AGRICULTURAL INSURANCE AND RISK MANAGEMENT: PRODUCT DEVELOPMENT AND RATEMAKING

Manual 8

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Agricultural Insurance and Risk Management: Product Development and Ratemaking
Prepared by: Dr. Lysa Porth for the International Finance Corporation (IFC)

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Preface and Acknowledgements

Agriculture insurance manuals were prepared by IFC for the development of agri-insurance markets where the public and private sectors work together in a partnership (PPP). The manuals are designed to strengthen the capacity of the government and market players to effectively design agri-insurance products, both traditional indemnity and index, introduce them to the market, and build sales. The manuals are designed to be succinct yet at the same time sufficient to create the technical and administrative foundation for a modern agri-insurance system, and to allow programs in early stages of development to properly plan the required system. Finally, the manuals are designed to train practitioners, to build local capacity for skills that are required to start the program, and to enable the program to grow over time.

The IFC Europe and Central Asia Agri-Finance Project implemented by IFC a member of the World Bank Group, in partnership with the governments of Austria and Hungary has initiated and issued this manual to share the knowledge and build capacity of agri-insurance market stakeholders. The Project covers Ukraine, Central Asia, Azerbaijan and the Western Balkans and is led by the Project Manager, Leah Soroka. The Project aims to contribute to development of a sustainable agricultural finance system. This approach will help to launch innovative financing and risk management tools designed particularly for financial intermediaries lending to the sector and required instruments to improve their risk management in agriculture.

The entire agri-insurance team in Ukraine, Azerbaijan and Kosovo made practical contributions to the manuals. A special recognition is expressed to Lysa Porth, Ph.D. MBA, Associate Professor and Guy Carpenter Research Chair in Agricultural Risk Management and Insurance in the Warren Centre for Actuarial Studies and Research, I.H. Asper School of Business, University of Manitoba, Canada and Andrey Zaripov, agri-insurance specialist and a member of the GIIF team for helping to develop manuals. The information in this manual is based in part from Lysa Porth's current and past research, both published and working papers. Lysa Porth would also like to acknowledge the helpful input from her colleagues at AgRiskCentre.com.

1.0. Introduction

Agricultural insurance and risk management have played an increasingly important role in helping to improve food productivity, achieve food security and protect economic growth. In particular, agricultural insurance is recognized as one of the most rapidly growing insurance markets. The crop insurance sector has experienced rapid growth since 2005, largely due to emerging markets driven by major growth in Brazil, China and India. As agricultural insurance programs continue to grow in terms of scale and scope, actuarial foundations have become more important in order to ensure that programs are efficient and actuarially sound.

There are several considerations in developing agricultural insurance programs. Considerations regarding the World Trade Organization (WTO) are very important for many countries around the world, including for example, decisions for premium subsidies, coverage levels, and product design, among others. Central to the sustainability of crop insurance programs worldwide is the ability to determine actuarially fair and sustainable premium rates. When premiums are not sound, a number of difficulties can result, including the limited development of agricultural insurance programs, as well as inadequate reinsurance capacity, among other implications. Even slight improvements in the accuracy of premium rates can have a considerable impact on reducing government spending and helping to ensure the long-term sustainability of the programs. Determining the actuarially fair premium rate can be a challenging task, especially in the case of agricultural insurance. This is attributed to a number of challenging issues including systemic risk, moral hazard, adverse selection, as well as data scarcity and credibility.

The remainder of this document is organized as follows. First, an overview of the WTO's Agreement on Agriculture is presented, as well as a discussion on implications for developing agricultural insurance programs. Next, an overview of international experience of agricultural insurance and risk management for the main agricultural producing countries of the world is presented. A summary of government and producer objectives and considerations for designing agricultural insurance and risk management programs is provided next. This is followed by an introduction to pricing basics and insurance concepts. Next, the principles of insurance are introduced, which is followed by a section on actuarial premium principles. After this, data issues are discussed, including a focus on aggregation bias and various restatement approaches. Finally, basics steps to ratemaking are presented, which includes the loss cost ratio method and the yield simulation approach. General remarks conclude the manuscript.

1.1. Trade Considerations under the World Trade Organization

Through the World Trade Organization (WTO), the Agreement on Agriculture (AoA) has taken significant steps to reform the agriculture sector to improve competitiveness and fairness. A primary focus of the WTO has been addressing the subsidies and high trade barriers that distort agriculture trade. The AoA has three main concerns: market access, domestic support, and export competition. These concerns are managed by setting limits on the tariffs that can be applied to individual products and on the levels of local support, and export subsidies. Market access refers to the use of trade restrictions, such as tariffs on imports. Domestic support pertains to the use of subsidies and other support programs that directly stimulate production and distort trade. Export competition is the use of export subsidies and other government support programs that subsidize exports. Agricultural insurance is an extensively used risk

Agricultural Insurance and Risk Management

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management tool, and its use has grown rapidly since the 1990's. One of the reasons for the growth is the potential exemption of such programs from reduction commitments under the Uruguay Round AoA of the WTO. Subsidies are typically classified in "boxes", as either green, amber, blue and a development box. They are described briefly in the following text

Green Box

To be classified as a green box subsidy, a program either must not trade-distort or must be deemed as minimally trade-distorting. Other criteria set out that subsidies must be government funded, programs must not be tied to production (decoupled, and must not involve price supports. Also, programs should not be specific to a commodity or a region. Green box subsidies can include direct payments to producers, such as decoupled income support measures (not linked to production decisions), and natural disaster relief, as two examples. The current WTO agreement allows green box subsidies without limits on expenditures, as long as they meet the criteria presented in the agreement.

Amber Box

Amber box subsidies have larger trade-distorting effects than green box subsidies. Amber programs typically provide price supports or subsidies that are tied to production. Thus, there are limits placed on expenditures. The subsidies are converted to an "Aggregate Measurement of Support", and each country commits to maintain its total current AMS below an agreed level. Minor programs are not subject to reduction commitments. Amber box subsidies capture policies, such as market price support measures, direct production subsidies or input subsidies. However, under AMS, there is no requirement to reduce trade-distorting domestic support when the aggregate value of the product-specific support is less than 5 percent of the total cost of production of the agricultural product in question (10 percent in the case of developing countries). Thirty-two WTO members have committed to reduce their amber box supports.

Blue Box

The blue box subsidy outlines conditions on the amber box criteria. The blue box captures policies that are too distortive to qualify as green box subsidies, but less distortive than amber box subsidies. The blue box conditions are intended to reduce distortion, and encourage the shift of programs to less distorting subsidies. The current WTO agreement has no limits on spending.

Development Box

The development box subsidy is intended to give flexibility to developing countries. Development subsidies are measures of assistance which can be direct or indirect. The goal is to help encourage agricultural and rural development. Development box subsidies can be related to investment and inputs, as two examples.

International Experience

The following section provides a brief overview of risk management and insurance systems internationally, which is summarized based on the review by Porth et al. (2018) [1] as part of Canada's Business Risk Management Review conducted in 2019. The countries examined, include Australia, Brazil, Canada, China, the European Union, India,

[1] Porth, L., Boyd, M., Porth, C.B., and Driedger, J. 2018. Business Risk Management Programs Review. Working Paper.

Mexico, New Zealand, and the United States. Over the past 30 years domestic agricultural policies have reduced support in many countries using output-related measures so that markets largely dictate what is produced.

1.1.1. Australia

Australian farmers have been receiving progressively less support from already low levels. Australia's Producer Support (PSE) is one of the lowest in the OECD at 1.9 percent for the 2014-2016 period. The total support to agriculture (TSE) is around 0.1 percent of GDP, and is based on support directly to producers (PSE) and general services support (GSSE). The strongly market-oriented agriculture sector in Australia does not offer any market price support programs, and the country is heavily reliant on export markets.

In 2016, 45 percent of the direct support provided to producers was for input use and other capital investments on the farm. The largest payments (given as loans) were made to help farmers recover from major natural disasters, such as a drought or flood. Another important form of support involves subsidies for improving water infrastructure on farms and making progress to more environmentally conscious practices. This has been achieved using public-private partnership such as the National Water Infrastructure Development Fund.

The remaining support to producers comprises about 42 percent of the total support. These supports are for farm management deposits, income tax averaging arrangements, and other environmental programs. General services support (GSSE) targets the Agricultural Knowledge and Innovation System (AKIS) and the development of infrastructure, accounting for 51 percent and 34 percent of GSSE expenditure, respectively.

In 2016, the Australian government introduced various reforms following the release of the Agricultural Competitiveness 'White Paper' [2]. Those improvements involved encouraging and enhancing producer risk management and building resilience. For example, establishing the farmers' government assistance program called the Managing Farm Risk Program, improving to the Farm Management Deposits Scheme and refining income tax averaging.

The Managing Farm Risk Program offers eligible farms rebates for seeking expert advice to help inform decisions and apply for a new insurance policy to protect against adverse weather and other production risks management. There is a maximum rebate of AUD 2,500 per farm. This program differs from many other countries programs because there is no support provided in the form of subsidized insurance premiums.

The Farm Management Deposit Scheme (FMD) was set up to double the deposit cap from AUD 400,000 to AUD 800,000 in July 2016. The FMD is offered by financial institutions, and farmers can access their accounts in the event of severe adverse weather. Farmers are given a 12 months grace period to use their funds without losing their claimed tax benefits. The intent of FMD's are to help farmers cope with climate and production risks.

A temporary assistance package was also provided to the dairy industry. Vulnerability to prices (mainly due to the wholesale market) created the impetus for new measures to protect the industry through a loan scheme and formation of a milk price index to improve market transparency and help inform farmers of price trends.

[2] Available at: agwhitepaper.agriculture.gov.au/white-paper

The overall challenge for the future is to improve the economic viability of farms while ensuring sustainable use of resources, mainly water. There is a clear policy priority on water market reforms and basin management, alongside efforts to help producers better adapt to climate change.

1.1.2. Brazil

As a competitive global exporter, Brazil provides a relatively low level of support and protection to its agriculture industry, at less than 4 percent of gross farm receipts (one-fifth the OECD average) and 0.5 percent of GDP. Direct support to farms makes up about 75 percent of support, with payments based on output and input use being the most important element.

Over one-third of support to producers is provided through measures that distort farm prices, such as regional minimum guaranteed prices and deficiency payments. There is significant variation across commodities. The role of direct payments is minor, and in most cases farmers have to meet certain environmental criteria for eligibility.

There are three main parts to the agricultural policy in Brazil: market price policy, rural credit and crop insurance subsidies. The Ministry of Agriculture, Livestock and Food Supply (MAPA) focuses only on commercial agriculture. Small-scale family agriculture is supported by the Special Secretariat for Family Agriculture and Agrarian Development (MDA).

Market Price Policy

The main part of the market price policy is based on minimum price guarantees set at the regional level. This covers a range of crops from rice, wheat, maize, cotton and soybeans, as well as some regional crops such as cassava and beans. Some livestock producers are also included. The government provides several market price support programs, including direct government purchases (AGF program), premiums to commercial buyers who pay minimum prices to producers, and public and private options contracts backed by a private risk premium option.

The National Food Supply Agency (CONAB) operates programs for both commercial and small-size farm operations. This includes the government purchase program (AGF) set by the MAPA Secretary of Agricultural Policy (SPA) for commercial and small-scale farms and the equivalent program established by the MDA for small-scale agriculture (PGAF). CONAB also manages the minimum price program for family farms (PGAF program) and makes direct acquisitions from family farms at market prices. The products either go into stock or are distributed as part of the food program. Guaranteed rates for small-scale farmers are based on the average regional product cost of family farms. Several programs offer deficiency payments calculated as the difference between the market

price and the minimum reference price. Producers also receive various marketing loans at reduced interest rates, allowing them to store grain in anticipation of a higher market price in the future.

Rural Credit

Agricultural credit is a main underpinning of policy direction for both the commercial and small-scale family farm sectors. The National Rural Credit System (SNCR) gives credit to farmers at favoured interest rates. For commercial agriculture, the SNCR system gives loans to help with marketing, working capital and investment. Support is also provided to producers through debt rescheduling.

Crop Insurance Subsidies

Agricultural insurance includes four main programs, targeting either insurance premium subsidies or compensation for production losses due to natural disasters. Two of the programs target commercial farmers and are administered by MAPA. The rural insurance premium program (PSR) provides premium subsidies for insurance for commercial farmers who deal with insurers suggested by the government. These programs provide coverage for crop and livestock, as well as forestry and aquaculture.

In 2016 the rural insurance program provided close to $115 USD million in insurance subsidies to commercial producers. Soybean producers receive approximately 40 percent of all subsidies, and corn producers receive about 20 percent. Typically, the subsidy is in the range of 35-45 percent of the actuarial premium. The general agricultural insurance program (PROAGRO) helps farmers with bank debt and working capital loans when they experience crop loss. Most of the resources from this program go to the southern region, and to grain crops, primarily soybeans.

1.1.3. Canada

Currently, the federal and provincial governments offer four programs to Canadian agriculture producers via a suite of Business Risk Management (BRM) programs. The programs include AgriInsurance, AgriInvest, AgriRecovery, and AgriStability, and an overview of each is presented next.

AgriInsurance (Production Insurance)

AgriInsurance provides protection to producers from production losses for named perils due to natural hazards, such as drought, flood, wind, frost, excessive rain or heat, snow, losses from uncontrollable disease, insect infestations and wildlife. AgriInsurance is the main program used by grain farmers in Canada. Premiums are generally subsidized 60 percent by governments, and producers are responsible for 40 percent. The program covers only production

losses, **and does not guarantee market prices or input costs.** This could be a challenge at times, because indemnity payments to farmers are based on an "insured price" set by the Federal Government, rather than a market price, and the insured price may be lower than the market price leaving the farmer vulnerable to market price risk.

AgriInvest

AgriInvest is a government-matched savings account that is intended to address net farm income declines. Accounts earn interest, and withdrawals can be made any time. AgriInvest helps producers protect their margin from small declines. Each year, producers can deposit up to 1.5 percent in the current GF2 framework, and 1 percent under the new CAP framework effective in 2018, of their Allowable Net Sales (ANS) into the AgriInvest account, and this is matched by government contribution. ANS is limited to $1.5 m per year, making the largest matching government contribution $22,500 per year under the current GF2 framework, and $15,000 per year under the new CAP framework effective in 2018. Further, the account balance is limited to 25% of a producer's average ANS.

AgriRecovery

AgriRecovery is a disaster-relief program offered by the Federal, Provincial, and Territorial (FPT) governments to assist producers with extraordinary costs of recovering from natural disasters. AgriRecovery provides a framework for FPT governments to respond with targeted assistance to help those producers affected by natural disasters resume business operations as quickly as possible. The main challenge with this program is that it is not bankable, as the program is ad-hoc with the form of assistance being unique to the specific disaster situation.

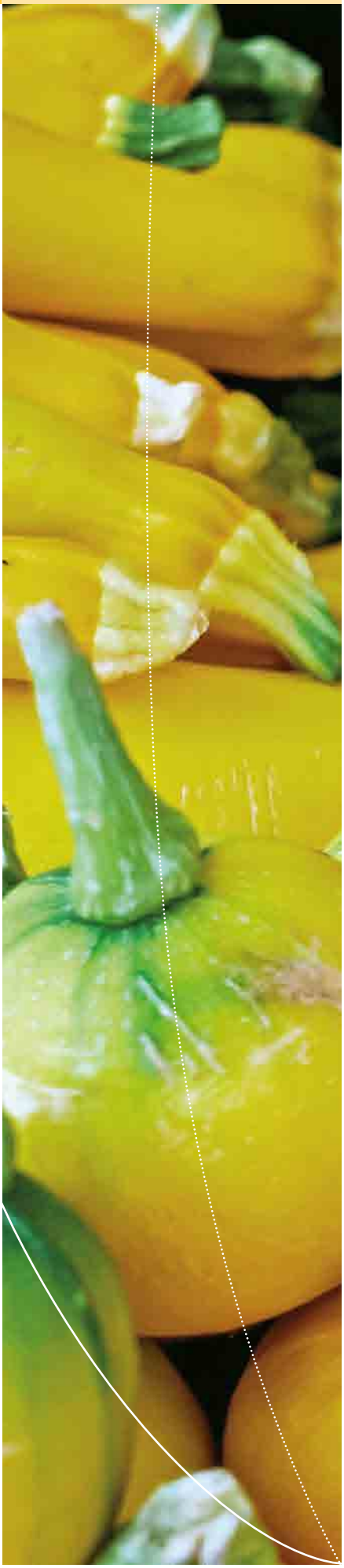
AgriStability

AgriStability is a whole-farm program that provides protection when a producer experiences a large margin decline. AgriStability is intended to provide protection against large decreases in farm income. Under the 2013-2018 Growing Forward 2 Framework, AgriStability payouts are triggered when a producer's current year program margin drops below 70 percent of their reference margin.

Program margin is determined based on allowable income minus allowable expenses in a given year, and adjustments are made for changes in receivables, payables and inventory. These adjustments are made based on information submitted on the AgriStability form.

Reference margin is the average program margin based on a five-year Olympic average, where the high and low values are dropped from the calculation. The reference margin is limited to the lower of the historical reference margin or average allowable expenses for the years used to calculate the reference margin.

Perhaps the major challenge of this program is in regards to the determination of the reference margin, which is based on the production history of the producer. This means that the programs coverage is based on inter-temporal market conditions, leaving some farmers with a large potential coverage gap compared to current market conditions. For example, farmers who have experienced significant losses in proceeding years will have lower reference margins in the program, thereby, reducing their eligible coverage substantially compared to those producers who have been more profitable in proceeding years..



1.1.4. China

The agriculture industry in China is tasked with a significant challenge, as it tries to feed 20 percent of the world's population with only 7 percent of the world's potable water and 10 percent of the world's agricultural land. Consequently, a key aspect of China's agriculture policy has focused on the country be self-sufficient in regards to key grains.

China is the global leader in total farm production, producing almost one-third more than all OECD countries combined when measured in value terms. Production takes place mostly on small family farms (less than one hectare on average). Large-scale production has been developing rapidly in more recent years. Livestock production mostly takes place on large-scale commercial operations. Over the past two decades growth in the agriculture sector has been rapid, and in more recent years it has stabilized, including the level of agricultural support. For example, total support is estimated to be 2.4 percent of GDP, which is about four times the OECD average.

Price Support

The main way Chinese farmers are supported is through market price support. This is done through measures such as tariffs, tariff rate quotas (TRQ) and state trading, and the case of rice and wheat through minimum guaranteed prices. There have been reforms to the maize purchasing and storage system, which began in 2016. This was first stressed in the 2016 Policy Document No. 1, the reform was done in order to move in the direction of a more open market. The minimum price support for maize was replaced with a new mechanism of 'marketized purchases' that would separate subsidies from prices (moving away from the national reserve policy). Therefore, farmers would start to receive support through direct payments. Self-sufficiency in rice and wheat remains a priority.

Agricultural Insurance

The crop insurance program in China has grown rapidly since 2007, which is when the central government began providing premium subsidies. There are premium subsidies for fifteen commodities, and the amount of subsidies have grown substantially over the years. For example, from 2015 to 2016 premium subsidies from the central government increase from 40 percent to 47.5 percent for central and western provinces, and from 35 percent to 42.5 percent for eastern provinces. Provincial and county governments provide additional complementary subsidies. In 2016 the total premium of Chinese agricultural insurance program had recorded 41.77 billion CNY (~6 billion USD), in which about 70% came from crop insurance and 30% from livestock insurance. According to premium volume in 2015, the top eight commodities covered by agricultural insurance are corn, rice, hog, wheat, forest, cotton, cow, and oil crops.

Currently, the agricultural insurance program covers the risk for more than 50 field crops, economic crops, fruits & vegetables, forest, livestock and aquatic across China. The main agricultural insurance product is yield-based, which is called "Cost of Production Insurance." This product protects against yield shortfall, and is very similar to Multi-Peril Crop Insurance (MPCI), however, the insured vale is limited to the value to the Cost of Production (COP) of the crop plant or livestock feeding.

While COP insurance is still dominant, more innovative agricultural insurance products have become available in recent years. Pilot products include weather index insurance, price and/or margin insurance, revenue insurance, and other products. For example, price insurance or margin

insurance has been developed for hogs, milk, chicken, vegetables, sugar cane, cotton, maize, and apples, which have been piloted in all provinces of China.

Similar to Canada, agriculture insurance premiums are subsidized and shared by all levels of government. The three levels of government in China are the central government, provincial government, as well as local government. The total subsidy ratio for most Chinese agricultural insurance products are 70% to 80%, with farmers usually paying 20%-30% of the premium. However, the specific subsidy ratios vary by crop and location. Table 1 shows detailed information of subsidies by commodity group, broken down by central and provincial government by region. The subsidy levels tend to depend on the importance of the insured crop in the local economy as well as the financial capability of the local government.

Table 1. Overview of the Chinese Agricultural Insurance Program Premium Subsidy

	Central Government Subsidy		**Provincial Government**
	East China	Middle & West China	Subsidy (minimum)
Crop	35%	40%	25%
Livestock	40%	50%	30%
Forest (public)	50%	50%	40%
Forest (commercial)	30%	30%	25%
Natural rubber and Tibetan commodities	40%	40%	25%

Direct Payments to Producers in China

Direct payments to farmers has increased, and partially replaced market interventions. There are two key programs. The first program combines direct payments for grain producers, subsidies on agricultural inputs, and an improved seed variety subsidy. These payments are paid based on a per unit of land. This was initially a pilot program in 2015, but, was implemented across the entire country in 2016. The second program provides subsidies for purchasing agricultural machinery. The program focuses on providing easier access to farm credit, local government guarantees for buyers, and improved access to equipment. For larger livestock farmers, they can also receive subsidy for plant establishment for feed, and all livestock farmers regardless of size receive free veterinary medicine to help prevent epidemics.

Catastrophic Programs

Although there are no national public catastrophic programs, however, there are many initial efforts underway in China. Like many countries, the Chinese government has disaster relief programs that can provide support to farmers after catastrophic disasters. Currently, there are three types of arrangements to help deal with catastrophic risk for the agricultural insurance program in China:

- All insurers who deliver agricultural insurance are required to load the mandatory catastrophic risk reserve fund, and balance their payment over the years. The insurers also will buy private reinsurance to cover their underlying risk.
- Some provincial governments have established a risk-sharing model with private insurers covering the catastrophic risk. In general, the provincial government will cover a part of or the entire risk after it exceeds a certain predetermined indemnity ratio (Indemnity/Premium), such as 200% or 300%.
- The China Agricultural Reinsurance Pool (CARP) is a mutual reinsurance organization established in 2014. It has a member of Reinsurance Company and 31 members of insurance companies. According to the CARP website, the reinsurance capability of CARP is estimated to 3 trillion CNY.

1.1.5. The European Union

The European Union's (EU's) agro-food sector is diverse and integrated in world markets. The policy legislation for agriculture is the EU Common Agricultural Policy (CAP). Member states may have other measures outside of CAP to target specific sectors, however, they must comply with rules so that competition isn't distorted in the common market. Support to farmers in the EU has stabilized at around 20 percent of gross farm receipts. Through several reforms in the last decades, the CAP has moved towards the dismantling of price supports for farmers. Support has shifted to payments that do not require production, which now account for approximately 40 percent of support.

The current CAP (2014-2020), provides help to farmers through two main pillars. The funds allocated under CAP are used to provide income support, develop market measures and rural development programs. It is estimated that the respective "weight" of instruments in the EU policies are 1% insurance, 39% safety nets, and 60% income support with direct payments [3].

Pillar 1: Market Support Measures and Direct Subsidies

Pillar 1 is funded by the European Agriculture Guarantee Fund (EAGF), providing support to farmers through "market support" measures and "direct subsidies." Of the total CAP budget, 76 percent is allocated to Pillar 1. The largest share of the current EU farm budget is allocated to direct payments. These decoupled payments are now estimated to account for almost 1/3 of the income of European farmers.

Direct payments have two main components, including a basic payment [4] per hectare (BPS for basic payment scheme) and an environmental component referred to as "greening". There are also other payments that relate to young farmers, support for natural constraint areas, etc, and Figure 1 provides an overview.

[3] Policy Department: Structural and Cohesion Policies. Comparative analysis of risk management tools supported by the 2014 farm bill and the CAP 2014-2020, European Parliament.

[4] Member States (MS) distribute part of their Pillar 1 budget through a basic payment scheme. MS that have joined the EU since 2004 will continue with a Single Area Payment Scheme (SAPS) until 2020.

Figure 1. Overview of the Farmer Accessible EU Direct Payments Program

EU FARMERS HAVE ACCESS TO:

Compulsory schemes (all Member States)	Voluntary schemes (Member States choice)
Basic payment	Coupled support
Green payment	Support in natural constraint areas
Young farmers scheme	Redistributive payment

All payments subject to cross compliance

OR

A simplified scheme for small farmers (voluntary for Member States)

Pillar 1 also funds market price support measures, providing coverage for adverse weather and high price volatility, as examples.

Pillar 2: Rural Development Programs

Measures under Pillar 2 are based on "Rural Development Programs," and are funded by the European Agricultural Fund for Rural Development (EAFRD). Of the CAP budget, 24 percent is allocated to Pillar 2. There are 118 different rural development programs in the 28 MS, and this helps to provide flexibility to respond to the specific needs for rural development. This includes 20 national programs and 8 MS opting to have two or more (regional) programs. Market support measure account for only a small share of the CAP budget (approximately 5 percent).

The current CAP also strengthened the risk management instruments that were introduced in 2009, but, transferred these instruments from Pillar 1 to Pillar 2. As a result, these instruments have become optional measures that may be co-financed by the MS. There are three tools:

- Premium on Insurances: financial support for crop and livestock insurance premiums due to losses arising from adverse climatic events and diseases.
- Mutual funds: financial support for mutual funds to compensate farmers for production losses related to climatic and environmental events.
- Income Stabilization Tool (IST): providing financial support for farmers who experience extreme income losses (defined as losses exceeding 30% of the average annual income).

1.1.6. India

Agriculture is critically important to India as the industry tries to ensure food and nutrition for over a billion people. Over half of the country's workforce is employed in the agriculture and related sectors. The industry faces many low income, poor and vulnerable farmers, particularly in rural areas. There are two growing seasons in India, including the summer Karif and the winter Rabi seasons. Monsoon rains are major concerns for production.

Agricultural Policy formulation in India is very complex. Several ministries, departments and institutions at both the Central and state level are involved in the process. India's major domestic agricultural policy is based on minimum support prices for major crops, input subsidies on fertilizer, power and investment in surface and ground water irrigation. Tariffs, quotas and non-tariff measures are also used to protect domestic producers from import competition. These measures also help to, manage domestic price levels and guarantee domestic supply. The National Policy for Farmers (NPF) was established in 2007. This included many aspects, including sustainability of land and water, bio-security systems, quality of seeds, improved soil fertility, the development of infrastructure, etc.

Through the Minimum Support Price (MSP) the government guarantees a minimum price for 23 crops. The Commission for Agricultural Costs and Prices (CACP) advises on the MSP levels. The cost of production is one of the important factors in determining the MSP, among other considerations. The Price Support Scheme (PSS) is used when prices fall below the MSP, and is continued until prices stabilize at or above the MSP. In this case, grain is acquired from farmers to ensure food security and supply to consumers through the Public Distribution System (PDS).

In addition to the MSP and PDS, subsidies on inputs are also used substantially to help keep costs low and production high. The intention is for farmers to benefit from lower costs, and also for some of these savings to be passed along in terms of lower food prices. The government also pays fertilizer companies to sell fertilizer at below-market prices. Other targeted approaches include supplying Irrigation and electricity directly to farmers at prices that are below the cost of production. It is estimated that effective subsidies to farmers are approximately to 75 percent for fertilizer and 70 to 90 percent for irrigation and electricity. Another major difficulty for farmers in access to credit. The majority of farmers are small, with less than two hectares of land. To help improve the financial situation of farmers, there are annual targets for providing access to credit. Mechanisms such as favorable interest rates, and bonuses for timely repayment are used.

The National Crop Insurance Program (NCIP) was introduced with component schemes of the Modified National Agricultural Scheme (MNAIS), Weather Based Crop Insurance (WBCIS) and Coconut Palm Insurance Scheme (CPIS). A new scheme approved in 2016 (PMFBY) included the restructured Unified Package Insurance Scheme (UPIS) and Weather Based Crop Insurance Scheme (WBCIS). A uniform maximum premium of only 2 percent was paid by farmers for Kharif crops and 1.5 percent for Rabi crops. For annual commercial and horticultural crops the maximum premium to be paid is 5 percent. The balance is paid by the government, and shared equally between the Central and State government.

1.1.7. Mexico

The economy in Mexico is closely linked to agriculture. There are some modern farms that are technologically advanced, however, most are small-scale and subsistence farmers. These smallholders tend to face challenges in terms of low productivity, among other challenges. The Government of Mexico has defined three target groups for the development of agricultural insurance programs and policies. The first group represents commercial farmers, with a focus on providing access to credit through agricultural insurance (which is a requirement to obtain financing). The second group are farmers that have some difficulty in obtaining credit, but, are able to pool risks and purchase insurance in order to access credit. The third group are small-scale, vulnerable farmers with no access to credit or insurance.

Mexico has a fairly complex public-private partnership (PPP) framework, which contains a subsidy scheme, support for small and marginal farmers, and reinsurance capacity from state-owned re/insurer Agroasemex. Premium subsidization is 38% overall, and other crops that are a top priority subsidies can be upwards of 60%. A centrestone of the program are meso-level mutuals that provide micro-insurance to farmers called the fondos de aseguramiento.

In addition, there are two emergency funds that provide post-disaster financing. The first fund is the Component for the Attention of Natural Disasters (CADENA) Program, which was launched in 2003 under the Ministry of Agriculture, Livestock, and Fisheries (SAGARPA). The intent is to internationally reinsure part of the costs of the state managed relief programs. There are two main components of the CADENA program, including the Catastrophe Agricultural Insurance (SAC) programs and the continued direct support (Apoyo Directo) compensation payments to vulnerable farmers for losses resulting from climatic disasters in States where SAC is not provided. Under CADENA-SAC macro-level parametric and index crop and livestock insurance programs are provided. Examples include parametric crop weather index insurance, crop area-yield index insurance, livestock-pasture NDVI, and traditional livestock. State governments purchase insurance from Agrosemex or private insurers and provide indemnities to small-scale farmers following major catastrophe

events. The federal government can provide direct support in the case where local government fails to purchase coverage.

CADENA is part of a larger national second emergency fund, the Fund for Natural Disasters (FONDEN). FONDEN focuses on property insurance to protect infrastructure and public assets. FONDEN has evolved significantly since it was introduced in 1996, and today it is one of the world's most sophisticate disaster financing tools. FONDEN transfers part of its risk to the international market through reinsurance and issuing catastrophe bonds. In 2006, FONDEN issued the world's first government catastrophe bond.

1.1.8. New Zealand

The level of support to New Zealand farmers has been among the lowest in the OECD. Almost all prices are aligned with world market prices due to open trade. The primary instruments to support the agriculture industry include animal disease control, relief payments in the event of natural disasters, and the agricultural knowledge and information system.

Initiatives include the Dairy Industry Restructuring Act 2001 (DIRA) to promote the efficient operation of the New Zealand dairy industry. In addition, OVERSEER is a nutrient management tool to help farmers improve their productivity (and manage nutrients within environmental limits). Another example is the Sustainable Farming Fund (SFF), which invests in projects that have benefits to the community. Approximately 90 SFF projects are underway at any one time. The country also provides support to large-scale off-farm investments in irrigation systems. There is also the Primary Growth Partnership (PGP) program, which is a government-industry partnership initiative that invests in research and innovation to improve productivity in the sector, as well as to take advantage of economic and sustainable opportunities. Finally, the New Zealand Emissions Trading Scheme (NZ ETS) helps to respond to climate change. It imposes reporting obligations on agriculture, including meat processors, dairy processors, etc. An emission cost is imposed on the transport fuels, electricity production, synthetic gases, and waste and industrial processes sectors.

1.1.9. United States

The 2014 Farm Bill provides the basic legislation governing farm programs for 2014-18. Almost 80% is allocated to domestic food assistance programs, and approximately 20% to farm programs. Levels of support to US farmers has been consistently below the OECD average. There has also been a shift away from direct output subsidies.

The U.S. Department of Agriculture (USDA) oversees several programs that provide coverage for low prices and natural disasters. There are three pillars that make up the farm safety net, including federal crop insurance, farm commodity programs, and disaster assistance. There is an increasing emphasis on insurance and risk management as a policy tool. The estimated "weight" of instruments in the US policies are 60% insurance, 40% safety nets and 0% income support with direct payments.

Federal Crop Insurance

The federal crop insurance program is the most prominent part of the farm safety net. The program covers approximately 130 commodities and targets risks associated with reductions in yield or revenue. The program is a partnership between the USDA's Risk Management Agency (RMA) and the private sector. The Standard Reinsurance Agreement (SRA) governs the relationship between the Federal Crop Insurance Corporation (FCIC) and the authorized private insurance companies that sell and service the crop insurance policies. It also establishes the terms and conditions for which

the FCIC provides subsidy and risk sharing agreements with the approved insurance companies. Premiums are subsidized on average 62%, with producers paying a larger portion for higher coverage levels. Administration and operating expenses are fully covered by the government.

All premium rates are set by the RMA, and unlike other types of insurance where the insurer can deny coverage to an individual, the approved insurance companies selling crop insurance must insure all eligible farmers. Therefore, to help encourage the involvement of the private sector insurance companies, insurance losses are reinsured by the USDA. The risk transferred to the USDA is determined by a fund allocation process, allowing insurers to allocate policies to either the "assigned risk pool" or the "commercial risk pool" based on the level of risk they want to accept. The assigned risk pool reflects riskier policies, and the government takes more responsibility for these policies. Conversely, the insurer would seek to allocate policies they deem less risky to the commercial risk pool. In addition to risk-sharing with the federal government, insurance companies may also choose to purchase reinsurance from the private market. This agricultural insurance framework is intended to bring efficiencies of a private sector delivery system and regulatory and financial strength from the Federal government. However, the administration and operating costs of the program are reported to be as high as 35% [5].

Federal Crop Insurance is a complex program with many insurance alternatives available to producers. The program is quite unique in that producers can choose from several programs that best suit their individual needs (rather than one standardized program available to all producers), and often producers purchase multiple policies depending on various factors, such as the number of crops grown. In general, policies provide coverage against individual farm losses in terms of yield, crop revenue, or whole farm revenue. Some area-wide policies are also available for certain crops. An additional alternative, is the whole farm unit, which is available for revenue insurance. Below is a short overview of insurance alternatives available to producers.

Individual plans use the actual producer's production on the farm (and for some coverage, revenue history). For **yield-based plans,** the producer selects the percentage of yield loss covered by the policy as well as the market price based on estimated market conditions. The most basic level of catastrophic coverage (CAT) is provided free of charge, which offers coverage of 50% of "normal" yield and 55% of the projected price of the crop. Producers can "buy-up" higher levels of insurance up to 75% of yield losses and 100% of estimated market price.

Yield Protection (YP) and Actual Production History (APH) plans account for approximately 10% of total premium volume (2016) [6], and more than 90% of the yield-based policies sold. YP and APH provides coverage from loss of production and guarantees the yield based on the producer's production history. If the production is less than the guaranteed amount, an indemnity is paid. The primary difference between YP and APH is how the price is determined. Crops covered through YP have a price set through a commodity exchange provision, while the APH plan is available for crops that do not have prices set by a commodity exchange, and instead the price for APH is set by the RMA.

A second type of individual insurance plan is **revenue-based**, where producers insure a target level of revenue based on the market prices of the covered crop and the producer's yield history. Since 2003, revenue products

[5] Smith and Glauber, 2012.

[6] Smith, V., and Glauber, J. 2012. Agricultural Insurance in Developed Countries: Where Have We Been and Where Are We Going?. Applied Economic Perspectives and Policy, 34. 10.1093/aepp/pps029.

have covered more acres than those covered by APH policies. According to premium volume in 2016, individual revenue plans accounted for almost 85% of the total.

The Revenue Protection (RP) and Revenue Protection with Harvest Price Exclusion (RP HPE) are the most widely used revenue policies. They include yield loss protection as in the APH policy, and in addition protection is added for loss of crop value due to a decline in price on the applicable board of trade. The policy uses the same projected price as the APH policy and adds a harvest price, which is the average closing price of the same futures contract used to determine the projected price for a specified period of time during the harvest season. The RP plan automatically provides the harvest price protection, however, producers can choose to exclude it by selecting the Harvest Price Exclusion (HPE) and in this case, would pay a lower premium for the RP HPE plan as it excludes the possibility of benefiting from the higher harvest prices.

For cherries, navel oranges and strawberries, the Actual Revenue History (ARH) plan is available in select counties and states, which is based on the producer's historical revenue information on a crop-by-crop basis. The plan is very similar to APH, however, rather than insuring historical yields, historical revenues are insured.

In addition to the revenue-based plans mentioned above, a fourth alternative is the new pilot program called Whole-Farm Revenue Protection (WFRP). WFRP is not meant for a single specific crop, but, for all crops and/or livestock grown on a single farm and insured together under one insurance policy. The plan provides coverage for any farm with up to $8.5 million in insured revenue (which is the total amount of insurance coverage provided by this policy), and this is available in all counties nationwide, and includes farms with specialty or organic commodities (both crops and livestock).

In contrast to individual policies, area-based policies provide coverage based on the experience of an entire area, typically a county. One common area-based policy is called Area Risk Protection Insurance (ARPI). In addition, the Supplementary Coverage Option (SCO) offers producers additional area-based insurance coverage in combination with traditional crop insurance policies (but excluding for crops for which producers have elected to participate in the ARC program). There has also been some introduction of Margin Protection insurance. This provides coverage against an unexpected decrease in operation margin (revenue less costs), caused by reduced county yields, reduced commodity prices, increases prices of certain inputs, or any combination. This is area-based, using county-level estimates of average revenue and input costs to establish the amount of coverage and indemnity payments.

Farm Commodity Programs

Farm commodity programs have the longest history, dating back to the 1930's. These programs aim to provide price and income support based on price or revenue targets (compared to crop insurance that is based on market prices) for covered commodities. The primary crop commodity programs make payments to producers with

historical base acres of program crops when prices fall below the statutory minimums or when crop revenue is low relative to recent levels. These programs are free for producers.

After more than 15 years of fixed annual payments based on historical production, the Directs Payments (DP) program was ended in 2014, as well as the Countercyclical Payments and the Average Crop Revenue Election (ACRE) program. Two new programs were created for producers of covered commodities to choose from including Price Loss Coverage (PLC) and Agriculture Risk Coverage (ARC) for producers with production histories for covered crops. PLC makes a payment when market prices for covered crops fall below their fixed reference prices. ARC is a revenue-based program, making a payment when actual revenue falls below the rolling average benchmark revenue. For both programs payments are made on 85 percent of base acres. Producers make a choice between PLC and ARC programs on a commodity-by-commodity basis.

Milk and dairy products are no longer supported by minimum prices, and the Dairy Product Donation Program (DPDP) makes purchases of dairy products for feeding programs under certain conditions. There has been an expansion to the Margin Protection Program (MPP) for dairy producers. The program provides direct payments when the difference between milk prices and feed costs falls below a minimum level.

Agri-environmental programs are targeted to specific objectives and tailored to the most effective means of reaching those objectives. But these programs face challenges including slippage effects, declining participation and climate change. These challenges could be addressed by relying more on the 'polluter-pays' principle and market-based approaches to reduce agri-environmental pressure from agriculture.

Agricultural Disaster Assistance

Authorized for livestock and orchards, under the 2014 Farm Bill now nearly all parts of the U.S. farm sector are covered by either a disaster program or federal crop insurance. This is expected to reduce the need for ad hoc assistance. Under the previous 2008 Farm Bill, to be eligible for disaster assistance programs producers were required to purchase crop insurance or NAP coverage, which is no longer the case under the 2014 Farm Bill. There are four main programs, including the Livestock Forage Program (LFP; coverage grazing losses), the Livestock Indemnity Program (LIP; covering mortality), Emergency Assistance for Livestock, Honeybees, and Farm-Raised Fish (ELAP; providing emergency assistance due to disease, adverse weather, or other conditions not covered by LFP and LIP), and the Tree Assistance Program (TAP; providing financial assistance due to natural disasters). Other disaster aid programs include the Emergency Loan Program, the Disaster Set-Aside Program, the Emergency Conservation Program (ECP), and the Noninsured Disaster Assistance Program (NAP).

2.0. Possible Criteria for Agricultural Risk Management and Insurance Programs

In order for agricultural risk management and insurance programs to be successful, a number of criteria should be considered. These possible criteria are based on potential government objectives, actuarial principles and regulatory requirements, and are outlined in Porth et al. (2018) [7]. These include:

2.1. Potential government objectives

1. Trade neutral programs (non-trade distorting and WTO compliant).
2. Cost efficient programs, and acceptable subsidy levels in terms of producer and taxpayer interests.
3. Provides choices for producer in terms of coverage level (e.g. producer may be able to purchase higher coverage, though maybe not as subsidized), and various lengths of coverage.
4. Avoids having producer have extended years of financial challenges with no program payment.
5. Satisfies long-term and short-term stability needs of producer, and is affordable for producer.
6. Effective for the bulk of crop and livestock production, and sufficiently high producer participation rate.
7. Suitable size and frequency of payments (indemnities) for producers.
8. Allows producers to maintain sufficient efficiency and size to compete worldwide.
9. As equitable as possible across producers.
10. Suitable in the eyes of bankers and those lending to producers.
11. Avoids having government crowd out the private sector in their risk management and insurance development efforts.

2.2. Actuarially principles and regulatory requirements

1. Actuarially sound and insurance based (analysis of liabilities, loss ratios, premiums, etc.).
2. Simple for producer to use and easy to understand, a timely payment of indemnities (funds owed to producers), low administration costs, and flexible.

[7] Porth, L., Boyd, M., and Porth, C.B. 2018. Business Risk Management Programs Review. Working Paper.

3.0. Pricing Basics

In a very general sense, the price of a product should reflect both the price the company is willing to sell the product and the consumer is willing to purchase it for. Typically, the price can be broken down into the costs associated with offering the product, as well as incorporating sufficient margin for profit. Therefore, price can be described as:

$$Price = Cost + Profit$$

In exchange for payment of a premium to an insurer, the insured receives a guarantee of compensation (i.e. indemnity) for a specified loss. In this context, it can be quite difficult to determine the price of insurance. This is because at the time the insurance policy is sold, the true cost is not known (i.e. the indemnity is unknown). Therefore, the price of an insurance policy is referred to as the premium, which is based on the premium rate per unit of exposure multiplied by the number of insured units, plus some provision for profit. Depending on the underlying risk characteristics, the premium rate can change substantially.

Determining the actuarially fair premium rate can be a challenging task, especially in the case of agricultural insurance. This is attributed to a number of challenging issues including systemic risk, moral hazard, adverse selection, as well as data scarcity and credibility.

3.1. Systemic Risk

Agriculture is a highly weather-sensitive sector that is largely exposed to adverse weather conditions, that appear to be increasing in frequency and severity in some regions. As a result, systemic risks, such as weather risk, have become a key focus for financial regulators, given these risks can be very difficult to predict and often they have a large impact on the insurance portfolio. As a result, it is imperative to incorporate systemic risk factors into the pricing framework for the Property & Casualty (P&C) insurance sector in general, and agricultural insurance specifically.

3.2. Information Asymmetry

It is well documented in literature that information asymmetry, including adverse selection and moral hazard, are main reasons in favor of the subsidization of crop insurance premiums. Moral hazard refers to farmers being less careful if they buy insurance and therefore undertaking more risky behavior because they feel they are covered. Adverse selection refers to riskier farmers buying the insurance at an underpriced level and lower risk farmers overpaying for the insurance. This could happen because the insurance company may not know each farmers' true risk level and cannot charge them the proper associated premium, and therefore causes insurance difficulties.

3.3. Credibility

In the case of agriculture, the loss experience data can be quite scarce and there is often concerns over its' credibility. For example, in most countries there is only one growing season per year, and hence only one loss observation per year. In countries with developed crop insurance programs where there is a long-time series of historical records, this means that approximately 30-40 years of annual historical loss observations can be used for rating products. However, there is a concern that older loss experience may not be as relevant today due to program modifications, technological advancements, deviations in farming practices, changes in

climate, etc. Coupled with the fact that extreme agricultural insurance losses, such as floods and droughts, tend to occur relatively infrequently, there is a need to balance using as much of the time series as possible to capture theses significant events, versus the concern that older data may not be credible and, therefore, should be discarded.

3.4. Public-Private Partnership Models

In most countries, a public-private partnership (PPP) approach is often necessary to help ensure a sustainable crop insurance program. This may be particularly true for emerging markets that often do not have the financial resources to adequately handle the extreme losses that may arise from severe natural disasters. The approaches to agricultural insurance, and the various forms of risk-sharing vary greatly across countries. Figure 2 below depicts the continuum of risk-sharing arrangements.

Figure 2. Continuum of Public-Private Partnership (PPP) Models

In some cases, crop insurance can be sold by private insurance companies and producers are responsible for the full premium, much like other types of property and casualty insurance. In this case, the private insurance premium (PremiumPR) is unsubsidized and defined as:

$$Premium_{PR} = E(Loss) + Loading_{PR},$$

where E(Loss) is the expected loss, which is also referred to as the pure or actuarially fair premium. The LoadingPR for a private insurance premium is intended to cover costs associated with administration and operating (A&O), the cost of obtaining reinsurance, uncertainty and profit, and possibly other charges, such as product research and development, cost of contingent capital, return on equity, etc.

At the other extreme, crop insurance may be delivered publicly, and premiums may be subsidized by government. In some cases, such as Canada, government crop insurance companies can sell the insurance, while in other markets, such as the U.S., delivery of the insurance can be by private insurance companies. Regardless of who delivers the insurance, a public model involves direct subsidy of the premium, which corresponds to a portion of the pure or actuarially fair rate (E(loss)). In addition, government support may cover a portion or all of the administration and operating expenses. It is also possible for subsidy to extend to government "reinsurance" or backstopping of extreme losses, as well as research and development expenses, among others. In this case, the premium under a public model (PremiumPU) is defined as:

$$Premium_{PU} = E(Loss) + Loading_{PU},$$

where E(Loss) is the expected loss, which is also referred to as the pure or actuarially fair premium, which can be shared at some percentage between the government and farmer. Therefore, the premium paid by the farmer is the total premium multiplied by (100% – % subsidy). For example, in Canada the government provides subsidy for 60% of the pure premium, with farmers responsible for 40%. In this public model, premiums are set to recover losses over the long-term and to maintain a sustainable program by paying off program debts and building a reasonable reserve. Therefore, loading under a public approach, LoadingPU, typically only accounts for reserves and catastrophic loss (i.e. no profit).

4.0. Insurance Concepts

In order to proceed, it is helpful to define some basic insurance concepts. A small glossary is provided in Appendix A.

4.1. Insurance Pooling

To begin, a fundamental concept of insurance is the notion of insurance pooling, which is largely based on the law of large numbers (or the related central limit theorem). The law of large numbers states that the average of a large number of independent identically distributed random variables is approximately equal to the expected value (mean), which serves as the basic component for setting premium rates as described above (actuarially fair premium rate). As more insureds participate in the pool, the variability of the average loss for each individual around the expected value is reduced. This means that the observed and expected values converge. The insurance pool continues to strengthen as more individuals are added, and the probability of ruin is reduced.

4.2. Premium Concepts

To derive premium rates, liabilities and indemnities are explained.

Liability

Liability (also referred to as the total insured value of the crop) measures the insurer's exposure to loss for an individual farmer or a group of farmers. Liability is calculated as follows:

$$Liability = Acres \times Expected\ Yield \times Coverage\ Level \times Price$$

The expected yield for an individual farmer is determined by averaging approximately 5-10 years of historical data. Often the number of years used to establish the expected yield depends on the availability of data as well as the trend in the yield. In some cases an Olympic average is applied to the data, in which the highest and lowest values are discarded fro the average. The coverage level is then selected by the farmer, usually ranging from 50% to 85%, and then multiplied by the expected yield to set the insured level. For example, if the average output for Canola is 45 bushels per acre, and the producer selects a coverage level of 80%, the insured yield per acre is 38.25. Then, if the current year yield (let's assume 30 bushels per acre) falls below the insured yield level (i.e. 38.25), the farmer will receive a payout based on the shortfall in yield (i.e. 38.25-30.00=8.25 bushels per acre) multiplied by the insured price per acre. The price is normally set. at the start of the growing season and typically represents the price expected at harvest, however, the method by which the price component is determined differs by country and insurance policy type.

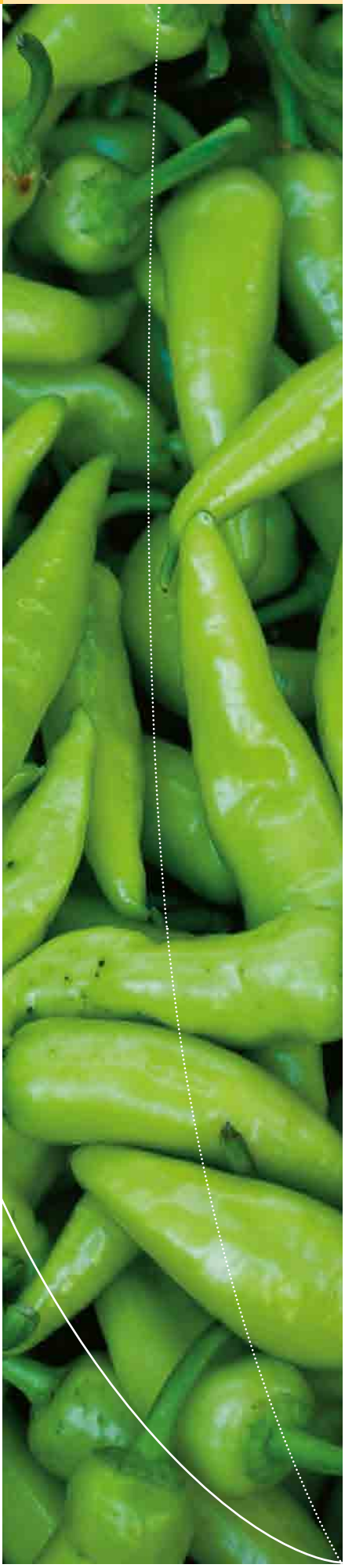
Indemnity

Indemnity refers to the amount the insurer pays to the farmer who suffers a covered loss. In the case of production insurance, an indemnity is paid when the actual production is less than the insured production. Production is determined as follows:

$$Value\ of\ Production = Acres \times Actual\ Yield \times Price$$

Therefore, the amount of the indemnity paid is equal to the liability minus the value of production, defined as:

$$Indemnity = Liability - Value\ of\ Production$$



Premium

Based on the above definitions, the premium can then be defined as:

$$Premium = Liability \times Rate \times Adjustment\ Factor$$

4.3. Underwriting Measures

In the underwriting process, several profitability metrics are considered by insurance companies, and the loss ratio, expense ratio, and combined ratio are discussed next. This is followed by an introduction to the concept of cash flow underwriting.

Loss Ratio

The loss ratio is defined as the ratio of total losses plus adjustment expenses divided by the total premiums earned. For example, if an insurance company pays $70 in claims for every $100 collected in premiums, the loss ratio is 70%.

Expense Ratio

The expense ratio is an important profitability metric considered in the underwriting process. It is defined as the ratio of expenses to earned premium. Examples of expenses might relate to costs with obtaining and underwriting premiums.

Combined Ratio

When the loss ratio is combined with the expense ratio (sum), the combined ratio can be determined. The combined ratio measures whether the premium revenue is sufficient to cover the underwriting operations. When the ratio is less than 100%, the company is considered profitable.

Cash Flow Underwriting

To be competitive, some insurance companies use a pricing tool called cash flow underwriting. This refers to the process of selling insurance below the actuarially determined premium, which takes into account investment capital that is expected to be earned from the increased business that will be generated from the lowering price.

4.4. Actuarial Risk Metrics

In stress testing premium rates, and as part of the reserving and overall risk management process of an insurance company, several actuarial risk metrics are considered. Following the paper by Wang et al. (2017) [8], mean surplus, expected shortfall, Value at Risk, and Conditional Tail Expectation are described next.

Mean Surplus

The mean reserve provides an indication of the average surplus in each of the funds and the overall health and sustainability of the program.

[8] Weng, C., Porth, L., Tan, K.S., and Samaratunga, R. 2017. A Crop Insurance Reserve Fund Process Under a Public-Private Partnership Model. *The Geneva Papers on Risk and Insurance – Issues and Practices*, 42(2), 226-246. https://doi.org/10.1057/s41288-017-0044-5.

Expected Shortfall

The Expected Shortfall (ES) of a risk X is defined as $ES(X) = E[X \mid X < 0]$ and measures the expected magnitude of the deficit.

Value at Risk (VaR)

The Value at Risk (VaR) of a risk X at the confidence level $(1-\alpha)$, where $0 < \alpha < 1$, is defined as $VaR_{\alpha}(X) = inf\{x \geq 0 : P(X > x) \leq \alpha\}$. VaR measures the potential size of the reserve for a given confidence interval. For example, a VaR of -$100 million in 2012 at a confidence interval of 10% implies that there is a 90% chance that the reserve will be above -$100 million in that year. Thus, it identifies the potential magnitude of the reserve deficits in catastrophic years.

Conditional Tail Expectation (CTE)

The Conditional Tail Expectation (CTE) of a risk X at the confidence level $(1-\alpha)$, where $0 < \alpha < 1$, is defined as $CTE_{\alpha}(X) = \frac{1}{a}\int_0^a VaR_s(X)ds$. The CTE measures the expectation of the reserve given that the reserve is within a certain range at a specified confidence interval. It is a coherent risk measure and provides deeper insight into the tail of the reserve distribution. In general, similar results are obtained for VaR as CTE, however, more distinction between the different reinsurance scenarios is observed.

5.0. Principles of Insurance

There are three main characteristics of insurance, which are discussed below, including properties of insurable interest, risk of loss, and concept of indemnity. These principles are important when considering the regulatory requirements regarding how products are classified. An important distinction is whether a product is considered an insurance product, or a financial derivative.

5.1. Insurable Interest

To be considered an insurance product, the insured must have "insurable interest" in the subject of the insurance, such as the property they own. In contrast, there is no restriction or requirement of owning the underlying asset when considering a financial product (i.e. derivative market). Further, insurance products are used exclusively to manage risk, while derivatives may also be used for speculation purposes, in contrast to insurance.

5.2. Risk of Loss

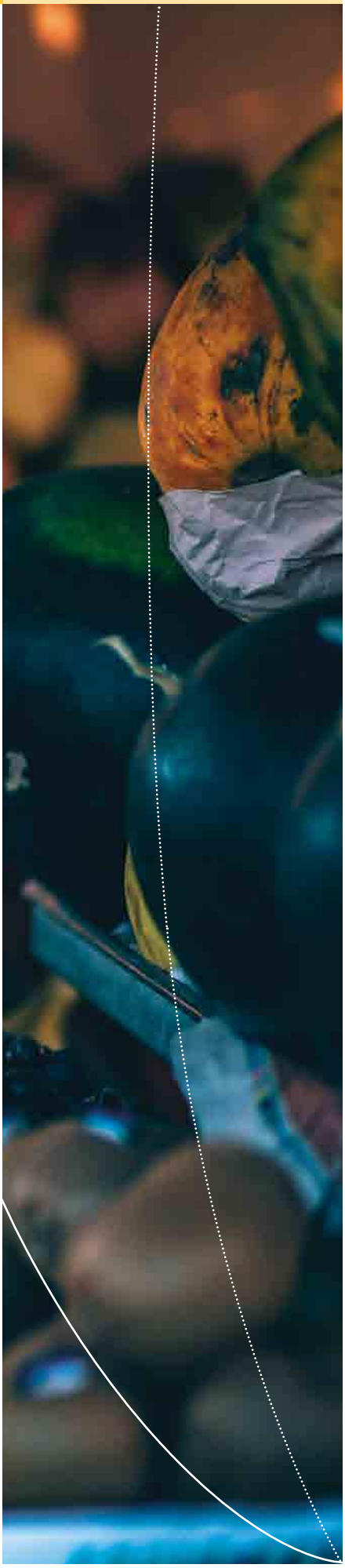
Extending the concept of insurable interest, a payment should only be made to an individual if they suffer a loss, or have a risk of loss. In traditional multi-peril crop insurance (MPCI) the loss of the farmer is determined by an adjuster that visits the farm to measure the loss. This loss assessment process can be costly, however, particularly in the case of developing countries where there tends to be a large number of smaller farms, which can make loss assessment prohibitively expensive.

Therefore, in more recent years there has been a focus on the development of index-based insurance products for agriculture. Index-based insurance pays a loss calculated from an underlying index, rather than actually assessing the farm level loss, and this can help to create cost efficiencies. In addition, index insurance can overcome other difficulties associated with traditional crop insurance, such as moral hazard and adverse selection. Examples of index-based insurance includes area yield and weather index insurance. Since index-based insurance products do not require verification that the individual actually sustains a loss, a new problem called basis risk arises, and more discussion is found in the section that follows. In order for index-insurance to be successful, the underlying index must be designed to be highly correlated with the individual suffering a loss.

In comparison, financial derivatives may be structured to pay out when an event occurs, even if the person does not sustain a loss, or does not have a risk of loss.

5.3. Concept of Indemnity

With insurance, it is expected that the individual cannot received more in payments than the loss suffered. This is amount is referred to as the value of the underlying asset, or property. In contrast, financial derivatives do not have these controls in place and the indemnity is not limited to the maximum value of the asset. Further, in insurance it is uncommon that the full value of the underlying asset can be recovered, and the producer often retains some level of risk. For example, the maximum coverage level is typically limited to approximately 85% of the insured value.



6.0. Premium Principles

In order for a premium principle to reflect the underlying riskiness of an insurance exposure, it should possess some desirable properties for it to be actuarially sound. The survey paper by Young (2004) extensively discusses these properties, together with an inventory of premium principles. The key properties of a premium principle can be summarized as follows, based on the work by Zhu et al. (2018) [9]:

1. Positive Risk Loading: $\Pi(X) \geq E(X)$ for all $X \in \mathcal{X}$. This property requires that the premium charged for insuring the risk is no less than the expected payout.

2. No Unjustified Risk Loading: For a degenerate risk X, i.e. there exists a constant c such that $P(X = c) \equiv 1$, then $\Pi(X) = c$. This property implies that if a risk results in a constant loss c for certain, then the corresponding insurance premium should assign no risk loading.

3. No Rip-off: $\Pi(X) \leq ess\ sup\ (X)$ for all $X \in \mathcal{X}$. This property ensures that the insurer should not charge higher than the maximum loss of the risk.

4. Translation Invariance: $\Pi(X + a) = \Pi(X) + a$ for all $X \in \mathcal{X}$ and $a \geq 0$. If a risk X is increased by a constant amount a, then the premium for the combined risk $X + a$ should just be the premium of the original risk plus a.

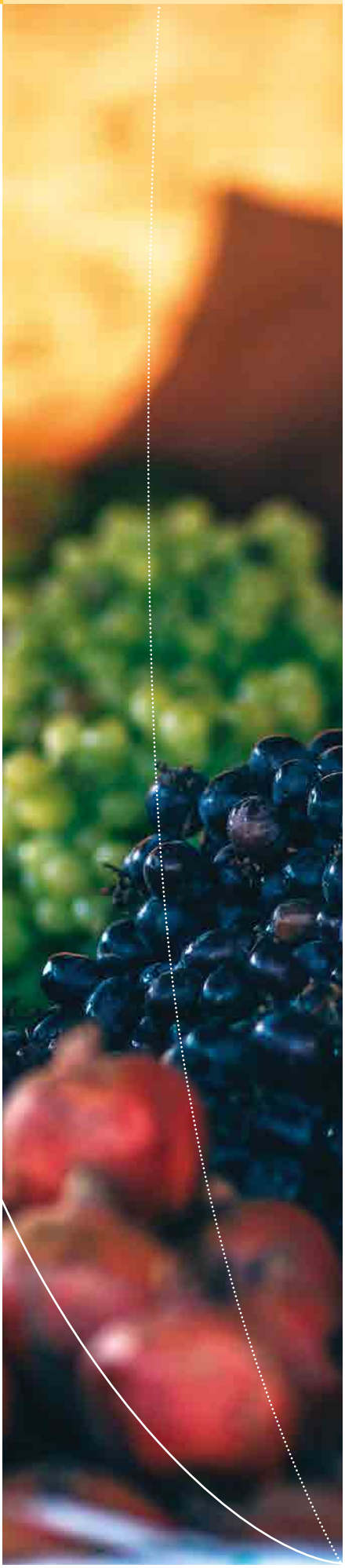
5. Scale Invariance: $\Pi(aX) = a\Pi(X)$ for all $X \in \mathcal{X}$ and $a \geq 0$. This property is also known as homogeneity of degree one in economic literature, and its significance is to avoid arbitrage opportunities. For example, the premium for $2X$ should correspond to the premium for two insurance policies for the risk X, otherwise, there is a possibility of arbitrage.

6. Subadditivity: $\Pi(X + Y) \leq \Pi(X) + \Pi(Y)$ for all $X \in \mathcal{X}$ and $Y \in \mathcal{X}$. Subadditivity requires that insuring a portfolio of homogeneous risk should be less expensive than insuring individual risks separately because of the risk pooling and diversification benefit. This property implies that the insurer cannot benefit from dividing risk into pieces.

While there are a large number of premium principles, some commonly used ones include the following:

1. Expectation Premium Principle: $\Pi^e(X) = (1 + \theta)E(X)$, where $\theta > 0$. This is the most widely used premium principle in agricultural insurance ratemaking, as well as in other insurance applications due to its simplicity.

2. Standard Deviation Premium Principle: $\Pi^{ST}(X) + \sqrt[\theta]{Var(X)}$, where $\theta > 0$ and $Var(X)$ is the variance of the random variable X. This premium principle incorporates a risk loading that is proportional to the standard deviation of the insured risk.



[9] Zhu, W., Tan, K.S. and Porth, L. 2018. Agricultural Insurance Ratemaking: Development of a New Premium Principle, Working Paper.

7.0. Aggregation Bias

Farm-level data may be limited to only a few years, or in some cases there are possibly no historical farm-level yield records. As a result, insufficient farm-level yield data can be one of the major challenges to the successful implementation of crop insurance programs. As an alternative to farm-level yield data, aggregate yield experience at the county (or municipal) level may be available. Since county-level data typically represents several producers' yield experience together in a region, there are often less challenges regarding missing data and insufficient time series.

However, the concern with using aggregated county-level data in place of farm-level data, is that aggregating data may lead to the possible cancellation of idiosyncratic risk, and hence there may be smaller total risk in the aggregated data. The result may be an underestimation of risk in the aggregate county-level data relative to the farm-level data. In literature, this occurrence is often referred to as "aggregation bias", and a thorough discussion can be found in Porth et al. (2018) [10]. Aggregation bias is known to decrease the correlation between county-level and farm-level yield. For example, Claassen and Just (2009) calculate that farm-level yield variation is understated by 50% when using county-level averages, and 61% of systemic variation and 42% of random variation is lost when yields are aggregated to the county-level.

It is most often the case that rates are established for each crop separately, given that different crops are impacted by different perils. It is also common that expected losses are aggregated to a group of similar risks for deriving rates, given that it is rare for there to be sufficient loss history at the individual level. Most often, this aggregation is done geographically by municipal or county level, and can be further grouped by risk zones, etc.

[10] Porth, L., Tan, K.S. and Zhu, W. 2018. A New Relational Data-Matching Model for Enhancing Individual Loss Experience: An Example from Cop Insurance, Working Paper.

8.0. Restatement Approaches

The goal of the loss restatement process is to help ensure that when historical yields or losses are used, they are representative of the present situation. If older observations in the time series are not indicative of current practice, due to such factors as crop mixing, changing climate, technological changes, farming practices, etc., then data should be "restated" to make it more credible and bring it on level with the current situation. In this manual, issues regarding crop mixing, changing climate, and technological changes are discussed, however, there may be other considerations as well. Following this discussion, an overview of possible restatement methods is presented.

8.1. Reasons to Restate Data

Crop Mixing

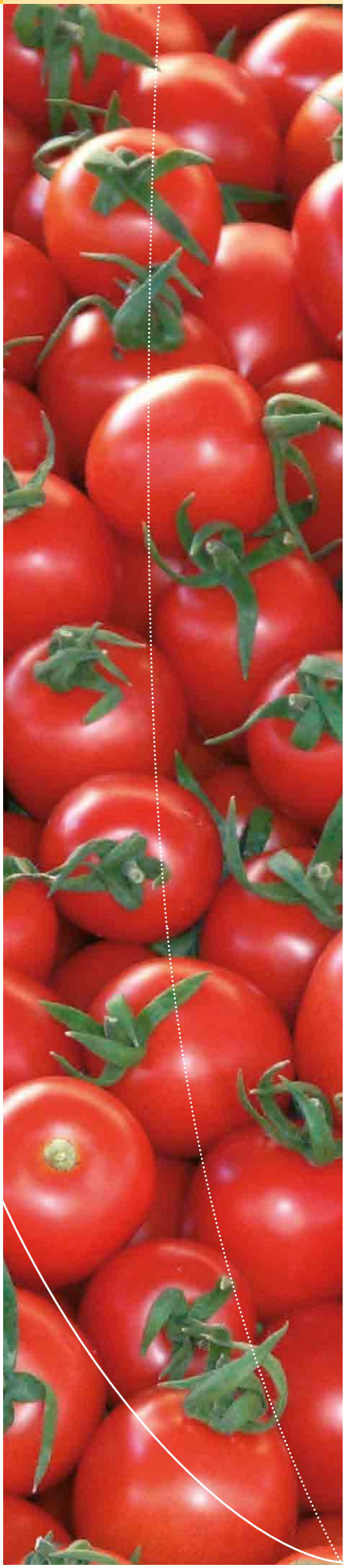
Crop Mixing refers to growing more than one type of crop on one piece of land. Farmers plant multiple crops to balance soil nutrition in an effort to help maximize production. Several studies have indicated that crop mixing is one of the most important factors for increasing agricultural output. Further, due to changing market conditions, producers may favor planting one crop type over another in order to obtain higher market prices. However, the changing crop mixing patterns over time can create challenges for insurers and reinsurers when trying to estimate losses from the time series. Since different crop types have different risk levels, when the percentage of each type of crop relative to the whole insurer portfolio changes, the underlying risk may change too. For example, the percentage of canola grown in recent years in Canada is increasing. Some empirical analysis shows that canola may have higher loss cost ratio's (LCR's) relative to other crop types. Therefore, if the percentage of canola insured in the portfolio increases relative to the whole portfolio, restating losses to correct for changing crop mix over time should in this example increase the LCR's of the older observations of canola to reflect the increased risk level in the portfolio. Therefore, adjusting historical data through a restatement process is necessary due to changing crop mixing patterns over time.

Changing Climate

It is well understood that adverse weather conditions are the greatest influence on crop production, with some estimates that likely it can account for between 70% and 90% of crop loss. There is concern that extreme weather events, such as floods or droughts, are increasing in both frequency and severity, and this could lead to widespread and substantial loss at times. It is plausable, however, that changing climate may bring about warmer conditions, and this could provide positive effects on agriculture. For example, warmer conditions could allow some crops to be grown in new regions that were previously not suitable, or production could increase in some cases, etc. Therefore, adjusting historical data through restatement is important to account for changing climate, which may include catastrophic weather risks, as well as other changing weather patterns, such as changing temperature or precipitation that may also impact crop yields. The impact of changing climate on crop yields (and hence crop losses) is still not well understood, and more research is needed.

Technology

The world population is increasing, but the capacity of agricultural land is limited. In order to meet demands and feed the growing population, innovations in agriculture are necessary. This technological innovation



contributes to improvements in the productivity of crops, and it is expected that it may be a key driver in growth. For instance, a study about the analysis of biotechnology adoption on corn yields and crop insurance in the U.S. Corn Belt show that the performance of crop insurance is improved by genetically modified corn, and the modified corn increased the crop yields and reduced yield risks caused by high temperatures and precipitation stress (Vado and Goodwin 2010) [11]. In recent years, more farmers in Canada have chosen to grow biotech crops, such as canola in Manitoba and corn and soy beans in Quebec. Therefore, trends in yields or losses due to the effects of biotechnology should be considered in teh loss restatement process if possible. However, significant more research and development is needed in this area as the impact of technology on yield is not well understood.

8.2. Overview of Restatement Methods

First Difference

The first order difference method is frequently used, and it removes a unit root component from the time series. Assuming a detrending formula for crop insurance:

$$y_t = \beta x_t + e_t$$

where xt is a linear or nonlinear function of time t, y_t is the trend-predicted LCR, and e_t is the derivations from the trend.

Linear Reweighting

A linear weighting scheme assigns more weight to more recent data:

$$w_i = \frac{t_i}{\Sigma t_i}$$

where t_i is the i^{th} number of observations over the historical data portfolio, and the sum of t_i is the total number of observations of inputs in the portfolio, where the sum of weights is 1. For example, if we have 16 years of crop loss data from year 1996 to 2011. Then the weight of loss data in year 2006 would be 11/136. After assigning weights to the historical data, forecasts can be obtained for several years. Then the moving average estimation can be used to restate the historical data over time based on the forecasts.

Distributed Lag Reweighting

An alternative weighting scheme is to give more weight to more recent data. Equally weighted historical data is unlikely to perform well in any subsequent period as the data may be reflecting market conditions that are no longer valid. One method is to apply a distributed lag approach [12].

$$y_t = \alpha + w_0 x_t + w_1 x_{t-1} + w_x x_{t-2} + \ldots + \varepsilon$$

where y_t is a function of explanatory variable x, a is the intercept term, and w_i is the lag weight.

[11] Vado, L., and Goodwin, B 2010. Analyzing the Effects of Weather and Biotechnology Adoption on Corn Yields and Crop Insurance Performance in the U.S. Corn Belt. No 61594, 2010 Annual Meeting, July 25-27, 2010, Denver, Colorado, Agricultural and Applied Economics Association.

[12] Ray, K. and Nawrocki, D. 1996. Linear Adaptive Weights and Portfolio Optimization. Available at: http://www.handholders.com/old/raylam.html

Weather Reweighting

As mentioned previously, adverse weather events can have a large impact on crop losses. In order to model trends in weather, it is generally believed that the time series needs to be sufficiently long. Normally, however, crop loss data is relatively limited and the probability of weather events are difficult to determine with reasonable certainty. As a result, a weather weighting method can incorporate additional information in order to weight the shorter time-series of LCR data based on longer-term weather data. To apply this approach, the first step involves choosing the weather variables, which can be either a single variable or a combination of different weather variables. The second step is to develop the weather index based on the chosen variables, and approaches such as Principal Component Analysis (PCA), or a Dynamic Factor model, as examples, may be used. The final step assigns weights for each year of observations, such as using variable bin widths (Coble et al. 2011) [13].

Crop Mix Portfolio Reweighting

To restate the historical data for crop mix, the first step should be to Identify the "main crop mix" that has been produced in recent years. The "main crop mix" can be defined as the minimum number of crop types that covers at least 90% of the total farming acres over the most recent five years, for example [14]. The "optimal crop mix" then consists of the "main crop mix" and "others", where "others" captures the remaining crops types that are not part of the "main crop mix", but, are produced in the last five years. The "optimal crop mix" determined in this way is assumed to be representative of the next year's farming practice and hence it will be used as "benchmark" for restating the historical crop yields.

8.3. Risk Classification

Often there is not enough information to calculate a price for one individual insured. Therefore, in order to calculate an insurance price individuals that are expected to have the same loses are grouped together. The actuary then calculates the premium rate for the group. This process of dividing individuals into similar groups based on their risk characteristics is knowns as "risk classification." Adequate risk classification helps companies overcome challenges associated with adverse selection (when the company doesn't charge the correct premium rate for an individual). Benefits of implementing a strong risk classification system is the ability to achieve favorable selection, which provides a competitive advantage.

For crop insurance, rating variables may include size of farm, crop type, soil quality, risk zone, etc. These variables can then be used to divide individual farmers into groups. When considering risk classification, four principles are often discussed, including:

- Separation of exposure units and class homogeneity.
- Reliability (i.e. class discriminators reflect loss experience).
- Provide incentive to insureds to reduce losses.
- Social acceptability.

[13] Coble, K.H., M.F. Miller, R. Rejesus, B.K. Goodwin, R. Boyles, and T.O. Knight. 2011. Methodology analysis for weighting of historical experience. U.S. Department of Agriculture, Risk Management Agency.

[14] Zhu, W., Porth, L., Tan, K.S. 2017. A Credibility-based Yield Forecasting Model for Crop Reinsurance Pricing and Weather Risk Management. Agriculture Finance Review, *forthcoming*.

9.0. Basic Steps to Ratemaking

As mentioned previously, in many cases crop insurance programs are subsidized to a considerable extent, including administration and operating, reinsurance, profits, etc. Therefore, the ratemaking approach for crop insurance often focuses on calculating the expected loss component. Two of the most common approaches to crop insurance ratemaking are described next, including the loss cost ratio method, and the yield and simulated loss experience appraoch. The choice of methods largely depends on the availability of data. When more data is available the loss cost ratio method is often used, however, when data is scarce the yield and simulated loss experience method is preferred. As mentioned in the restatement section, it is imperative that the underlying data is representative.

9.1. Loss Cost Ratio Method

Where the insurance product has been offered for some time, and there is sufficient historical experience, as is the case in the U.S. and Canada, for example, the historical indemnities and liabilities can be used to develop a premium rate based on the loss cost ratio (LCR). The LCR is a measure of loss per unit of exposure, and is defined as the ratio of indemnities to liabilities. A main advantage of this approach is that it is a normalized rate and trends in indemnities and liabilities are accounted for to some degree, making it plausible to directly use the LCR data.

The general steps to pricing are as follows:

1. *Adjusting to a common coverage level.* In order to use as much of the time series as possible, the historical loss experience is adjusted to a common coverage level (CCL). In most cases, this is 65%, with actual coverage levels (ACL's) ranging from 50% to 85%, in 5% increments.

Recall from above that the LCR is the ratio of indemnities to liabilities. Therefore, the adjustment to a CCL is done separately for each of the indemnities and liabilities. For the liability component, the current liability is multiplied by the ratio of the CCL (i.e. 65%) to the current coverage level (say for example, 85%), as follows:

$$Adjusted\ Liability = Li_C \times \left(\frac{CCL}{ACL}\right)$$

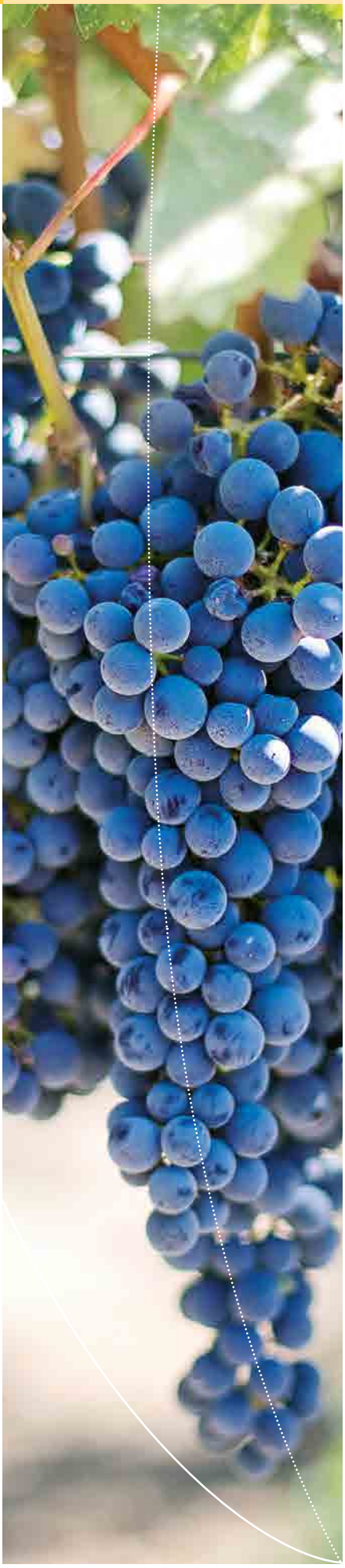
where Li_C is the current liability, CCL is the common coverage level, and ACL is the actual coverage level.

For the indemnity component, the adjustment can be more difficult given that for lower coverage levels only the actual insured loss is known (i.e. indemnities paid under higher coverage levels are not known). For example, when the ACL is larger than the CCL, the adjusted indemnity is equal to the unadjusted indemnity (i.e. actual indemnity) minus the reduction in liability (when actual yields are lower than the CCL).

$$Adjusted\ Indemnity_{ACL>CCL} = Unadjusted\ Indemnity - Reduction\ in\ Liability.$$

For yields greater than the CCL the adjusted indemnity is zero.

In the scenario where the ACL is lower than the CCL, calculating the adjusted indemnity is problematic. Take for example a ACL of 50%, and adjusting to a CCL of 65%. In this case, actual yields higher than the ACL did not generate an indemnity and hence are not known. Various interpolation



approaches can be used to try to uncover an estimated adjusted indemnity in this scenario [15].

Once the indemnities and liabilities have each been adjusted for every year, the adjusted LCR can be calculated as the ratio of adjusted indemnities to adjusted liabilities [16].

2. *Restatement.* Once the adjusted LCR's have been determined, generally the next step is to determine the number of observations to use. There are several factors to consider when making this decision. Recall that there is a tradeoff between data volume and representativeness, and the goal is to find the optimal balance.

Actuarial principles seek to maximize data volume while maintaining the integrity of the data. In crop insurance, there is often a trade-off between data volume and data quality. Given that there is generally only one crop produced each year, there is correspondingly only one data point per year. Therefore, actuaries typically have no more than 30 years of historical yield and loss experience data, even for data rich countries such as Canada and the US, and this creates serious statistical limitations regarding shortness of data. For example, current statistical tests to examine trending processes, such as the Augmented Dickey-Fuller test (ADF test), the Phillips-Perron test (PP test), the Dickey-Fuller with Generalized Least Squares Detrending test (DF-GLS test), and the Kwiatkowski-Phillips-Schmidt-Shin test (KPSS test), are found to

[15] The Risk Management Agency (RMA) in the U.S. uses an adjustment procedure that interpolates between minimum and maximum bounds.

[16] An alternative to using an adjustment method is to treat each coverage level separately and perform the rating for each group of coverage levels. However, the main disadvantage with this approach is that the historical loss experience data may be too limited to conduct a robust analysis and compute premiums from a statistical inference point of view.

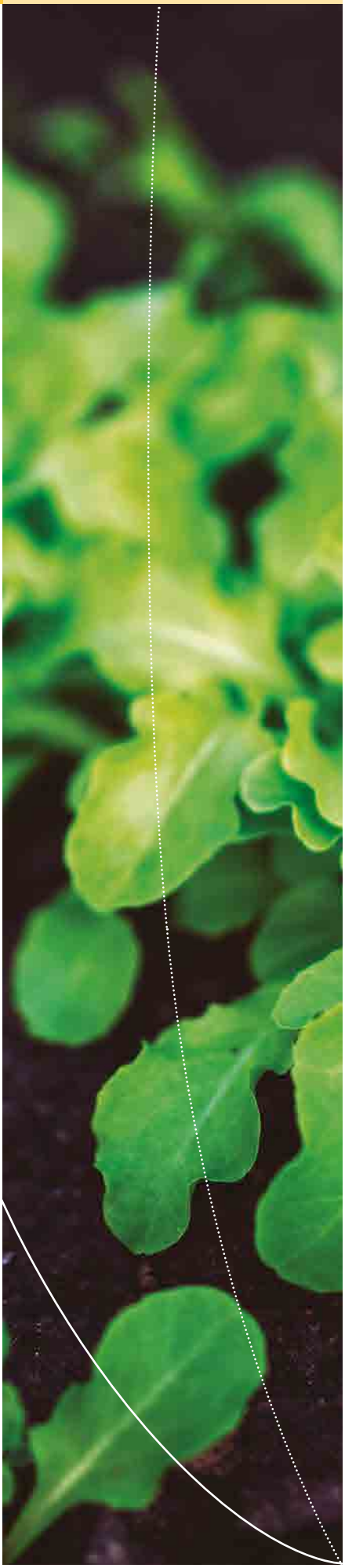
perform poorly when sample sizes are smaller than 50, as is the case in crop insurance.

In addition to issues regarding shortness of data, there is also concern over the integrity of the data. As the gap between the observed data and the present widens (i.e. the number of years in the time series grows), it becomes less likely that the data is representative. There have been many changes in crop insurance over the years, including changes in coverage levels, participation, technology, crop mix, and other considerations, suggesting that only the most current (i.e. recent) data should be considered. However, to ensure that the data set contains sufficient "catastrophe" experience (i.e. catastrophe loading) there is a desire to utilize as much data as possible. As a result, it is commonly accepted that the data should be restated and made "on-level" with the current year, preserving as many data points as possible.

To achieve this goal, several restatement approaches may be considered, which were presented above. It is important to recognize that there does not appear to be consensus on the best approach, or the extent to which restatement should be performed.

9.2. Yield and Simulation Method

In the case of launching a new insurance product, or in countries with limited crop insurance experience, a second approach to compute premiums is using yield data, and from this, losses are simulated. The first step to this approach is to estimate the data generating process of yields through parametric or non-parametric methods. Then, based on the distribution function of yields, the distribution function of indemnity payments is determined. The main drawback of this approach is that the yields used to determine the underlying distribution function are based on uninsured farmers. In reality, the yields for insured farmers may be different (due to moral hazard issues), and thus, may be understated in some cases.



10.0. Summary

Agricultural insurance and risk management have played an increasingly important role in helping to improve food productivity, achieve food security and protect economic growth. As agricultural insurance programs continue to grow in terms of scale and scope, actuarial foundations have become more important in order to ensure that programs are efficient and actuarially sound. There are several considerations in developing agricultural insurance programs, and this report provides information on the key aspects, including:

- World Trade Organization (WTO) and the impact on trade considerations.
- International overview of insurance and risk management programs from key agricultural producing regions.
- Desirable criteria and objectives for government and producers for designing agricultural risk management and insurance programs.
- Pricing basics.
- Insurance concepts.
- Principles of insurance.
- Actuarial premium principles.
- Aggregation bias.
- Restatement approaches.
- Basic steps to ratemaking.

11.0. Appendix A: Basic Insurance Definitions

Exposure: Insurance exposure refers to the basic unit of risk that makes up the insurance premium. In crop insurance, the unit of exposure is often a function of the crop value per acre.

Premium is the amount that the insured pays (usually a fixed amount) in exchange for an insurance company's guarantee to cover any losses incurred.

Claim: In return for the premium the insured pays to the insurance company, the insurer promises to pay an indemnity if a covered loss occurs. Typically claims are a result of sudden events, and in the case of crop insurance, usually adverse weather events.

A Peril refers to a specific risk or cause of loss that is covered by an insurance policy. Examples of a peril include a flood, fire, windstorm, theft, etc. A named-peril insurance policy covers the policyholder only for the specific risks named in the policy. This is contrast to an all-risk insurance policy that covers all causes of loss (except those specifically excluded).

Loss: An insurance loss is the amount of compensation paid to the insured based on the terms of the insurance policy. There is some overlap between claim and loss, however, a claim normally refers to the demand for compensation while loss refers to the amount of the compensation.

Adverse Selection: Refers to the situation where an insured knows more about their risk characteristics relative to the insurer. Adverse selection can result from mispricing, which leads to higher risk individuals seeking insurance and lower risk individuals opting not to purchase the insurance. This cycle of mispricing is referred to as the insurance death spiral in some literature.

A Claim refers to the process of an insured demanding damages resulting from an event specified in the policy.

The Claimant refers to the person or company that has suffered a loss and makes a claim against the insured.

Combined Ratio: The sum of the Incurred Loss Ratio and the Expense Ratio.

The credibility refers to the confidence given to the historical loss experience. Normally, a value between zero and one (100%) is assigned.

Expected Loss Costs: The loss cost шы at the mean confidence level, or is the expected value of the probability distribution of the amount of loss, which may occur during one defined period.

Expense Ratio: The ratio of expenses incurred expressed as a percentage of written premium. It refers to the portion of premium used to pay all the cost of acquiring, writing and servicing a policy of insurance.

Experience: The loss record of an insured or of a class of coverage.

Frequency refers to the number of claims (or occurrences) per exposure unit. Sometimes incorrectly used to refer to the number of claims or occurrences; a relative, not an absolute, measure.

Homogeneity: The concept of subdividing or combining statistical data related to loss exposures into groups exhibiting similar characteristics in order to improve rate-making accuracy.

Indemnify: To pay for loss suffered.

Insurance: The transfer of risk from one party to another party, in which the insurer promises to pay the insured an amount of money for economic losses sustained from an unexpected event, during a period of time for which the insured makes a premium payment to the insurer.

Insured: The party protected by an insurance policy.

Insurer: The insurance company, or other organization providing insurance coverage.

Liability: An obligation imposed by law or equity; money owed or expected to be owed.

Premium loading is an amount added to the pure risk rate. It can be used to compensate the insurance company for expenses, adverse selection, or other hazards.

Loss refers to the amount of money the insurer pays when an insured event occurs. A happening that causes the company to pay; the overall financial result of some operation, as opposed to profit; the amount suffered by a person or property, with or without insurance.

Loss Cost: The portion of the premium rate that is applicable solely to loss, without provision for company expenses or profits.

Loss Event (Occurrence): The total loss to the insurance company resulting from a single cause.

Loss Ratio: Proportionate relationship of incurred losses to earned premiums expressed as a percentage.

Losses: Amounts paid or payable to claimants under the terms of insurance policies.

Premium refers to the payment that is made to obtain the insurance coverage.

Pure Premium: The portion of the premium that is allocated to enable the insurance company to pay losses, but in which no loading has been added for commission, taxes or other expenses; average loss per unit of exposure; the product of frequency per unit of exposure and severity.

Rate: The price per unit of insurance.

Ratemaking: The process of establishing rates used in insurance or other risk transfer mechanisms.

Risk refers to the uncertainty of loss.

Risk Classification: The process of systematically arranging risks into groups or categories according to similar characteristics.

Severity provides an indication of the average loss per claim.

Surplus: The remainder after a company's liabilities are deducted from its assets.

Contact information:
International Finance Corporation
2121 Pennsylvania avenue, NY
Washington, DC 20433, USA
www.ifc.org

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