVA, and 24.2% of employment), in which food industry stands out (3.7% and 2.3% of GVA and employment, respectively). Closely connected to this sector, RER is among the leading agricultural regions in Italy, generating 11.3% and 7.5% of national agricultural GVA and employment, respectively. RER holds a series of competitive advantages for the development of agriculture: large and fertile lowlands, proximity to international markets, and a favourable climate, including warm summers with abundant sunlight and winters with high precipitation. For centuries, RER has created and updated a sophisticated network of canals, dykes, reservoirs and drainage systems to develop or improve existent agricultural areas across the region. RER ranks among the Italian regions with a largest share of irrigated surface (259 668 ha, 24.4% of RER Utilised Agricultural Area, UAA) and irrigable surface (650 487 ha, 61.1% of RER UAA) (ANBI, 2013; ISTAT, 2013). These advantages, combined with a recent structural reorganization aiming at the production of high-quality products, result in one of the most competitive agricultural areas in Italy, contributing to 2.7% of GVA and 3.3% of employment at a regional level (as compared to 1.9% and 3.8% at a national level) (ISTAT, 2014). RER comprises 46 ADs (*Regione Agrarie*), which display in some cases significant differences regarding management practices and crop portfolios.

Wheat (38.1% of the UAA, excluding permanent pastures), corn (25.1%) and other cereals (18%) are the most important crops, along with fruit trees (most notably pear tree, peach tree, apricot tree, apple tree, and plum tree) and vineyards for the production of internationally marketed wine brands (10.2%) (ER Statistica, 2014).

RER territory is mostly located within the boundaries of the Po River Basin District (PRBD) (66.61% of the RER territory) and the Reno River Basin District (RRBD) (20.75% of the RER territory), with 12.64% of the RER territory located in other basins[9] (see Figure 1). RER watercourses are heavily modified water bodies, the result of centuries of intensive investment in physical capital to divert water flows and drain marshlands, starting back in the XIIth Century. As a matter of fact, the RRBD is an artificial basin: the course of the Reno River originally flowed into the Po River, causing major floods in the lowlands; to avoid the negative impact of these inundations, the Reno River was diverted in the XVIIIth century into an artificial channel, the so-called *Cavo Benedettino*, which flowed directly into the Mediterranean Sea.

Figure 1: The RER



Source: Own elaboration

[9] Mostly the minor basins of Fiumi Uniti (5.71%), Savio (3.1%), Marecchia (1.97%), Lamone (1.64%) and Foglia (0.09%), but also a marginal part of the Tiber River Basin (0.13%).

Intensive and lasting physical capital investments have increased the agricultural output but also came at the expense of a high exposition to (low probability and high impact) flood events. In addition, the RER has been showing recently an increasing exposure to drought spells. Since 2003, the state of (national) emergency under the law 224/1992 has been declared three times in the PRBD following intense drought events (2003, 2006, 2007), for a total duration of 21 months (Mysiak et al., 2013). The increasingly frequent meteorological droughts in the PRBD are exacerbated by the fact that the RER and other regions located upstream lack major water storage infrastructures, and thus low rainfall rapidly evolves into hydrological droughts with negative impacts on agriculture. Other natural hazards with a recurrent and negative impact on agricultural output in the RER include hail, frosts and wind (ISMEA, 2014a).

RER has pioneered the adoption of insurance to compensate for yield damages caused by these risks, now exacerbated by climate change. While producing 11.3% of the agricultural output, RER accounts for 18% of the total insured value, 15% of the total indemnity and 20% of the total premium in Italy (ISMEA, 2014a). Insured value in the RER experienced a remarkable growth in the period 2004-2012 following the passing of the Legislative Decree 102/2004 (GU, 2004b) (growing 45.2%, above the 38.5% figure for the whole country), with peaks in the years following campaigns with particularly intense losses[10] (2004, 2008, 2011). The period 2004-2012 coincided also with the expansion of combined insurance schemes: while only 1.8% of the agricultural insured value, 0.3% of the total premium and 0.2% of the indemnities corresponded to combined insurance in 2004, these figures had grown to 56.4%, 69.5% and 80.6% in 2012[11] (ISMEA, 2014a), showing a clear move towards increasingly comprehensive insurance systems. Combined insurance policies in RER offer coverage against different combinations of the following: frost, hail, heatwave, excess rain, flood, drought, heat wind (*scirocco*), wind and temperature leap (ISMEA, 2014a).

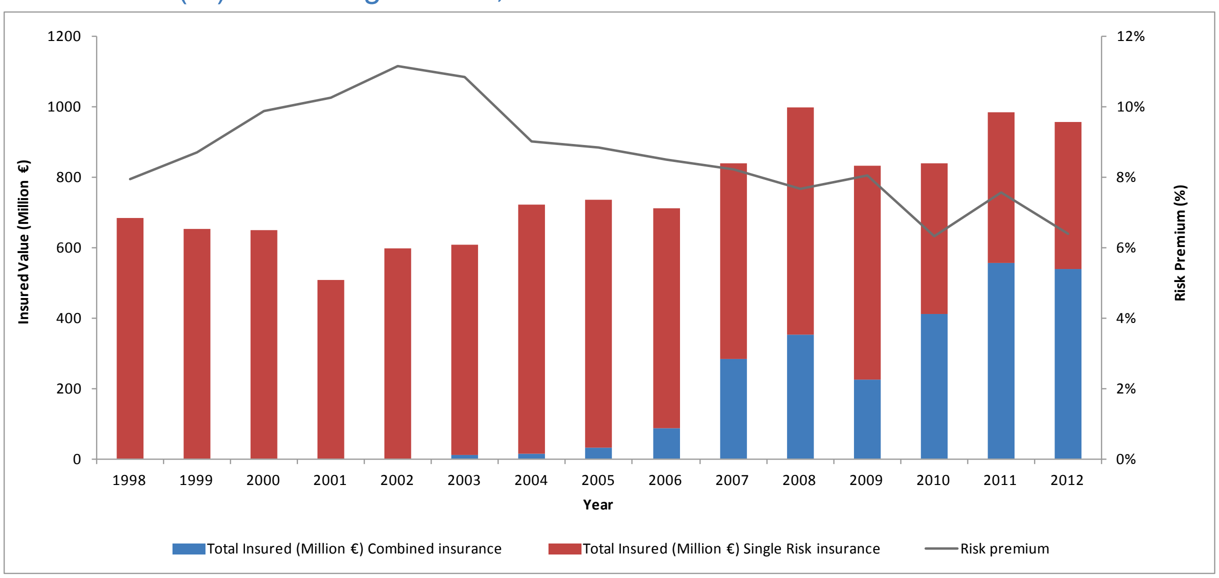
[10] As measured by the indemnity to premium ratio (ISMEA, 2014a)

[11] The comparatively larger share over the total premiums and indemnities of combined insurance is explained by its larger indemnity to premium ratio as a result of its wider risk coverage as compared to single risk insurance. For example, in 2012 the indemnity to premium ratio was 62% for combined insurance and 34.1% for single risk insurance (ISMEA, 2014a).

Product bundling has come along with a sustained reduction of the premium to insured value ratio (average *risk premium*), from a peak value of 11.1% in 2002 to 6.4% in 2012 (4.5% and 7.9% for single risk and combined insurance, respectively). The average *risk premium* for the period 1998-2012 was 8.6% (8% for single risk insurance and 8.9% for combined insurance), while the average indemnity to insured value ratio (*basic risk premium*) was 6.2% (5.5% and 6.9% for single risk and combined insurance, respectively) (ISMEA, 2014a). Noteworthy, crop insurance policies in Italy apply deductibles[12] that range between 10% and 30% (ISMEA, 2011).

The indemnity to premium ratio, an indicator of the solvency of the system, has been reduced and stabilized during the period 2004-2012 (average indemnity to premium ratio of 67.6%, with a standard deviation of 22.6%), as compared to the oscillating figures of the period 1998-2004 (80.5% and 44.4%, respectively) (ISMEA, 2014a).

Figure 2: Insured Value by risk coverage (combined and single risk, Million €) and Risk Premium (%) in RER agriculture, 1998-2012



Source: Own elaboration from ISMEA (2014a)

[12] Deductible are the initial share of the damage that is not protected. Deductibles avoid full damage recovery, and are applied to reduce moral hazard. A deductible of 30% implies that a maximum of 70% of the insured damage is eligible for compensation. With this deductible, in an extreme situation in which all the insured value is damaged, the indemnity would equal 70% of the insured value. If there have been damages attributable to an insured risk but these are below the deductible, the indemnity would be zero. Finally, if damages are between 30% and 100% of the insured value, the indemnity would equal the maximum possible indemnity minus the remaining insured value that is not damaged, meaning that the loss recovery ratio would be in the interval (0%, 70%).

4. METHODS

This section develops a methodology to estimate farmers' Willingness to Pay (WTP) in order to guarantee a minimum share of their expected income (i.e., considering different deductibles). The section is divided in two parts. Section 5.1 presents a Revealed Preferences Model (RPM) that shows the motivations behind farmers' decisions through the estimation of their utility function. This part of the methodology is based on the work by Gómez et al., 2013; Gutierrez-Martin and Gomez, 2011; Gutiérrez-Martín et al., 2014.

Section 5.2 builds upon the aforementioned RPM and integrates the Certainty Equivalent (CE) theory in the modelling framework. The CE is the guaranteed amount of money that an individual would view as equally desirable as a risky asset. Using this concept and the utility functions obtained in the first subsection, the amount of money that farmers would be willing to pay to guarantee a minimum share of their expected income (i.e., their WTP) is estimated.

4.1 THE REVEALED PREFERENCES MODEL (RPM)

Ex-ante, agents' preferences may be shown in two ways: either through RPMs or through stated preference models. Stated preferences are those voiced by agents when asked. They are based on survey research and are certainly useful when the necessary information for data intensive RPM is not available. However, they have some limitations[13]. This is why economists generally prefer to assess policies or

[13] Most notably, measure is not incentive compatible: not all of the participants fare best when they truthfully reveal any private information asked for by the mechanism, leading to problems with nonresponses, strategic responses and protest responses[13]. In addition, people are not calibrated to value non-market goods and appear sensitive to framing, this leading in turn to starting-point bias, scenario misspecification bias and even to responses ignoring income constraints. Finally, responses provided for a particular scenario may not be transferable to a different location or moment of time, increasing the resources that must be devoted to surveying (Diamond and Hausman, 1994; Halstead et al., 1992; Pearce, 2002; Rabin and Kőszegi, 2007). Although fruitful research has been produced to address these criticisms (Arrow et al., 1993; Campos et al., 2009; Collins and Rosenberger, 2007; Cunha-e-Sá et al., 2012; de Boer et al., 2014; Poussin et al., 2013; Soliño et al., 2010), recommendations are many and demand a high burden of proof to satisfy before the results can be seen

projects using “hard” data (i.e., observable behavior) instead of “soft” data (i.e., declared behavior).

This subsection presents briefly the methods to calibrate a RPM able to anticipate farmers decisions (for a comprehensive description, see Gómez et al., 2013 and Gutierrez-Martin and Gomez, 2011). The implicit assumption of this model is that the decisions taken at this stage respond to an underlying utility function that can be revealed from observed farmers behavior (Gutierrez-Martin and Gomez, 2011). This utility function can be described as follows:

$$\underset{x}{\mathrm{Max}}\, U(x) = U(z_1(x);\ z_2(x); z_3(x) \dots z_m(x)) \quad [1]$$

$$\text{s.t.:} \quad 0 \leq x_i \leq 1 \quad [2]$$

$$\sum_{i=1}^{n} x_i = 1 \quad [3]$$

$$X \in F(x) \quad [4]$$

$$z = z(x) \in R^m \quad [5]$$

Where $x \in R^n$ is the available alternative decisions to distribute land among crops (a vector representing the crop mix), with x_i measuring the share of land corresponding to the crop i. $F(x)$ represents the space of feasible decision profiles, given the different constraints: land availability, available water resources, agricultural vocation (crops that have not been planted in an area before cannot appear in that area in the short run), crop rotation, CAP restrictions and ligneous crops restrictions (the surface of ligneous crops cannot change significantly in the short run). The vector z contains the attributes that farmers value; for example, it is reasonable to assume that farmers will prefer a crop mix with a high expected income, low risk and not too many management complexities such as hiring additional labor.

Provided that the crop mix and the constraints are known and the relevant decision attributes are measurable, it is possible to calibrate the model and reveal farmers’ preferences (Gutierrez-Martin and Gomez, 2011). This is done in two steps: i) first, the relevant attributes explaining farmers’ decisions are found; ii) second, the distribution of

as meaningful. Surveys meeting all these criteria are very expensive to operate. As a result, it is still observed that agents’ stated preferences often do not match their actions (Rabin and Kőszegi, 2007).

the available resources among the relevant attributes is explored so as to find the utility maximizing crop mix.

4.1.1 THE RELEVANT ATTRIBUTES

It is assumed that the relevant set of attributes is the one to which the observed decision is closest to the attributes possibility frontier. In real situations this efficiency frontier cannot be analytically defined with a closed mathematical function and the only way to represent it is by using numerical methods. One practical solution consists in estimating the mean squared error of the distances between each pair (subset) of observed decision attributes and their corresponding possibility frontier, for each set of potentially relevant attributes for the farmer. This procedure is repeated for every set of potentially relevant attributes within the Power set $Z(\tau)$.

The power set $Z(\tau)$ comprises all the 2^m possible combinations of potentially relevant attributes z_r $(r = 1, \dots, m)$ for the farmer. Each combination of attributes conforms a set whose position in the m-dimensional space is determined by the crop portfolio x and denoted by $\tau(x, l)$ $(l = 1, \dots, 2^m)$. For the observed crop portfolio x_o, the position is denoted by $\tau(x_o, l)$. The position of each subset or pair of attributes z_r, z_j belonging to a set l is represented by $\tau_{z_r,z_j}(x, l)$, and that of the observed values x_o by $\tau_{z_r,z_j}(x_o, l)$. The relevant set of attributes (τ^*) will be that with the lower distance to the efficiency frontier, which is measured by the mean squared error ε as follows:

$$\underset{l}{\text{Min}}\ \varepsilon = \frac{1}{l^2 - l} \sum_{r,j} \left(\tau_{z_r,z_j}(x^+, l) - \tau_{z_r,z_j}(x_o, l) \right)^2 ; \forall z_r, z_j \in l;\ z_r \neq z_j \qquad [6]$$

Where:

$$x^+ = \text{ArgMax}_x \left[\tau_{z_r,z_j}(x, l) - \tau_{z_r,z_j}(x_o, l);\ 0 \leq x_i \leq 1;\ \textstyle\sum_{k=1}^{n} x_k = 1;\ X \in F(x); \forall \tau \epsilon Z(\tau) \right] \qquad [7]$$

$$l = (1, \dots, 2^m) \qquad [8]$$

Among the many factors that might be of relevance in farmers preferences, τ^* is the set that takes the observed decision closer to the attributes efficiency frontier.

4.1.2 THE UTILITY FUNCTION

Starting from the relevant decision attributes obtained above, the multi-attribute utility function is that eliciting farmers' preferences in such a way that the observed decision becomes the optimal choice. Rational decisions imply that in equilibrium farmers' marginal willingness to pay in order to improve one attribute with respect to any other equals the marginal opportunity cost of this attribute with respect to the other. In other words, the marginal transformation relationship between any pair of attributes over the efficiency frontier $(\mathrm{MTR_{kp}})$ is equal in equilibrium to the marginal substitution relationship between the same pair of attributes over the indifference curve tangent to the observed decision $(\mathrm{MSR_{kp}})$. This value can be obtained numerically by solving partial optimization problems in the proximity of the observed decision (for example, searching by how much expected profits would need to be reduced in order to have a 1% less uncertainty). In equilibrium, decisions over crop surfaces are such that:

$$\beta_{kp} = \mathrm{MTR_{kp}} = \mathrm{MSR_{kp}} = -\frac{\partial U/\partial z_p}{\partial U/z_k}\ ;\ p, k \in (1, .. l); p \neq k \qquad [9]$$

This information for the reference point over the efficiency frontier is enough to integrate a utility function that makes the observed decision the optimal one, given the existing constraints. Following Gómez et al. (2013) and Gutierrez-Martin and Gomez (2011), a Cobb-Douglas functional form is used. The utility function in [1] can be now expressed as:

$$U(\tau) = \prod_{r=1}^{l} z_r^{\alpha_r}; \qquad \sum_{r=1}^{l} \alpha_r = 1 \qquad [10]$$

The marginal substitution relationship among any pair of attributes is:

$$-\frac{\partial U/\partial z_p}{\partial U/z_k} = -\frac{\alpha_p}{\alpha_k}\frac{z_k}{z_p} \qquad [11]$$

And the parameters of the Cobb-Douglas utility function are obtained from the following system:

$$-\frac{\alpha_p}{\alpha_k}\frac{z_k}{z_p} = \beta_{kp} \qquad [12]$$

$$\sum_{r=1}^{l} \alpha_r = 1 \qquad [13]$$

In the next section, the RPM is calibrated for each ADs in the RER. The model uses the high quality microeconomic data available for the RER in different databases, containing information on land use and yields (ER Statistica, 2014), market prices (ISMEA, 2014b), production costs (variable and fixed) and labour employment (INEA, 2014), water use and irrigation efficiency (ISTAT, 2013). This information is available for 66 crops representing 85% of the agricultural surface in RER, and covers the period 1996-2011. Data is disaggregated at an AD level. All prices and costs were adjusted to constant values of 2011.

Calibration errors capture the distance between the observed data and the values offered by the RPM after being calibrated. Error terms are described in Annex I, and their numerical values are presented in Section 6.

4.2 THE CE AND THE WTP FOR INCOME INSURANCE

4.2.1 THE CERTAINTY EQUIVALENT (CE)

Farmers are risk averse individuals that are reluctant to accept a bargain with an uncertain payoff rather than another bargain with a more certain, but possibly lower, expected payoff (Binici et al., 2003; Kim and Chavas, 2003; Lien and Hardaker, 2001; Tobarra-González and Castro-Valdivia, 2011). In order to simulate this tradeoff two attributes ($z(x)$) need to be introduced in the model to capture *expected income*[14] and *income variability*.

Agricultural income in the model is measured using the gross variable margin as a *proxy*. Gross variable margin is calculated as the selling price of the agricultural output, minus the variable costs of the output sold, plus subsidies. For the observed crop decision vector x, the gross variable margin ($\pi(x)$) is obtained as follows:

$$\pi(x) = \sum_i x\pi_i \qquad [14]$$

[14] In the EU insurance system, farmers are eligible for a compensation if the agricultural output observed is below a predetermined percentage of the average historical value (Bielza et al., 2008). With large enough data series, this average should be close to the expected value.

Where π_i is the matrix of the observed gross variable margins per hectare for the year i. Therefore, $\pi(x)$ estimates the agricultural income that would have been obtained with the observed crop decision in the past. $\pi(x)$ follows a continuous probability density function $g(\pi(x))$ with the following moments:

$$E(\pi(x)) = \int_{-\infty}^{\infty} \pi(x) g(\pi(x))\, dx \qquad [15]$$

$$Var(\pi(x)) = \sigma^2(\pi(x)) = \int_{-\infty}^{\infty} \left(\pi(x) - E(\pi(x))\right)^2 g(\pi(x))\, dx \qquad [16]$$

From the equations above it is possible to define two attributes $(z(x))$ to capture income and income variability. Expected income $(z_1(x))$ is captured by the expected value of the gross variable margin, i.e.:

$$z_1(x) = E(\pi(x)) \qquad [17]$$

On the other hand, income variability is measured through *risk avoidance* $(z_2(x))$, which is obtained as the difference between the risk associated with the crop decision $\bar{x}$ leading to the maximum expected income $(\bar{\sigma})$ and the risk associated with the alternative crop decision x $(\sigma(\pi(x)))$:

$$z_2(x) = \bar{\sigma} - \sigma(\pi(x)) \qquad [18]$$

Where $\bar{\sigma}$ is the standard deviation of the agricultural income of the crop decision $\bar{x}$ $(\pi(\bar{x}))$, which follows a probability density function $h(\pi(\bar{x}))$.

Equation [10] can be now reformulated as follows:

$$U(z) = z_1^{\alpha_1} z_2^{\alpha_2} \prod_{r=3}^{m} z_r^{\alpha_r}; \qquad \sum_{r=1}^{l} \alpha_r = 1 \qquad [19]$$

Finally it is possible to define the CE, which is the amount of money (CE) with zero risk $(\sigma(\pi(x)) = 0$, i.e., $z_2(x) = \bar{\sigma})$ that an individual would view as equally desirable (i.e., with the same utility U) as the current (risky) asset:

$$U(z) = U_{CE}(z) = CE^{\alpha_1} \bar{\sigma}^{\alpha_2} \prod_{r=3}^{l} z_r^{\alpha_r} \qquad [20]$$

After a simple transformation, the CE can be defined as[15]:

$$CE = \left(\frac{U(z)}{\bar{\sigma}^{\alpha_2} \prod_{r=3}^{l} z_r^{\alpha_r}} \right)^{\frac{1}{\alpha_1}} \qquad [21]$$

[15] The difference between the expected income $(z_1(x))$ and the CE can be interpreted as farmers' WTP for full income security (i.e., no income variability). It should be noted, though, that insurance companies only cover negative deviations from the expected income.

4.2.3 THE WTP FOR INCOME INSURANCE

Agricultural income insurance guarantees a minimum income to farmers in exchange of a regular payment. This minimum threshold is generally below the expected income, since insurance companies usually decline offering full income insurance and define instead a deductible ($\delta \in [0,1]$) over the insured product in order to avoid moral hazard. In Italy, δ ranges between 10% and 30% (ISMEA, 2014a). Accordingly, the minimum income guaranteed by agricultural insurance products can be defined as:

$$\underline{z_{1,\delta}}(x) = (1-\delta)E(\pi(x)) \qquad [22]$$

Income insurance guarantees a minimum income and reduces risk exposure, but does not completely remove it, being risk an incentive towards productive behaviour. This will result in a higher expected income (excluding insurance premium) ($z_{1,\delta}(x) > z_1(x)$) and a lower risk exposure ($\sigma_\delta(\pi(x)) < \sigma(\pi(x))$) in the scenario with income insurance (denoted by the subscript δ) as compared to the baseline scenario without income insurance in the previous section.

Formally, we may see income insurance as an intervention that truncates the probability distribution of the per hectare income of the crop decision x ($g(\pi(x))$). Accordingly, the expected income ($z_{1,\delta}(x)$) and risk avoidance ($z_{2,\delta}(x)$) with insurance are defined as follows:

$$z_{1,\delta}(x) = \int_{\pi(x)=0}^{z_1(x)} g(\pi(x))\underline{z_{1,\delta}}(x)\,dx + \int_{\pi(x)=\underline{z_{1,\delta}}(x)}^{\max_{\pi(x)}} g(\pi(x))\pi(x)\,dx \qquad [23]$$

$$z_{2,\delta}(x) = \overline{\sigma} - \sigma_\delta(\pi(x)) \qquad [24]$$

Where $\max_{\pi(x)}$ is the value of the variable $\pi(x)$ that make its cumulative density function equal to 1 (i.e., the probability of any value above this limit is zero). The risk associated with the alternative crop decision x with insurance ($\sigma_\delta(\pi(x))$) is now:

$$\sigma_\delta(\pi(x)) = \left(\int_{\pi(x)=0}^{z_1(x)} g(\pi(x))\left(\underline{z_{1,\delta}}(x) - z_{1,\delta}(x)\right)^2 dx + \int_{\pi(x)=\underline{z_{1,\delta}}(x)}^{\max_{\pi(x)}} g(\pi(x))\left(\pi(x) - z_{1,\delta}(x)\right)^2 dx\right)^{1/2} \qquad [25]$$

Akin to equation [19], the utility function with income insurance ($U_\delta(\tau)$) can be expressed as follows:

$$U_\delta(z) = z_{1,\delta}{}^{\alpha_1} z_{2,\delta}{}^{\alpha_2} \prod_{r=3}^{l} z_r^{\alpha_r}; \qquad \sum_{r=1}^{l} \alpha_r = 1 \qquad [26]$$

And the CE with income insurance (CE_δ) can be defined as:

$$CE_\delta = \left(\frac{U_\delta(z)}{\bar{\sigma}^{\alpha_2} \prod_{r=3}^{l} z_r^{\alpha_r}} \right)^{\frac{1}{\alpha_1}} \qquad [27]$$

The CE of the scenario with income insurance (CE_δ) is higher than the CE of the baseline scenario without income insurance (CE), since the former has a higher expected income and risk avoidance and these are attributes that agents value positively. The WTP for income insurance (WTP_δ) can be now obtained as the difference between the CE with and without income insurance:

$$WTP_\delta = CE_\delta - CE \qquad [28]$$

By changing the value of the deductible δ it is possible to calculate the WTP for different income insurance policies, from the baseline scenario without income insurance in which $\delta = 1$ (and therefore $CE_\delta = CE$ and $WTP_\delta = 0$) to full income insurance ($\delta = 0$).

5. RESULTS

The above-introduced methodology is applied in the RER. Section 6.1 calibrates de utility function for each one of the 46 ADs in this region. Section 6.2 estimates the CE and the WTP for income insurance using different deductibles.

5.1 MODEL CALIBRATION

In section 5, two attributes that risk averse farmers value were introduced: expected income ($z_1(x)$) and risk avoidance ($z_2(x)$). In addition, it is assumed that farmers also avoid crop portfolios implying large management complexities. Management complexities are captured in three complementary attributes:

i) Total labor avoidance, the first way to measure management complexities avoidance through the reluctance to use too much labor (both hired and family labor).

$$z_3(x) = \overline{N} - N(x) \qquad [20]$$

Where $N(x) = \sum_i x_i N_i$ is the total labor used per hectare (daily wages/ha), being N_i the total labour required per hectare for a crop i, and $\overline{N}$ is the labour required to implement the crop decision leading to the maximum expected profit.

ii) Hired labor avoidance, the second way to measure management complexities avoidance through the reluctance to use too much hired labor.

$$z_4(x) = \overline{H} - H(x) \qquad [21]$$

Where $H(x) = \sum_i x_i H_i$ is the total hired labor used per hectare (daily wages/ha), being H_i the total hired labor required per hectare for a crop i, and $\overline{H}$ is the hired labor required to implement the crop decision leading to the maximum expected profit.

iii) Variable costs avoided, the third way to measure management complexities, which includes all the seeds, fertilizers, hired equipment and all the other variable costs (excluding labor) required to implement a particular crop decision.

$$z_5(x) = D(x) - \overline{D} \qquad [22]$$

Where $D(x) = \sum_i x_i D_i$ is the variable cost of a crop decision x, being D_i the variable cost per hectare for a crop i, and $\overline{D}$ are the variable costs required to implement the crop decision leading to the maximum expected profit.

The Cobb-Douglas Utility Function now adapts the following form:

$$U(z_1, z_2, z_3, z_4, z_5) = z_1^{\alpha_1} z_2^{\alpha_2} z_3^{\alpha_3} z_4^{\alpha_4} z_5^{\alpha_5}; \qquad \sum_{r=1}^{5} \alpha_r = 1 \qquad [23]$$

Where there are five attributes $(z_r; r = 1, \dots 5)$ and five unknown alpha coefficients $(\alpha_r; r = 1, \dots 5)$. Alphas are constants that capture the utility elasticity of their corresponding attribute in each AD. Therefore, a 1% increase in the attribute z_r will result in a α_r% increase in utility. Attributes with a higher alpha are thus valued higher by the agent than attributes with a lower alpha.

Following the methodology above, the relevance of each attribute is assessed by estimating the alpha coefficients for every AD. These coefficients are used to calibrate the Cobb-Douglas Utility Function. Finally, the calibration errors for every AD are also obtained (see Annex I for a description of the error terms). The results are displayed in Table 1:

Table 1: Alpha coefficients and calibration errors

	Alpha Values					Errors			
Agricultural District	α_1	α_2	α_3	α_4	α_5	e_f	e_a	e_d	e
Pianura di Rimini	55.2%	1.0%	0.0%	42.8%	1.0%	13.3%	1.1%	14.6%	6.6%
Pianura di Reggio Emilia	68.3%	6.2%	0.0%	25.4%	0.0%	10.9%	2.6%	10.4%	5.1%
Pianura di Modena	84.5%	15.5%	0.0%	0.0%	0.0%	5.4%	1.2%	5.4%	2.6%
Pianura Forlivese e Cesenate	85.1%	6.6%	0.0%	8.3%	0.0%	3.2%	1.5%	2.9%	1.5%
Pianura di Ferrara	80.7%	2.8%	0.0%	16.5%	0.0%	1.7%	1.3%	1.4%	0.8%
Pianura di Carpi	82.6%	10.6%	0.0%	6.8%	0.0%	7.9%	1.3%	6.6%	3.5%
Pianura del Senio e del Lamone	99.0%	1.0%	0.0%	0.0%	0.0%	14.3%	5.4%	14.3%	7.0%
Pianura dell'Idice e del Santerno	94.9%	5.1%	0.0%	0.0%	0.0%	4.6%	2.7%	2.4%	1.9%
Pianura del Lamone	81.9%	1.5%	0.0%	16.7%	0.0%	4.2%	2.4%	4.3%	2.1%
Pianura di Ravenna	97.6%	2.4%	0.0%	0.0%	0.0%	9.6%	5.7%	9.6%	4.9%
Pianura di Busseto	86.3%	1.0%	0.0%	12.7%	0.0%	3.8%	0.1%	3.8%	1.8%
Pianura a sinistra del Reno	80.8%	7.1%	0.0%	12.1%	0.0%	7.4%	1.1%	7.4%	3.5%
Pianura a destra del Reno	90.4%	5.9%	3.7%	0.0%	0.0%	20.5%	6.4%	19.5%	9.7%
Bonifica Ferrarese Occidentale	82.9%	9.4%	0.0%	7.7%	0.0%	9.1%	2.0%	11.4%	4.9%
Bonifica Ferrarese Orientale	85.8%	3.6%	0.0%	10.6%	0.0%	13.7%	2.7%	14.0%	6.6%
Basso Arda	75.1%	0.7%	0.0%	24.2%	0.0%	3.4%	1.8%	4.7%	2.0%
Bassa Reggiana	76.3%	1.4%	0.0%	22.3%	0.0%	7.6%	2.1%	7.0%	3.5%
Bassa Modenese	80.7%	4.8%	0.0%	14.5%	0.0%	2.6%	0.5%	2.7%	1.3%
Pianura di Parma	86.1%	1.3%	0.0%	12.6%	0.0%	6.3%	0.9%	6.0%	2.9%
Pianura di Piacenza	87.5%	1.9%	0.0%	10.6%	0.0%	2.2%	0.9%	0.0%	0.8%
Colline del Nure e dell'Arda	84.5%	3.7%	0.0%	11.7%	0.0%	2.9%	4.3%	3.9%	2.1%
Colline del Montone e del Bidente	88.6%	0.7%	0.0%	10.7%	0.0%	1.9%	2.1%	1.4%	1.1%
Colline int. Rubicone	89.9%	10.1%	0.0%	0.0%	0.0%	6.6%	2.0%	6.6%	3.2%

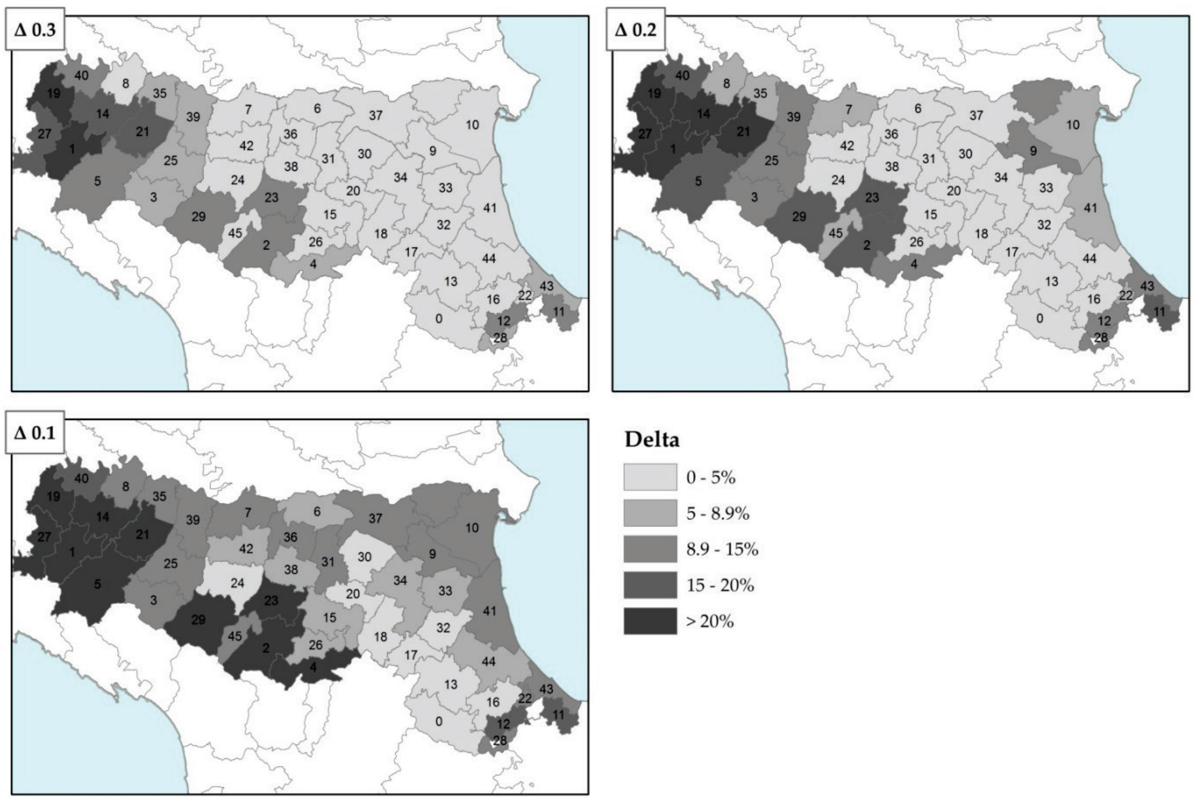
	Alpha Values					Errors			
Agricultural District	α_1	α_2	α_3	α_4	α_5	e_f	e_a	e_d	e
Colline Savio	90.2%	0.7%	0.0%	9.1%	0.0%	13.7%	5.2%	13.7%	6.7%
Collina del Senio e del Lamone	85.2%	1.3%	0.0%	13.5%	0.0%	8.4%	4.1%	8.5%	4.2%
Colline del Sillaro e del Santerno	99.7%	0.3%	0.0%	0.0%	0.0%	4.5%	5.7%	4.5%	2.8%
Colline di Bologna	98.9%	1.1%	0.0%	0.0%	0.0%	9.9%	4.2%	9.9%	4.9%
Colline di Salsomaggiore	75.4%	8.7%	0.0%	15.9%	0.0%	7.2%	0.3%	0.1%	2.4%
Colline Modenesi	88.9%	11.1%	0.0%	0.0%	0.0%	8.3%	3.7%	8.3%	4.1%
Colline tra Enza e Secchia	99.5%	0.5%	0.0%	0.0%	0.0%	3.7%	0.2%	0.1%	1.2%
Medio Parma	98.9%	1.1%	0.0%	0.0%	0.0%	4.1%	2.9%	4.0%	2.1%
Colline del Conca	97.3%	1.1%	0.0%	1.6%	0.0%	0.7%	0.4%	0.4%	0.3%
Colline del Trebbia e del Tidone	81.3%	4.9%	0.0%	13.8%	0.0%	0.8%	4.5%	2.0%	1.7%
Colline del Reno	99.0%	1.0%	0.0%	0.0%	0.0%	7.0%	5.7%	7.0%	3.8%
Colline del Montefeltro	98.1%	1.9%	0.0%	0.0%	0.0%	2.3%	1.2%	2.1%	1.1%
Valli del Dragone e del Rossenna	79.6%	0.5%	0.0%	19.9%	0.0%	2.2%	3.6%	2.0%	1.5%
Alto Taro	97.6%	2.4%	0.0%	0.0%	0.0%	4.6%	0.5%	0.1%	1.5%
Alto Reno	83.5%	16.5%	0.0%	0.0%	0.0%	25.0%	2.3%	0.1%	8.4%
Alto Parma	98.8%	0.7%	0.0%	0.5%	0.0%	4.7%	0.6%	0.1%	1.6%
Alto Panaro	86.3%	13.7%	0.0%	0.0%	0.0%	9.6%	3.3%	9.6%	4.7%
Montagna del Medio Trebbia	99.9%	0.1%	0.0%	0.0%	0.0%	20.6%	3.5%	0.1%	7.0%
Montagna del Medio Reno	97.2%	2.8%	0.0%	0.0%	0.0%	8.5%	3.3%	9.0%	4.3%
Montagna del Montefeltro	99.0%	1.0%	0.0%	0.0%	0.0%	2.4%	0.1%	0.3%	0.8%
Montagna tra l'Alto Enza e Alto Dolo	99.2%	0.8%	0.0%	0.0%	0.0%	1.2%	0.1%	0.1%	0.4%
Alto Nure	94.0%	1.0%	0.0%	4.7%	0.0%	10.1%	1.4%	7.0%	4.1%
Montagna del Savio e del Montone	99.8%	0.2%	0.0%	0.0%	0.0%	20.5%	0.7%	0.1%	6.8%

Source: Own elaboration from ER Statistica (2014); INEA (2014); ISMEA (2014b); ISTAT (2013)

5.2 THE WTP FOR INCOME INSURANCE

Figure 2 shows the WTP for an income insurance product that covers 70% ($\delta = .3$), 80% ($\delta = .2$) and 90% ($\delta = .1$) of the expected income, which are those coverages typically observed in agricultural insurance in Italy (ISMEA, 2011). A normal Probability Density Function (PDF) is used to adjust agricultural income. The value of the moments ($z_{1,\delta}(x)$ and $\sigma_\delta(\pi(x))$) for deductibles of $\delta = 1$ (no insurance), $\delta = .3$, $\delta = .2$ and $\delta = .1$ are available in Annex II.

Figure 3: Willingness to Pay for income insurance in RER ADs[16] (as a % of expected income without insurance, $z_1(x)$)



Source: Own elaboration from ER Statistica (2014); INEA (2014); ISMEA (2014b); ISTAT (2013).

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[16] RER ADs are: 1. Alto Nure; 2. Alto Panaro; 3. Alto Parma; 4. Alto Reno; 5. Alto Taro; 6. Bassa Modenese; 7. Bassa Reggiana; 8. Basso Arda; 9. Bonifica Ferrarese Occidentale; 10. Bonifica Ferrarese Orientale; 11. Colline del Conca; 12. Colline del Montefeltro; 13. Colline del Montone e del Bidente; 14. Colline del Nure e dell'Arda; 15. Colline del Reno; 16. Colline Savio; 17. Colline del Senio e del Lamone; 18. Colline del Sillaro e del Santerno; 19. Colline del Trebbia e del Tidone; 20. Colline di Bologna; 21. Colline di Salsomaggiore; 22. Colline interne Rubicone; 23. Colline Modenesi; 24. Colline tra Enza e Secchia; 25. Medio Parma; 26. Montagna del Medio Reno; 27. Montagna del Medio Trebbia; 28. Montagna del Montefeltro; 29. Montagna tra l'Alto Enza e Alto Dolo; 30. Pianura a destra del Reno; 31. Pianura a sinistra del Reno; 32. Pianura del Lamone; 33. Pianura del Senio e del Lamone; 34. Pianura dell'Idice e del Santerno; 35. Pianura di Busseto; 36. Pianura di Carpi; 37. Pianura di Ferrara; 38. Pianura di Modena; 39. Pianura di Parma; 40. Pianura di Piacenza; 41. Pianura di Ravenna; 42. Pianura di Reggio Emilia; 43. Pianura di Rimini; 44. Pianura Forlivese e Cesenate; 45. Valli del Dragone e del Rossenna; 46. Montagna del Savio e del Montone.

Higher WTP appears in the mountainous and hilly ADs to the south and west of the RER. These ADs are generally more risk averse and therefore practice a more traditional agriculture than others, with their crop portfolios displaying lower margins. Notwithstanding these efforts, soil quality and steepness and the climatic conditions of these areas reduce their productivity as compared to the plains, while making them more exposed to extreme events. As a result, the coefficient of variation in these ADs is also higher, and all this results in a higher WTP.

The modernized ADs in plains along the course of the Reno and Po rivers, and those in coastal areas, also show a moderate to high WTP, but for different reasons: in the former the main source of income variability is the exposure to periodic floods; in the latter, the exposure to drought events.

Higher income protection levels (i.e. lower δ) are associated with proportionally larger WTP values in the model. The reason is higher deductibles require higher income losses in order to trigger the compensation mechanism, and this income losses have a low probability of occurrence (they fall in the extreme of the left hand tail of the income PDF, $g(\pi(x))$). As a result, even if they are not compensated, farmers may prefer not to pay the insurance premium given the low probability of these events. On the other hand, a low deductible implies more likely compensations and higher WTP.

The average WTP (weighted by ADs' corresponding surface) for income insurance in the RER with customary deductibles (i.e., $.1 \leq \delta \leq .3$) ranges between 4% ($\delta = .3$) and 10.9% ($\delta = .1$) of the expected agricultural income in the baseline ($z_1(x)$). On the other hand, the average yield insurance premium rate in Italy is 8% for single risk insurance and 8.9% for combined insurance (ISMEA, 2014a). It appears to be room to extend the coverage of agricultural insurance towards a more comprehensive income insurance, although it should be noted that existent premiums are largely owed to generous subsidies (accounting only for *ex-ante* premium subsidization, the subsidy to premium ratio is 70%) (ISMEA, 2014a). Moreover, current premiums only refer to existing yield insurance and are to be recalculated if income insurance is finally developed, although past evidence shows that premiums follow positive though decreasing trends and tend to stabilize as the number of risks covered is increased (AGROSEGURO, 2012; Bielza et al., 2009; ISMEA, 2014a). Noteworthy, although raising deductibles increases more than proportionately the WTP for income insurance and thus may reduce the need for public subsidies, premiums also have an inverse relationship with deductibles (Bielza et al., 2009).

6. CONCLUSIONS

This paper constitutes the first thorough viability assessment of income insurance in the EU, considering both supply and demand. Results are internally consistent and provide useful insights for areas resembling our case study. The methodology used in this paper is general and replicable in the areas where the necessary data is available.

The paper reviews the Italian and EU context for agricultural insurance provision, and assesses the implementability of the recently promoted income insurance scheme in the RER in Italy. Using the risk premium extracted from the observed agricultural insurance supply as a benchmark, the paper develops a methodology to estimate farmers' WTP for income insurance. After comparing observed supply and potential demand, it is concluded that the WTP for income insurance is close to the average risk premium, supporting in principle the development of such a policy. However, this is largely explained by high insurance premium subsidization, which represents 70% of the premium value.

The results displayed in this paper, while primarily aimed towards assessing the viability of an income insurance scheme, may also serve to understand and amend the disparities in agricultural insurance subsidization present in public-private partnerships in the EU and particularly in Italy, which may be generating inefficient and even ineffective subsidies allocations. For example, total subsidies to insurance amount 80% of the total premiums in Italy, while in Spain and Austria (with a similar or even more developed insurance system and varied risk coverage) this figure equals 49% and 46%, respectively (Bielza et al., 2009).

Further research should focus on some critical points of our study. The programming could be changed to incorporate alternative forms of the utility function and analyse the sensitivity of the results to the chosen functional form. Comparisons with conventional stated preference methods may be also used to critically validate the findings obtained by RPM and test the extent to which results depend on the chosen methodology. Finally, future work should also address the extent to which the 'Rabin Critique' (Rabin, 2000; Rabin and Thaler, 2001) may be applicable to this model and have effect on its estimations of the certainty equivalent and the WTP.

ACKNOWLEDGEMENTS

The research leading to these results has received funding from the Italian Ministry of Education, University and Research and the Italian Ministry of Environment, Land and Sea under the GEMINA project and from the EU's Seventh Framework Program (FP7/2007-2013) under grant agreement n° 308438 (ENHANCE - Enhancing risk management partnerships for catastrophic natural disasters in Europe).

We thank Mattia Amadio for drawing figures 1 and 3.

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ANNEX I: ERROR TERMS

Farmers' decisions are simulated in accordance to the observed crop portfolio, which is the crop portfolio that maximizes the representative farmers' utility function in accordance to a set of relevant attributes. Deviations of the model's calibrated crop portfolio (x_i^*) from the observed crop portfolio (x_i^o) may result in prediction errors in the model, and this is the first calibration error (e_x). The second source of error is the distance between the observed attributes and the attributes' efficiency frontier (e_f) already presented in equation [6]. A large distance would mean that the agent is actually taking a sub-optimal decision, and this goes against the main economic assumption that farmers are individuals that seek to maximize their utility. Finally, the third calibration error (e_τ) is the distance between the observed attributes (z_r^o) and the calibrated ones (τ_r^*). If this distance is large, it would mean that the model is not capturing the real source of utility for the representative farmer, and therefore it would be simulating someone else's utility function.

Summing up, the RPM provides three types of calibration errors that give an idea of the accuracy of the model's adjustment:

-The relative distance between the observed crop pattern and the utility maximizing one:

$$e_x = \frac{1}{n}\sum_{k=1}^{n}\left(\frac{\left({x_i^o}^2 - {x_i^*}^2\right)^{1/2}}{x_i^o}\right) \qquad [A1]$$

-The distance between the observed attributes and the attributes' efficiency frontier (from equation [6]):

$$e_f = \varepsilon \qquad [A2]$$

-The distance between the observed attributes and the calibrated ones:

$$e_\tau = \frac{1}{l}\sum_{r=1}^{l}\left(\frac{\left({z_r^o}^2 - {\tau_r^*}^2\right)^{1/2}}{z_r^o}\right) \qquad [A3]$$

Finally, the mean calibration error is defined as a combination of these three calibration errors:

$$e = \frac{\sqrt{{e_x}^2 + {e_\tau}^2 + {e_f}^2}}{3} \qquad [A4]$$

ANNEX II: PDF MOMENTS AND FARMERS' WTP

Agricultural District	$\delta = 1$ (No insurance) $z_{1,\delta}(x)$	$\delta = 1$ (No insurance) $\sigma_\delta(\pi(x))$	$\delta = .3$ $z_{1,\delta}(x)$	$\delta = .3$ $\sigma_\delta(\pi(x))$	$\delta = .3$ WTP_δ	$\delta = .2$ $z_{1,\delta}(x)$	$\delta = .2$ $\sigma_\delta(\pi(x))$	$\delta = .2$ WTP_δ	$\delta = .1$ $z_{1,\delta}(x)$	$\delta = .1$ $\sigma_\delta(\pi(x))$	$\delta = .1$ WTP_δ
Pianura di Rimini	673.5	142.8	675.9	138.3	6.47%	685.1	123.9	9.38%	702.2	101.2	13.21%
Pianura di Reggio Emilia	1374.5	192.1	1375.4	190.4	0.75%	1381.0	179.6	3.22%	1402.4	148.1	8.90%
Pianura di Modena	4657.6	440.1	4657.6	439.9	0.05%	4660.3	433.3	0.90%	4692.1	380.2	6.91%
Pianura Forlivese e Cesenate	3200.4	422.3	3201.7	419.4	0.60%	3212.6	398.8	2.99%	3256.7	331.2	8.62%
Pianura di Ferrara	2345.3	460.8	2352.1	448.4	2.40%	2378.6	405.0	4.98%	2434.6	329.8	8.96%
Pianura di Carpi	2987.5	426.4	2989.4	422.2	1.04%	3002.6	397.1	4.25%	3049.7	327.2	11.24%
Pianura del Senio e del Lamone	2859.9	353.1	2860.6	351.4	2.78%	2868.1	337.0	4.87%	2903.0	282.3	7.50%
Pianura dell'Idice e del Santerno	2431.9	309.8	2432.6	308.0	0.37%	2439.6	294.2	2.00%	2471.0	245.5	6.32%
Pianura del Lamone	6200.0	397.6	6200.0	397.6	1.90%	6200.0	397.2	1.91%	6200.0	374.9	2.32%
Pianura di Ravenna	1243.2	170.4	1243.9	169.0	3.00%	1248.6	159.8	6.53%	1267.3	132.1	10.75%
Pianura di Busseto	718.6	194.3	724.1	186.0	5.85%	739.6	164.5	8.54%	761.5	137.8	12.05%
Pianura a sinistra del Reno	1639.0	286.7	1641.9	281.0	1.79%	1656.4	257.3	4.82%	1689.8	209.5	10.00%
Pianura a destra del Reno	1789.7	182.3	1789.8	182.1	0.06%	1791.7	178.4	0.60%	1806.9	154.1	3.70%
Bonifica Ferrarese Occidentale	1699.0	372.6	1706.3	360.3	4.83%	1731.0	322.0	9.07%	1775.2	263.7	14.90%
Bonifica Ferrarese Orientale	1188.1	248.4	1192.4	240.9	4.17%	1208.2	216.2	7.47%	1238.2	176.5	11.97%
Basso Arda	929.7	242.9	935.9	232.8	4.59%	954.8	206.1	7.08%	983.5	171.7	10.59%
Bassa Reggiana	987.4	238.4	993.4	229.4	4.47%	1010.6	203.6	7.07%	1038.4	168.2	10.67%
Bassa Modenese	2431.3	280.1	2431.7	279.3	0.22%	2436.6	270.0	1.71%	2461.4	228.7	6.38%
Pianura di Parma	786.6	196.3	791.8	188.6	6.79%	806.2	167.2	9.39%	830.0	138.3	13.08%
Pianura di Piacenza	628.6	210.5	635.5	200.8	11.97%	652.4	179.0	15.36%	674.8	155.6	19.58%
Colline del Nure e dell'Arda	466.7	170.0	472.3	162.4	16.17%	486.2	145.9	20.15%	503.1	129.0	24.76%

Agricultural District	$\delta = 1$ (No insurance) $z_{1,\delta}(x)$	$\sigma_\delta(\pi(x))$	$\delta = .3$ $z_{1,\delta}(x)$	$\sigma_\delta(\pi(x))$	WTP_δ	$\delta = .2$ $z_{1,\delta}(x)$	$\sigma_\delta(\pi(x))$	WTP_δ	$\delta = .1$ $z_{1,\delta}(x)$	$\sigma_\delta(\pi(x))$	WTP_δ
Colline del Montone e del Bidente	1801.0	165.6	1801.1	165.6	0.97%	1802.9	165.6	1.07%	1818.2	165.6	1.91%
Colline int. Rubicone	1912.0	366.0	1916.8	356.7	2.94%	1937.8	323.1	6.73%	1981.0	263.2	12.57%
Colline Savio	1336.1	188.8	1337.0	187.1	0.32%	1342.9	176.2	1.19%	1362.7	145.4	3.27%
Collina del Senio e del Lamone	6301.7	1057.4	6310.9	1038.6	0.62%	6358.7	956.1	1.91%	6480.1	780.1	4.58%
Colline del Sillaro e del Santerno	3417.1	235.4	3420.4	219.9	0.01%	3427.1	194.0	0.01%	3381.9	158.4	0.07%
Colline di Bologna	1225.1	238.0	1228.6	231.8	0.68%	1242.4	209.6	1.82%	1271.2	170.6	4.18%
Colline di Salsomaggiore	438.8	147.2	444.1	140.4	16.04%	455.9	125.2	20.76%	471.0	109.0	26.08%
Colline Modenesi	5594.4	2224.7	5866.5	1707.5	11.51%	6012.1	1514.5	16.06%	6208.2	1296.7	21.46%
Colline tra Enza e Secchia	845.3	147.0	846.9	144.2	0.43%	853.8	132.0	1.24%	871.6	107.4	3.35%
Medio Parma	454.4	136.0	458.6	129.8	7.27%	469.6	115.0	10.14%	484.6	97.9	13.88%
Colline del Conca	470.8	163.6	476.4	156.2	12.10%	489.8	139.6	15.43%	506.7	122.3	19.48%
Colline del Trebbia e del Tidone	159.5	93.4	162.0	91.2	43.37%	166.9	86.9	47.72%	172.3	83.0	52.53%
Colline del Reno	1817.5	191.9	1817.6	191.6	1.47%	1820.1	187.0	3.82%	1836.7	160.5	6.52%
Colline del Montefeltro	341.9	94.2	344.5	90.1	9.36%	352.3	79.6	12.49%	362.7	66.9	16.25%
Valli del Dragone e del Rossenna	854.2	233.8	861.2	223.8	3.84%	879.3	198.0	6.22%	906.8	166.0	9.69%
Alto Taro	361.7	124.8	365.9	119.1	12.92%	376.2	106.4	16.50%	389.0	93.0	20.76%
Alto Reno	600.8	145.6	604.1	140.0	8.48%	615.0	124.2	14.24%	632.8	102.4	21.64%
Alto Parma	334.3	106.6	337.8	101.7	7.49%	346.6	90.3	10.45%	358.1	77.8	14.22%
Alto Panaro	5648.1	1716.3	5701.2	1638.5	12.80%	5840.4	1452.6	17.86%	6029.2	1240.9	23.77%
Montagna del Medio Trebbia	234.4	105.2	237.8	101.2	18.66%	245.4	93.3	22.45%	254.0	85.8	26.74%
Montagna del Medio Reno	2106.4	430.8	2113.4	418.2	2.00%	2139.5	376.2	4.22%	2191.8	306.8	7.82%
Montagna del Montefeltro	341.9	94.2	344.5	90.1	6.68%	352.3	79.6	9.46%	362.7	66.9	12.91%

Agricultural District	$\delta = 1$ (No insurance) $z_{1,\delta}(x)$	$\delta = 1$ (No insurance) $\sigma_\delta(\pi(x))$	$\delta = .3$ $z_{1,\delta}(x)$	$\delta = .3$ $\sigma_\delta(\pi(x))$	$\delta = .3$ WTP_δ	$\delta = .2$ $z_{1,\delta}(x)$	$\delta = .2$ $\sigma_\delta(\pi(x))$	$\delta = .2$ WTP_δ	$\delta = .1$ $z_{1,\delta}(x)$	$\delta = .1$ $\sigma_\delta(\pi(x))$	$\delta = .1$ WTP_δ
Montagna tra l'Alto Enza e Alto Dolo	322.1	117.7	326.1	112.4	12.81%	335.6	100.9	16.15%	347.1	89.3	20.15%
Montagna del Savio e del Montone	431.9	184.0	458.8	140.9	6.96%	471.1	125.3	9.98%	486.3	108.4	13.66%
Alto Nure	298.7	134.8	303.3	129.8	23.11%	312.8	119.8	26.95%	323.9	110.3	31.42%