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Abstract

Risk management in agriculture is crucial and policymakers are implementing policy reforms to foster farmers' adoption of *ex-ante* risk management tools such as crop insurance: their effectiveness is the core of policy evaluations exercises. The Italian subsidised crop insurance market has been interested by major reforms in 2013 and 2015. The 2013 reform removed subsidies to the mono-risk insurance contracts, whereas the 2015 reform replaced the multi- and pluri-risks contract schemes with packages, devoted to providing coverage over different set of adversities, thus altering the framework that has been used for several years. We highlight a correlation between the first reform and a drop in the quantity of insurance purchased, and between the latter reform and an increase in the value of the purchased insurance.

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JEL codes: G22, Q14, Q18

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Abstract

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1. Introduction

Risk management is a key practice in agriculture, due to the inherent riskiness of agricultural activities, exacerbated by climate change. Due to the financial and societal unsustainability of *ad hoc ex-post* interventions (Cordier and Santeramo, 2020), policymakers are pressing toward the adoption of *ex-ante* risk management tools[1] such as crop insurance[2], that is subsidised in several countries, such as the United States

[1] Risk is the effect of uncertainty on objectives (say, agricultural activities) and, consistent with the risk management guidelines defined in ISO 31000:2018, is expressed in terms of risk sources (say, climate change), potential events (say, occurrence of extreme weather events because of climate change), their consequences (say, production losses due to extreme weather events, such as hail) and their likelihood (say, chance of hail damaging farms in leopard spots). *Ex-ante* risk management tools provide solutions to the consequences of a risk (production losses in the example above) "before" the potential occurrence of an event (hail in the previous hypotheses). They differ from *ex-post* risk management tools that allow to manage the consequence of a risk "after" its expression

(US) and Member States of the European Union (EU). Despite the allocation subsidies and the introduction of frequent policy reforms, the insurance market tends to have a persistently low and jeopardised demand (e.g., Enjolras et al., 2012; Santeramo et al., 2016; Santeramo, 2019). The low uptake of crop insurance contrasts with the potential economic benefits. By helping farmers coping with income losses, crop insurance contributes to stabilise farms' income (Cole and Xiong, 2017) and long-term economic performances (Sporri et al., 2012), in synergy with other income stabilisation interventions (Severini et al., 2019). To the extent that a more stable income favours the acquisition of financial loans, crop insurance pays off insured farmers who improve their ability to invest in their activities, with beneficial effects in terms of farms' growth and adaptation to changing environments (e.g., Atwood et al., 1996). In fact, insured farms tend to improve their economic performances partly because some activities are too risky without insurance (Meuwissen et al. 2001), partly because alternative on-farm risk management strategies may be unapplicable or inefficient (Sporri et al., 2012): differently, insured farms are more capable to adjust their production strategies (e.g., Glauber, 2004). For instance, when an adverse event occurs, the indemnities tend to be used to restore the production potential of farms, implying a lucrative use of crop insurance.

The Italian interventions on risk management in agriculture have a long history and date back to 1970, with *ex-post* compensations, replaced more recently by *ex-ante* interventions. Despite subsidies, the crop insurance uptake is still low and concentrated (in acreage and value terms) in Northern regions and on few

(e.g., compensations provided by policymakers after a loss due to natural disaster or extreme events). *Ex-post* risk management tools, being strongly related to the occurrence of a potential event, are not schedulable and this press policymakers to encourage alternative (*ex-ante*) strategies to cope with risks in agriculture.

[2] Agricultural insurance is the most widespread *ex-ante* agricultural risk management tool worldwide. In Europe, the Common Agricultural Policy (CAP) offers financial supports to also mutual funds and income stabilisation tools (i.e., a mutual fund giving compensation for income losses). The policy objective of these instruments is to shift from *ex-post* compensations, heavily supplied in pasts years, to the adoption of *ex-ante* tools, that promote a greater farmers' economic responsibility. *Ex-ante* risk management tools provide for the economic participation of beneficiaries (i.e., farmers), who are responsible for the outcome (e.g., production outcomes) and are incentivised to adopt good practices to prevent and/or avoid the potential occurrence of the event. For instance, farmers have to pay an *insurance premium* (i.e., price of insurance) for the insurance coverage and a participation fee to be part of a mutual fund. Differently, *ex-post* compensations are supplied without economic contributions by farmers.

crops (ISMEA, 2020a)[3]. In 2013 and 2015, the Ministry of Agriculture has approved two major reforms to foster uptake: the first reform stopped subsidies to mono-risk contracts[4]; the second one introduced new and more flexible types of contracts. The 2013 reform consisted in a "restrictive" change in subsidised insurance contracts in that it added constrains on existing options, subsidising insurance contracts that were already known by farmers (i.e., pluri- and multi- risks contracts[5]). The 2015 reform has been more "innovative" as it introduced new types of subsidised insurance contracts, hereafter (in accordance with the official terminology) named "packages"[6]. We evaluate whether and to what extent a correlation exists between the policy reforms and the (subsidised) insurance market. As argued in Sherrick et al. (2003), policymakers tend to opt for less flexible approaches (provided in Italy prior to the 2013 reform) in order to limit potential problems of asymmetric information (i.e., moral hazard, adverse selection)[7], whereas the farmers tend to prefer larger flexibility (provided in Italy by the 2015 reform).

The literature on the effects of policy reforms in crop insurance markets are limited in number. Remarkable studies are those on the effect of insurance subsidies on planted acreage and farmers' crop choices (e.g., Yu et al., 2018) and on the supply side of insurance contracts (e.g., Pearcy and Smith, 2015). Yu et al. (2018) show that the insurance subsidies generate a direct profit effect (i.e., premium subsidies enlarge expected profit) and an indirect coverage effect (i.e., more subsidies imply less income variability), which result in

[3] This may be due to the availability of other and cheaper risk mitigation strategies, such as farm management practices and capital investments (Santeramo and Ramsey, 2017).

[4] Mono-risk (i.e., single peril) contracts cover only one adversity. Adversities are classified as catastrophic (i.e., infrequent perils such as flood, frost and hoarfrost, drought), frequency (i.e., frequent perils such as hail, intense wind, heavy rain, excessive snow), accessory (i.e., other perils such as sunstroke and warm wind, temperature leap).

[5] Multi-risks (i.e., multiple perils) contracts cover all adversities; pluri-risks contract cover at least three adversities.

[6] Packages offer coverage against different combinations of adversities according to the type of package (more details are provided in section 2.1).

[7] The problem of asymmetric information in the insurance market is due to a mismatch of information between the insurer and the insured, manifesting itself in the form of moral hazard and adverse selection, the latter being the most serious in the crop insurance market (Goodwin, 1993). Moral hazard consists in the adoption of risky behaviours (e.g., lowering irrigation) by insured (farmers) who is aware ("informed") of the insurance coverage for any potential losses. Adverse selection arises if insured perform better than insurers in verifying their likelihood of suffering losses, with an increase in the share of risky insured and, consequently, of insurance premia.

larger insured acreage. However, while farmers prefer a marginal increase in the premium subsidy rate, the insurance companies would rather prefer a marginal increase in the subsidy rate of administrative and operational costs (Pearcy and Smith, 2015). Most studies are micro-level analyses; a remarkable exception is the macro-level analysis of insurance demand of Iowa corn producers by Goodwin (1993), who concludes that different levels of loss-risk[8] are associated to different demand elasticities. Macro-level analyses on the effects of policy reforms should be promoted in European countries where the policy reforms induced by the Common Agricultural Policy (CAP) are substantial and potentially of large impacts. The Italian crop insurance system is particularly active and represents an informative case study for the EU. The post-2020 CAP will be more flexible and guided by the subsidiarity principle which provides greater flexibility to Member States in terms of decisions. In addition, the National Recovery and Resilience Plan will guarantee an important allocation of funds to the agricultural sector.

This article investigates potential linkages between the 2013 and 2015 policy reforms and the demand for subsidised crop insurance in Italy. Consistent with Goodwin (1993), we model the insurance demand as insured acreage (proxying the demanded quantity) and insured value per hectare (proxying the demanded unit value). The insured acreage informs on the amount of utilised agricultural area covered by insurance contracts, hence proxying the quantity of purchased insurance, but being not informative of the type and value of insured crops. For a given amount of utilised agricultural area covered by insurance contracts (say, about 125 ha on average), the insured value per hectare tends to differ depending on the type of insured products (say, about 190 EUR/ha for durum wheat and about 1,320 EUR/ha for grapes, on average) and even on the end use of insured products (say, about 850 EUR/ha for wine grapes and 1,800 for table grapes, on average). The higher the insured value per hectare, the higher the value of insured crops is likely to be. Both policy reforms are likely to favour the unit value of the insured production but not their quantity. In fact, the end of subsidies to mono-risk contracts in 2013 is expected to wipe off from the insurance market the less-valued products, to reduce the insured acreages and to increase the average insured value per hectare. For instance, in 2012, 65% of the insured acreages of durum wheat in Bologna province was under mono-risk contracts, the remaining under pluri-risks contracts. From 2012 to 2013, the insured acreages (regardless of

[8] The loss-risk ratio measures the likelihood of collecting indemnities (i.e., payments that insured receive in the event of losses) higher than premium (i.e., price paid to be insured) payments.

types of insurance contracts) of durum wheat in Bologna province reduced by 17%, despite the share of acreage insured under pluri-risks contracts, which absorbed most of the acreage insured under mono-risk contracts in the preceding year, increased by 135%. In the same two-years period, the insured value per hectare in Bologna province grew by 2% on average: the tendency has been even stronger after the 2015 reform (+8% on average from 2014 to 2015). Therefore, we expect the 2013 reform to be more relevant on the insured acreage and the 2015 reform to be decisive for the insured value per hectare. In fact, the "restrictive" change in subsidised insurance contracts imposed by the 2013 reform is likely to exclude from the insurance market acreages of low-risky products (e.g., insured against only one adversity). Products that do not require coverage against more than one peril are also expected to have lower insured value per hectare: thus, their exit from the insurance market, due to the lack of suitable insurance contracts (i.e., mono-risk contracts), is not expected to have relevant consequences on the insurance values. Differently, the "innovative" change brought by the 2015 reform is likely to increase the insured values more than the insured acreage: in fact, the high-value products may need to uptake insurance even if producers are not familiar with the new types of insurance contracts because of potentially high losses in case of occurrence of an adverse event. We test these hypotheses and conclude on the potential role of the reforms.

2. Subsidised agricultural insurance

2.1 Legislative framework: a focus on Italy

Government subsidisation of crop insurance has a long tradition in several countries. In the United States (US), the Federal Crop Insurance Program is a large direct agricultural subsidy programme supporting farmers through hedge funds, revenue insurance programs, mutual funds, and weather indexes[9] (e.g., Woodard and Yi, 2020). Countries in the European Union (EU) have supported farmers through independent national subsidy programmes although, in 2013, the EU Regulation 1305/2013 introduced three common

[9] Revenue insurance programmes cover revenue losses instead of only production losses. Weather indexes are insurance contracts based on indexes calculated considering the weather conditions. These are innovative kind of insurance, providing the indemnity payment after the exceeding of a threshold (e.g., Tappi et al., 2022).

measures of risk management: i.e., crop insurance (art. 37), mutual funds (art. 38), and the income stabilisation tool (art. 39)[10] (e.g., Santeramo et al., 2016; Coletta et al., 2018).

In Italy, the market for subsidised crop insurance has low and heterogeneous uptake, with an adversely selective participation process (Santeramo, 2019). The limited adoption of insurance contracts, that characterised the period between 2004 and 2010, experienced a decline in the number of subscriptions since 2008; however, the insured areas and values increased respectively by 5% and 20% between 2010 and 2015 (ISMEA, 2018). The insured values tend to be concentrated in northern regions, accounting for more than 80% of the insured value, and in a few crops (i.e., apple, corn, rice, grapes, tomatoes), covering more than half of the total insured value (ISMEA, 2018). The limited and heterogeneous participation is likely due to a lack of familiarity with the instrument (e.g., Santeramo, 2018), to the complexity of the policy environment (Severini et al., 2017), to limited experience with crop insurance contracts (e.g., Santeramo, 2019), to behavioural aspects associated with risk aversion, ambiguity aversion, and time preferences[11] (e.g., Coletta et al., 2018). The adoption of insurance contracts is also related to risk management strategies, such as crop diversification (e.g., Enjolras and Sentis, 2011) which farmers tend to consider an alternative to the insurance contracts (e.g., Santeramo et al., 2016). In addition, adverse selection may undermine the effectiveness of these policies. According to ISMEA (2018), during the last decade, the increases in premium rates[12] (+4% from 2010 to 2015) have been accompanied by substantial reduction in subsidised crop insurance contracts (-20% from 2010 to 2015), signalling a relatively elastic demand for subsidised crop insurance. The insureds, knowing their own riskiness and degree of risk aversion, have an informational advantage with respect to the

[10] Crop insurance (art. 37, EU Regulation 1305/2013) provides compensations (indemnities) in case of production losses due to natural events, after the payment of a premium (considerable as the price of being insured). Mutual funds (art. 38, EU Regulation 1305/2013) share the risk among participants (producers), who pay to be part of the fund and are compensate (by the fund) in case of losses exceeding a minimum threshold. Income stabilisation tool (art. 39, EU Regulation 1305/2013) is a type of mutual fund providing compensations for income losses.

[11] Risk aversion, ambiguity aversion, and time preferences are behavioural factors influencing farmers' choices about insurance and risk management. A risk averse farmer prefers to have a lower outcome with higher probability than a higher outcome with lower probability. That is to say that risk averse farmers want to know what they will face in the future. So, even if they could have a higher outcome, they will prefer to have more certainty. Ambiguity is similar to risk, but with unknown probabilities of the occurrence of the event. Time preferences are related to farmers' expectation about future.

[12] A premium rate is the ratio between the total paid premia and the total insured value.

insurers (De Meza and Webb, 2001). As a result, the demand for subsidised crop insurance policies is characterised by two components: high-riskiness and less risk averse insureds who, having a greater demand and a higher likelihood of loss, generate adverse selection; low-riskiness and more risk averse insureds who, having a greater demand but a lower likelihood of loss, determine advantageous selection[13] (He et al., 2018). Due to an informational disadvantage, the insurers tend to increase contracts' premium to avoid losses, contributing to exclude from the market low-riskiness and more risk averse insureds[14] (Goodwin, 1993).

All the above-mentioned factors (i.e., behavioural issues, knowledge of instruments, level of experience, adverse and advantageous selection) are able to affect dynamics in the subsidised crop insurance, but policy changes may be crucial. In Italy, the subsidised crop insurance programme has undergone some changes since 2004 when the Legislative Decree 102/2004[15] launched the multi-risks contracts. While the mono-risk (i.e., single peril) contracts cover only one adversity, the multi-risks (i.e., multiple perils) contracts offer coverage against all adversities and compensate farmers for losses due to a realised yield lower than the average historical yield (i.e., yield insurance). A further type of policy introduced is the pluri-risks contract covering at least three adversities[16] (table 1).

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[13] A little attention has been paid to the role of adverse selection versus advantageous selection. He et al. (2018) examine sources of advantageous selection in Philippine crop insurance market at the farm level; Goodwin (1993) introduces a measure of adverse selection in the empirical analysis; however, if dominant, the presence of advantageous selection may confound the empirical observation of adverse selection (He et al., 2018).

[14] As suggested in Goodwin (1993), if the decline in contracts is marked and the withdrawal comes mostly from low low-riskiness and more risk averse insureds, premium increases may jeopardise the effectiveness of subsidised crop insurance policies.

[15] The Legislative Decree 102/2004 marked the transition from a system of *ex post* compensation to a scheme based on *ex ante* subsidies.

[16] With pluri-risks contracts, farmers could freely choose the insured adversities, regardless of their classification (i.e., catastrophic, frequency or accessory adversities).

Table 1 - adversities covered by different types of insurance contracts.

<table>
<tr><th></th><th></th><th colspan="9">Adversities</th></tr>
<tr><th></th><th></th><th colspan="3">Catastrophic</th><th colspan="4">Frequency</th><th colspan="2">Accessory</th></tr>
<tr><th>Year</th><th>Contract</th><th>Flood</th><th>Frost and hoarfrost</th><th>Drought</th><th>Hail</th><th>Intense wind</th><th>Heavy rain</th><th>Excessive snow</th><th>Sunstroke and warm wind</th><th>Temperature leap</th></tr>
<tr><td>2010-2012</td><td>Mono-risk</td><td colspan="9">1 adversity</td></tr>
<tr><td>2010-2014</td><td>Multi-risks</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>2010-2014</td><td>Pluri-risks</td><td colspan="9">3 adversities</td></tr>
<tr><td>2015</td><td>Package A</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>2015</td><td>Package B</td><td></td><td></td><td></td><td colspan="4">At last 1</td><td colspan="2">Optional</td></tr>
<tr><td>2015</td><td>Package C</td><td></td><td></td><td></td><td colspan="4">At last 3</td><td colspan="2">Optional</td></tr>
<tr><td>2015</td><td>Package C1</td><td></td><td></td><td></td><td colspan="4">At last 3</td><td></td><td></td></tr>
<tr><td>2015</td><td>Package D</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Source: Authors’ elaboration.

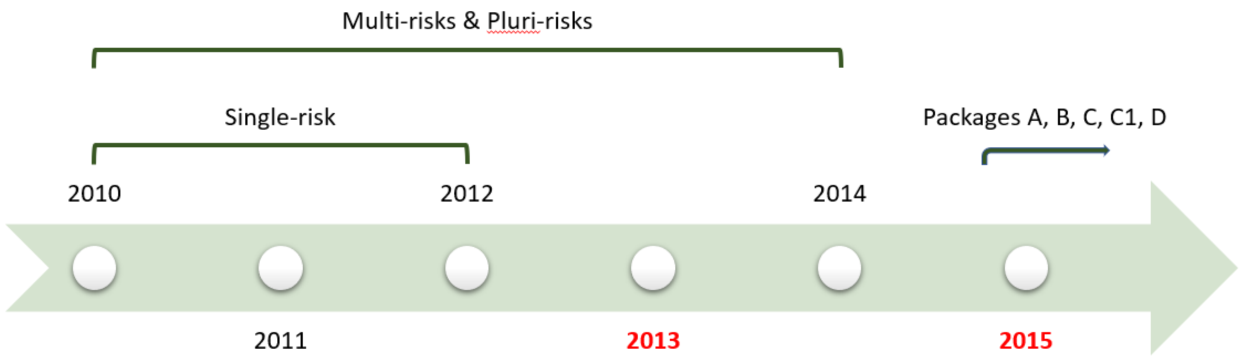
Since 2004, the objective of risk management policies has been to shift from *ex-post* compensation to *ex-ante* risk management tools (Santeramo, 2019; Capitanio and De Pin, 2018)[17]. The share of single peril contracts decreased progressively. In 2013, a policy reform interrupted the subsidies to mono-risk contracts limiting, *de facto*, the set of insurance contracts: with the entry into force of this reform, the choice is restricted to multi- and pluri-risks contracts (figure 1). In 2015, another policy reform replaced multi- and pluri-risks contracts with a set of contracts, the so-called "packages" (types A, B, C, C1 and D)[18] (table 1). This reform aimed at enlarging the insured farms base and addressing farmers' need of greater flexibility of subsidised contracts. The packages provide coverage against different combinations of infrequent perils (i.e., catastrophic adversities), frequent perils (i.e., frequency adversities), and other perils (i.e., accessory adversities) (table 1). Similar to the previous multi-risks contracts, package A covers against all the adversities. Package B covers against catastrophic adversities (i.e., flood, frost and hoarfrost, drought) and at least one frequency adversity (i.e., hail, intense wind, heavy rain, excessive snow). Similar to the previous pluri-risks contracts, package C covers against at least three frequency adversities and, optionally, accessory adversities (i.e., sunstroke and warn wind, temperature leap); in addition, package C1 covers against frost and hoarfrost. Package D covers against all the catastrophic adversities.

These policy changes joint with the last reform of the Common Agricultural Policy (CAP), that moved the support to risk management measures to the Rural Development Programmes (RDPs) 2014-2020, have contributed to a decline in subsidised crop insurance (Coletta et al., 2018).

[17] Every year, the *Ministry of Agriculture, Food and Forestry Politics* promulgates a document (called "*Piano Assicurativo Agricolo Nazionale*" – PAAN) defining crop and adversities eligible for insurance subsidies and declaring terms and conditions to access contributions.

[18] The packages are introduced by the Legislative Decree n. 5447 of the 10th of March 2015, "*Piano assicurativo agricolo 2015*".

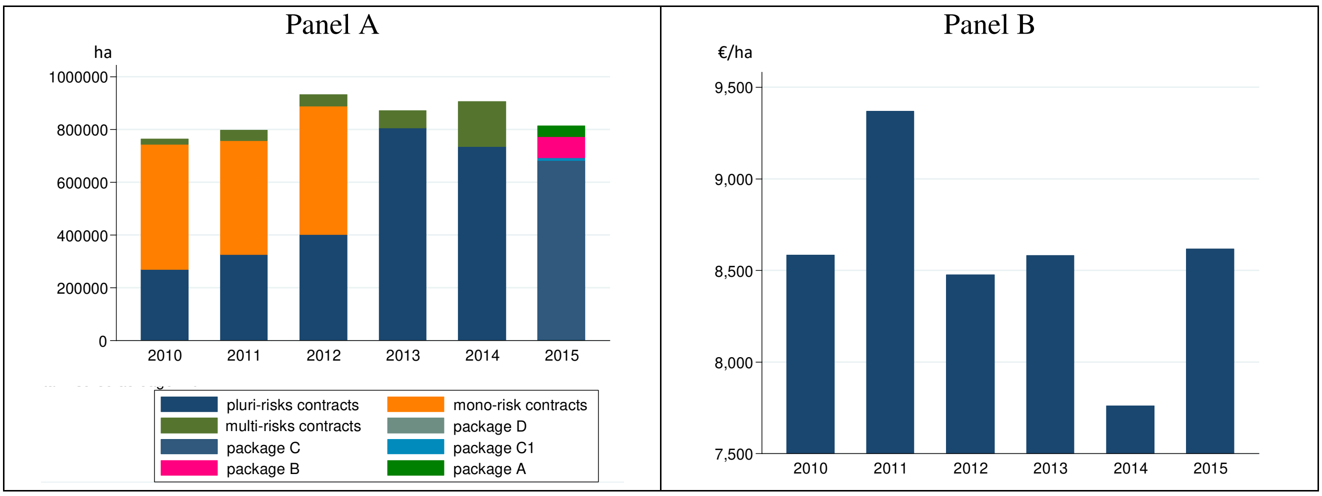
Figure 1. Policy reforms.



Source: Authors' elaboration.

Figure 2 shows the total acreage insured under different types of insurance contracts (panel A) and the average insured value per hectare (panel B) during the period 2010-2015. Over the period between 2010 and 2012, most of the insured acreage is covered by mono-risk contracts, with the multi-risks type being the less adopted contract. The most widespread contract are pluri-risks contracts after the first policy reform in 2013 and package C after the second policy reform in 2015.

Figure 2. Total insured acreage (panel A) and average insured value per hectare (panel B).



Source: Authors' elaboration.

After both reforms, the total insured acreage decreased and the average insured value per hectare increased. Both the reduction in the insured acreage and the increase in the insured value per hectare are greater in 2015, suggesting a potential concentration of insurance contracts on high-valued crops for the effect of the introduction of unknown type of contracts (i.e., packages).

In 2014, one year after the entry into force of the first reform, both the total insured acreage (figure 2, panel A) and the total insured value (figure s2 in the Supplementary material) show an increase, whereas the average insured value per hectare (figure 2, panel B) decreases: it is likely that low-valued crops have been insured in this year, suggesting a potential recover after the first policy reform.

2.2 Evidence from literature

The low farmers participation in insurance programmes in the 1980s fostered the academic debate on crop insurance demand (Knight and Coble, 1997). Since then, several studies have investigated the insurance demand and the economic sustainability of insurance subsidies in different contexts (e.g., Sherrick et al., 2004; Santeramo, 2018). Macro-level analyses of the crop insurance demand are rather scant. A relevant study is the one by Goodwin (1993), who analyses the insurance demand of corn producers in Iowa (US) and conclude that the loss-risk negatively affects the insurance demand elasticity. Previous studies are mainly based on micro-level analyses: they investigate factors affecting insurance purchase and deepen on farms and farmers' characteristics and, because risk and uncertainty are gaining increasing importance in farming activities, on farmers' attitudes to risk (e.g., Jose and Valluru, 1997; Hellerstein et al., 2013; Just and Just, 2016, Meraner and Finger, 2019; Santeramo and Russo, 2021). Insured farms tend to have specific characteristics: large quantities of inputs used, land endowment and farm income greater than uninsured farms, more dislocated farms, availability of off-farm income, high level of crop specialisation, farmers younger than uninsured farms (e.g., Sherrick et al., 2003; Capitanio, 2010; Di Falco and Chavas, 2009; Di Falco et al., 2014; Enjolras et al., 2012; Santeramo and Ramsey, 2017). Blank and McDonald (1996) conclude that crop insurance preferences are guided by the risk environment faced and the commodities produced by farmers (e.g., annual or perennial). Smith and Watts, (2019) argue that farmers choices depend on the availability of other risk managements strategies and their convenience in relation to insurance products. Several authors (e.g., Foudi and Erdlenbruch, 2012; Santeramo et al., 2016; Was and Kobus, 2018) report that irrigation, crop diversification, and income diversification might be substitute for insurance, since they are alternative strategies to reduce risks. Accordingly, farmers tend to use crop diversification as a "natural" insurance (Weitzman, 1992; 2000; Schlapfer et al., 2002) and to prefer it to insurance contracts characterised by higher costs. The availability of these alternatives to cope with risks may have contributed to limit the crop insurance demand overtime. Several studies document that high premium subsidies foster the insurance demand, but without subsidies farmers are not willing to pay for insurance (e.g., Chang, 2009; Smith and Glauber, 2012; Babcock, 2015; Menapace et al., 2016). Yu et al (2018) demonstrate that insurance premium subsidies increase expected profits and reduce revenue variability, inducing farmers to enlarge the cultivated area of insured crops.

Several policy reforms have been introduced to improve the insurance demand. The Federal Crop Insurance Reform Act of 1994 in the US successfully expanded the pool of insured farmers (Jose and Valluru, 1997). The American Agricultural Risk Protection Act of 2000 increased the subsidy levels inducing a 45% increase in the insured acreage with respect to the previous two years (Glauber, 2013). In Poland, the statutory obligation was an important stimulus for farmers to purchase insurance (Biernat-Jarka and Pawłowska-Tyszko, 2018). Ghosh et al. (2021) argue that the design and implementation mechanism of the insurance instruments tend to limit the insurance uptake: considering farmers preferences and needs, if well implemented, policy reforms have the potential to foster the insurance demand.

3. Empirical application

3.1 Modelling approach and identification strategy

We follow a standard expected utility profit-maximisation approach, subject to marketing and production constraints (e.g., type of insurance contracts, among others), with an optimal level of insurance demand function of producer's risk attitude (not directly observable) and other constraints (Goodwin, 1993; Enjolras and Sentis, 2011; Enjolras et al., 2012; Santeramo 2019): $E\left[U\left(\pi(I=1,\cdot)\right)\right] > E\left[U\left(\pi(I=0,\cdot)\right)\right]$, where $E\left[U\left(\pi(\cdot)\right)\right]$ stands for the expected utility of profits with ($I=1$) or without ($I=0$) crop insurance.

While the insurance decision is made at the micro (farm) level, a broader range of stakeholders, such as supply chain actors, banks and insurance companies, associations and cooperatives, media and consumers, are involved in and influence risk management strategies (Bertolozzi-Caredio et al., 2021). A macro (province) level analysis of the insurance demand is based on common patterns in micro decisions but has the advantage to moving from the single farm viewpoint to a system perspective and capturing the influence of all stakeholders involved in the risk management in a specific region, as highlighted in recent resilience literature (Meuwissen et al., 2019). Thus, we rely on a macro-level analysis to investigate the potential linkages between policy reforms and the quantity and unit value of insurance demand. We assume that the insurance demand just before (our counterfactual, e.g., 2012) and just after (e.g., 2013) the implementation of a policy reform (e.g., the 2013 reform) varies little in all observables (e.g., premium) and non-observables (e.g., province- and crop-specific characteristics) factors, except for the policy reform implementation. Accordingly, we measure the average effect of the policy reforms that is valid around the period of implementation (i.e., local average treatment effect).

From the above equation we derive the farmer decision problem under the scenario of a policy change ($\Delta Policy$). The farmer decision to be insured is conditional to the change in expected utility being positive: $\Delta E\left[U\left(\pi(I,\cdot\,|\Delta\, Policy)\right)\right] > 0$. Since we observe uptake at provincial level, our estimates measure the province-level sum of *N-th* (marginal) impact of a policy change on profits: $\sum_{i=1}^{N} \pi_i'(\cdot\,; I_i)|\Delta\, Policy$. Empirically, we regress the insurance demand for the *k*-th crop in the *i*-th province at the *t*-th year ($Y_{ik,t}$) on the level of past insurance and policy reforms ($Y_{ik,t-1}\boldsymbol{R}_l$), the premium ($P_{ik,t}$), and other unobservable determinants:

$$Y_{ik,t} = \alpha + \beta_i + \beta_k + \gamma Y_{ik,t-1}\boldsymbol{R}_l + \delta P_{ik,t} + \varepsilon_{ik,t} \qquad (1)$$

where α is a constant and $\varepsilon_{ik,t}$ is a random error; γ and δ are parameters to be estimated. Consistent with the literature (e.g., Diffenbaugh et al., 2021; Burke et al., 2015; 2018), province and crop fixed effects (β_i and β_k) are introduced to isolate the effect of policy reforms from unobservable factors that differ across provinces and crops and could affect the insurance demand (e.g., different riskiness and value of productions, different weather conditions).

The insurance demand equation in (1) is estimated in two specifications to control for the quantity and value effect of policy reforms: the insurance level at time *t* and *t-1* ($Y_{ik,t}$ and $Y_{ik,t-1}$) is alternatively proxied by the insured acreage (specification i) and the insured value per hectare (specification ii). The insured acreage proxies the insurance uptake at the province-crop level and captures the quantity effect on the insurance demand. The insured value per hectare measures the unit value of the insured crops in a province and captures the value effect on the insurance demand.

To capture the (quantity and value) effect of policy reforms on the insurance demand, we interact the level of past insurance with the timing of policy reforms. The matrix $\boldsymbol{R_l}$ includes three terms: a constant that, interacted with the lagged dependent variable, allows us to control for the level of past insurance; two dummy variables that take the value 1 in the year of entry into force of the two policy reforms (i.e., 2013 and 2015) and, interacted with the lagged dependent variable, capture the level of insurance demand in the year prior to the reforms (i.e., 2012 and 2014). Many economic relationships are dynamic in nature. See, for example, Haile et al. (2016) on dynamic acreage and yield response of cereals to international price change and volatility, Kim and Moschini (2018) on dynamic supply for biofuel feedstocks, Lamonaca et al. (2021) on dynamic acreage allocation in the wine sector. The same applies for the insurance demand whose decision-making process is highly affected by past experiences (e.g., Santeramo, 2019). The presence of lagged dependent variables among the regressors in equation (1) allows us to better capture the dynamics of adjustment in the relationship between the insurance demand and policy reforms (e.g., Baltagi, 2008).

Following Goodwin (1993), the premium in (1) is modelled as the average premium per hectare in specification i (i.e., quantity effect) and as the premium rate[19] in specification ii (i.e., value effect).

The insurance demand equation in (1) is estimated in levels through least squares and marginal effects[20] in the level of insurance demand are expressed in percentage variation. However, the Ordinary least Square (OLS) estimator may be biased and inconsistent due to the fact that lagged dependent variables in the right-hand-side of equation (1) may be correlated with the error term. Baltagi et al. (2008) reviews different alternative methods of estimation of dynamic panel data models, such as the model in equation (1), and suggest that the generalised method of moments (GMM) procedure, proposed by Arellano and Bond (1991)

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[19] Premium rate is computed as the ratio between the total paid *premia* and the total insured value.

[20] $Marginal\ effects = \gamma * \frac{|\bar{y}|}{|\bar{x}|} \Rightarrow \frac{\Delta y}{\Delta x} * \frac{|\bar{x}|}{|\bar{y}|}$, where $\bar{x}$ is the difference of the insurance level between the year of the reform and the year preceding the reform, $\bar{y}$ is the average insurance level in the whole period. The insurance level is alternatively the insured acreage (specification i) and the insured value per hectare (specification ii).

and extended by Arellano and Bover (1995) and Blundell and Bond (1998), is more efficient than the fixed effect estimator, both the Within estimator (Nickell, 1981)[21] and the corrected Within estimator (Kiviet, 1995), the random effects generalised least squares (GLS) estimator, the Anderson and Hsiao (1982)[22]. To test whether the OLS estimates are biased, we run a one-step GMM estimation with robust standard errors, using the lagged endogenous variables as instruments (Roodman, 2009).

We test the robustness of the model controlling for different combinations of fixed effects and introducing a set of control factors, such as production and climatic variables. Production variables are the preceding year's yield, the preceding year's harvested yield and the preceding year's loss per hectare. To control for the heterogeneity of climate conditions, we introduce the province-specific variation over two periods (*t* and *t-1*) in the minimum temperatures, maximum temperatures, and precipitations.

3.2 Data sources and sample description

The empirical analysis covers the period between 2010 and 2015 and refers to the 111 Italian provinces and to 11 crops (i.e., artichoke, corn, durum wheat, soft wheat, apple, pepper, pear, tomato, soybean, table grapes, wine grapes) with grater insured values. The selected crops include different commercial categories such as same crops with and without geographical indications (e.g., wine grapes), crops covered and uncovered by other risk management tools (e.g., anti-hail nets for apples): they are listed in detail in table s2 of the Supplementary material. For each combination of province and crop we collected contract-specific[23] data on insured acreage, insured value, and premium[24] from the *Istituto di Servizi per il Mercato Agricolo*

[21] The Within estimator could bias the true value of the coefficient of interest as much as 20% (Judson and Owen, 1999).

[22] Based on a first difference transformation, the Anderson and Hsiao (1982) estimator may yield consistent but not necessarily efficient estimates of the parameters of interest (e.g., Ahn and Schmidt, 1995). Moreover, Arellano (1989) suggests that estimators that use differences, such as the Anderson and Hsiao (1982) estimator, has larger variances over a significant range of parameter values with respect to estimators that use instruments in levels, therefore they are not recommended.

[23] Additional descriptive statistics by subsamples are in tables s3 and s4 of Supplementary material.

[24] The insured acreage and value (per hectare) have 5,872 non-missing observations (missing observations are associated with provinces-crops not insured in certain years) that reduce to 4,913 when we consider the one-year lagged variables (used as explanatory variables in the model). Associated with the 4,913 non-missing observations of the lagged variables, we have 700

Alimentare (ISMEA). Production data are from the *Istituto Nazionale di Statistica* (ISTAT) and climatic data are from the *Ministero delle politiche agricole alimentari e forestali* (Mipaaf). Main variables are described in table 2[25].

On average, the insured acreage is 866 ha valued 8,526.30 €/ha, and 965.29 ha (valued 8,476.53 €/ha) and 759.96 ha (valued 7,761.09 €/ha) in the two years proceedings the entry into force of the reforms (respectively, 2012 and 2014). The average premium per hectare is 598.01 €/ha and the average premium rate is 0.06.

Table 2. Description of main dependent and independent variables.

Variable	Model specification	Description	Dimension	Unit	Descriptive statistics
Insured acreage	Quantity effect	Total insured acreage	*ik,t*	ha	866.12 (±2,642.45)
Reform 2013	Quantity effect	Total insured acreage in 2012	*ik*	ha	965.29 (±3,399.10)
Reform 2015	Quantity effect	Total insured acreage in 2014	*ik*	ha	759.96 (±2,345.78)
Insured value per hectares	Value effect	Total insured value per total insured acreage	*ik,t*	€/ha	8,526.30 (±10,075.83)
Reform 2013	Value effect	Total insured value per total insured acreage in 2012	*ik*	€/ha	8,476.53 (±10,246.22)
Reform 2015	Value effect	Total insured value per total insured	*ik*	€/ha	7,761.09 (±7,186.99)

missing observations for the premium variables (both average premium per hectare and premium rate). Therefore, our regression results are based on 4,213 observations (4,913 – 700).

[25] Detailed descriptive statistics are in the Supplementary material.

		acreage in 2014			
Average premium per hectare	Quantity effect	Total *premia* paid per total insured acreage	*ik,t*	€/ha	598.010 (±842.55)
Premium rate	Value effect	Total *premia* paid per total insured value	*ik,t*	-	0.06 (±0.05)
Yield	Both (sensitivity analysis)	Total production (lagged) per cultivated acreage (lagged)	*ik,t-1*	q/ha	298.07 (±4,640.54)
Harvested yield	Both (sensitivity analysis)	Harvested production (lagged) per cultivated acreage (lagged)	*ik,t-1*	q/ha	357.13 (±6,866.98)
Loss per hectare	Both (sensitivity analysis)	Not harvested production (lagged)per cultivated acreage (lagged)	*ik,t-1*	q/ha	-59.06 (±5,446.39)
Minimum temperature variation	Both (sensitivity analysis)	Variation in the minimum temperature over two periods	*i,t*	°C	0.24 (±0.68)
Maximum temperature variation	Both (sensitivity analysis)	Variation in the maximum temperature over two periods	*i,t*	°C	0.39 (±1.03)
Precipitation	Both (sensitivity	Variation in	*i,t*	mm	-44.73 (±291.43)

variation	analysis)	precipitation over two periods

Notes: Descriptive statistics are average values and standard deviation in parentheses. Dimensions are province i, crop k, year t.

A potential limitation of our empirical application is the data availability. However, as shown in the figure 2, changes in the insurance demand are already observable in the years of entry into force of policy reforms. For instance, the total insured acreage inverts the upward trend of the first three years of the panel and reduces both in 2013 (year of entry into force of the first reform) and in 2015 (year of entry into force of the second reform) (figure 2, panel A); the average insured value per hectare increases both in 2013 and (substantially) in 2015 (figure 2, panel B). In fact, the crop insurance decision-making process occurs on a year-by-year basis and farmers freely decide whether to subscribe or not insurance contracts depending, among others, on the type of available contract alternatives (e.g., Severini et al., 2017; Santeramo, 2018). Moreover, the risk management policy framework, characterising the time period under investigation, is highly unstable. Two policy reforms occurred only two years apart from each other. For instance, in 2015, the introduction of types of insurance contracts completely new impedes prolonged impacts of the 2013 reform in subsequent years. This incentivises measuring the average effect of policy reforms around the period of their entry into force.

4. Results and discussion

The estimation results of the insurance demand equation are reported in table 3 and show the linkages between policy reforms introduced in 2013 and 2015 and insurance demand's shock both in terms of quantity of insurance purchased and unit value of insurance demand. Overall, we find that both policy reforms are positively correlated with the unit value of production insured but not with the quantity of insurance purchased. The results are robust to different specifications controlling for the effects of other confounding factors related to the crops productivity and climate characteristics of the Italian provinces (tables 4 and 5), and to crop-specific analyses[26].

Table 3. Estimates of insurance demand equation.

	Dependent variables	
	Insured acreage	Insured value per hectare
Variables		
Reform 2013	-0.384*** [-3.06%]	0.108*** [0.04%]
	(0.020)	(0.020)
Reform 2015	-0.150*** [-0.19%]	0.105*** [0.54%]
	(0.023)	(0.025)
Observations	4,213	4,213
R-squared	0.694	0.551

Note: OLS estimate of equation (1). The dependent variable is the insured acreage in the first model's specification and the insured value per hectare in the second model's specification. Both models include premium, past insurance level, crop fixed effects, province fixed effects. Standard errors are in parenthesis. Marginal impacts are in brackets.

*** significant at the 1 percent level.

[26] We tested for the robustness of our results estimating the main model by groups of similar crops (i.e., fruit, cereals, vegetables, grapes) and by crops (i.e., artichokes, durum wheat, soft wheat, corn, apples, peppers, pears, tomatoes, soybean, table grapes, wine grapes). The results of the robustness check are reported in the supplementary material. The insured acreage response is in line with main results for all groups of crops but grapes, both table and wine grapes, whose estimated coefficients for 'Reform 2013' and 'Reform 2015' are significant and positive. In line with the expectations, policy reforms (both restrictive, such as the one in 2013, and innovative, such as the one in 2015) may exclude from the insurance market less-valued crops, but not high-performance crops such as grapes. Similarly, the positive correlation between policy reforms and the insured value per hectare is more evident on high-value crops such as fruit and grapes.

We find a negative relationship between the insured acreage and both policy reforms, but the 2015 reform introducing new types of subsidised insurance contracts is less impactful: the insured acreage reduces only by 0.19% as compared to a 3.06% reduction determined by the 2013 reform. Such a difference is likely to depend on the characteristics of the insurance demand in the two periods. Before the 2013 reform, the mono-risk contracts were dominant in the subsidised crop insurance market. The removal of subsidies to this type of contracts may have contributed to a marked drop in the total insured acreage and the exit of farms with specific needs (i.e., cover a single peril) from the subsidised insurance market. As argued in Glauber (2013), an increase in the insured acreage can be reached mainly with an increase in subsidies. Differently, after the entry into force of the 2015 reform, we observe a shift from the pluri-risks contracts (i.e., the most widespread in 2014) to the most similar type of contract introduced in 2015 (i.e., package C, see figure 2). Recently, ISMEA (2018b, 2020b) reported that Italian farmers are asking for the reintroduction of subsidies for the mono-risks contracts.

Findings also suggest a positive relationship between the insured value per hectare and both the 2013 and 2015 policy reform, indicating that high-valued crops tend to be insured at the expense of low-valued crops. This is consistent with Goodwin (1993) who concludes that the insured value is more price elastic than the insured acreage. The 2015 reform is decisive: the shock on the insured value per hectare is +0.54% as compared to +0.04% associated with the 2013 reform[27]. Differences in the shocks may be due to the different nature of the policy reforms. The 2015 reform, by introducing new types of subsidised insurance contracts, required a greater decisional effort of farmers in choosing a proper type of insurance contract. It is likely that only farmers with high-valued crops sustained this effort and kept being insured, contributing to increase the insured value per hectare. According to Paulson et al. (2016), policy reforms providing additional choice options give more flexibility to producers but unavoidable complicate the decision-making process, requiring a significant amount of knowledge on the details and functioning mechanisms of the new available tools. For instance, the authors find that the Supplemental Coverage Option provided by the 2014 Farm Bill in the US

[27] The 0.04% increase in the insured value per hectare associated with the 2013 reform is to be considered as close to zero. In fact, the GMM estimates of the insurance demand equation, reported in the appendix, reveal that only the coefficients estimated for 'Reform 2013' in the second model's specification (with the insured value per hectare as dependent variable) are statistically different.

was beneficial for the most risk-averse farmers, who benefitted of both the increase of subsidies and the additional coverage eligible to subsidies. Similarly, it is likely that the 2015 reform, increasing the flexibility and the available types of insurance contracts, had a positive effect on more risk-averse farmers with high-valued crops, increasing the insured value per hectare. Differently, less risk-averse farmers may have preferred alternative risk management strategies: farmers tend to analyse the relative costs and benefits of risk management strategies (Smith and Watts, 2019) and building new experience may be a huge cost.

Overall, the 2013 and 2015 policy reforms have a role which differs depending on the change brought by the reform. The 2013 reform seems to limit mostly farmers used to uptake mono-risk contracts to the detriment of insured acreage; the 2015 reform seems to limit all farmers, who had to learn in a short time how to manage new types of subsidised insurance contracts, to the benefit of insured value per hectare driven by the higher responsiveness of farmers with high value (and, possibly, high risk) crops.

Table 4. Sensitivity analysis on insured acreage.

Variables	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)	(x)
Reform 2013	-0.4080***	-0.3970***	-0.4010***	-0.3840***	-0.3830***	-0.3830***	-0.3830***	-0.0304**	-0.0304**	-0.0304**
	(0.0189)	(0.0190)	(0.0192)	(0.0192)	(0.0195)	(0.0195)	(0.0195)	(0.0139)	(0.0139)	(0.0139)
Reform 2015	-0.1510***	-0.1500***	-0.1530***	-0.1500***	-0.1500***	-0.1500***	-0.1500***	-0.1680***	-0.1680***	-0.1680***
	(0.0228)	(0.0228)	(0.0229)	(0.0228)	(0.0232)	(0.0232)	(0.0232)	(0.0145)	(0.0145)	(0.0145)
Premium per hectare	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Insured acreage (lagged)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Crop fixed effect	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province fixed effect	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Yield (lagged)	No	No	No	No	Yes	No	No	Yes	No	No
Harvested yield (lagged)	No	No	No	No	No	Yes	No	No	Yes	No
Loss per hectare (lagged)	No	No	No	No	No	No	Yes	No	No	Yes
Min temperature variation	No	No	No	No	No	No	No	Yes	Yes	Yes
Max temperature variation	No	No	No	No	No	No	No	Yes	Yes	Yes
Precipitation variation	No	No	No	No	No	No	No	Yes	Yes	Yes
Observations	4,213	4,213	4,213	4,213	4,093	4,093	4,093	3,952	3,952	3,952
R-squared	0.684	0.687	0.689	0.694	0.694	0.694	0.694	0.878	0.878	0.878

Note: OLS estimate of equation (1). The dependent variable is the insured acreage. Standard errors are in parenthesis.

*** significant at the 1 percent level. ** significant at the 5 percent level.

Table 5. Sensitivity analysis on insured value per hectare.

Variables	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)	(x)
Reform 2013	0.1270***	0.1130***	0.1250***	0.1080***	0.0302	0.0301	0.0302	0.0488**	0.0487**	0.0488**
	(0.0219)	(0.0202)	(0.0221)	(0.0203)	(0.0226)	(0.0225)	(0.0225)	(0.0244)	(0.0244)	(0.0244)
Reform 2015	0.1880***	0.1080***	0.1800***	0.1050***	0.0867***	0.0866***	0.0867***	0.0853***	0.0852***	0.0854***
	(0.0268)	(0.0251)	(0.0271)	(0.0253)	(0.0247)	(0.0247)	(0.0247)	(0.0280)	(0.0280)	(0.0280)
Premium rate	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Insured value per hectare (lagged)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Crop fixed effect	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province fixed effect	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Yield (lagged)	No	No	No	No	Yes	No	No	Yes	No	No
Harvested yield (lagged)	No	No	No	No	No	Yes	No	No	Yes	No
Loss per hectare (lagged)	No	No	No	No	No	No	Yes	No	No	Yes
Min temperature variation	No	No	No	No	No	No	No	Yes	Yes	Yes
Max temperature variation	No	No	No	No	No	No	No	Yes	Yes	Yes
Precipitation variation	No	No	No	No	No	No	No	Yes	Yes	Yes
Observations	4,213	4,213	4,213	4,213	4,093	4,093	4,093	3,952	3,952	3,952

R-squared	0.455	0.538	0.465	0.551	0.557	0.557	0.557	0.554	0.554	0.554

Note: OLS estimate of equation (1). The dependent variable is the insured value per hectare. Standard errors are in parenthesis.

*** significant at the 1 percent level. ** significant at the 5 percent level.

5. Concluding remark

In this article we investigated the linkages between policy reforms and subsidised crop insurance demand's shocks. We found that shocks on the subsidised crop insurance demand, as induced by the policy reforms in 2013 (i.e., removal of subsidies to mono-risk insurance contracts) and 2015 (i.e., introduction of new types of subsidised insurance contracts) had opposing directions on insured acreages and insured values per hectare. We observed that the quantity of subsidised crop insurance demand reduced after the introduction of policy reforms, with the removal (in 2013) of subsidies to the most adopted type of insurance mono-risk contracts. Differently, the unit value of subsidised crop insurance demand increased after the entry into force of both reforms, but the benefits were greater after the introduction of packages in 2015. This suggests that only high-valued crops kept being insured after the reforms. Understanding how farmers reacted to previous policy reforms is the first step to better calibrate new policy reforms of the subsidies crop insurance market. It should be kept in mind that farmers ask for a greater flexibility but are also attached to the already-known types of subsidised insurance contracts (Sherrick et al., 2003). Evidence from this analysis may serve as benchmark for countries with similar insurance markets, such as the EU Member States. Considering that the CAP provides the same risk management tools to the Member States and given the relatively recent tradition and limited experience of EU countries in agricultural risk management strategies, findings from this analysis may be extended to other Member States having due regard to the peculiarities of (and similarities across) each agricultural sector(s) and insurance market(s). For instance, the insurance market in Italy and Spain are quite similar: in both markets the insurance premium and public-private partnerships are heavily subsidised by governments (Dick and Wang, 2010; Reyes et al., 2017). Following the Italian example, in 2010 France took advantage from the European legislation, subsidising the premium paid by farmers (Salmon, 2013). A few years before the introduction of the 2015 reform in Italy, the Hungarian government implemented a similar reform, by establishing the National Damage Mitigation Fund to cope with different combinations of perils and experienced a reduction in the insurance demand during the period 2007-2011 (Zubor-Nemes et al., 2018). Learning from past experiences is crucial to face limits (e.g., weak connections with agricultural insurance intermediaries such as farmers unions and cooperatives) and challenges (e.g., customisation of insurance products to meet farmers' needs) that tend to be common to different contexts, especially in the wake of the incoming post-2020 CAP.

The relevance of the risk management sector in agriculture was recently stressed by the Italian Minister of Agriculture, Patuanelli, during a public speech to the joint commissions of agriculture of Senato and Camera in December 2021, when reminded the importance of the agricultural sector and the chances offered by the incoming post-2020 CAP and National Recovery and Resilience Plan. Within the CAP, each Member Sate will define a National Strategic Plan identifying the target to reach, the needs acknowledged, and the financial support allocated. The risk management sector will help to reach more than one objective of the new CAP, by contributing to ensure a basic income to farmers and the economic sustainability of agricultural productions, and to face the economic implications of climate change. As a demonstration of the importance of the risk management, the Minister Patuanelli had asked for the possibility to take the 3% from the first pillar to this sector to face the economic effects of climate change and the increasing frequency of the natural disasters. Moreover, a National Mutual Fund against catastrophic risks (i.e., flood, frost and drought) has been implemented to support all farmers, with funds of 350 million EUR per year. This instrument is likely to have an important role, since catastrophic risks are increasingly affecting the whole Italian peninsula.

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Italian subsidised crop insurance: what the role of policy changes

Supplementary material

Examples of ex-ante risk management tools

Diffenbaugh et al. (2021) found out that crop insurance losses in the United States (US) increased because of global warming in recent years. They also suggest that, because of the expected trends of climate change and extreme events magnitude and frequency, losses are likely to increase in the agricultural sector. In U.S. and Canada, several new insurance tools have spread recently, while in Europe efficient insurance tools to face climatic risks (that are systemic and are becoming more and more relevant) were not introduced yet (e.g., Meuwissen, et al., 2018; Vroege et al., 2019; Finger and El Benni, 2021). In fact, in U.S. and Canada, different kinds of index insurances are available as well as income or revenue insurance, farm level insurance policies – i.e., Revenue Protection (RP) and Revenue Protection – Harvest Price Exclusion (RP-HPE), that use future market prices to determine the revenue (Santeramo and Ramsey, 2017). Other policies available in the U.S. are: Actual Revenue History (ARH), Yield Protection (YP), Actual Production History (APH), Area Risk Protection (ARP), Area Risk Protection – Harvest Price Exclusion (ARPHP) and Area Yield Protection (AYP). Since 2015, in U.S. it is also available the Whole Farm Revenue Protection (WFRP), an instrument similar to the European IST. However, this kind of insurance tool has problems of information asymmetries, since historical and guaranteed farm revenue are based on farm operation reports (Meuwissen et al., 2003).

Europe is trying to enhance the adoption of *ex-ante* risk management tools by providing financial supports, since the importance of subsidies is underlined in many studies (e.g., Glauber, 2004; Mishra and Goodwin, 2003). Specifically, in Europe particular relevance has been given to agricultural insurance with supports to private insurance and multi-peril contracts (Enjolras and Sentis, 2011). Some new tools are the weather-based insurance (proposed in France and Spain) and the Italian revenue insurance for grain (Santeramo and Ramsey, 2017). Some European Member States implemented new index insurances such as the 'Assurance des Prairies' in France (Roumiguié et al., 2015) and the 'Gras-Pauschalversicherung KLIMA' in Switzerland (Schweizer Hagel, in Vroege et al., 2019). Other index-based insurances are being implemented in German (Santeramo and Ramsey, 2017). The high cost to cope with imperfect information and the role of market imperfections in catastrophe risk sharing made policy supports fundamental for the agricultural insurance sector (Gardner and Kramer, 1986; Smith and Goodwin, 1996; Niehaus, 2002).

History of risk management in Europe

At the European level, the strategic relevance of the risk and crises management in the agricultural sector was stressed by the European Commission with the *Communication from the Commission to the Council* (Bruxelles Com (2005) 74, 24.01.2006). In this Communication, the Commission analysed three tools: insurance, mutual funds and compensation to losses due to income crisis. Between 2008 and 2009, risk management tools were introduced in the Reg. 1182/2007 (CMO for fruit and vegetables), in the Reg. 479/2008 (CMO for wine) and in the CAP *Health check* reform (Reg. Ce 73/2009). In the last cited regulation, the art. 68 gave to Member States the possibility to use found to subsidise crop insurance premiums against natural disasters and mutual funds against losses due to animal or crop diseases. Also the CAP 2007-2013 included *ex-post* compensation and premium subsidies as risk management measures. The latest European CAP reform (Common Agricultural Policy 2014-2020) gave major attention to risk management (Santeramo, 2018; Capitanio and De Pin, 2018; Meraner and Finger, 2019; Cordier and Santeramo, 2020), providing subsidies to three tools (art. 36-39 of the Reg. UE 1305/2013): agricultural insurance (subsidies to the premia – art. 37), mutual fund (art. 38) and income stabilisation tool (art. 39). An innovation introduced with the CAP 2014-2020 was the shift of the risk management sector to the second pillar, giving to Member States the opportunity to co-finance tools. In 2017, the Reg. UE 2393/2017 (also called *Omnibus*) was issued to modify the Reg. UE 1305/2013. The *Omnibus* gave further opportunity to enhance the risk management sector, since it enlarged the premium subsidies and lowered the loss threshold required to access contribution (see Table s1).

Table s 1 - Risk management tools subsidised with the European Regulation 1305/2013 and 2393/2017

	Reg. 1305/2013		Reg. 2393/2017	
Risk management tool	Threshold	Subsidies	Threshold	Subsidies
Agricultural insurance (art. 37)	30%	65%	20%	70%
Mutual fund (art. 38)	30%	65%	30%	70%
Income stabilisation tool (IST - art.39)	30%	65%	30%	70%
Sectorial IST (art. 39bis)	-	-	20%	70%

The Italian risk management sector is regulated at National and European level. Italy is one of the European Countries with the older political history of this sector: according to Santeramo and Di Gioia (2018), the political implementation and subsidisation of risk management strategies in Italy started in 1970[28] (Figure s1), whereas in Europe the first political document was promulgated in 2005[29].

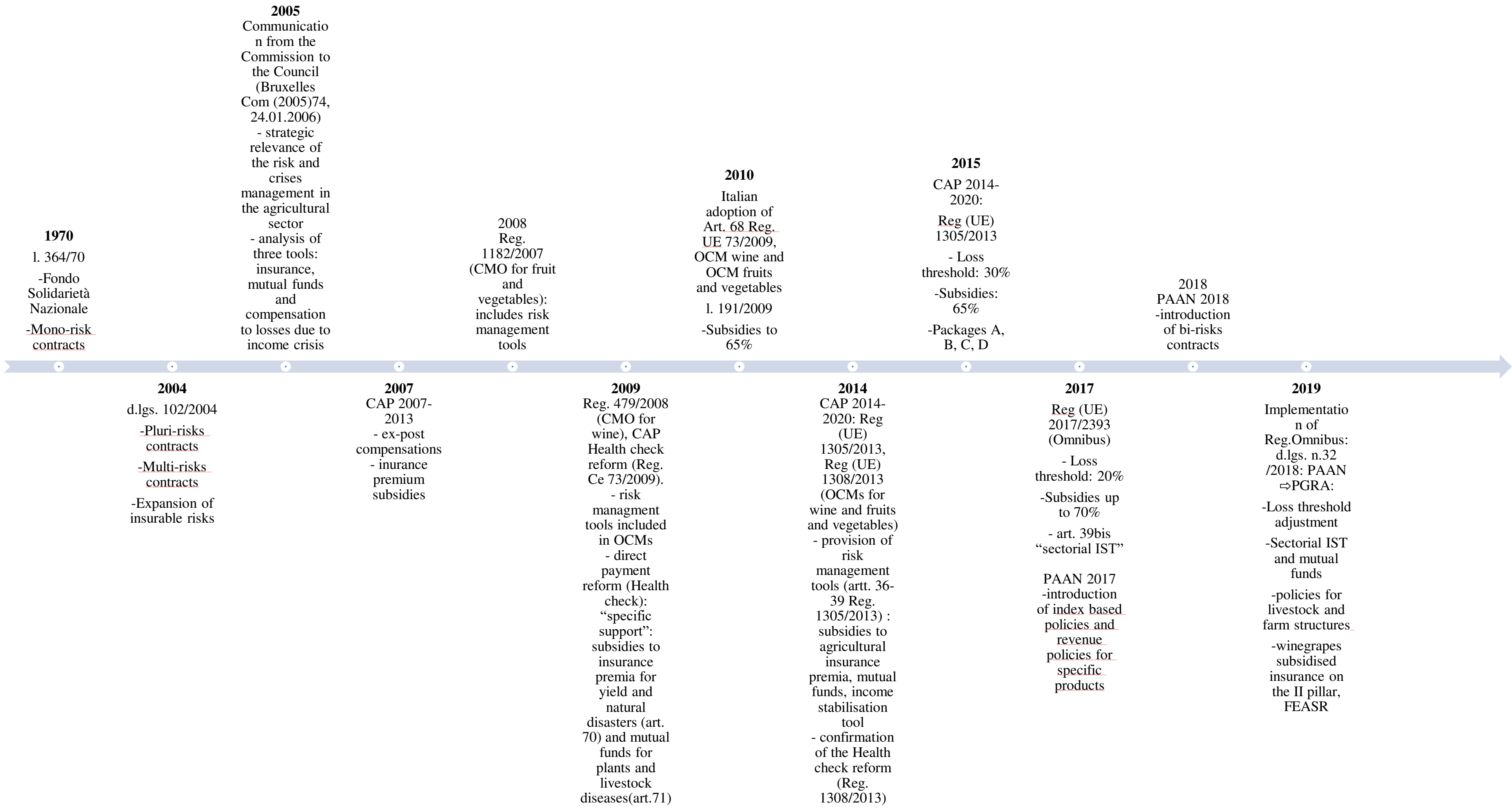
In Italy, Reg. UE 1182/2007 (CMO for fruit and vegetables), 479/2008 (CMO for wine) and Reg. Ce 73/2009 (CAP reform) were adopted in 2010. Starting from 2013, subsidies to mono-risk insurance contracts were abolished to enhance the adoption of Multi- and Pluri- risks contracts. The CAP 2014-2020 (Reg. UE 1305/2013) was implemented in 2015. In the same year there was the introduction of the "packages" as new type of contracts, as described in the main text. The *Omnibus* Regulation was adopted in 2019, with the Legislative Decree 32/2018. This decree signed the introduction of Sectorial IST, index-based insurances, income insurances (only for selected sectors) and the adjustment of the loss threshold. Since 2019, the document promulgated by the *Ministry of Agriculture, Food and Forestry Politics* is called "*Piano di*

[28] In this year, there was the emanation of the law n. 364 of 25th May 1970. This law established the *Fondo di Solidarietà Nazionale* (FSN) that is still active. Since then, the FSN has been including *ex-post* intervention (i.e., compensation for losses due to natural disasters) and promoting *ex-ante* instruments (subsidising agricultural insurance, prominently mono-risk contracts against hail). From then, several subsidies have been allocated to help the diffusion of *ex-ante* risk management tools.

[29] In this year, the European Commission stressed the strategic relevance of the risk and crises management in the agricultural sector with the *Communication from the Commission to the Council* (Bruxelles Com (2005)74, 24.01.2006). More details about the history of European risks management politics are given in the supplementary material, paragraph s1 "History of risk management in Europe". So that, starting from 2005, the Italian risk management politics met the European ones.

Gestione dei Rischi in Agricoltura", as it includes also mutual fund and income stabilisation tool. These instruments did not spread so far, so no data were available at the time of our study.

Figure s1. Italian and European reforms through the years



Sample description

Figure s2. Total insured value through the year.

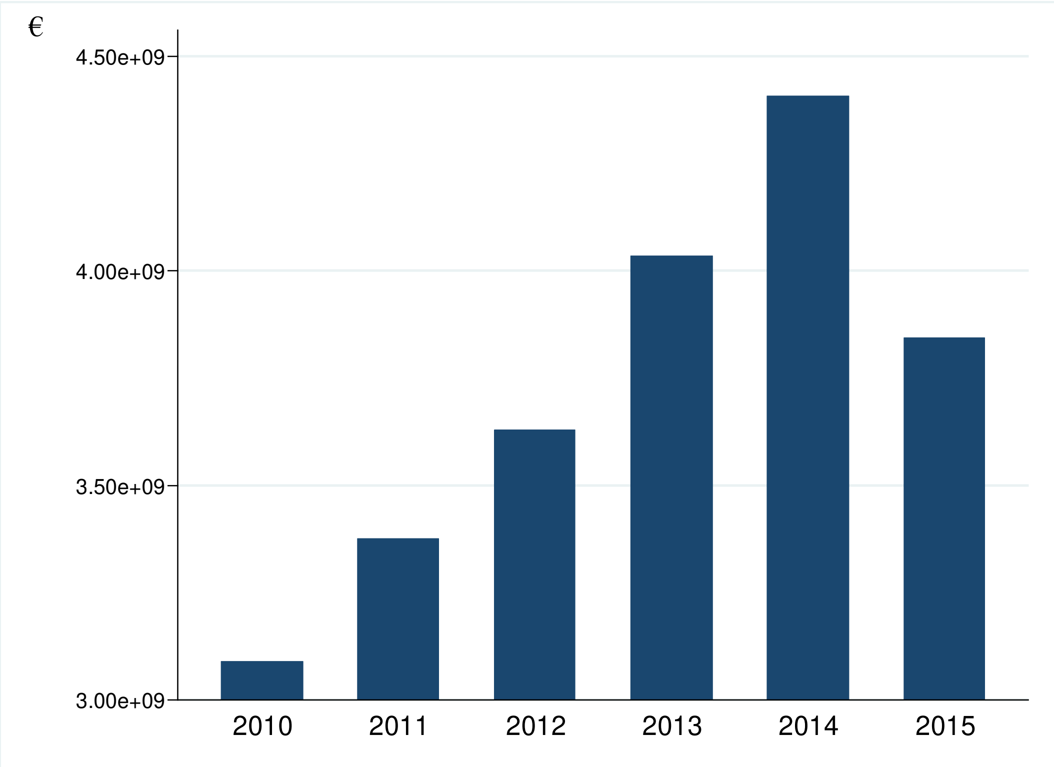


Table s2. Crops involved in this study.

Crops	Economic categories
Artichoke	Artichoke
Durum wheat	Durum wheat, Durum wheat seed, Polonian wheat
Soft wheat	Wheat, Wheat seed
Corn	Grain corn, Silage maize, Seed maize, Sweet corn
Apple	Apple, Apple with anti-frost system, Apple with anti-hail net
Pepper	Pepper
Pear	Pear, Precocious pear, Pear with anti-hail net, Precocious pear with anti-hail net
Tomato	Tomato paste, Salad tomatoes, Peeled tomatoes
Soybean	Soybean
Table grapes	Common grapes with anti-hail net, D.O. grapes with anti-hail net, Table grapes, IG grapes with anti-hail net, Table grapes under protection, Gooseberry
Wine grapes	Common wine grapes, D.O.C. wine grapes, Varietal wine grapes, Wine grapes, I.G.T. wine grapes, Wine grapes with anti-hail net, Varietal grapes with anti-hail net

Table s3. Descriptive statistics of production variables, sub-samples with and without insurance observations.

Variable	Description	Unit	Descriptive statistics
With insurance observations			
Yield (t-1)	Preceding year's yield; computed as: [Total production$_{(t-1)}$ / cultivated acreage]	q/ha	556.828 (±6693.271)
Harvested yield (t-1)	Preceding year's harvested yield; computed as: [Harvested production $_{(t-1)}$ / cultivated acreage]	q/ha	776.635 (±11495.970)
Loss per hectare (t-1)	Preceding year's loss per hectare; computed as: [[Total production$_{(t-1)}$ - Harvested production $_{(t-1)}$] / cultivated acreage]	q/ha	-219.807 (±9710.065)
Without insurance observations			
Yield (t-1)	Preceding year's yield; computed as: [Total production$_{(t-1)}$ / cultivated acreage]	q/ha	186.265 (±3382.775)
Harvested yield (t-1)	Preceding year's harvested yield; computed as: [Harvested production $_{(t-1)}$ / cultivated acreage]	q/ha	175.862 (±3213.284)
Loss per hectare (t-1)	Preceding year's loss per hectare; computed as: [[Total production$_{(t-1)}$ - Harvested production $_{(t-1)}$] / cultivated acreage]	q/ha	10.404 (±1315.054)

Note: Average values and standard deviation in parentheses.

Table s4. Reform variables, mean of the whole period, in the text is the mean only of selected years (2012 or 2014).

Variable	Description	Unit	Descriptive statistics
Model 1: dependent variable = insured acreage			
Reform 2013	Total insured acreage for each crop-province in 2012	ha	189.797 (±1554.693)
Reform 2015	Total insured acreage for each crop-province in 2014	ha	184.538 (±1200.644)
Model 2: dependent variable = insured value per hectare			
Reform 2013	(Total insured value / total insured acreage) for each crop-province in 2012	€/ha	1666.666 (±5654.840)
Reform 2015	(Total insured value / total insured acreage) for each crop-province in 2014	€/ha	1884.589 (±4859.188)

Note: Average values and standard deviation in parentheses.

Robustness check

We tested for the robustness of our results estimating the main model by groups of similar crops (i.e., fruit, cereals, vegetables, grapes) and by crops (i.e., artichokes, durum wheat, soft wheat, corn, apples, peppers, pears, tomatoes, soybean, table grapes, wine grapes). The insured acreage response is in line with main results for all groups of crops but grapes, both table and wine grapes, whose estimated coefficients for 'Reform 2013' and 'Reform 2015' are significant and positive. In line with the expectations, policy reforms (both restrictive, such as the one in 2013, and innovative, such as the one in 2015) may exclude from the insurance market less-valued crops, but not high-performance crops such as grapes. Similarly, the beneficial role of policy reforms on the insured value per hectare is more evident on high-value crops such as fruit and grapes.

Table s5. The role of policy reforms on insured acreages by group of crops.

Variables	All	Fruit	Cereals	Vegetables	Grapes
Reform 2013	-0.384***	-0.157*	-0.0942***	-0.913***	0.265***
	(0.020)	(0.087)	(0.013)	(0.100)	(0.039)
Reform 2015	-0.150***	-0.111	-0.258***	-0.334**	0.785***
	(0.023)	(0.071)	(0.013)	(0.148)	(0.071)
Observations	4,213	1,023	1,577	962	651
R-squared	0.694	0.560	0.949	0.217	0.821

Note: OLS estimates of equation (1). The dependent variable is the insured acreage. Both models include premium, past insurance level, crop fixed effects, province fixed effects. Standard errors are in parenthesis. *** significant at the 1 percent level, ** significant at the 5 percent level, * significant at the 10 percent level.

Table s6. The role of policy reforms on insured value per hectares by group of crops.

Variables	All	Fruit	Cereals	Vegetables	Grapes
Reform 2013	0.108***	0.0724	0.00569	-0.0772**	0.477***
	(0.020)	(0.062)	(0.009)	(0.033)	(0.035)
Reform 2015	0.105***	0.121*	-0.0279***	0.0363	0.185***
	(0.025)	(0.062)	(0.009)	(0.042)	(0.063)
Observations	4,213	1,023	1,577	962	651
R-squared	0.551	0.179	0.870	0.589	0.636

Note: OLS estimates of equation (1). The dependent variable is the insured value per hectare in the second model's specification. Both models include premium, past insurance level, crop fixed effects, province fixed effects. Standard errors are in parenthesis.

*** significant at the 1 percent level, ** significant at the 5 percent level, * significant at the 10 percent level.

Table s7. The role of policy reforms on insured acreages by crops.

Variables	All	Artichokes	Durum wheat	Soft wheat	Corn	Apples	Peppers	Pears	Tomatoes	Soybean	Table grapes	Wine grapes
Reform 2013	-0.384***	0.0806	0.0128	-0.147***	-0.211***	-0.134***	-0.00349	-0.883***	-0.0354	0.0997*	0.278***	0.0806
	(0.020)	(0.0514)	(0.0324)	(0.0158)	(0.0260)	(0.0207)	(0.152)	(0.126)	(0.0579)	(0.0526)	(0.0377)	(0.0514)
Reform 2015	-0.150***	0.199***	-0.506***	-0.243***	-0.575***	-0.801***	4.581***	-0.326*	0.172***	-0.528***	0.515***	0.199***
	(0.023)	(0.0561)	(0.0285)	(0.0167)	(0.0209)	(0.0245)	(0.163)	(0.176)	(0.0428)	(0.0496)	(0.0742)	(0.0561)
Observations	4,213	49	407	403	591	427	224	596	689	176	181	470
R-squared	0.694	0.863	0.823	0.942	0.972	0.970	0.989	0.763	0.228	0.966	0.927	0.877

Note: OLS estimates of equation (1). The dependent variable is the insured acreage. Both models include premium, past insurance level, crop fixed effects, province fixed effects. Standard errors are in parenthesis.

*** significant at the 1 percent level, ** significant at the 5 percent level, * significant at the 10 percent level.

Table s8. The role of policy reforms on insured value per hectares by crops.

Variables	All	Artichokes	Durum wheat	Soft wheat	Corn	Apples	Peppers	Pears	Tomatoes	Soybean	Table grapes	Wine grapes
Reform 2013	0.108***	0.00750	-0.0252	0.0775***	0.00735	0.0187	-0.100*	0.0216	-0.0770*	-0.0703***	0.584***	0.0465**
	(0.020)	(0.0643)	(0.0212)	(0.0178)	(0.0139)	(0.0355)	(0.0584)	(0.110)	(0.0399)	(0.0178)	(0.0662)	(0.0184)
Reform 2015	0.105***	-0.0189	0.0636***	0.0102	-0.0426***	0.0343	-0.0409	0.116	0.0758	0.0683***	-0.0254	0.0953***
	(0.025)	(0.0858)	(0.0215)	(0.0176)	(0.0140)	(0.0349)	(0.0800)	(0.114)	(0.0498)	(0.0214)	(0.164)	(0.0202)
Observations	4,213	49	407	403	591	427	224	596	689	176	181	470
R-squared	0.551	0.829	0.767	0.718	0.785	0.734	0.618	0.132	0.629	0.618	0.684	0.901

Note: OLS estimates of equation (1). The dependent variable is the insured value per hectare in the second model's specification. Both models include premium, past insurance level, crop fixed effects, province fixed effects. Standard errors are in parenthesis.

*** significant at the 1 percent level, ** significant at the 5 percent level, * significant at the 10 percent level.

Table s9. Comparing OLS and GMM estimates of insurance demand equation.

	Dependent variables			
	Insured acreage		Insured value per hectare	
Variables	OLS	GMM	OLS	GMM
Reform 2013	-0.384***	-0.383*	0.108***	0.109
	(0.020)	(0.209)	(0.020)	(0.085)
Reform 2015	-0.150***	-0.150**	0.105***	0.106***
	(0.023)	(0.070)	(0.025)	(0.037)
Observations	4,213	4,213	4,213	4,213

Note: OLS and GMM estimates of equation (1). The dependent variable is the insured acreage in the first model's specification and the insured value per hectare in the second model's specification. Both models include premium, past insurance level, crop fixed effects, province fixed effects. Standard errors are in parenthesis.

*** significant at the 1 percent level, ** significant at the 5 percent level, * significant at the 10 percent level.

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