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Featured Article

Agricultural Insurance in Developed Countries: Where Have We Been and Where Are We Going?

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Abstract *Agricultural insurance in developed countries originates in named peril products that were originally offered by private companies approximately two hundred years ago, first in Europe and then in the United States. Today, many agricultural insurance products are offered, most of them heavily subsidized by governments. In the context of developed economies, this article examines the evolution of agricultural insurance products, the economics of the demand and supply sides of agricultural insurance markets, and the economic welfare, political economy, and trade relation implications of private and public agricultural insurance in developed countries.*

JEL codes: Q10, Q12, Q18, D81.

Introduction

Agricultural insurance markets were initiated in Europe over 200 years ago in the form of privately offered protection against livestock mortality and named peril events such as crop-hail. Yet, only in the last 50 years has there been a rapid expansion and development in the range and scope of insurance products offered to producers. Most of this expansion is accounted for by an extensive range of government supports, including subsidized premiums, subsidized delivery and loss adjustment expenses, and the public provision of reinsurance services. By 2007, premium subsidies among high income countries totaled almost $12 billion, with the United States accounting for $3.8 billion (Mahul and Stutley 2010). Since 2007, the U.S. program has grown rapidly, with total liability in 2011 topping $115 billion and premium subsidies totaling almost $7.5 billion (Glauber 2012). While the U.S. crop insurance program is the world's largest in premium volume, significant programs operate in Spain,

Canada, Italy, and Japan, and programs have recently been introduced or are being expanded in several other countries such as France, Austria, Slovenia, and the Netherlands. Recent proposals within the European Union would broaden rural development support to include risk management programs such as crop, animal and pest insurance (Council of the European Union 2011).

This article examines agricultural insurance programs in developed countries. A central theme throughout the article involves the question of why agricultural insurance is becoming a dominant, if not the dominant, form of agricultural subsidy programs in the developed world. It is difficult to escape the conclusion that, without large subsidies, agricultural insurance markets are likely to remain small. Yet as a means of transferring subsidies to producers, and depending on how subsidy programs are managed, insurance markets can be inefficient relative to other subsidy schemes.

The article begins by providing a brief history of agricultural insurance programs and examining the range of current programs in developed countries. Crop insurance is then examined in the broader context of insurance markets, how such markets address insurance problems such as adverse selection and moral hazard, and the demand for crop insurance in the absence of government subsidies. Next, arguments for government intervention in agricultural insurance markets are evaluated and generally found to have limited relevance. We then describe the extent to which developed countries intervene in agricultural insurance markets.[1]

In many developed countries, multiple peril (all risk) crop and livestock insurance are now offered along with a host of other domestic support programs, in addition to named peril insurance, and, most recently, index-based insurance products. Therefore, we next consider the implications of the interactions between these crop insurance programs and the other domestic support policies that influence agricultural commodity and related markets.

Crop and livestock insurance delivery systems differ widely among developed countries. These alternative delivery systems are described, and their impacts on the delivery costs incurred by producers and governments are examined. The discussion is then widened to consider and assess the general economic welfare effects of crop insurance programs and alternative delivery systems. Next, we examine the links between the 1994 WTO agreement and the recent expansion of subsidized crop and livestock insurance programs. The summary and conclusions are presented in the final section.

History of Crop Insurance

Crop and livestock insurance has a long history in Western Europe. Crop-hail insurance was offered in Germany as early as the late-1700s (Mahul and Stutley 2010) and, by the late-19th century, in many European countries, as well as the United States. Livestock insurance was offered in Germany in the 1830s and in Sweden and Switzerland by 1900. Early insurance schemes were largely provided by small mutual companies

[1]*Here the work draws on results from a 2008 World Bank survey of agricultural insurance markets in developed and developing markets (Mahul and Stutley 2010), and a 2011 OECD survey of agricultural risk management strategies and policies in five developed economies (OECD 2011).*

offering coverage on single or named perils. Limited attempts to sell multiple peril crop insurance largely ended in failure (Gardner and Kramer 1986).

Government involvement in multiple peril crop insurance began in the late-1930s in the United States. Federal crop insurance was first authorized in Title V of the Agricultural Adjustment Act of 1938 (Benedict 1953; Kramer 1983). The program was offered on a pilot basis and initially covered only wheat; in 1939, about 165,000 wheat policies were issued on approximately 7 million acres in 31 states (Rowe and Smith 1940). For its first 40 years, federal crop insurance was offered for a limited number of crops and in a limited number of counties. County crop programs were often withdrawn if heavy losses were experienced and coverage levels were adjusted to limit loss exposure. By 1980, only about half of the nation's counties and 26 crops were eligible for insurance coverage (Chite 1988).

The Federal Crop Insurance Act of 1980 made crop insurance the primary form of catastrophic protection available for producers (Glauber and Collins 2002). This act eliminated standing disaster programs for producers if crop insurance programs were available in their county; to increase participation, premiums were to be subsidized. Prior to the 1980 act, agricultural producers paid the full premium on the risk of loss, but delivery and loss adjustment costs were paid by the government. The 1980 act provided an additional subsidy that covered up to 30% of the premium costs. Lastly, the 1980 act put delivery of crop insurance in the hands of private insurance companies to enhance policy sales. Nevertheless, in the 1980s and early 1990s, the program exhibited only slow growth, and by 1994 less than 100 million acres were enrolled. Successive reform acts, passed in 1994 and 2000, increased premium subsidy levels, particularly at higher levels of coverage, and by 2011 over 265 million acres were enrolled in the program. Concurrently, liability grew from $14 billion in 1994 to almost $115 billion in 2011.

Japan implemented a multiple peril crop insurance program in 1939 that provided nationwide coverage for paddy rice, wheat, barley and mulberries, and subsidized 15% of premium costs (Yamauchi 1986). Canada passed legislation authorizing multiple peril crop insurance in 1959 (Sigurdson and Sin 1994), and after World War II multiple peril crop insurance programs were gradually introduced throughout much of Europe, with subsidized programs implemented in Austria in 1955, Italy in 1970, Spain in 1980, and France in 2005 (Mahul and Stutley 2010; OECD 2011).

In 2008, the World Bank surveyed a number of developed and developing countries on their use of crop and livestock insurance (Mahul and Stutley 2010). Table 1 includes data from that survey on the availability of crop and livestock insurance for selected developed countries. Of the 21 high income countries who responded to the survey, seven provided no subsidies to insurance programs. In these countries, privately offered named peril products such as crop-hail or livestock mortality insurance were common, but multiple peril crop insurance was offered in only one country. However, 10 of the 14 subsidizing countries offered multiple peril crop insurance (MPCI) policies. In 2008, revenue products were offered in only three countries (Sweden, Canada and the United States).

Table 1 Availability of crop and livestock insurance in selected countries, 2008

Country	Crop-hail/ named peril	MPCI	Revenue	Livestock	Index-based
Unsubsidized:					
Australia	X	—	—	Mortality	—
Germany	X	X	—	All risk	—
Greece	X	—	—	All risk	—
Hungary	X	—	—	Mortality	—
New Zealand	X	—	—	Mortality	Crops
Sweden	X	—	X	Mortality	—
The Netherlands	X	—	-	Mortality	—
Subsidized:					
Austria	X	X	—	Mortality	—
Canada	X	X	X	All risk	Crops
Cyprus	X	—	—	—	—
Czech Republic	X	—	—	Mortality	—
France	X	X	—	Mortality	Crops
Israel	X	—	—	Mortality	—
Italy	X	X	—	Mortality	—
Japan	X	X	—	All risk	—
Portugal	X	X	—	—	—
Slovenia	X	—	—	All risk	—
South Korea	X	X	—	Mortality	—
Spain	X	X	—	Mortality	Crops
Switzerland	X	X		Mortality	—
United States	X	X	X	Price/ margin	Crops, rangeland

Source: Mahul and Stutley (2010), Appendix E.

The Current Agricultural Insurance Product Landscape

The range of agricultural insurance products offered in a country is a function of the willingness of the government to subsidize them, the existence of a viable infrastructure for providing insurance (including regulatory structures, trained loss adjusters, product delivery mechanisms, etc.) and the information and data available to support underwriting and actuarial analysis that enables them to be viable products. Developed economies are more able, and often more willing, to provide subsidies than developing countries. They are also more likely to have the data, information, and insurance infrastructure needed for delivering such insurance.

Table 2 presents a representative taxonomy of the range of subsidized multiple peril and index-based agricultural insurance programs offered in different developed countries. Many of these products are offered on a widespread basis in the United States and/or Canada, for example, "whole farm" multi-crop insurance and index-based rangeland insurance, but other developed countries utilize at least some similar products. Spain, for example, offers whole farm insurance for citrus fruits, and Sweden and Norway offer index insurance for forage; the Netherlands offers a subsidized multiple peril insurance product that requires a weather index trigger before the farm can be eligible for indemnities,

Table 2. A taxonomy of agricultural insurance products

	Multiple Peril Crop Insurance: Individual Farm Plans	Index Insurance: Area Plans
Yield and Revenue Insurance	Offered for single crop, multiple crops, crop quality, and whole farm	Offered for area yield and revenue
Weather Insurance	Not offered on a farm-by-farm basis	Offered using single and multiple indicators (weather and temperature)
Vegetation Insurance	Offered (at least in the United States for forage)	Offered (at least in the United States using satellite-based vegetation indexes)
Commodity Price Insurance	Not offered on the basis of individual farm prices	Offered using national and futures price information (for example; LRP and AGM products in the United States)
Livestock Margin Insurance (revenues – costs)	Not offered on the basis of individual farm revenues and costs	Offered using national and futures price information for livestock prices and animal feed prices

while Spain subsidizes both privately offered single peril and multiple peril policies (OECD 2011).

In general, agricultural insurance policies offered in developed countries fall into three broad categories: specific or named peril products, multiple peril or all-risk products, and index-based products. Specific peril products provide coverage against a farm's losses from clearly specified or "named" perils like hail or range fires; these products have been offered successfully by the private sector because the occurrence of such events is relatively easy to verify, mitigating moral hazard and adverse selection issues. Single peril insurance products have been offered by the private sector in many countries, for example Sweden, Germany, France, the United Kingdom, Spain, the Netherlands and Austria. However, some governments, for example at the state level within the United States and at the national level in France, have also offered subsidized specific peril products, most often against crop losses from hail (Kramer 1983; OECD 2011).

Multiple peril products offer coverage against a farm's crop losses from many perils, as opposed to a clearly specified small set of perils, and may include revenue as well as pure yield insurance products. Revenue products, introduced in the United States in the late 1980s, typically utilize futures market contracts and the farm's yield history to establish liabilities and indemnities, while yield products provide indemnities only when yields fall short of their "trigger" levels and value losses at a price determined when the farmer signs up for coverage. Typically, multiple peril policies require farmers to use standard/best practice production techniques to be eligible for indemnities for crop losses, but monitoring costs are large and both moral hazard and adverse selection are substantial problems. As a result, the private insurance sector has not successfully offered

these products on a purely commercial basis. The evidence from the United States and Spain, as well as several willingness-to-pay (WTP) studies, suggests that substantial subsidies (covering all administrative costs and about 40% of the actuarially fair premium) are needed to achieve participation rates of about 50% (Goodwin and Smith 2010; Garrido and Zilberman 2008; OECD 2011).

Index insurance products are essentially derivatives. Farmers can insure against shortfalls in a weather-based, area (county) yield, or satellite-based plant growth index. In fact, index products for crops and livestock have also rarely been offered successfully on a purely commercial basis, not least because of basis risk; that is, the indexes are imperfectly correlated with a farm's yields (Miranda 1991) and surprisingly often fail to provide indemnities when the farm experiences losses (Smith and Watts 2009). Hence, farmers have been reluctant to pay very much in the way of a loading factor for the risk protections they provide. When index products are heavily subsidized and are not competing with similarly subsidized multiple peril products, as is the case in the United States for forage insurance based on rainfall indexes and satellite images of plant growth, farmers are willing to purchase them, even though basis risk may be substantial, mainly because the subsidized products increase their expected incomes.

Most index products are based on a single variable such as rainfall, county yield, and satellite-based normalized difference vegetation index (NDVI) values. More recently, in Canada the province of Alberta has introduced a complex weather-based product that allows for insurance against multiple events such as lack of rainfall, frost, heat, etc. Similar products targeted to farmers have also recently been introduced on a purely commercial basis by private companies in the United States. It is not clear whether they will be successful over the longer term.

Pure price protection insurance products have also been introduced in the United States on a pilot basis. These products, for example Livestock Risk Protection for swine, provide subsidized puts based on futures markets for a limited number of animals. To prevent farmers from "harvesting" the premium subsidies, participants are prohibited from taking offsetting positions in the futures markets. Livestock margin products are designed to provide livestock producers and feeders with indemnities when livestock prices and feed prices move closer together to squeeze margins relative to the levels implied by futures prices when the animals were obtained and placed on feed. It is noteworthy that in almost every case, the same risk protection could be obtained on a commercial basis through the use of private futures and options markets, but then there would be no government subsidy and farmers would have to pay brokerage fees to cover administrative expenses.

The Theory of Agricultural Insurance

In many ways, agricultural insurance is just like any other insurance: private companies will offer insurance policies to customers when premiums cover all of their costs. These costs have two components: the indemnities that have to be paid out to cover losses, and the costs the companies incur when delivering and managing the policies, often called

administration and operating (A&O) costs. For a private market to exist, the individuals purchasing the insurance must be willing to pay premiums that are sufficiently large to cover the A&O costs incurred by insurance companies in providing the policy. Conventionally, buyers of insurance are presumed to be risk-averse and therefore willing to pay insurance companies for services that reduce the spread of their potential income outcomes by reducing their expected incomes.

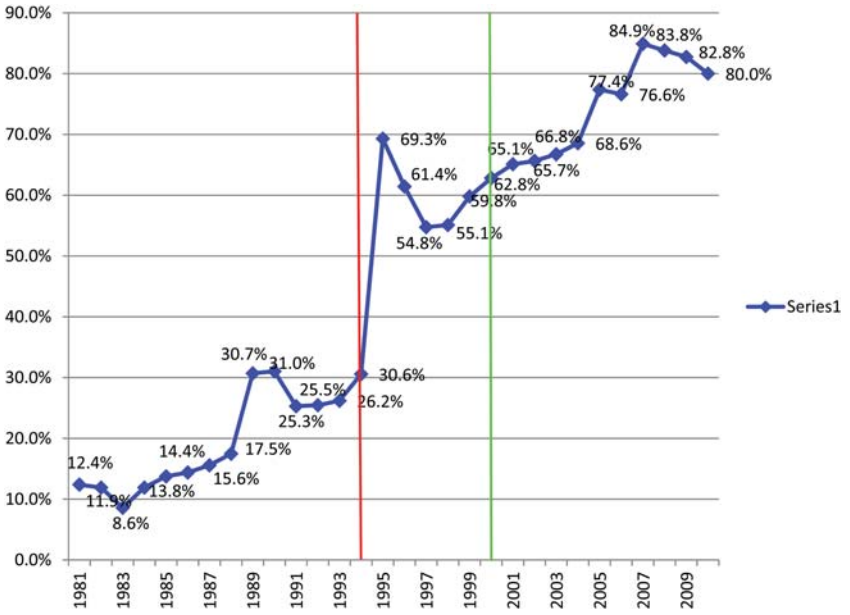
In an ideal world, risk-averse individuals will choose to purchase a policy that provides them with "complete insurance" (Borch 1986), under which they always receive the same income (net of premiums paid and indemnities received). However, such policies are rarely if ever offered because the frequency and size of many indemnifiable losses are typically endogenous to the actions taken by an individual who purchases insurance. In principle, some of those actions can be observed and monitored, and specific practices can be required for losses to be indemnified, for example, reducing the risk of fire damage in a garage by keeping a working fire extinguisher there. Others are much more difficult and costly to identify, monitor, and enforce, for example, ensuring that a farmer has followed best practices in herbicide or fertilizer applications on an insured crop, resulting in moral hazard behaviors (Halcrow 1948). Moral hazard has been shown to exist with respect to crop insurance in a wide range of studies (Quiggin et al. 1993; Smith and Goodwin 1996; Babcock and Hennessy 1996; Coble et al. 1997; and Goodwin and Smith 2003).

One approach to mitigating moral hazard is to require the insured person to share some of the loss. Loss sharing can occur through co-payments (the insurance company pays only part of each dollar of loss and the insured bears the rest of the loss) or deductibles through which the insured person bears all of the cost of any loss up to some maximum amount (say $1,000) before the company provides an indemnity for the rest of the loss. Such contracts have been shown to be optimal for crop insurance (Chambers 1989). Alternatively, as Raviv (1983) and Vercammen and Van Kooten (1995) have demonstrated, requiring farmers to insure crops over multiple years can mitigate moral hazard effects.

Agricultural insurance is also subject to adverse selection (Goodwin, 1993), which occurs when the insurer faces a pool of potentially insurable clients who are heterogeneous with respect to their risks of loss in ways that cannot be observed by the insurer. The insurer offers the same contract with the same premium rate to all members of the pool, pricing the contract at a premium rate that reflects the expected indemnity for the whole pool. The result is that the contract is priced too high for clients in the pool with below average risks of loss, but too low for those in the pool with above average risks. The low risk clients who are effectively subsidizing the high risk clients drop out, with the result that losses and premium rates eventually increase, potentially driving more clients from the market.

The private insurance sector addresses adverse selection in commercial products by creating pools that include more homogeneous clients with more similar risks of loss. This has not typically been the approach of government subsidized programs. The history of the U.S. federal crop insurance program from 1981 to 2010 provides an illustrative case study of how it has been dealt with by a government. Figure 1 presents participation rates in the U.S. program from 1980-2010. In the 1980s, following the guidance provided by the 1980 Crop Insurance Act, the USDA Risk

Figure 1 Proportion of total U.S. crop acres insured through using subsidized Federal crop insurance products: 1981–2010



Source: Computed by the authors using data areas insured, published by RMA on its home page and on total planted areas published by the USDA National Agricultural Statistical Service.

management Agency operated the program with subsidies that covered A&O expenses and paid up to 30% of the actuarially fair premium for a contract based on average losses in a county. In that environment, participation averaged only a little over 20%, except in 1989 and 1990, when participation was required for farmers to be eligible for disaster aid. After 1994, under the provisions of the 1994 Crop Insurance Reform Act, subsidies were increased to about 40% and participation rates increased to between 50-60%. Subsidies were again increased to about 60% in 2000, after which participation rates also further increased, reaching 80-85% between 2007 and 2010, by which time adverse selection became a relatively small issue for the program.

It is important to note that adverse selection only diminished because farmers were increasingly subsidized, not because the U.S. government did a better job of establishing insurance pools that were less heterogeneous. Effectively, the U.S. government achieved extensive participation in a single insurance pool by subsidizing lower risk farmers to enter the insurance pool. From the perspective of the public exchequer as well as economic welfare this was a much more expensive exercise than focusing on making the pools more homogeneous, but that course of action would have involved charging substantively different premiums to farmers who lived close to one another, with substantial political costs for policymakers and program administrators.

In commercial insurance markets, premiums have to cover all costs, including indemnities and A&O expenses. The term A&O covers several types of costs, including the administrative and operating costs common to any business, but also those costs associated with monitoring insured

clients' compliance with the terms of their contracts, loss adjustment expenses, and expenses associated with mitigating moral hazard incentives. Insurance companies are also required to maintain highly liquid assets to cover indemnities involving financing costs, and/or obtain reinsurance from reinsurance companies. In a subsidized market, at a minimum, private companies require premiums paid by insured producers and the subsidies they receive from the government to cover all of those costs. However, once the government subsidizes the program, then, as discussed below, the private sector has incentives to capture the regulatory authority and lobby for increased subsidies to enhance their revenues and returns.

Private companies also typically adjust premium rates to account for events that could potentially occur but whose effects are not embedded in the loss histories available to the companies for setting premium rates, for example 100-year droughts or floods. Another source of adjustment to premium rates is the impact of the line of insurance on the overall riskiness of a company's entire business, which will typically include several very different types of insurance such as agricultural insurance, automobile insurance, life insurance and other property and casualty insurance. To the extent that moral hazard and monitoring costs are a concern, A&O expenses are likely to be larger and premium rates commensurately more substantial, reducing the probability that potential insured clients will be willing to pay the commercial rate for coverage.

It is likely that most crop insurance products would not exist in the absence of subsidies, and the subsidies are typically justified by farm groups and policymakers as providing "an essential risk management tool" for farmers who "face unique and unmanageable risks." This may be useful political rhetoric, and reducing farm income variability is one public policy objective. However, given the unwillingness of farmers to pay very much in the way of a loading factor for crop insurance, as discussed below, from the perspective of farm lobby groups, the most important outcome of subsidized insurance programs may well be that they transfer income to farmers from the rest of society. Whether or not this is the case, the efficiency with which each dollar of income is transferred to farmers by crop insurance programs is an important question.

Any income transfer program that involves using interventions in markets rather than lump sum transfers creates distortions and costs in the markets in which direct intervention occurs. Crop insurance subsidies are no exception to this general rule. It is not clear how large the distortions are at the margin, but it is clear that they exist because in the absence of subsidies, no market would exist for most crop insurance products. At a minimum, therefore, almost every dollar spent on A&O expenses and every dollar spent on government regulatory and program management represent income transfer costs. There may also be additional costs associated with other markets if all distortion costs are not captured in the insurance markets, for example increased environmental degradation resulting from the expansion of farming onto environmentally sensitive lands. Welfare costs may also be derived from rent seeking activities along the lines originally discussed by Peltzman (1976). Finally, the subsidies have to be funded by either taxes or deficit borrowing, both of which generate distortions and deadweight costs in other markets (Gardner 1983;

Alston, Carter and Smith 1993) and these costs appear to be substantial (Fullerton 1991).

Crop insurance programs are, therefore, not necessarily low cost efforts from a transfer efficiency perspective and, as argued by Babcock and Hart (2006) and Smith (2011), at least with respect to the U.S. program, income transfers via crop insurance may be one of the most expensive ways of providing farmers with public funds. Still, transfers via crop insurance programs may be less inefficient in other countries. In the 2008 World Bank survey, for example, Canada reported that delivery costs were less than ten cents for every dollar of premium in its program, which is entirely managed by the public sector. However, it is not clear that the distortions created by crop insurance subsidies are any less deleterious than those created by other subsidy programs, for example export subsidies, import tariffs, or deficiency payments. Surprisingly, very little research has actually been carried out on the welfare costs of crop insurance programs relative to other farm programs.

Willingness to Pay for Crop Insurance

Most farmers are simply not willing to pay very much for crop insurance. In 1986, Hazell, Pomereda, and Valdes observed that "... the fact is that, with few exceptions, farmers in both developed and developing countries have been unwilling to pay the full cost of all-risk crop insurance" (Hazell et al. 1986, p. 7). A quarter of a century later, there is no evidence that their assessment was wrong. To date, four studies have investigated the willingness of farmers to pay for crop insurance products using information on farm behavior. Two of these studies focus on the willingness of farmers located in high risk, semi-arid regions of Australia to pay for rainfall insurance (Bardsley, Abey and Davenport 1984; Patrick 1988), while another examines multiple peril crop insurance products in which indemnities are tied to their own farms' losses (Patrick 1988). The other studies examine willingness to pay for rainfall index-based crop insurance in two developing countries, Morocco (McCarter 2003) and Tanzania (Sarris et al. 2006).

The results reported in the four WTP studies consistently show that many farmers are not even willing to pay the actuarially fair premium rate for either individual yield or rainfall index insurance. In a developed country context, Patrick (1988) reported that more than 56% of the farmers in his sample were not willing to consider rainfall insurance, very few were willing to pay more than 110% of the actuarially fair premium, and almost no one would buy insurance if the load exceeded 20% of the actuarially fair premium. The findings presented by Bardsley et al. (1984) have similar implications; their results indicated that a loading factor in excess of 5% would be sufficient to deter private insurers from offering individual yield or index insurance because farmers simply would not pay more than that amount.

The question, then, is why, when left to their own devices, most farmers place such a low value on multiple peril or index-based crop insurance as a risk management tool relative to the costs of providing them, especially if most farmers are risk-averse. Wright and Hewitt (1994) and Goodwin and Smith (2010) suggest that the reason may simply be that farmers have

many other less expensive ways of managing risk. These include enterprise diversification and spatial diversification of their farms, self-insurance and the use of pesticides, herbicides and other input- related means of controlling production risks. Atwood, Watts and Baquet's (1996) analysis indicated that in fact, the provision of subsidized crop insurance has probably reduced the use of these traditional risk management tools, as farmers with given risk preferences will adjust their portfolio of activities towards other more risky activities when the riskiness of some activities in their portfolio is reduced through government policy. It should also be recognized that in many developed countries any opportunities that might exist for insurance companies to successfully offer purely private agricultural insurance products have been eliminated by the availability of heavily subsidized public crop and livestock insurance programs.

Rationales for Government Intervention

A primary justification for government intervention has been the inability of private agricultural insurance markets to successfully provide all risk crop insurance products (see, for example, Appel et al. 1999; Hazell et al. 1986; Goodwin and Smith 1995). In the late-1800s and early part of the 1900s, there were several attempts by private companies to offer all risk insurance but the companies, in general, were unable to protect themselves from large losses (Valgren 1922; Kramer 1983).

Arguably, private crop insurance markets today are crowded out by subsidized crop insurance and other agricultural support programs. However, whether a viable market for agricultural insurance would exist today in the absence of government programs is not clear. There have been substantial developments in financing catastrophic risks, particularly over the past 10 years (see, for example, Froot 1999; Cutler and Zeckhauser 1999; Kleindorfer and Kunreuther 1999), and there has been much interest in developing private crop insurance products outside of the United States (Skees et al.1999; Meuwissen 2000; Bielza et al. 2008). Yet apart from similarly subsidized crop insurance programs in other countries, for example, in Canada and Japan, to date no large scale private crop insurance markets have emerged (Goodwin and Smith 1995 and 2010; Wright and Hewitt 1994).

As discussed above, one reason why private crop insurance markets have not developed is the relatively high loading costs of associated crop insurance, coupled with the fact that farmers and ranchers have a variety of other risk management strategies to mitigate the risks that they face (Harwood et al. 1999; U.S. GAO 1999). These strategies include futures and options markets, contracting, cultural practices that reduce crop loss, for example irrigation, pesticide use, crop and livestock diversification, non-farm income, savings and borrowing (self-insurance), leasing, government price and income support programs, and government disaster assistance payments.

On the supply side, researchers have questioned the viability of private crop insurance markets because of the presence of moral hazard and adverse selection problems (Ahsan et al. 1982; Chambers 1989; Nelson and Loehman 1987; Goodwin and Smith 1995). To combat moral hazard,

insurance contracts typically include deductibles, co-payment provisions, or other mechanisms where losses are shared between the insurer and the insured. However, because of the high costs of monitoring agricultural production, private crop insurance would require relatively high deductibles and/or high premium costs, both of which reduce producer demand for insurance (Goodwin and Smith 1995).

As discussed above, adverse selection occurs when a producer has more information about the risk of loss than the insurer, and is better able to determine the fairness of premium rates (Harwood et al. 1999). More accurate risk classification reduces adverse selection problems, but risk classification, like monitoring for moral hazard, is potentially costly. Compulsory insurance coverage can mitigate adverse selection by forcing lower risk buyers to buy coverage, but as pointed out by Appel et al. (1999), mandatory coverage generally reduces the welfare of those low-risk buyers and therefore is likely to be politically unpopular.

Systemic risk, the fact that yield losses tend to be positively correlated across farmers, is often cited as the reason why there is no significant private market for crop insurance (Bardsley et al. 1984; Miranda and Glauber 1997; Duncan and Myers 2000). The argument is that, because of this correlation, insurers cannot easily diversify their risks across space and, in the absence of reinsurance, would have to hold large reserves in the event of a large crop loss. As a result, a higher premium loading would be necessary to cover the insurer's opportunity cost of capital (Appel et al. 1999). In practice, however, insurance companies can diversify their risks through the use of reinsurance. Crop liabilities, while large in absolute terms, are small relative to the size of the global reinsurance market (Goodwin and Smith 2010). Reinsurance comes at some cost to the insurance company, which will be reflected in higher premium costs for producers, but these costs do not derive from any essential form of market failure.

Adverse selection, moral hazard and correlated risks are not problems unique to crop insurance. Other lines of insurance face similar problems, yet private markets exist. However, the costs of addressing these problems for crop insurance appear to be sufficiently large to make crop insurance too expensive for most producers, although in some settings this might not be the case. However, crop insurance would likely be too expensive relative to other ways of managing risk for most producers, especially in high-risk areas.

The potential disparity in the availability of private insurance between regions and crops is sometimes cited as a reason for government intervention (U.S. GAO 1980; Appel et al. 1999), but here again crop insurance is not unique. Many risk management tools used by farmers are available only in certain regions. For example, cash forward contracting is widely available for corn and soybean producers in the Midwest, as well as for fruit and vegetable growers in many states, but the same is not necessarily true for producers in regions where basis risk is high. However, there is little impetus for government intervention in those markets.

A third rationale for public subsidies for crop insurance, noted by Goodwin and Vado (2007), is that farmers with crop insurance are more likely to report the incidence of infectious plant and animal diseases and pest infestations without delay because they will receive compensation for their losses. The early reporting of such incidents may allow for

government and private sector actions that substantially reduce the adverse impacts from the rapid spread of such diseases and infestations. However, Goodwin and Vado (2007) also note that other mechanisms for encouraging early reporting exist and, in addition, this rationale may be applicable only in rare circumstances, although in a forestry context with respect to forest fires the issue may be more germane.

Scope of Government Intervention

Government intervention in agricultural insurance markets differs widely across developed countries. Intervention can take the form of either direct premium subsidies or indirect subsidies for delivery costs, loss adjustment, or provision of reinsurance. If governments are involved in ratemaking, there may be implicit subsidies involved in how rates are set. While many countries simply provide subsidies to cover some portion of insurance premiums, for example France, others subsidize almost all aspects of multiple peril agricultural insurance, for example Canada and the United States.

Measuring the degree of intervention is often difficult because, while premium subsidies may be directly measured, indirect costs such as delivery costs, provision of reinsurance or the impacts of government ratemaking are often less transparent. In its 2008 survey of government support to agricultural insurance, the World Bank found that premium subsidies were one of the most prevalent ways of providing support to agriculture insurance markets in high income countries. Of the 21 countries interviewed, two-thirds provided some sort of government support to agricultural insurance markets (Mahul and Stutley 2010).

Using the World Bank Survey data, table 3 includes premiums, indemnities and producer subsidy rates for eight high income countries. Six of the countries reported subsidy rates of 49% or higher. While indemnities were smaller than total premiums (including subsidies) for all of the countries over the time period in question, accounting for subsidies resulted in

Table 3. Premiums, indemnities and loss ratios for select high income countries

	Period	Total premium ($US mil.)	Total indemnities ($US mil.)	Loss ratio (%)	Producer subsidy (%)	Producer loss ratio (%)
Austria	2003-07	254.9	165.4	85	34	98
Canada	2003-07	3,647.4	2,657.1	73	61	186
Israel	2003-07	122.3	104.1	85	24	112
Italy	2003-06	1,270.3	728.9	57	61	147
Japan	2003-05	3,022.0	2,840.7	94	49	184
Portugal	2003-07	55.4	16.3	29	67	88
Spain	2003-07	3,171.7	2,696.1	85	71	294
United States	2003-07	22,708.4	15,889.1	70	59	170
Total	2001-11	61,059.0	51,821.4	85	66	194

Sources: Mahul and Stutley (2010), Appendix E; Federal Crop Insurance Corporation, Summary of Business, 2012.

producer loss ratios (indemnities expressed a percent of producer paid premiums) in excess of 100% for all six of the countries. In the United States, for example, the loss ratio (indemnities expressed as a percent of total premiums, including government subsidies to the premium pool) over the period 2001 to 2011 was 85%.

Agricultural Insurance and the Interactions with Other Risk Management and Farm Policies

When a sector is affected by multiple government programs, as is the case with agriculture, one set of policies may have important implications for other programs. Disaster aid programs have long been recognized to have an impact on crop insurance programs, and in particular crop insurance program participation rates. Ad hoc disaster programs can be viewed as free crop and livestock insurance by farmers, albeit with indemnities that are somewhat unpredictable. To the extent that farmers believe they can obtain a substantial amount of aid through such programs on a fairly regular basis, and especially when losses from drought or other natural catastrophes such as hurricanes are relatively large, they may be less likely to obtain crop insurance to cover the same risks. Most, if not all, studies of the demand for crop insurance provide evidence in support of this hypothesis (for example, Hojjati and Bockstael 1989; Goodwin 1993, Smith and Baquet 1996; Knight and Coble 1997; Just et al. 1999; and Goodwin and Smith 2003).

Interactions between crop insurance and other programs can also be more complex. For example, crop insurance can be established as a prerequisite for eligibility for participation in other government programs, as in the United States in 1990 and 1996 with respect to ad hoc disaster aid and from 2008 to 2012 with respect to several "permanent" disaster programs. One of these programs, the crop disaster aid Supplemental Revenue Assistance Payments or SURE program, based the amount of disaster aid payments on the amount of a farm's crop insurance liability and covered losses that, effectively, formed the farm's deductible on its crop insurance coverage. Smith and Watts (2010) showed that this linkage increased incentives for moral hazard behavior and Bekkerman, Smith and Watts (forthcoming) present empirical evidence that the introduction of the SURE program significantly increased crop insurance participation in areas where moral hazard incentives for participation were likely to be relatively substantial.

Shallow loss programs designed to cover losses that would otherwise form crop insurance policy deductibles have recently been advocated by US farm groups and gained traction with Congressional policymakers. One version of these programs, the Average Crop Revenue or ACRE program, was introduced in the 2008 farm bill but, because payments were triggered by state yields and revenues rather than farm yields, had little or no direct effects on moral hazard incentives at the farm level. However, several recent shallow loss proposals link payments under those programs directly to farm yields, also effectively buying down a farmer's deductible in their crop insurance policies and again providing incentives for moral hazard behaviors that could potentially affect crop insurance indemnities. Also, by increasing incentives for crop production, shallow

loss programs would also affect the budgetary costs of subsidized crop insurance programs. The same holds true, of course, for any other program that increases crop production by expanding the area planted to the crop or increasing average yields of the crops for which farmers can purchase insurance coverage.

In addition, crop insurance programs may have implications for the costs and impacts of environmental programs. Some of these effects may be adverse. For example, subsidized crop insurance programs have been shown to increase soil erosion (Smith and Goodwin 2003), or to some extent encourage the expansion of crop production on environmentally sensitive lands that might otherwise be placed into paid land retirement programs (Goodwin, Vandeveer, and Deal 2004). One consequence is that participation in paid land retirement programs, such as the Conservation Reserve Program, would be lower; another possibility is that government spending on those programs to achieve the same level of participation would increase. Other effects may be more positive for the environment. Babcock and Hennessey (1996), Smith and Goodwin (1996), and Goodwin and Smith (2003) have shown that farms participating in crop insurance reduce their use of agricultural chemicals, through moral hazard effects, with attendant reductions in water pollution from chemical leaching into aquifers, streams and rivers. In summary, while the net environmental effects of subsidized crop insurance are difficult to gauge, the empirical evidence indicates that the effects are substantial and complex.

Delivery Systems for Agricultural Insurance

Government involvement in the delivery of agricultural insurance differs widely among developed countries. At one end of a continuum are countries where insurance services are solely provided by commercial insurance companies. This is typically the case for named peril products like crop-hail which, in this regard, are much like other property casualty lines of insurance. The insurer sets premium rates to reflect the underlying risks of loss, plus an expense load to cover delivery expenses, including loss adjustment and costs of reinsurance, and obtains reinsurance in the commercial reinsurance market. Government support, if any, comes in the form of a direct premium subsidy to the producer. This model is prevalent in many European countries, including France, the Czech Republic, Slovenia and Austria, and reflects the fact that these programs largely grew out of existing markets of unsubsidized private sector products, primarily named peril products such as crop-hail. At the other end of the spectrum, the government plays the principal role in rate setting, selling and adjusting policies. This is the way crop insurance was provided for in the United States prior to 1981, and is the manner that crop insurance is currently operated in Canada, where most of the functions are provided by the provincial governments.

For many countries, however, public-private partnerships do exist, where the government provides key support in enabling sales of insurance products by private companies or producer cooperatives. For example, one of the larger of these programs is in Spain. In 1980 the Spanish government created the Agroseguro Pool, composed of private insurance companies and a national reinsurer. Agroseguro sets insurance rates for a

variety of insurance products which are provided to producers at subsidized rates. Companies are also free to offer their own products, but those products do not qualify for premium subsidies (Mahul and Stutley 2010; OECD 2011). Comprehensive stop-loss reinsurance is provided for by the government.

Private-public risk sharing has been an important and unique feature of the U.S. federal crop insurance program since 1981 (Glauber 2004). Under the 1980 act, the Federal Crop Insurance Corporation was encouraged to privatize delivery functions "to the maximum extent possible." Private sector involvement was perceived as critical for ensuring a rapid expansion of the program. Today, the program is delivered entirely by private crop insurance companies. As in other federally-backed disaster insurance programs, such as the National Flood Insurance Program, the federal government subsidizes delivery costs. For crop insurance, the reimbursement rate for A&O expenses has been halved over the last 30 years. In the mid-1980s, companies received reimbursements equal to 38% of total premium costs. Responding to criticisms by the U.S. General Accounting Office and USDA Inspector General, in the subsequent 25 years, Congress periodically reduced reimbursement rates, and the current reimbursement rate is capped at 19% of premium costs.

A unique feature of the federal crop insurance program is that the government shares underwriting losses and gains with companies through the Standard Reinsurance Agreement (SRA) program. Risk sharing was seen as an inducement for companies to participate in the program by allowing them to share in underwriting gains. By requiring companies to share in underwriting losses, reinsurance encourages companies to underwrite polices and adjust claims more carefully (Bohn and Hall 1999).

The degree of risk sharing has always been a controversial aspect of the program. Under the SRA, if a private company chooses to write crop insurance policies in a given state, it must offer crop insurance products to any farmer in that state. Moreover, insurance companies must accept the premium rates and underwriting guidelines established by the Risk Management Agency. Thus, private crop insurance companies face a potentially large risk exposure without recourse to raising rates to adequately cover the costs of insuring high-risk individuals. Companies were therefore initially reluctant to share in much of the underwriting risks.

The degree of risk sharing between the companies and the Federal Crop Insurance Corporation (FCIC) was changed significantly with the negotiation of the 1992 SRA. Under this act, companies were allowed to place policies in separate funds that offer varying degrees of retention and exposure. In return for taking a larger share of gains, companies accepted more financial exposure in the event of crop losses. The 1992 SRA introduced the basic structure embedded in the current SRA; subsequent renegotiations of the SRA (in 1993, 1994, 1995, 1998, 2004, and 2010) increased the companies' exposure to potential gains and losses.

The costs of private sector delivery in the United States have been large. From 2007-2011, private sector delivery costs averaged $3.3 billion annually, and accounted for about 52% of total program costs (Glauber 2012). In 2010, a new SRA was negotiated with the companies that capped A&O reimbursements at 19%, and reduced gains to the companies through the risk-sharing aspects of the reinsurance agreement. It is anticipated that, as

a percentage of total crop insurance outlays, delivery costs will decline over the next 10 years to less than 30% of total costs (Congressional Budget Office 2012).

When comparing net producer gains to total costs, crop insurance is relatively inefficient. From 2001-2011, for every $1 of government cost, producers have received, on average, about $0.51 in benefits (Glauber 2012). Babcock and Hart (2006) have criticized the program as inefficient compared to other government programs such as the Conservation Reserve Program or direct payments that provide benefits to producers at lower delivery costs. Because crop insurance losses are variable, transfer efficiency is variable and tied to actuarial performance in a given year.

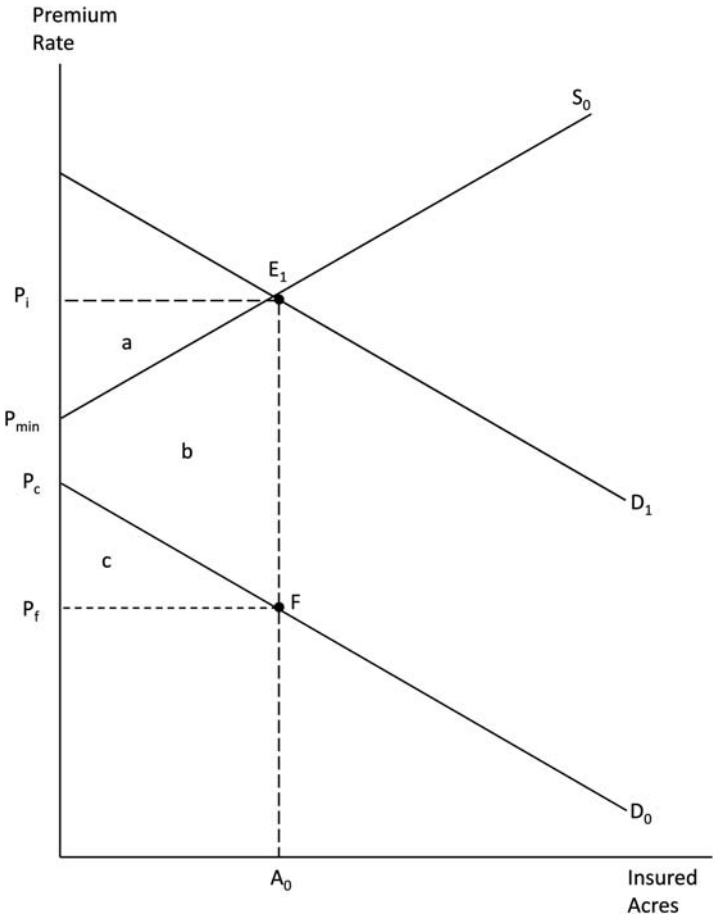
Finally, the data reported by Mahul and Stutley (2010) suggest that, as a percentage of total premiums, delivery costs vary widely among countries, and the United States program ranks at the top in terms of delivery expenditure per dollar of premium and, almost surely, coverage. The Canadian system appears to have relatively low delivery costs, as do other models. While much of the agricultural economics profession's attention has been devoted to other aspects of crop insurance, such as demand, willingness to pay, environmental impacts, etc., the economic welfare, costs and other implications of different delivery systems perhaps deserve more consideration than they have been given in the past.

The Economic Welfare Effects of Crop Insurance Subsidies

Very little conventional theoretical or empirical applied welfare analysis has been applied to the analysis of agricultural insurance markets and crop insurance subsidies. Rather, most analysis has focused on the impact of agricultural insurance on the welfare of producers, their willingness to pay for the risk management services the insurance provides, and the dynamic welfare effects associated with the incentives that agricultural insurance creates for the adoption of new technologies (see, for example, Nelson and Loehman 1987; Chambers 1989; Bourgeon and Chambers 2003; Carter 2008). Almost no study has systematically evaluated the effects on consumer, producer, and taxpayer welfare, either qualitatively or quantitatively. Nor has any study integrated externality effects on third parties in a welfare analysis by, for example, quantitatively assessing environmental impacts using a money metric. However, as discussed above, it should be noted that several studies have examined the quantitative impacts of crop insurance participation on environmental indicators like soil erosion and chemical use.

Figure 2 presents a simple single market welfare analysis of the impact of crop insurance subsidies. The market is for crop insurance coverage, where insurance protection is measured by the volume of acres insured. In the absence of government intervention, the farm level demand curve for coverage is represented by D_0 and the private insurance company supply curve is S_0. The two functions do not intersect in the positive quadrant, so no insurance is offered without government intervention; that is, the choke price at which the quantity demanded falls to zero, P_c, is lower than the minimum supply price at which insurance companies are willing to offer coverage, P_{min}. This initial "no product" equilibrium is a reasonable representation of the market for multiple peril insurance,

Figure 2 Welfare effects of crop insurance subsidies



which was not offered by the private sector prior to the introduction of government subsidies.

To create a market for crop insurance, absent a regulatory requirement that crop insurance be purchased, per unit premium rate subsidies have to be provided, either to the private companies or the farmers, that exceed the difference between the minimum supply price and the choke price. In figure 2, which in part mimics the U.S. system that provides subsidies to both farmers and insurance companies, farmers are assumed to receive a premium rate subsidy of E_1F, which shifts the demand for crop insurance to D_1. The post-subsidy market equilibrium is at E_1. The amount of crop insurance purchased is A_0, insurance companies receive a premium rate of P_i, farmers pay a premium rate of P_f, and taxpayers pick up the difference (E_1F). Total taxpayer costs equal the rectangle $P_iE_1FP_f$, equal to the sum of areas a, b, and c. Farmers obtain consumer surplus equal to area c, which includes their benefits from increased income and reductions in the risks associated with their income streams, and the insurance industry obtains producer surplus equal to area a. Assuming that consumer, producer and taxpayer welfare is equally weighted, the minimum deadweight cost of the insurance subsidy program is area b.

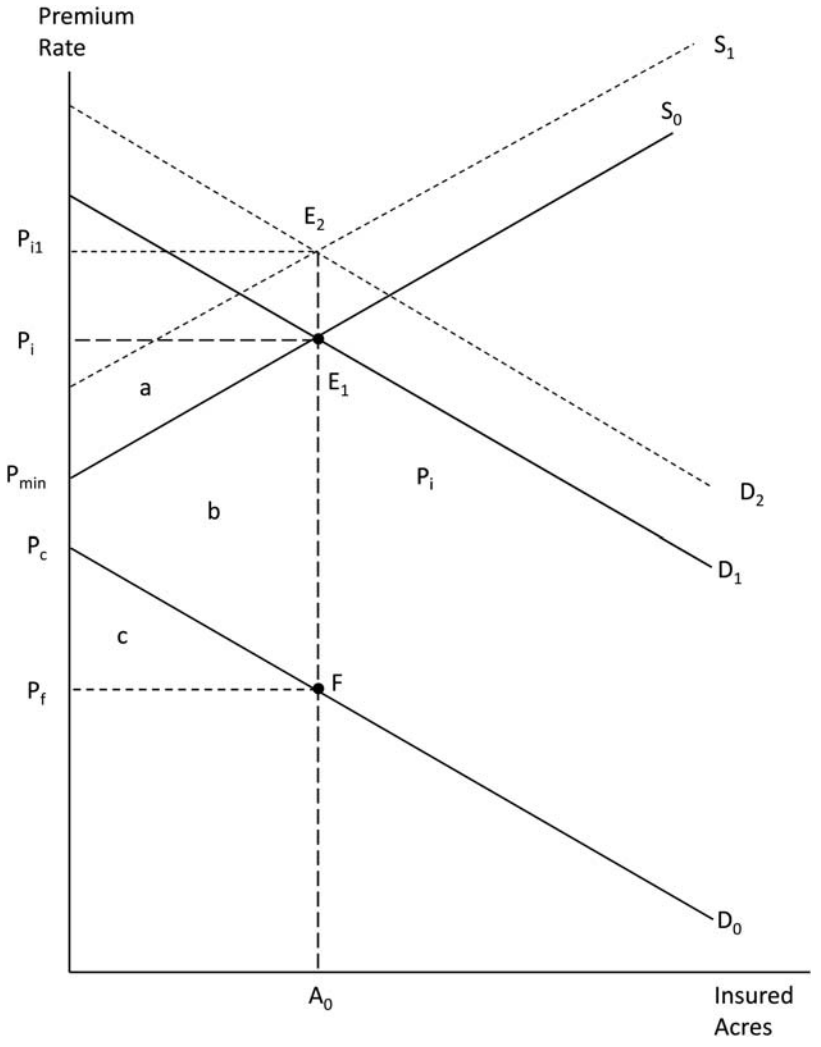
Following Fullerton (1991) and others such as Gardner (1983) and Alston and Hurd (1990), at the very least, the deadweight cost to the economy of raising the taxes needed to fund the subsidy program should also be included, along with any government expenditures on administration and regulation, because those would not otherwise be incurred. A more complete analysis would also have to account for all externality effects of the crop insurance subsidy program, which would certainly include the program's environmental impacts.

The above analysis skirts an important question, however: Is subsidized crop insurance delivered at minimum cost? As discussed above, delivery systems for subsidized crop insurance vary a great deal among developed countries, ranging from delivery solely by government agencies, as in Canada, to delivery solely by private companies, as in the United States. The various delivery systems have different costs. There is sometimes a presumption that the private sector will be more efficient than government agencies. However, that does not appear to be the case in every circumstance. Canada, for example, claims that its purely government-based delivery system costs are low (Mahul and Stutley 2010), as little as 10 cents per dollar of total premium, measured as the sum of producer-paid premiums and premium subsidies. In contrast, over the past five years the U.S. system, which relies heavily on private insurers, generates about $10 billion of total premium, of which an average of about $3.5 billion (35%) accrues to the companies (Smith 2011; Glauber 2012). In terms of transfer efficiency, defined as the ratio of net indemnities paid to farmers divided by total program costs, Glauber (2012) reports that between 1981 and 2006, farmers received about 60 cents for every dollar of government outlay. The data presented by Smith (2011) imply a much lower transfer efficiency of 41 cents per dollar of government outlay for the U.S. program from 2007-2011.

A government agency-based delivery system might well be thought of as less efficient than a system in which private companies deliver program benefits because of the inefficiencies that tend to arise in such government agencies due to incentive incompatibility problems (see Niskanen 1971). In "private-public partnerships," if many private-sector companies compete with one another over both price and quality continuums to deliver a specific service, then they may be more cost efficient and provide better service than a government agency. However, they can also collude to lobby for industry-wide benefits through the political process (selling either votes or donations to elected representatives in exchange for taxpayer subsidies and other policies that favor the industry), and work to capture the government agency that has regulatory oversight over their operations. This may be the case in the United States (Smith, Glauber and Dismukes 2012), where subsidy transfers appear to be so inefficient.

The welfare implications of an inefficient delivery system are illustrated in figure 3, in which the efficient supply curve is S_0, the inefficient delivery supply curve is S_1, and the policy objective uses a subsidy to ensure that farmers insure A_0 acres (as they do in figure 2). The implications are straightforward; relative to the market in which agricultural insurance is provided at minimum marginal cost (represented by S_0), the total premium rate is larger (P_{i1} instead of P_i), but the farmer-paid premium remains P_f, and the per unit subsidy required to achieve the same level of participation are larger by the amount (P_{i1} - P_i). If the efficient and

Figure 3 Welfare impacts of excessive delivery costs



inefficient supply curves are parallel to one another and the shift derives from the use of "wasted" resources, the welfare costs of the program increase by the amount of the additional subsidies (rectangle $P_{i1}E_2E_1P_i$) and the deadweight costs of raising the taxes to fund them. If the increased costs are pure transfers resulting from rent-seeking activities, then the additional welfare costs consist of the deadweight cost of raising taxes, plus any expenditures by the insurance companies on rent seeking, which, as Peltzman (1976) has shown, may be large and even exceed the size of the transfer.

Agricultural Insurance and the WTO

Potential exemption from reduction commitments under the World Trade Organization (WTO) has often been cited as an impetus for the development of crop and livestock insurance (Mahul and Stutley 2010). Under Annex 2 of the Uruguay Round Agreement on Agriculture

(URAA), domestic support measures that have, at most, a minimal impact on trade, so-called green box policies, are excluded from reduction commitments. Such policies include general government services, for example in the areas of research, disease control, infrastructure and food security. Annex 2 also includes income insurance and income safety-net programs (paragraph 7, World Trade Organization 2012) and natural disaster assistance programs (paragraph 8, World Trade Organization 2012).

Under paragraph 7 of Annex 2, eligibility is determined by "an income loss, taking into account only income derived from agriculture, which exceeds 30% of average gross income or the equivalent in net income terms (excluding any payments from the same or similar schemes) in the preceding three-year period, or a three-year average based on the preceding five-year period, excluding the highest and lowest entry" (World Trade Organization 2012). The amount of payments cannot exceed 70% of the producer's loss in that year, and any payment in combination with payments under paragraph 8 of Annex 2 cannot exceed 100% of the producer's loss in that year.

Paragraph 8 of Annex 2 covers payments provided to producers who suffered losses from natural disasters. Eligibility for such payments is determined by a "formal recognition by government authorities that a natural or like disaster (including disease outbreaks, pest infestations, nuclear accidents, and war on the territory of the Member concerned) has occurred or is occurring; and shall be determined by a production loss which exceeds 30% of the average of production in the preceding three-year period, or a three-year average based on the preceding five-year period, excluding the highest and lowest entry," (World Trade Organization 2012). Payments should not compensate for more than the total cost of replacing such losses and must not require or specify the type or quantity of future production. Any payment in combination with payments under paragraph 7 of Annex 2 cannot exceed 100% of the producer's loss in that year (World Trade Organization 2012).

Despite eligibility for treatment as a green box policy, most high-income countries classify their agricultural insurance subsidies as amber box policies largely because their insurance programs fail to meet one or more of the criteria outlined in paragraphs 7 and 8 of Annex 2 of the URAA. Indeed, most countries offer policies that provide coverage greater than 70% or establish losses based on average production levels at variance with the 3-year average or 5-year Olympic average outlined in paragraphs 7 and 8.

Table 4 summarizes recent WTO notifications by selected high-income countries. Most countries notify part of their agricultural insurance support as non-product-specific amber box support. Israel, for example, notifies all of its government support for agricultural insurance programs under paragraph 8. Japan notifies support for policies covering losses at 30% or more as green box, and notifies as non-product-specific amber those policies covering losses less than 30%. The United States notifies its premium subsidies as non-product-specific amber support and delivery expenses as green box under paragraph 2 covering general services

There has been criticism of countries that classify agricultural insurance subsidies as non-product-specific support. Proponents have argued that since subsidies are often available to cover a set percentage of premium costs, regardless of the crop produced, they are not specific to one crop over another. Critics have pointed out that since the level of riskiness

Table 4. WTO domestic support notifications for selected countries

Country	Year Notified	Currency Unit	Amount notified	How notified	Total Aggregate Measure of Support
Canada	2009	$ Can	801.3 mil	Non-product specific amber	1,398.1 mil
European Union	2008	Euro	526.0 mil	Non-product specific amber	11,795.5 mil
Israel	2009	$ US	31. 9 mil	Green box, paragraph 8	513.7 mil
Japan	2009	Yen	159.5 bil	Non-product specific amber	564.8 bil
			47.4 bil	Green box, paragraph 8	
South Korea	2008	Won	49.06 bil	Non-product specific amber	33.1 bil
United States	2009	$ US	5,426.0 mil	Non-product specific amber	4,267.0 mil
			1,602.0 mil 1/	Green box, paragraph 2	

Source: World Trade Organization (2012).

varies by crop, the premium subsidy varies as well, and is crop-specific (Blandford and Orden 2011). The advantage of notifying subsidies as non-product-specific is that if the total non-product-specific subsidies are less than 5% of the total value of a country's agricultural production, they are considered de minimis for reporting purposes and are not added to a country's Aggregate Measurement of Support (AMS), the total amount of support subject to reduction commitments. Table 4 shows that the level of non-product-specific support may be significant compared to a country's reported AMS. For example, in 2009, the amount of premium subsidies reported by the United States as non-product-specific support exceeded its total AMS for that year.

Summary and Conclusions

In developed countries, agricultural insurance coverage has been offered privately since the early-1800s when German insurance companies provided livestock protection, but purely private sector offerings have almost exclusively consisted of specific or named peril products. Government involvement is a much more recent phenomenon, beginning in the United States in 1938 and in Japan in 1939, and spreading among many European countries and Canada over a sixty-year period beginning in the 1950s. Only after governments became involved (providing, in varying degrees, premium subsidies to farmers, A&O subsidies to insurance companies, and stop loss and other loss-related guarantees to comfort reinsurance companies) did multiple peril or all risk insurance become available for crops. Other types of crop insurance such as index-based products linked to weather station or satellite information were not available until the early 2000s, and their introduction was also largely

driven by government support in Canada and the United States. However, more recently some private companies have begun to offer weather-based products to farmers on a purely private basis, although the extent to which the products will be commercially successful is currently not clear.

Multiple peril yield and revenue insurance, when heavily subsidized, is widely used by farmers because it is an effective income transfer and removes some of the downside production and price risks associated with crop production. However, the evidence from willingness to pay studies and demand studies consistently indicates few farmers are willing to pay the full commercial cost of such products. This is not because farmers are not risk-averse – many behave as if they are – but most likely because they have many other, cheaper ways of managing risk.

Arguments that private insurance companies do not offer viable multiple peril products because of market failures have largely been based on the idea that systemic risk (the fact that crop losses are sometimes highly correlated among farmers in regional insurance pools) causes insurance companies to be unable to cope with such losses due to inadequate financial depth. However, that argument pays insufficient attention to the financial depth of the international reinsurance sector, which is able to cope, at a price, with systemic risks associated with events such as hurricanes and other natural disasters that involve much larger potential indemnities than a widespread drought or pest infestation would generate because of crop losses.

Subsidized crop insurance programs interact with many other government policies and impact farm-level production decisions. A wide range of studies have demonstrated that these effects occur at the margin, encouraging expanded crop production on new acreage, including lands more susceptible to soil erosion. These effects also occur infra-marginally; for example, farmers with crop insurance coverage tend to reduce their use of chemical inputs in ways consistent with moral hazard behaviors. A serious concern with respect to several policy proposals and initiatives to cover "shallow losses" is that those proposals, by effectively reducing the deductibles associated with crop insurance coverage, will substantially increase moral hazard incentives.

As a result, a perhaps ironic element of subsidized crop insurance programs is that, to the extent they encourage farmers to use fewer chemicals in the form of fertilizers, herbicides and pesticides, those programs also reduce the adverse environmental consequences of farm practices. However, whether crop insurance programs are a least-cost way of addressing such problems is subject to question, as the evidence indicates that they also increase soil erosion and crop production on ecologically fragile lands.

The overall economic welfare effects of crop insurance programs in developed countries have, in fact, received surprisingly little attention from economists. While many studies have examined the impacts on farmers' utilities, often in the context of assessing the demand for agricultural insurance, we know of no qualitative or quantitative assessments of the full welfare consequences of subsidized agricultural insurance programs. While we have presented a simple, single-market, textbook discussion of those consequences in this article, much more needs to be done in this area.

Similarly, most of the analytical and quantitative work by economists on agricultural insurance has focused on the demand side of the market and issues associated with how premium rates should be set. Relatively little attention has been given to the economics and costs of alternative crop insurance program delivery systems, which appear to be very different depending on the systems being used. Nor has much attention been given to political economy and regulatory capture issues associated with relying solely on the private insurance sector for program delivery. These are areas that deserve more consideration.

Finally, one political argument for government crop insurance programs is that the subsidies involved are WTO compatible and essentially green box programs. This is not in principle the case for most of the programs currently being provided by developed countries, and countries report most of their expenditures on crop insurance programs as amber box, production-distorting subsidies. However, those expenditures are also typically reported as general subsidies rather than crop-specific subsidies and, thus far, have met the WTO criterion of being *de minimis* distortions. Whether a WTO Dispute Resolution Panel would necessarily agree that those subsidies are relatively benign in a crop-specific case has yet to be tested.

In summary, the expansion of crop insurance programs among developed countries over the last fifty years, and especially since the early-1990s, has been widespread and largely accomplished at the taxpayer's expense. A large body of economics research has examined various aspects of crop insurance, including demand, willingness to pay, adverse selection and moral hazard effects on production decisions, as well as extensive analyses of premium rate-setting procedures, and some work on the interaction between crop insurance and other government programs. However, surprisingly little work has been done on the fundamental question of the overall welfare costs of subsidized crop insurance programs. This issue, which should probably have been the first step, is therefore an increasingly urgently needed next step for agricultural insurance research.

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