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Interviews With Risk Professionals

Communities of hedgers, speculators, and service providers ultimately determine the success or failure of any new market. So, for these last chapters (this chapter and the next), I interviewed over 35 firms and institutions from the ENSO risk community. In those interviews, I tested assumptions that arose out of the research in my previous chapters against the opinions of experts - likely ENSO hedgers, speculators, brokers, and service providers.

The results overturned many of the assumptions that lead me to favor exchange-traded futures and options for ENSO risk. But, they also highlight the opportunities for ILS markets to provide a low-risk alternative to exchange-traded futures and options. Those markets would catalyze trading activity in the near-term that could transition to exchanges. Based on this information, it is likely that CAT bonds offer the best chance for ENSO to reach sustainable levels of trading. Supplemented by a liquidity facility that provides options-like hedges to smaller businesses, CAT bonds would adequately address most of the social concerns presented in chapter 4.

This chapter includes:

- a road map for the launch of ENSO markets based on qualitative interviews with likely ENSO hedgers, speculators, brokers, and service providers; and
- the interview results that informed that road map, organized by firm/institution type.

To the extent possible, I've tried to arrange the tested assumptions in order of their importance to the ultimate shape of ENSO markets.

Road map to launch ENSO markets

Drawing heavily from expert interviews, the following is one possible road map for ENSO markets. This road map covers the likely

hedgers exchanging risk, the speculators making up for any imbalances in hedging interest, the brokers consummating those deals, and the service providers underwriting all that activity with their data and analysis. It also covers the market structure that is most likely to cover the greatest volume of trading activity in the short term.

Market structure

With a few exceptions, interview subjects suggested a greater willingness to invest in and transact on ILS markets (in the form of CAT bonds) than on exchange-traded futures and options. Many agreed with the suggestion that ENSO's natural home is on exchange markets, given the nature of the risk. However, most speculators and brokers were clear that, while not categorically opposed to exchange-traded ENSO markets, they and their colleagues prefer ENSO-based ILS because:

- ILS allow speculators to avoid costly up-front investment in dedicated expertise required by exchange-traded markets; and,
- ILS allow brokers to capture a greater return on their investment in the educational effort necessary to attract new hedgers to a market. Brokerage firms are the only firms likely to make any such investments.

While hedgers do not have the same strong preference for ILS, nor were they committed to exchange-traded markets. In existing markets, even when they have the option of trading weather or catastrophe risk on-exchange, they generally elect to use OTC or block trades. As they already prefer bilateral negotiation on their trades, likely ENSO hedgers are indifferent to one of the key advantages of exchange-traded derivatives.

A brokerage associated with the CME's exchange-traded hurricane derivatives reinforced this story, suggesting that ILS would offer better short-term opportunities for liquidity than exchange-traded markets. That brokerage has made substantial investments in exchange-trading and is firmly committed in principle to moving catastrophic risk on-exchange. Consequently, their opinion was particularly influential.

Hedging

If ENSO markets launch as CAT bonds, who will be the first hedgers on those markets?

In rough descending order of their importance to the prospects for active ENSO-based CAT bond markets, I consider the following firm-types to be early hedge adopters:

1. Peruvian fishing companies - My interviews suggest that large fisheries in Peru will likely be the single most important source of early hedging interest on ENSO markets. The risk is an existential threat to their industry. Importantly, some firms in the industry also have the internal capacity to quantify that risk and manage it on traded markets.

2. International agribusinesses - Despite their scope and vertical integration, international agribusinesses have geographically concentrated supply chain risk that will push them into experimenting with new ENSO markets as well, regardless of the form they take (ILS, derivatives, etc.). Those firms are comfortable experimenting in new markets and ENSO is unlikely to be an exception. However, it is difficult to assess the prerequisites for them to scale into consistent, large positions.

   Even if their initial positions are small, I consider them second only to fisheries in their importance to new ENSO markets because other hedgers consider these firms bellwethers for new risk management techniques. Without some support from large agribusinesses, ENSO markets will likely remain at low liquidity.

3. US energy firms - US energy firms' experiments with ENSO markets will likely mirror those of large agribusinesses. The firms would gladly take exploratory positions in ENSO risk. The size of those initial positions would vary greatly, depending on the support they had from trusted weather experts. In particular, their first El Niño trades might focus on hedging summer electricity price spikes in Texas and California. If, after those initial trades, they saw no specific reasons to doubt the integrity of the index and there was good momentum in attracting new hedging interest, they would increase their trade sizes.

   Given that wait and see attitude, ENSO exchange markets appear likely to attract anemic volumes unless they build a coalition of progressive firms that agree to dedicate the resources needed to generate substantial intra-industry volume on day 1. Multiple such consortia have formed to compete for the business created by the *futurization of swaps* in response to Dodd-Frank regulations[1]. (For overviews of the futurization process and its impacts on derivatives markets see Duffie [2013], Litan [2013], and Parsons and Mello [2013].)

4. Australian power transmission firms - Reinsurance rates in Australia are very low. That competitive dynamic will likely crowd-out a great deal of latent ENSO hedging. However, some power transmission firms are deeply concerned with bushfires that have a

[1] Joe Rennison. Swaps vs futures: OTC market speaks out, April 14 2013a

strong link to ENSO. In fact, they have already incurred legal liabilities related to that risk. Those liabilities have jeopardized their future access to low-cost (or perhaps any) reinsurance coverage. As parastatals, they are required to actively manage their liabilities to protect taxpayers from losses. That leaves them motivated hedgers in search of new risk management tools - ideal early adopters of formal El Niño hedging.

5. Peruvian banks - Peru's banking sector lacks expertise in hedging. However, reasearch by Dr. Benjamin Collier[2] suggests that they have enough exposure to El Niño risk to justify their own CAT bond issue. Converting that interest into hedging activity will require substantial educational support, which is why I consider the sector less important to the prospects for ENSO risk than other less vulnerable firms.

[2] Then with GlobalAgRisk/the University of Kentucky, now doing postdoctoral research at University of Pennsylvania's Wharton School.

6. Australian hydro-power producers - Australian power generators with hydro-power installations offer another promising source of hedging interest. Like the multinational agribusinesses I spoke to, hydro-power companies would strongly consider ENSO trading. Given careful and sustained support from brokers, they could eventually be important sources of hedging interest. However, basis risk may limit their contribution to ENSO markets. Rainfall in Eastern Australia and Tasmania show a strong correlation to the ENSO cycle. But hydro-producers are more focused on the interaction of rainfall with water resource management, so ENSO hedges have higher basis risk for hydro-producers than might otherwise be expected.

7. Peruvian agribusiness, energy, and mining - A small subset of at risk firms in Peru have the sophisticated risk management, scale, and interest necessary to participate in formal hedging, given attractive pricing. But that interest will be vary greatly from firm to firm and project to project. I do not believe that I can accurately estimate the aggregate size of hedging interest from these individual projects.

8. Australian agribusiness, mining and tourism - In addition to the utility companies and hydro-power generators mentioned above, there may be acute demand for ENSO risk management in Australia linked to specific projects in coal mining, tourism, and agricultural lending.

9. Conventional reinsurance and ILS funds - Firms holding reinsurance related risk are unlikely to provide much hedging interest to ENSO markets in the near term despite the phenomenon's negative correlation between ENSO and hurricanes. The basis risk is too high in the tail loss scenarios that drive capital reserving.

This profile of early hedging activity is skewed in favor of El Niño hedging. That means that speculators will balance the market, regardless of its form.

Market access

If ENSO risk initially trades as CAT bonds, and access to CAT bond markets are generally limited to large sophisticated firms (like those discussed in the hedging subsection above), what hope is there that ENSO markets can offer widespread access to well-priced hedges and disseminate important forecast information about extreme ENSO events?

John Seo of Fermat Capital suggested one attractive compromise that could link small, or socially important, hedgers to ILS markets. After ILS brokers have consummated the first large El Niño/La Niña trades, a development institution (probably the IFC, the World Bank's arm dedicated to financing individual socially responsible businesses) could use the prices of those bonds in the secondary market to offer option-like coverage to the smaller hedgers who could not easily participate in the CAT bond issue. The development institution, interested in the emergence of stable, commercially viable climate change mitigation tools, could offer to aggregate hedging interest for a small fee using a liquidity fund.

The fund would price an option chain using prices implied by secondary CAT bond trading. Available trades would be capped both in terms of the the nominal value per hedge and the total nominal value per hedger. As the facility sold protection, it could hedge the risk in secondary markets and sell on any basis risk between their portfolio and the secondary markets to ILS funds. Alternatively, it could just sell the risk on the policies directly to ILS funds who would be happy to quote prices on a basket of small options trades but not one-off transactions. By passing on that risk, the facility could maintain a risk neutral portfolio.

If the IFC wanted to subsidize risk management for socially important firms and institutions, this facility would offer an efficient means of doing so. However, the facility could price all the premiums at market rates. By pricing the options fairly, it would operate at no net cost it its host institution.

This would allow large sophisticated hedgers to transact directly in CAT bond markets and still provide smaller hedgers flexible, fair access to option-like protection. It would also advance the eventual cause of a stable, self-sufficient ENSO options market, allowing investors to get a sense of the overall market size while skirting the fixed cost problem of a direct launch. Eventually, once investors were ready,

that pseudo-options facility would be discontinued and all the hedging would be shifted to a genuine exchange along with the ILS trading that underlies the facility.

The World Bank already has two similar programs. The Caribbean Catastrophe Risk Insurance Facility allows Caribbean countries to jointly purchase hurricane and earthquake reinsurance coverage[3]. More recently the World Bank launched a similar facility aimed at tsunami risk in the Pacific Islands[4]. Those facilities aggregate demand from hedgers (national governments) who might not otherwise have access to reinsurance markets on favorable terms. These facilities are also conduits for direct subsidies to poor countries. The World Bank pays the insurance premiums of some participating countries, both through soft loans and, as in the case of Haiti, grants[5].

[3] Caribbean Catastrophe Risk Insurance Facility (CCRIF). The Caribbean Catastrophe Risk Insurance Facility (CCRIF): Homepage, May 2013. URL http://www.ccrif.org/

[4] The World Bank Group. The Pacific Disaster Risk Financing and Insurance Program, May 2013. URL http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTFINANCIALSECTOR/EXTDISASTER/0,,contentMDK:23093927~menuPK:8707838~pagePK:64168445~piPK:64168309~theSitePK:8308421,00.html

[5] Steven Stichter and Simon Young. Esri federal user's conference. February 2010. URL http://proceedings.esri.com/library/userconf/feduc10/papers/user/esri_feduc_2010_stichter.pdf

Speculation

Launching ENSO risk in the form of a CAT bonds assures reinsurance risk professionals a role in the new market. The markets for new CAT bond issuance is one-sided (see chapter 4), with specialized financial firms (see figure 6.3) taking the risk of hedgers in exchange for speculative returns.

The firm types most likely to participate in that issuance in descending order are:

1. ILS funds - ILS funds would be very excited to trade CAT bonds on ENSO risk in the near future. They are highly skeptical of exchange-traded options for their firms and believe that, in the current pricing environment, hedgers would enjoy little if any price advantage from options relative to CAT bonds.

2. Dedicated weather trading desks at hedge funds (or within ILS funds) - These groups would be unequivocally supportive of exchange traded El Niño/La Niña derivatives although they noted that trading volumes throughout the weather markets had fallen in recent years (confirming the story told by figures 6.10 and 6.11).

   While they support exchange-traded markets, the weather trading firms I interviewed, are also entirely comfortable transacting on bilateral markets.[6] OTC transactions account for the majority of their overall deal flow and most of their on-exchange trades are bilaterally negotiated blocks. Hence, they would be willing and able to provide speculative capital to ENSO hedgers, regardless of the form of those hedges.

   Some large ILS funds have dedicated weather-trading groups. Those I interviewed suggested that they would classify ENSO risk as weather rather than catastrophe, assuming that it was traded as

[6] There was one exception - a firm whose mandate is restricted to trading cleared weather products.

a derivative. It remains an open question where ENSO CAT bonds would be housed within these organizations - on the weather desks that trade more actively and use ENSO SSTs to guide that trading, or in their parent ILS funds that mange buy-and-hold portfolios of tail risk.

3. Conventional reinsurance groups - My interviews suggest that reinsurers will not be at the vanguard of speculative trading of ENSO risk. A few progressive reinsurance firms will participate in any market. Firms with managers who previously worked at ILS funds are most likely to fall in this category. That subset of firms will participate enthusiastically if the risk is offered as a CAT bond less so if it is launched as a derivative. But in general, the sector has a well-defined business strategy and actively traded risk is, optimistically, on the periphery of that strategy.

In general I am confident that these three groups of speculators will be eager to manage whatever volume of ENSO risk they can access via CAT bond markets.

Brokerage

More than any other group of interviewees, brokers were emphatic that ENSO should initially launch as CAT bonds rather than exchange-traded futures and options. Before interviewing brokers I expected this reaction, given that they have an interest in remaining the primary avenue controlling the follow of information between hedgers and speculators, and exchange-traded risk-management products would offer fewer opportunities for asymmetric information.

However, I was surprised to learn that in fact many brokerages, or specialized units within large brokerages, had previously invested in projects intended to move reinsurance risk onto exchanges. Those brokerages' inclination toward CAT bonds was born of experience. Based on their past projects, they believed that:

- Brokerages are the only firms within the catastrophic risk industry that consistently invest in the education of clients on new risk management techniques. Even if that investment is less then necessary to capitalize on many solid ideas, it is the only investment available within the industry.

- Brokers as a whole have less incentive to make that investment if ENSO markets launch as futures and options because:

  - Futures and options offer less first mover advantage to innovative firms;

- Brokers find it difficult to convince hedgers to use traded markets without existing liquidity. Meanwhile, those hedgers have no expectation of liquidity on bespoke CAT bond transactions;

- Some brokerages with the expertise to catalyze ENSO trades simply do not deal in derivatives. In fact, they may consider them competition for ongoing brokerage activities.

But not all brokerages will support ENSO risk enthusiastically, even in the form of a CAT bond. The central pillar of support will come from the subset of capital markets groups within large brokerages that have driven past innovation in CAT bonds. Even among the handful of capital markets groups that might promote ENSO CAT bonds, there is wide range of institutional capacity and willingness to promote innovative deals. Some capital markets groups may consider ENSO CAT bonds beyond their core competency.

Despite general skepticism about the country's competitive reinsurance environment, I also found that traditional reinsurance brokers who were particularly interested in extending ENSO coverage to Australia. Their enthusiasm stems from their familiarity with specific opportunities to sell El Niño/La Niña coverage.

Service provision

ENSO CAT bonds will enjoy strong support from ILS funds and the capital markets groups at some brokerages. But those key constituents will need help from climate researchers and risk modelers to provide trusted data and risk analysis.

Based on my conversations with catastrophe risk modelers, I believe that it is quite likely that these firms will provide branded ENSO analysis for ENSO CAT bonds. Given that the firms that license their risk models deal overwhelmingly in reinsurance and CAT bonds, they also favor bonds over derivatives for ENSO risk.

To the extent that ENSO CAT bond risk is managed by weather trading groups, they will look to a different set of service providers specializing in weather. Those firms already closely monitor the ENSO cycle, so I do not believe that it will be difficult to convince them to augment their existing analytical products with information specific to ENSO trading.

Finally, climate scientists, specifically those at NMS are enthusiastic supporters of ENSO markets in general. The scientists I interviewed were open to changing their operating procedures to support markets, including new safeguards to ensure that new ENSO data are released at one time to the public. However, NMS are unlikely to provide actual settlement indexes for ENSO CAT bonds, given the bureaucratic hurdles in front of public-private partnerships.

While it would be ideal to see revenues from CAT bond settlement indexes going back to NMS to support basic research, if they are unwilling or unable to collect those revenues, there are a host of other firms who would be willing to step into that role, including weather data firms, catastrophe risk modelers, or financial firms specializing in index provision.

Hedger interviews: Peruvian fishing

Peru hosts El Niño's most immediate and devastating effects (see chapter 2). Consequently, the country must be at the center of any future ENSO risk market. Even if it is not the largest source of economic risk, it is home to the world's most motivated ENSO risk hedgers and some of its most capable speculators.

Within Peru, the single most important source of hedging interest will likely be the fishing sector. Fishing in Peru is:

1. a large industry,
2. with direct vulnerability,
3. concentrated in the hands of domestic firms,
4. often with world-class CFOs and climate expertise.

Peru fishing industry is large both as a percent of the global total and in absolute dollar terms. The country accounts for roughly 10 percent of the global fish catch[7]. Recent estimates place the revenue from Peruvian fishmeal at USD 1.8 billion annually[8].

[7] Yvonne Evans and Sigbjorn Tveteras. Status of fisheries and aquaculture development in Peru: Cast studies of peruvian anchovy fishery. *Shrimp Aquaculture, Trout Aquaculture, and Scallop Aquaculture*, 2011

[8] Reuters América Latina Newswire. Perú más que duplica cuota de pesca anchoveta tras recuperación de biomasa, April 23 2013

El Niño risk and Peruvian fisheries

Peru's fisheries are some of the most productive in the world precisely because they sit at the end of the current system at the heart of the El Niño/La Niña cycle. In normal years, cold, nutrient rich water rises from the floor of the Pacific, just off the coast of Peru. This water is the basis for a vibrant marine ecosystem that sustains a productive fishery. In particular, the system hosts the world's largest anchovy population. Anchovies are the main precursor to fishmeal and fish oil, both of which are key components of many livestock and aquaculture feeds. They represent 86 percent of the country's catch by volume[9]. So, Peruvian fishing industry's profitability is fundamentally tied to anchovies. Anchovies, in turn, are particularly sensitive to the ENSO cycle. That means that Peruvian fishing company's profits are tightly linked to the ENSO cycle.

[9] Yvonne Evans and Sigbjorn Tveteras. Status of fisheries and aquaculture development in Peru: Cast studies of peruvian anchovy fishery. *Shrimp Aquaculture, Trout Aquaculture, and Scallop Aquaculture*, 2011

In El Niño years, that upwelling of cold water ebbs and shifts further into the Pacific, interrupting the ecosystem that is so important

to fishery companies. Anchovies migrate to cooler waters and spawn at depressed rates. That means that anchovies are not only scare in El Niño years, but their populations are dramatically lower in the years following an event[10].

Perhaps more importantly, El Niño creates a incentive problem among fishing companies that exaggerates the impacts of the climate phenomenon[11]. Modern fishing is capital intensive. It requires boats and processing plants, generally financed through debt. However, high levels of debt create serious cash flow problems for fishing companies. While industry revenues are highly vulnerable and subject to catastrophic drops in El Niño years, debt servicing is a fixed cost that is hard to avoid in case of a disaster. Consequently, companies that have historically over-fished even in normal years have been particularly disrespectful of ecosystem dynamics in El Niño years, when stocks are most vulnerable.

This dynamic led the industry as a whole into bankruptcy and nationalization after the 1972/73 El Niño[12]. The industry was gradually released back into private hands over the coming decades, but it was not until after the 1997/1998 El Niño that the modern fishing sector emerged, with the government allowing private ownership of industrial scale vessels[13]. Consequently, fishery companies have highly variable institutional memory of the devastating impacts of El Niño, with some firms lacking any top management who were working in the industry in 1997/1998.

[10] Richard T Barber and Francisco P Chavez. Biological consequences of El Niño. *Science*, 222:1203–1210, 1983

[11] Martin Aranda. Evolution and state of the art of fishing capacity management in peru: The case of the anchoveta fishery. *Pan-American Journal of Aquatic Sciences*, 4(2): 146–153, 2009

[12] Michael H Glantz. Science, politics and economics of the Peruvian anchoveta fishery. *Marine Policy*, 3(3): 201–210, 1979

[13] Martin Aranda. Evolution and state of the art of fishing capacity management in peru: The case of the anchoveta fishery. *Pan-American Journal of Aquatic Sciences*, 4(2): 146–153, 2009

Peruvian fisheries management

To prevent a repeat of the 1970s, the Peruvian government has experimented with many fisheries management systems. The current *Individual Vessel Quota* system launched in 2009 effectively allocates a set percentage of the country's annual industrial catch to individual firms with the overall catch set by the government's oceanographic institute, IMPARPE. Some portion of that allocated catch is tradeable, making the system similar to the *cap and trade* system used for carbon emission trading in the EU. Estimating a sustainable annual catch requires complex modeling and extensive sampling.

The Individual Vessel Quota system has increased industry profitability. That in turn has fostered optimism about the industry's future, with neutral academic observers suggesting that the system has altogether ended the incentive problems that lead to past population crashes[14]. We heard that sentiment echoed in meeting with some firms. Given that all of the largest historical crashes and times of most severe incentive incompatibility were catastrophic El Niños, it is very difficult to take that claim seriously. Indeed, to the extent that such

[14] Sigbjorn Tveteras, Carlos E Paredes, and Julio Pena-Torres. Individual Vessel Quotas in Peru: Stopping the race for anchovies. *Marine Resource Economics*, 26(3):225–232, 2011

"this time is different" thinking leads firms to increase their reliance on debt or ignore risk management, it may deepen the severity of the next crash.

It is difficult to estimate what percentage of the industry's USD 1.8 billion in revenues are lost in large El Niño events, because the current firms were too young to face the 1997/1998 El Niño. As an upper bound, we can look at the 1997/1998 El Niño and its impacts on anchovy catch. In the years prior to that event, Peru's annual catch was in the range of 7 million tons annually. In 1998, that dropped to roughly 1 million tons. Making the simplifying assumption that all industry revenue comes from anchovies, a large El Niño will cause revenue shortfall of roughly 85 percent or USD 1.53 billion.

Industrial fishing in Peru today

Following the government's decision to open fisheries to large private vessels, the sector consolidated quickly. Today, roughly a half dozen fishing companies, all associated with larger Peruvian conglomerates or international fishing companies, account for 70% of the country's overall pelagic fish production[15]:

- Tecnológica de Alimentos S.A.- TASA (parent conglomerate: Grupo Brescia)
- Corporación Pesquera Inca - COPEINCA (Grupo Dyer)
- Austral Group (Austevoll, Norwegian fishery company)
- Pesquera Hayduk (Grupo Martinez-Baraka)
- Pesquera Diamante (Grupo Ribaudo)
- Pesquera Exalmar (Grupo Matta)
- CFG Investment (China Fishery Group)
- Pesquera Centinela (Grupo Romero)

[15] Scotiabank. Sector pesca: Harina y aceite de pescado, situación actual. Technical report, Scotiabank Departamento de Estudios Económicos, 2010. URL http://www.scotiabank.com.pe/i_financiera/pdf/sectorial/20100418_sec_es_pesca.pdf

Despite aggressive (and sometimes successful) bids by foreign firms, the industry remains fundamentally domestic. Most of the firms listed with "Grupo" next to their name remain in the hands of industrial conglomerates with their roots in Peru and are managed out of Peru.

But international competition has attracted top talent to these firms. The CFOs we met with were shrewd negotiators, suggesting prices for insurance coverage at or below the pure risk. In many cases they had direct experience hedging interest rates and foreign currencies. Some had served as CFOs or top risk managers at large US firms.

Perhaps more importantly, they also had dedicated climate scientists who not only had the best available forecasts of sea surface temperatures across the Pacific, but also had the added advantage of data from their own fleets.

These climate teams provided the fisheries with information on the likelihood of sea surface temperature anomalies that was, in my opinion, as good or better than anything available to reinsurance companies. This created the possibility of adverse selection and is one reason why derivatives on El Niño/La Niña may be more appropriate for those fisheries than insurance. A dynamic price that moves to reflect the information available across all Peruvian fishing companies might provide a useful starting point for fishing companies and speculators to trade risk. Speculators will certainly remain suspicious of transactions with fishery companies that may have informational advantages. But a dynamic price can provide speculators with the assurance that competition is limiting the scope for information asymmetries.

This sophistication, both in climate analysis and in risk management, will allow fisheries to take outright bets on monthly SSTs. In so doing, they will provide information to the futures markets whose prices will be the basis for settling the options that will interest most hedgers. While these fishing firms would prefer to hedge with Niño 1.2 rather than 3.4, their climate teams will be comfortable forecasting either index.

Impressive climate staffs account for only a small percentage of the cost that Peruvian fisheries already incur because of El Niño. In addition to using mitigation strategies, like moving their fleet to different regions in the Pacific, fisheries maintain large cash reserves to service their debts in case of El Niño[16]. That strategy is costly because it requires companies to forgo current investment. By managing a portion of their El Niño risk through insurance, fisheries can invest more in their business today while benefiting from the same risk protection they would have received with a low-return strategy based exclusively on reserving. (See Introduction: Direct Climate Markets for a review of the academic literature documenting increased investment and firm value among firms that use formal risk management tools.)

[16] Milena Arias Schreiber, Miguel Niquen, and Marilú Bouchon. Coping strategies to deal with environmental variability and extreme climatic events in the Peruvian anchovy fishery. *Sustainability*, 3: 823–846, June 2011

The opportunity cost of savings

Of course, savings are a vital risk management tool. Insurance, derivatives, and related assets should never replace savings entirely. However, for companies with high internal rates of return, like those in the fishing industry, the opportunity cost of managing risk primarily through savings can be high. For a simple explanation of the benefits of insurance, compare the opportunity cost of using reserves to cover

El Niño risk to the opportunity cost of buying insurance.

Here I define the opportunity cost of reserving as the difference between the return a firm would have earned on the money it sets aside for risk management, if instead they had invested it in their business at their internal rate of return (IRR), and the return they did earn by keeping the funds in a liquid asset at the risk-free rate (RFR). By that definition, opportunity cost of reserving USD 100 is:

$$\begin{gathered}(\text{IRR} - \text{RFR}) * \\ \text{USD } 100 \\ = \text{Opportunity cost of reserving USD } 100 \\ \text{for an El Niño}\end{gathered} \tag{7.1}$$

Imagine that instead of reserving USD 100, a firm bought insurance coverage that would pay USD 100 dollars in the case of an El Niño. The firm pays a premium for that insurance and invests the rest at rate IRR. After paying that premium, the firm owns an insurance policy that has an expected value (E[insurance]). So the opportunity cost of buying insurance is the difference between IRR (what the firm would have earned if it had reinvested the premium) and the expected value of the insurance (as a percentage of the dollar paid in premium):

$$\begin{gathered}(\text{IRR} - \text{E[insurance]}) * \\ \text{premium per USD 100in notional coverage} \\ = \text{Opportunity cost of buying insurance that pays USD } 100 \\ \text{in case of an El Niño}\end{gathered} \tag{7.2}$$

When choosing between insurance and savings, a firm worried exclusively about El Niño should buy insurance whenever the opportunity cost of reserving is higher than the opportunity cost of insuring, since the firms receives the same protection (USD 100 in case of a disaster) at a lower cost:

This is equivalent to the condition:

$$\begin{gathered}(\text{IRR} - \text{RFR}) \\ * \text{USD } 100 \\ > (\text{IRR} - \text{E[insurance]}) \\ * \text{premium per USD } 100 \\ \text{in notional coverage}\end{gathered} \tag{7.3}$$

Now apply a conservative calibration (calibration that likely errs favor of reserving) to see if the condition holds:

- IRR = 1.2 meaning that the firm targets an internal rate of return of 20 percent for its projects
- RFR = 1.05 meaning that the firm can achieve a return of 5 percent on liquid assets that are set aside as reserves

- E[insurance] = 0.5 meaning that the firm expects to collect USD 0.5 of insurance payout for every USD 1 paid in premium. (Most insurance has an expected value below 1 because the insured must pay the insurance company a small fee for managing their risk. In this case, we have set the fee high to provide a very conservative estimate of the opportunity cost of the insurance.)
- premium per USD1 in notional coverage = 0.06 meaning that the firm pays 6 for every 100 of risk protection

Given these values, the condition for buying insurance holds true:

$$(1.2 - 1.05) * 100 > (1.2 - 0.5) * 0.06 * 10015 > 4.2 \qquad (7.4)$$

To be sure, this example makes some strong assumptions. No firm is exclusively interested in El Niño risk. But given the historical link between Peruvian fisheries and the ENSO cycle, that assumption is close enough to some managers' actual experience to demonstrate the idea that even with a modest internal rate of return, the implicit cost of reserving is relatively high and firms should consequently manage their most extreme El Niño risk through insurance, regardless of their risk aversion. Using insurance for some portion of a highly vulnerable firms' El Niño risk allows higher rates of safe investment.

Hedger interviews: International agribusiness

This section deals with large, vertically-integrated firms such as Cargill, Bunge, ADM, and Mars. They manage production and logistics for basic agricultural commodities (like soybeans) and industrial commodities related to agriculture. With some exceptions, their supply chains connect regions heavily influenced by ENSO to larger markets around the world. This means that they have substantial exposure to ENSO risk. Their scope also means that they are diversified, able to reshape their supply chains in response to climate anomalies. While they are natural hedgers, formal financial hedges will only be a part of a larger risk management scheme. Their interest in hedges will form around breakdowns and inefficiencies in their existing sophisticated risk management strategies.

ENSO risk and international agribusiness

The clearest indication of the importance of ENSO risk to these firms comes from the firms themselves. Bunge's 2010 and 2011 annual reports to shareholders suggest that ENSO risk does indeed overwhelm the firms' existing risk management plan.

Like both Cargill and ADM, Bunge relies heavily on southern Brazil and northern Argentina for agricultural production (particularly in

soybeans and sugar) and weather in the region has important and immediate consequences for their profitability. Historically, the region experiences drought during La Niña and flood during El Niño[17]. In fact, according to some of the weather experts I spoke with, the region hosts one of the strongest connections to the ENSO cycle, outside of Peru and Australia.

[17] Alice M Grimm, Vicente R Barros, and Moira E Doyle. Climate variability in southern South America associated with El Niño and La Niña events. *Journal of Climate*, 13(1): 35–58, 2000

The La Niña conditions of 2010 and 2011 were no exception to that historical pattern. Those years saw weather conditions that Bunge chairman and CEO Alberto Weisser called "hard to manage" in his 2010 letter to shareholders. The annual report details the specific losses catalyzed by La Niña's drought[18]:

> In sugar and bioenergy, results were adversely affected by dry weather in Brazil which reduced the volume and quality (sucrose content) of sugarcane available for milling, thus reducing the production of sugar and ethanol and lowering our capacity utilization which resulted in increased fixed cost absorption. The drought also damaged our sugarcane plantations, resulting in increased depletion of these assets, which will require replanting.

[18] Alberto Weisser. 2010 annual report. Technical report, Bunge Limited, April 2010. URL http://phx.corporate-ir.net/phoenix.zhtml?c=130024&p=irol-reportsannual

Interestingly, in the 2011, annual report, we see that Bunge has contingencies in their forward contracts that are meant to manage this type of risk. Sugar suppliers paid Bunge for failure to deliver on contractual shipments. Those contingencies triggered in 2010, paying Bunge "approximately USD 14 million"[19]. Even with that compensation and a rise in the market price of the sugar-related products they did produce from the region, the company still suffered.

[19] Alberto Weisser. 2011 annual report. Technical report, Bunge Limited, April 2011. URL http://phx.corporate-ir.net/phoenix.zhtml?c=130024&p=irol-reportsannual

One weather analyst specializing in natural gas and agribusiness suggested, the exposure of firms like Bunge goes beyond production and processing in the impacted region. The companies themselves sign forward contracts to deliver large shipment of soybeans (for example) to a specific port within a short window of time. Their global scope and world-class management allow them to do this. But weather may require them to rely on a less efficient supply chain, shipping from the US rather than Brazil. The differences between the cost of shipping from the more efficient and the less efficient supply chain may be substantial. Given the thin margins that they work on, it may in fact jeopardize their profitability.

While Argentina and Brazil will be the center of attention for agribusinesses looking to hedge ENSO risk[20], there are other regions where niche industries create even higher risk concentration. For example, Mars is susceptible to interruptions in the cocoa supply chain, concentrated in West African countries that also have substantial ENSO-related weather risk. That vulnerability is also likely to generate hedging interest. According to my interviews, it has already led Mars to hire a particularly large meteorology department that closely

[20] One experienced weather trader indicated that Brazil's regulatory and tax treatment of hedging with derivatives was highly disadvantageous. He said that those concerns had scuppered past deals with large international agribusiness firms and would require attention for any ENSO hedges.

watches ENSO. That investment appears astute given the importance of ENSO forecasts to recent volatility in the world price of cocoa.[21].

[21] Ruona Agbroko. Cocoa at nine-month high in weather fear, August 1 2012

Business models and concentrated geographic risk

Bunge's troubles with weather during the 2010/2011 La Niña suggest a paradox also impacting reinsurance companies. Both these large agribusinesses and large reinsurers have the scale to do things that other companies cannot - pay on large claims or deliver massive commodity shipments with great regularity. However, taking full advantage of that institutional capacity often means concentrating in high return activities with barriers to entry related to scale. Only large firms can insure hurricanes, so there is handsome compensation for the firms that do. Similarly in agribusiness, only large firms can effectively build their own logistics infrastructure in productive regions of the world that have chronically under-invested in infrastructure, like Brazil. The firms that make that investment and manage it well, can supply then entire world with basic commodities.

Both strategies create large contingent liabilities that may outweigh the diversification that their scale would otherwise allow. Reinsurer's capital resources allow them to diversify and insure risks, like the explosion of a space shuttle, that are entirely uncorrelated to their portfolio. But they never achieve great diversification because the largest and least elastic demand for that capacity is for perils like Florida hurricanes. The returns from those peak risks goad reinsurers into focusing their portfolios.

Similarly, large firms like Cargill, Bunge, and ADM can and do produce more products in more places around the world than other agribusinesses. But much of their logistical expertise ends up focused on moving soybeans from Brazil and Argentina to the rest of the world.

Chatting with the head risk manager at one of these firms, I asked if he enjoyed visiting Brazil. I assumed that the occasional trip to the tropics would be a welcome change of pace for someone otherwise bound to a skyscraper in a northern American city. His response told volumes about the company's risk exposure in Brazil. His work trips were too frequent, too long, and too intense to enjoy personally.

Risk management at large international agribusinesses

The head risk manager I interviewed at one large firm suggested that not only are these firms vulnerable to ENSO risk, but they would be comfortable managing that risk through trading. His firm rarely uses weather derivatives because they feel that the basis risk is too high, especially on rainfall indexes. He would however gladly consider ENSO

contracts provided that he had analysis on the contract from a trusted weather advisory firm like MDA EarthSat.

With that information, he said that the research time required to enter their first trade was approximately 45 days. Presuming that initial research did not raise any serious concerns, his firm would enter very small trades simply to learn more about how a contract works. He said that they often felt they had little choice but to start with the smallest possible positions in new markets because the exchanges failed to provide valuable educational materials.

He was relatively open to any form of ENSO hedging although he preferred derivatives trades that were costless to open. While he believed his firm would be allowed to freely trade swaps as *end-users* under Dodd-Frank, he still wanted to avoid those contracts if possible.

Hedger interviews: US energy

In January and February of 2013, I spoke with weather experts at a handful of US power and energy firms. Those firms primarily trade electricity and natural gas. Electricity markets are more regional as the inability to store electricity creates geographic pockets of supply regulated on a state by state basis.

Weather and climate analysis in the US energy sector

Like the Peruvian fisheries, all the energy firms I talked with have dedicated meteorologists who closely follow ENSO forecasts. Those meteorologists indicated that summer temperature spikes in the western US (primarily Texas and California) were their primary ENSO-linked risks that they would like to see hedged. In particular, firms with physical assets would have a "powerful incentive" to hedge, according to one interview subject.

Occasionally meteorology teams at these firms help hedge using weather derivatives. More often, they simply provide their gas and electricity traders with daily updates on weather patterns. Those updates are considered so fundamental to trading decisions that they must be ready daily before traders arrive. Meteorological teams get to their offices in the early hours of the morning to prepare those reports.

Most gas and electricity traders prefer this weather information in its most simple format possible. One meteorologist described how his forecasts filtered down to traders as little red and green arrows indicating whether temperatures were forecast to rise or fall in specific areas on a map.

The meteorologists I interviewed were puzzled by this behavior,

both at their firms and in the industry as a whole: Firms are paying for top-quality expertise. But they systematically water down the resolution of the resulting analysis. Why not simply use the high information directly in weather markets either for hedging or speculation?

Weather derivatives and the US energy sector

Energy firms could use their climate teams for speculative bets on weather, just as they do for speculative bets on energy prices. However, Chincarini [2011] (discussed in chapter 3 with tables reproduced in Miscellaneous Appendix) matches weather prices to actual outcomes on major exchange-traded weather indexes and finds remarkable price discovery, despite their low liquidity. Some of the markets studied did not offer either side of the trade a consistent premium. So, it is possible that energy firms do not believe that they can consistently profit from speculative trades.

The superficial answer for why the firms do not hedge more aggressively is that standardized weather markets involve too much basis risk. This was a common theme from all my interviews with firms engaged in weather trading. When firms hedge weather, they strongly prefer bespoke transactions, often structured as OTC swaps, to standardized weather indexes. But specialized agreements have low liquidity and increase the chance of information asymmetries, as discussed above in the context of the first weather derivatives trades. So basis risk forces firms into contracts that create a *market for lemons problem* [22].

[22] George A Akerlof. The market for "lemons": Quality uncertainty and the market mechanism. *The quarterly journal of economics*, pages 488–500, 1970

While all the traders I talked with mentioned basis risk, they were also careful to point out that the power and energy industry's unwillingness to bring weather trading into their core business is, above all, a collective action problem. Many people at many firms would like to trade with one another, if only there were more people trading in these markets.

The work in chapter 5 tested path dependence for trading activity. If there were no path dependence and volumes followed a log-normal random walk, then all of the probabilities in that chapter's transition matrices would be roughly equivalent. But those probabilities vary greatly from one level of volume to another, herding contracts into liquidity buckets. This suggests that there is indeed some path dependency to trading, consistent with traders' beliefs.

Enron famously may have solved that collective action problem, if they had continued to operate. They aggressively sought to bring trades across a host of markets, including the weather derivatives they helped launch, onto their electronic platform. But that electronic plat-

form was unlike its contemporaries in the equities markets - sophisticated matching engining allowing firms to transact directly[23]. Instead, Enron would act as counter-party to all trades on their platform. In that sense they were a clearinghouse, but since they also considered themselves part of a trading firm, they were willing to take relatively speculative, non-standardized trades that would be difficult to offload on to other traders[24].

[23] Scott Patterson. *Dark Pools: High-speed Traders, AI Bandits, and the Threat to the Global Financial System*. Crown Pub, 2012

[24] Bethany McLean and Peter Elkind. *The Smartest Guys in the Room: The Amazing Rise and Scandalous Fall of Enron*. Portfolio Trade, 2004

Background on Australian Hedgers

Eastern Australia may be the single largest concentration of ENSO exposure on the planet. Given that fact, I was optimistic that Australian businesses, particularly in insurance, mining, agribusiness, and power generation, would enthusiastically support the emergence of ENSO markets.

Risk premiums on catastrophic Australian risk

What I did not appreciate before my trip to Australia was how inexpensive indemnity-based reinsurance coverage was for Australian risk. Talking to large reinsurance brokers in Sydney, I learned that indemnity coverage for most risk was written at or near actuarial fair value. Reinsurers and brokers in Bermuda and the United States were emphatic that Australian risk is under-priced and competition for that under-priced risk is fierce. One strong supporter of El Niño markets in general summed up the sentiment saying, "[g]ood luck with Australia." That news was sobering.

Australia has relatively strict prudential supervisory rules for insurers[25]. But reinsurance prices are so low in the country that reinsurance brokers reported to me that local insurance companies routinely exceed prudential benchmarks. It will not be easy to attract Australian hedging interest to ENSO risk markets. New markets will be hard-pressed to beat the combination of low price and basis risk offered by indemnity-based (re)insurance in Australia.

[25] Aon Benfield. Regulatory capital: Requirements ofn the rise. Technical report, Aon Benfield, June 2009. URL http://thoughtleadership.aonbenfield.com/

With those competitive pressures in mind, I view the following as low probability firms and applications for early ENSO hedging in Australia:

- Any risk that can be packaged as business interruption or liability coverage without creating substantial moral hazard or adverse selection
- Australian insurance companies
- Utility companies and agribusinesses looking to protect assets against flood or drought

While that list is broad, it does suggest a way forward for ENSO markets. To succeed in Australia, ENSO risk markets must focus on markets that cannot or will not be covered by indemnity (re)insurance. Also, there is a niche for ENSO risk markets to service hedgers who place a premium on early payments with low legal uncertainty, a feature that indemnity payments simply cannot offer.

Hedger interviews: Australian Utility companies with a legal mandate to perform preventative maintenance

Australian reinsurance brokers offered one opportunity for covering Australian ENSO hedgers that is unlikley to be stymied by competition from under-priced reinsurance: utilities with a legal mandate for preventative maintenance of brush that tends to catch fire during El Niño.

Under drought conditions power transmission lines "arc", igniting dry brush in the Australian outback[26]. In 2009, such an arc started the Black Saturday Bushfire that caused 173 deaths, destroyed over 2,030 homes, and displaced an estimated 7,562 people in Victoria[27,28]. These fires are, however, largely preventable with careful maintenance of brush around transmission lines.

Australian courts have ruled that power transmission companies have a positive obligation to perform that maintenance and found the companies liable for property claims related to the fires. Those damages were passed to insurance companies (particularly Lloyds syndicate members) who sold liability coverage to the power transmission companies.

The reinsurance brokers I talked to in Sydney indicated that Lloyds members have concluded that there is too much moral hazard built into the liability coverage they were selling. The power transmission companies do not have the necessary incentive to perform preventative maintenance of the brush around their transmission lines. Moreover, the coverage had been so mispriced that it is unlikely that the line of business will produce a profit in the foreseeable future. Consequently, some reinsurance brokers in Australia believe that Lloyds members will not continue offering coverage for bushfires.

I believe that power transmission companies represent the best opportunity that ENSO markets have to gain a foothold in Australia:

- They clearly need and want risk coverage against the type of systemic drought in Eastern Australia caused by El Niño.

- If they can get traditional liability coverage in the future, it will be under stricter terms than in the past.

[26] Gary Hughes. Electric arc "was cause" of bushfire, September 25 2009

[27] Victoria is home to Australia's second largest city Melbourne.

[28] Parliament of New South Wales. Full day hansard transcript (legislative assembly, 13 March 2009, corrected copy, March 13 2009. URL http://www.parliament.nsw.gov.au/prod/parlment/hanstrans.nsf/V3ByKey/LA20090313?Open&refNavID=

- Courts have already found these companies liable for their failure to perform preventative maintenance, so the companies should place a special premium on risk management solutions that facilitate mitigation.

- Many of those companies are parastatals with explicit mandates to use risk management tools to insulate taxpayers from the costs of their operational risks.

But, to meet the needs of those firms, ENSO coverage will have to be combined with some other parametric indexes to provide coverage for high risk conditions not related to the ENSO cycle. Specifically, the 2009 event will loom large for these hedgers and so a regional drought index will have to offer them payouts if 2009 conditions re-occurred. The climate scientists I interviewed suggested that there would be no problem constructing regional ENSO-linked indexes for hedgers. As long as the index decomposed ENSO risk, it could easily accommodate hedging on dedicated ENSO markets.

Hedger interviews: Peruvian banking

The Peruvian banking sector's risk was a prime focus of GlobalAgRisk's Gates Foundation sponsored work. Dr. Benjamin Collier[29] spearheaded that effort, quantifying the impacts of El Niño risk on Peruvian banks and on credit within vulnerable communities[30,31]. His forthcoming dissertation (Collier [2013]) provides a full treatment of the topic, so I will restrict my discussion here to briefly reviewing some of his estimates of the potential scope of the sectors' formal hedging.

Dr. Collier estimates that 8 firms (including both microcredit lenders and parastatal banks targeting larger loans) represent roughly USD 100 million in notional exposure to extreme El Niño. That estimate is based on his research of past El Niño related losses. His analysis indicates that smaller banks with lending portfolios concentrated in at-risk areas should target hedging that protects roughly 5 percent of the value of their portfolios, while larger but still geographically vulnerable institutions should target hedging of 1 percent[32].

The country's commercial banks are also vulnerable to El Niño shocks but their lending is better diversified. Dr. Collier estimates that their loans to highly vulnerable sectors (agribusiness, fisheries, and other financial institutions) total roughly USD 2.9 billion. So even if they formally manage a relatively small portion of that vulnerable portfolio on ENSO markets, their hedging interest alone would be of sufficient scale to justify a CAT bond issue.

[29] Then with GlobalAgRisk/the University of Kentucky, now doing post-doctoral research at University of Pennsylvania's Wharton School.

[30] Benjamin Collier and Jerry Skees. Increasing the resilience of financial intermediaries through portfolio-level insurance against natural disasters. *Natural Hazards*, 64(1):55–72, 2012

[31] Benjamin Collier, Ani L Katchova, and Jerry R Skees. Loan portfolio performance and El Niño, an intervention analysis. *Agricultural Finance Review*, 71(1):98–119, 2011

[32] Benjamin Collier and Jerry Skees. Increasing the resilience of financial intermediaries through portfolio-level insurance against natural disasters. *Natural Hazards*, 64(1):55–72, 2012

Hedger interviews: Australian Hydropower

Besides power transmission firms, the second most important source of likely hedging interest are electricity producers interested in hedging reservoir levels on their hydro-power dams. Hydro-power companies manage the flood and drought risk inherent in their long term delivery contracts by actively trading electricity on spot and futures markets. They should, consequently, be excellent candidates for El Niño hedging.

I heard about two factors complicating that story when I spoke with traders in the risk management department at one large hydro-power company with assets across Eastern Australia. First, drought does not create immediate problems for hydro-power producers with large reservoirs. They face shortfalls only after successive seasons of drought. That increases the basis risk on El Niño hedging.

Second, when they do face production shortfalls, their first line of risk protection will always come from hedges on electricity markets, since they believe that those hedges have low basis risk and those markets have acceptable liquidity.

Historically, prices on electricity markets have been subject to manipulation and risen far above their long-term equilibrium in time of systematic shortfall[33]. So, electricity hedges have a great deal of basis risk as well. But that basis risk is difficult to quantify on relatively young markets. This means that brokers may need to help hydro-power producers stress test their portfolios before they are willing to trade ENSO derivatives as part of their drought risk management portfolio.

[33] Eunmi Cha. Risk management in ERCOT power markets. Presentation, May 2012. URL http://www.rinfinance.com/RinFinance2012/agenda/

Hedger interviews: Peruvian agribusiness, energy, and mining

Beyond fisheries and banking, there are large agribusiness, mining, and energy firms that face El Niño risk in Peru. I have grouped them together here because, to the extent that they would be interested in El Niño hedging, that interest would revolve around specific installations or projects. Stress tests for El Niño vulnerabilities on individual installations will not generally port simply over to other such installations. So identifying and hedging vulnerabilities in among firms in these industries will be a resource intensive process.

GlobalAgRisk has met with many such groups to discuss applications of El Niño hedging. Based on those meetings, I believe that a small subset of those groups have the sophisticated risk management, scale, and interest necessary to participate in formal hedging, given attractive pricing on their hedges. I do not believe that I can accurately estimate the aggregate size of hedging interest from these individual

projects.

Hedger interviews: Australian agribusiness, mining and tourism

In addition to power transmission firms and hydro-power generators (discussed below), there are three other groups/opportunities that I could not adequately evaluate on my trip to Australia, but suspect may still be sources of early ENSO hedging. The first are Australian coal firms with assets in eastern Australia that were damaged by the 2010 and 2011 La Niña floods[34]. Those floods forced at least one firm, Macarthur Coal, to invoke a force majeure clause in their loan agreements[35]. Within the year, a larger American rival purchased the firm, despite earlier failed attempts at the same acquisition[36].

While traditional indemnity insurance and diversification through international mergers, I suspect that Australian mines could easily mitigate their flooding risk with strategic spending as soon as strong La Niña forecasts begin to emerge. Unfortunately, I was not able to test those suspicions on my research trip to Australia. I reached out to some of the mining groups identified by Oxley [2011] but none responded to my requests for a meeting.

Another uncertain opportunity is embedding options in loans. I met with a multinational agribusiness lender with substantial exposure in Australia. They were skeptical that their bank needed its own ENSO hedges, but they were receptive to the notion that they could implicitly bundle options with loans by offering loans with debt relief triggered by ENSO.

I discuss my experience attempting to bundle loans with insurance in Peru in greater detail in the following section on Peruvian banks. Based on that work, I believe that they are unlikely to produce much ENSO hedging in the first years of the market's existence. Many agricultural lenders in Peru had a similar reaction as the bank I spoke with in Australia. They did not want to incur any short term expense hedging their ENSO risk, but they recognized that such risks are a drag on their long-term loan performance. Consequently, they were attracted to the idea of passing those risk management costs off to borrowers. However, once the Peruvian banks saw the cost of a fully priced ENSO hedge built into a loan, they told us that their clients would be sensitive to the price difference and unwilling to sign up for risk protected loans, even with substantial education on the value of the embedded option.

The clients of large multinational agribusiness lenders are likely more familiar with formal risk management than the clients of microfinance groups in northern Peru. While that may leave them open to hearing about the value of risk protected loans, it also means that

[34] Lawrence J Oxley. *Extreme Weather and The Financial Markets: Opportunities in Commodities and Futures*, volume 538. Wiley, 2011

[35] Australian Associated Press. Macarthur coal lifts profit guidance, May 4 2011

[36] Peabody Energy. Peabody Energy (NYSE: BTU) completes acquisition of Macarthur Coal. Technical report, Peabody Energy, December 2011 2011. URL http://www.peabodyenergy.com/content/261/Press-Releases/2011

clients will have access to traditional indemnity insurance. It is not clear to me, based on my research to date, which of those countervailing factors would dominate in Australia.

Tourism risk that cannot be covered by business interruption may also provoke some hedging. Many Australian reinsurance brokers mentioned that ENSO hedging would be valuable for operations related to tourism, particularly in Northeastern Australia. Those businesses have clear ENSO risk but that risk may not translate simply into insurable interest on business interruption policies. To the extent that this is true, then some of the larger and more professionally managed tourism related businesses may provide important early support to ENSO markets. Ski resorts in the United States offer precedence for tourism related businesses adopting new weather hedges, providing important early support for new markets. My research did not reveal specific tourism-related hedging opportunities (i.e. individual businesses seeking coverage), so while I believe this is a promising avenue for hedging, reinsurance brokers and financial intermediaries with strong relationships in the industry will be critical to generating tangible hedging.

Finally, flood map coverage in Australia is poor relative to the US and much of Europe. That circumstance could provide the justification for some ENSO hedging. Given the importance of SSTs to the hydrological cycle in Australia, it is possible that insurance companies, eager to extend flood-related coverage to data-poor regions of Australia, may be willing to price their coverage as best they can, given their limited data and then imperfectly hedge their model uncertainty using ENSO derivatives. If those hedges check an insurance company's flood related exposure then they will be able to think of those early policies as loss leaders. The policies will provide them the information they need to improve their pricing over time, without the risk that they will suffer a large loss that will knock them out of the market altogether. That type of exploratory underwriting is subject to substantial moral hazard and adverse selection. Therefore, traditional reinsurance groups should be skeptical of providing coverage on pools of that risk. While that is theoretically a strong case for a derivatives or parametric reinsurance, I heard from many reinsurance brokers that such skepticism may not prevail in the current competitive environment, with reinsurance-type capital growing at an exponential rate while hedging interest for reinsurance-type risk is only growing arithmetically.

Hedger interviews: Conventional reinsurance and ILS

As I discussed in chapter 2, reinsurers and reinsurance related funds should, theoretically, be interested in selling El Niño coverage as a hedge against their own book of risk. Selling that protection would

add an asset to their portfolio that is negatively correlated to their peak risk. They would effectively be paid to hedge their own books. It is rare that anyone has an opportunity to hedge their own risk directly and get paid to take that protection. (The important exception being an asset with positive return that lowers your risk through diversification. But this is distinct from an asset that has a direct, negative causal link to losses in your portfolio, an outright hedge.)

Indeed most of the ILS funds I talked to were excited to participate in an El Niño market. However, even those interested funds indicated that were unlikely to view El Niño exposure as a hedge. They saw El Niño exposure as an impressive diversifier, but not something that they could or should use explicitly for the purpose of managing hurricane exposure.

Portfolio management and basis risk

Reinsurers offered many explanations for their reluctance to hedge with ENSO markets. Some of the groups said they simply do not hedge. They said that reinsurance is a buy and hold business and that they managed risk exclusively by limiting their exposures to certain lines of business. That response was common among traditional reinsurance groups, who also indicated that they categorically did not use their balance sheets in a way that allowed for the ad hoc addition of derivative exposure, even if that exposure improved their overall risk position.

At least the first few times I heard that response, it puzzled me. Anyone in risk management should jump at the chance to get paid to hedge their own portfolios. My confusion was shared by Richard Sandor decades earlier when he first began investigating exchange-traded alternative to reinsurance:

> I had always harbored a romantic image of the group of insurance syndicates, mainly because of the 1936 movie Lloyd's of London. The movie painted the members of Lloyd's as innovative risk takers who insured the British merchant fleet during the Napoleonic wars. Lloyd's had been instrumental in helping Lord Nelson win the battle of Trafalgar. I was crestfallen and disillusioned when Bob described to me the actual lack of imagination of many of the syndicates. I found it paradoxical that those who were willing to underwrite nontraditional risks would not consider new risk management tools.

The more nuanced rejection that I heard from a few seasoned veterans in ILS/reinsurance was that risk management in their industry is focused almost exclusively on loss scenarios that threaten solvency. Basically, a reinsurer needs to worry only about making good on large claims. If years of small or moderate claims prove difficult for reinsurers, then they simply are not running their business well, and their

problems are deeper than any marginal hedge could fix. To them, selling El Niño protection seemed to be just such a marginal hedge. If the premiums for hurricane risk closely matched expected losses then ENSO's marginal offset would matter a great deal to portfolio returns. But the industry insists on large markups for hurricane risk specifically to avoid having to fine tune (or over-fit) their risk estimates. (I look at a related dynamic at the end of chapter 4.)

Moreover, ENSO markets would offer hedges with a great deal of basis risk. El Niño years may, on average see, on average, 4 billion less hurricane damage in the US and Caribbean than neutral and La Niña years. But the link is probabilistic. Hurricanes have occurred in El Niño years and if, in the future, one of those storms happened to hit Miami then the hedge would be worse than worthless (i.e. leaving them to pay losses on the hurricane claims and ENSO bets that went bad).

It is possible, they said, to decompose hurricane risk, isolating some ENSO component. That decomposition may well lower expected losses. But reinsurers' lower probability loss scenarios remain unchanged or even deteriorate with ENSO hedging, since it is theoretically possible to lose money on your insurance book and on your hedge in the same season. Those scenarios will only occur with low probability. But those low probability scenarios drive capital adequacy considerations.

Uncorrelated risks and risk premiums

Not only does this basis risk problem check ENSO's value as a risk management tool, but because capital requirements for low probability events remain unchanged, it is difficult to offer clients a large discount on their coverage in recognition of ENSO's negative correlation to peak risks. The risk professionals I talked to argued that pricing for off-peak risks is driven by the the cost of reserve capital. Margins on those risks are in fact already quite low. The fact that El Niño risk is objectively better than other off-peak risks from a Markowitz portfolio prospective is immaterial.

To be sure, the connection between El Niño and hurricanes interested my interview subjects at ILS funds. But one interviewee summed up the general attitude, advocating a "soft sell." He said that industry understands that hedgers should get an attractive pricing on their El Niño hedges, but that offset may be difficult to quantify.

Dynamic risk management and live CAT trading

I also suggested to interview subjects that reinsurance related businesses could change their El Niño exposure within the predictive win-

dow, as the phenomenon looked more or less likely. Given their expertise in meteorology, this might allow them to recover some of the cost of hedges that weren't likely to be exercised. Most of the organizations I talked to, including the more traditional reinsurance groups, likened that type of strategy to *live CAT* trading, adding or subtracting storm exposure in the days and hours before a hurricane landfall.

Despite the fact that traders at those organizations personally relished any opportunity for CAT trading[37] it remains a very small part of their businesses. They considered that small part speculative rather than true risk management. Moreover, they suggested a handful of organizational factors that curtailed the growth of live CAT trading:

[37] They offered this opinion unprompted by me.

- The capital for trading specific risks is alloted at the beginning of their budgeting cycle. That makes it difficult to change portfolios in response to emerging threats.

- The reinsurance and ILS businesses are relationship-based. One accepted way that reinsurers and ILS funds maintaining relationships with the brokers and issuers that give them access to deal flow, is to accept exposure on a deal they consider a loss-leader. That desire to maintain relationships clouds some risk management decisions. Seo [2012] laments that "... many ILS managers have become obsessed with deal access and flow. The horse-trading of good deals against marginal deals has inevitably brought about mediocre returns in the average ILS execution."

- The shareholders of reinsurance groups and ILS funds are increasingly traditional asset managers like hedge funds. Those asset managers want exposure to peak risks at high expected rates of return and believe that they can take care of their own risk management by keeping the stakes at a small percentage of their overall portfolios.

I do not accept any of those arguments as reasons why the reinsurers and ILS funds should not start selling ENSO coverage. However, these arguments are strong enough and sufficiently prevalent in the industry to undermine the pressure to sell ENSO coverage in the near term.

Speculator interviews: ILS funds

Insurance-linked security funds are eager to participate in ENSO markets. Although they would prefer that trading concentrate in CAT bonds, they expressed the will and ability to trade derivatives as well. Based on the uniformity of that reaction, I believe that ILS funds will

provide all the speculative capital necessary to consummate the first round of hedging on an ENSO market.

Innovation in ILS

In a low interest rate environment, with fierce competition driving down prices for off-peak risk in particular, and a flood of new capital entering such funds, I also believe that ILS funds will speculate in ENSO markets at more aggressive prices than traditional reinsurers. Multiple top fund managers told me explicitly that this was an auspicious time to scale up El Niño/La Niña risk coverage because hedgers would receive rates that were unattainable in the market just a few years ago. One suggested that CAT bonds issued on ENSO risk would enjoy a "crushingly low price."

Regardless of its form, the first hedges placed in these markets will be loss leaders (at least in terms of opportunity cost), for the funds offering protection and the brokers arranging the deal. Both brokers and funds will naturally look to recoup some of those losses by trading on higher margin, bilaterally negotiated trades. That is one reason why they strongly prefer that ENSO markets launch as CAT bonds rather than options.

Even if bilateral negotiation does not provide brokers and funds higher margins, it does help preserve the first mover advantage that both will have for subsequent deals. Firms involved in innovative ILS trades are more likely to be contacted about similar future trades.[38] One ILS manager estimated that his fund could expect to enjoy preferential access to related deal flow for up to two years after an innovative trade. By contrast, he explained, the ability to extend that advantage is much lower if you create the infrastructure for others to do the same trade, as would be the case with exchange-traded products where all counter-parties selling protection are perceived as equals - with equal opportunity to bid on the marginal dollar of coverage extended on identical legal terms with equal counter party risk (thanks to central clearing).

[38] Seo [2012] suggests, "... the two most important qualities that attract good deal flow have been reputational value of the ILS manager, and the manager's willingness to trade counter to the market..."

ILS funds' views on ENSO options

One ILS fund manager explained that the fixed costs of trading a full options chain on ENSO would actually be higher than for individual CAT bonds. Trading a CAT bond is a one-time decision for an ILS firm. For a risk as straight-forward as ENSO, that decision would require no dedicated resources from a fund.

By contrast, if a fund decided to act as a market maker on ENSO derivatives markets, it would first need to develop a model for changing prices over time, in response to new information, just as I did in

chapter 3. That will require an initial investment of expensive staff time. But the investment will not end when the model is complete.[39]

Someone will have to revisit that model every time a new trade comes in. That will require dedicated staff time, if not a full-time staff member. The cost of hiring a technically capable individual, with a background in trading, and interest in meteorology, is high.

Derivatives markets allow hedgers to enter relatively small trades. Given the opportunity, hedgers will limit themselves to especially small trades in the first days after a market opens. This means that dedicated staff will have to pay their own salary through fees stemming from a trickle of small trades until the market gains wide acceptance.

Moreover, low volumes will seed funds' suspicion that they are on the wrong side of asymmetric information. Knowing that fisheries have sophisticated proprietary analysis of Pacific SSTs, funds will naturally assume that they will be at a disadvantage on a fraction of trades inside of the predictive window.

This would not be a problem if funds could operate as genuine market makers, quickly off-loading exposures to other traders. But in an illiquid market, where would-be market makers may have to inventory significant exposure as they wait for new trades, asymmetric information is a particularly serious threat.

The ILS funds I spoke to said they would only be willing to make markets within the predictive window on an exchange, if they were protected by large bid-ask spreads. That precondition might be enough to provoke a *market for lemons* problem, unraveling the whole market.

By contrast, in a bilateral market, funds would have some room for price discrimination that they could use to insulate themselves from the effects of asymmetric information - trading with groups like the fisheries only when they are extremely confident in their models.

Finally, in a related but subtly different problem, if funds were true market makers in ENSO options they would have to post bids and asks for a whole options chain (contracts with a range of triggers). This means that they would be subject not just to asymmetric information on the occurrence of large events (the primary problem in dealing with fisheries) but also to asymmetric information about every probabilistic outcome short of a catastrophic El Niño/La Niña.

By noticing pricing discrepancies between a fund's posted prices, traders could make smaller amounts of money through arbitrage. One fund manager suggested that arbitrage would "bleed to death" a single fund bold enough to act as market maker. That may be hyperbole, but it illustrates a more modest problem: that arbitrage losses could overwhelm the revenues from market making. The danger of that type

[39] I believe that I've already done a great deal of the necessary work. Hence, those costs should not be prohibitive.

of arbitrage is lower when market makers can reference an arbitrage based pricing formulas, as in equities markets. As discussed in chapter 3, no such formula is available for ENSO.

For all those reasons, if ENSO were launched on an exchange, most trades would be bilaterally negotiated *block trades*. Block trades might offer greater post-trade transparency than is currently available in ILS markets. But both trade types would offer similar pre-trade transparency (see chapter 4 for a discussion of pre and post-trade transparency,) so it is not clear that exchange-traded markets would offer clients substantially better pricing.

Transitioning ENSO from CAT bonds to exchange-traded derivatives

Those factors clearly favor ILS over options for the first iteration of ENSO markets. However, none preclude the eventual emergence of an options market. Conceivably, after an initial phase in which brokers and funds recoup the fixed costs associated with their early modeling, establish a client base, and confirm that there is in fact sufficient hedging interest to support dedicated staff, then market activity could move over to an exchange.

At that point, the primary problem in establishing liquid markets would be the incentives created by high-margin trading on ILS markets. In my interviews I heard that brokers and more traditional speculators actively opposed previous high profile attempts to move reinsurance risk to exchanges (discussed above), suggesting to hedgers that moving their business to such markets would negatively impact their working relationship going forward. One reason why some interview subjects believed that ENSO markets might succeed where those experiments failed was precisely because the entire risk market today consists only of one reinsurer selling a small policy to one client. If they launched tomorrow, there would be no entrenched interests opposing ENSO derivatives.

Exchange-traded El Niño/La Niña markets will have to pick their poison: face a collective action problem related to high start up costs now, or face a principal-agent problem in the future.

Speculator interviews: Dedicated weather trading desks

The small set of hedge funds dedicated trading weather derivatives[40] offers another promising source of interest in ENSO markets. These firms use ENSO as an input to their current trading; they are very comfortable with traded risk; and, perhaps most importantly, their trading is guided by an attitude toward risk that is diametrically opposed to that of traditional reinsurers.

[40] Most of these funds are linked either to larger ILS funds or to multi-strategy hedge funds.

I spoke at length with the head trader for one successful weather fund. He said that while it has a specific mandate to weather, the firm sees risk in generic terms. In fact, the firm traded for a substantial part of its early life without any meteorologists on staff. Then, as now, they saw their strategic advantage coming not from any particular expertise in weather but from rigorous quantitative portfolio management.

Relatively low risk-adjusted returns do not preclude their participation in any given trade. Instead, they evaluate how every trade contributes to their portfolio, presuming it offers more than a few hundred basis points ins expected value. The contrast was particularly clear in their answers to my quantitative survey. (See chapter 8.) Dedicated weather traders rarely marked any contracts as un-tradeable during the survey's calibration exercises.

Confident that they can construct profitable portfolios out of a diverse collection of risks, these funds are more concerned with the search for motivated weather hedgers. In general, they cannot find enough counter-parties to pay them to take on weather risk.

That is an important reminder for ENSO markets: even if ENSO markets are supported by aggressive speculators, eager to close bid/ask spreads, sclerotic or unbalanced hedging will stymie the development of liquidity.

All of these groups were unequivocally supportive of exchange traded El Niño/La Niña derivatives although they noted that trading volumes throughout the weather markets had fallen in recent years (confirming the story told by figures 6.10 and 6.11). OTC transactions accounted for the majority of their overall deal flow and most of their on-exchange trades were bilaterally negotiated blocks. One firm I spoke with does not trade off-exchange and was understandably interested in seeing any ENSO risk market begin as futures and options.

As mentioned above, the large ILS funds with dedicated weather-trading groups that I interviewed indicated that they would classify ENSO risk as weather rather than catastrophe - assuming that it was traded as a derivative.

Speculator interviews: conventional reinsurance groups

El Niño coverage could act as a hedge on a traditional reinsurance portfolio. However, GlobalAgRisk's reinsurance partners priced their coverage for Peruvian banks as a speculative bet on the occurrence of El Niño, without much, if any, consideration of how the risk fit into their larger portfolios. In the first sales season, that produced a rate on line for that coverage three to four times the expected risk on the

policy.[41] So, if reinsurers' first instinct is to price El Niño coverage at speculative rates, it makes sense to ask, would those same reinsurers continue to speculate on larger, more standardized ENSO markets?

[41] GlobalAgRisk helped negotiate that rate down after it became clear that the markup was a threat to sales

The answer appears to be a qualified yes. I interviewed many conventional reinsurance groups (reinsurers as well as the host of groups that supply conventional reinsurance coverage through sidecars and collateralized reinsurance). In virtually all those interviews, managers and underwriters had similar reactions to my research agenda. They were:

- Interested in GlobalAgRisk's work;
- Encouraging of my interest in bringing ENSO markets to scale and addressing some of the issues discussed in chapter 4 (i.e. predictability, two-sided market, etc.);
- Aware of the history of exchange-traded insurance risk and pessimistic about the future prospects for the idea;
- Weary of competitive pressures in the Australian market that have driven prices to potentially unsustainably low levels;
- Open to, but not enthusiastic about, hybrid reinsurance that might contain a level of coverage with a parametric trigger for El Niño/La Niña. They suggested that reinsurers had experimented with this form of coverage, but the experiments were not successful and it is now uncommon to see such agreements. However, ENSO's opportunity for advanced payment was special in the world of insurance and clearly would be of value to clients.

Beyond those baseline reactions, traditional reinsurers' responses fell into three general categories:

- "We are interested in selling El Niño/La Niña coverage, but we exclusively work with reinsurance and closely related structures." - This response was common from the most traditional reinsurance groups including members of the Lloyds syndicate. According to underwriters and managers, the balance sheets of these groups were built to take on the liabilities of reinsurance and that was the only function they would serve for the foreseeable future. So if this coverage was not sold as reinsurance, they would not participate.
- "We are interested in selling El Niño/La Niña coverage, and we could find a way to make whatever risk coverage is available into reinsurance using transformers." - A small subset of traditional reinsurance groups were not daunted by the unconventional nature of the El Niño/La Niña coverage I proposed. In one meeting

I met with an underwriter who was especially encouraging, but skeptical of El Niño/La Niña markets. However, part-way though the meeting we were joined by the chief underwriter for the reinsurer, a three-decade veteran in reinsurance markets. After hearing my pitch for why traded markets could provide better El Niño/La Niña coverage than traditional reinsurance, the chief underwriter suggested various precedence for offering coverage that straddles insurance and reinsurance markets and even suggested that reinsurance losses in Australia would be a powerful reason why reinsurers should encourage their Australian clients toward such structures. He also said that *transformers*, groups that specialize in bringing financial agreements into and out of reinsurance markets, would be able to facilitate dual-trigger insurance policies involving coverage from capital markets (derivatives or ILS).

- "Diversification into new risks is not a core goal in our business strategy." - After large loss events, such as Hurricanes Andrew or Katrina, new reinsurers have entered the market to take advantage of rising premium rates. Some of those groups have gradually become conventional reinsurance groups while others have continued to focus on smoothing the reinsurance capital cycle, only using their full underwriting capacity after large events. (See Froot [2001] for a detailed description of the reinsurance capital cycle.) Those groups do not actively look to balance their peak risks with new, offsetting risks. Instead, they look to compile portfolios particularly concentrated in the industry's peak risks at temporarily high risk-adjusted returns. The few groups I talked to in this category were very interested in El Niño/La Niña, but considered the risk outside of their core strategy.

Brokerage interviews

No one set of firms working in catastrophic risk has a strong financial incentive to invest in the educational outreach needed to convince new clients of the value of hedging. Industry participants believe that there is chronic underinvestment in these activities. However, to the extent that anyone in the industry does systematically catalyze new hedging, it is brokers.[42]

Hedgers have more trust in brokers because they circulate pricing information that is especially valuable for markets with low pre- and post-trade transparency. They also value brokers because there are some economies of scale in preparing the analysis necessary to make a risk management decision. For example, an individual CAT bond sponsor may not want to license costly risk models that they may only

[42] Some fund managers I interviewed reported that they occasionally felt overwhelmed by brokers' proposals for new deals. They believed that most of those proposed trades were simply distractions, offering little value to their firm.

use for a few transactions in any given year, when a broker could buy the same license to price more transactions[43].

Like the funds they work with, brokers operate with a host of business models, many of which favor specific transaction types, like ILS, traditional reinsurance, retrocessional reinsurance[44], and even derivatives. I've divided my discussion of brokers into parts that reflect those business models.

[43] Paul Schultz. Insurance-linked securities. Technical report, Aon Benfield Securities, 2012. URL http://thoughtleadership.aonbenfield.com/

[44] Retrocessional reinsurance is reinsurance for reinsurers.

Capital markets groups at large reinsurance brokerages

The capital markets groups at large reinsurance brokerages are responsible for most ILS issues. (See Evans [2012] for details on the brokers involved in a large sample of CAT bond deals.)

The most progressive capital markets groups I interviewed, described their work as shepherding catastrophe bonds from cradle-to-grave. They propose new risks and structures to hedgers. They oversee the legal and regulatory logistics of bond issues. They provide indicative pricing for bonds using risk models from RMS, AIR, and EQECAT. They work with funds to convince them to purchase their bonds. Finally, some actively trade catastrophe bonds in secondary markets. This allows them to manage risk on deals that they warehouse (hold until they can sell to a speculator), improve their understanding of available prices, and provide critical intelligence on "favorable issuance strategies.[45]" Many of those brokerage groups will have employees who actively manage small ILS portfolios, just as they would at speculative ILS funds.

[45] Paul Schultz. Insurance-linked securities. Technical report, Aon Benfield Securities, 2012. URL http://thoughtleadership.aonbenfield.com/

However, not all capital markets groups conceive of their work so broadly. A manager from one of the capital markets group said his team's function was confined to financial engineering for existing reinsurance deals, closer to the work of the *transformers* mentioned earlier. Responding to client demand, the reinsurance brokers within his parent firm propose transforming their existing deals into derivatives or securities and the capital markets group helps them to accomplish that goal. They are reticent to warehouse any risk.

Brokers in that first category were responsible for the first CAT bond issues in the mid-1990s and continue to drive innovation in ILS. I believe that their enthusiastic support is key to launching ENSO markets.

The directors of these progressive groups offered a similar reaction to exchange traded markets as the seasoned ILS fund managers mentioned above. They were skeptical of exchange-traded markets, but not antagonistic. One said that he would gladly support exchange-traded ENSO markets and indeed believed that much reinsurance risk should be traded on exchanges. However, for all the reasons discussed above,

he suggested that ENSO risk markets should begin with a private CAT bond issue.

The director of one such group noted that the willingness of the ILS market to accept indemnity risk might pose a problem for ENSO markets. (See figure 6.8 for estimates of indemnity triggers' prevalence in recent CAT bond deals.) He said that investors were willing to accept indemnity risk, with its attendant moral hazard, at low mark-ups over similar parametric deals because they now accepted the risk models underlying those deals[46]. If, as now, there is no great price difference between parametric and indemnity triggered deals, then hedgers will always prefer the low-basis risk indemnity deals. Despite that initial skepticism, he ultimately agreed that the lack of infrastructure for indemnity-based reinsurance in Peru and the value of a forecast trigger might merit a CAT bond issue covering ENSO.

[46] Morton N. Lane. The loss file - WYSIWYG. Technical report, Lane Financial L.L.C., March 2013. URL lanefinancialllc.com/

Futures brokers

The opinions of one ILS broker were especially helpful in understanding the hurdles that exchange-traded ENSO derivatives will likely face. While his brokerage's primary business was retrocessional reinsurance, they were also responsible for launching the CME's hurricane markets, based on their own proprietary index.

The broker I interviewed at that firm had more direct experience relevant to ENSO futures and options than anyone else I encountered in the course of this research. Coming after almost a decade of involvement in those markets, his most important take-away lesson was powerful: start with OTC trades, then worry about moving those trades to an exchange.

In the early 2000s his brokerage designed their own parametric index for hurricanes along the eastern seaboard of the US. They took the idea to the CME, confidant that the relative cost and ease of exchange trading would lure hedgers facing this large, standardize-able risk.

Early on in the process, he noticed that most of the responsibility for generating hedging interest fell to the brokerage itself. Echoing the comments that Richard Sandor made in his book regarding the support of the CBOT for ILW markets in the early 1990s, the broker told me that I simply should not expect substantial product development support from any exchange. The marginal cost of a new contract is low for an exchange and they expect low payouts from those marginal contracts. Hence, they are reluctant to devote substantial resources to product development. This opinion was close to a consensus. In my interviews, it was echoed not just by the brokers and independent contract innovators frustrated by lackluster volumes on their pet con-

tracts, but by current and former representatives of the exchanges themselves.

The second surprise for the hurricane contract broker was just how difficult it was to convince hedgers to open up margin accounts for trading. In his estimation, the process was neither costly nor time consuming, but it nevertheless proved too taxing for many firms new to derivatives markets. He reported that hedgers perceived the process as an upfront cost linked to a product they might never use.

Third, he was weary of other brokers incentives vis-à-vis highly transparent, exchange-traded products. Incumbents in the reinsurance industry saw hurricane derivatives as a competitor to traditional insurance and were consequently reluctant to embrace them. He suggested that some brokerages had expressed their opposition explicitly to hedgers.

Years after their launch, the CME's hurricane markets have not achieved substantial on-exchange volume. (See figure 6.13 for volumes of a similar suite of contracts launched at roughly the same time.) Interestingly, he did not consider the experiment a failure. The brokerage still uses its hurricane indexes (the rights to which they recently sold to the CME for a nominal fee) to settle many OTC contracts. He believes that if they had established that OTC volume first, the exchange-traded contracts may have enjoyed greater volumes.

Until speaking with that broker, I remained skeptical of other brokers and fund managers suggesting that ENSO markets should begin with some form of bilateral trade off an exchange. Those other individuals had at least some vested interest in keeping the risk off-exchange. However, the broker working on the CME hurricane markets clearly shared my interest in the transparency and value of exchange trading. His firm, unlike the others I spoke with, is registered with the National Futures Association (NFA) to broker deals in exchange-traded derivatives. So, he actually has a strong incentive to push volumes onto an exchange, where other brokerages, mostly lacking that designation, would not be able to broker trades. Despite that incentive, he felt strongly that ENSO's best shot at success would begin with CAT bond transactions.

Traditional reinsurance brokers

I met with traditional reinsurance brokers in Australia and Peru and found them supportive of new ENSO risk markets. In particular, the Australian brokers were optimistic about the prospects of selling to Australian hedgers, whereas fund managers and brokers in the United States and Bermuda were not. Australian reinsurance brokers brought my attention to the opportunities in the power transmission sector

and feature La Niña risk prominently in their promotional literature.[47] One group in particular was eager to meet with me because they had multiple clients come to them to discuss La Niña coverage.

Those brokers clearly favor traditional reinsurance policies to cover ENSO risk but they would support CAT bonds as well. Most suggested that they were less likely to support exchange-traded derivatives except as part of a hybrid reinsurance policy.

While brokers in Australia were more optimistic about ENSO hedging than industry watchers outside the country, it is worth adding a note of caution. Some of these groups have known about GlobalAgRisk's El Niño insurance for years and have not actively sold it to clients, despite GlobalAgRisk's pledge to support their efforts. In fact, one reinsurance broker contacted me by email to let me know that his firm already had a similar product for sale and sent me marketing materials that I had helped draft as part of my work with GlobalAgRisk. That signaled to me that there is a gap at traditional reinsurance brokers between the enthusiasm of analysts and sales teams and the institutional knowledge and support necessary to consummate reinsurance deals on an innovative risk.

[47] Even through La Niña is a risk they do not currently help insure.

Service provider interviews: Risk modelers

All of the ILS funds I spoke with mentioned the potential value of branded analytical tools that explicitly covered ENSO risk from the major catastrophe risk modeling firms (RMS, AIR, and EQECAT). Weather funds expressed a similar hope, only they focused on a different group of data and analytics firms dedicated to weather (including MDA EarthSat and Galileo).

What risk modelers do

Three firms, RMS, AIR, and EQECAT, effectively act as ratings agencies for CAT bonds and reinsurance agreements. (Note that in some cases the traditional ratings agencies also rate CAT bonds.) These large firms hire experts in natural disaster risk (geologists, meteorologists, etc.) to build stochastic simulations linking historical insurance losses to natural disasters. Although many funds perform additional analysis on new deals, the risk modelers' software provides reference pricing throughout the industry. Those models are used by brokers and firms, not just to price individual transactions, but also to model the performance of whole portfolios of risk.

It will be important to convince these firms to explicitly model the influence of the ENSO cycle on loss outcomes. My understanding is that the ENSO cycle is currently a background factor in their hur-

ricane models. Analysts at ILS funds told me that it would be very difficult to recognize any negative correlations between El Niño and hurricanes in particular, unless that correlation were filtered through these firms' main risk models.

I spent an afternoon with analysts and managers from one of the large modeling firms. They were interested by, and optimistic about, the prospects for traded ENSO risk, although their experience with exchange-traded catastrophe products left them skeptical about ENSO futures and options.

Although they were cautious about attributing long-term changes in Pacific SSTs to climate change, the individuals I spoke to recognized the value of markets that could bridge the gap between climate and weather. They suggested that they personally wanted to see the idea succeed and were very helpful in establishing subsequent interviews.

Accuracy of risk modeling and opportunities for model arbitrage

Today's major risk modeling firms were founded in the late 1980s and early 1990s. Consequently, there remains is a great deal of uncertainty about their ability to consistently estimate catastrophic losses over a long time horizon. Nevertheless, their track record so far has been encouraging. Over the ILS market's short life, realized losses have closely matched the expected losses estimated by the large modeling firms[48].

[48] Morton N. Lane. The loss file - WYSIWYG. Technical report, Lane Financial L.L.C., March 2013. URL lanefinancialllc.com/

But limited data is not the only reason to approach risk modeling with some skepticism. Industry watchers have noticed some opportunities to arbitrage risk models, with CAT bond issuers strategically placing their bonds using, for example, the modeling firm with the lowest estimate of expected hurricane losses Swiss Re [2012].

> On 28 Feb 2011, Risk Management Solutions (RMS) released their new US Hurricane model, causing an increase in modeled expected loss. The US Wind new issue pipeline slowed, which was a dramatic change for the market. Sponsors typically come to market at that time of year to secure protection prior to the North Atlantic hurricane season. On the release date, RMS was the modeler on 32 percent of outstanding US Wind bonds. Over USD 454 million of US Wind bonds modeled by RMS matured in 2011. Since the model change, RMS has been utilized on one natural catastrophe transaction (EQ - Worker's Comp) while AIR modeled 16 transactions and EQECAT modeled three.

That is clearly a limited sample, given the lumpiness of CAT bond issuance, but it points to one systematic weakness within the business model.

Not only could that weakness undermine the integrity or risk estimates in general, it could also have immediate consequences for ENSO

risk markets. If, for example, one of the modeling firms begins offering ENSO specific analysis that encourages firms to consider managing their US wind exposure through ENSO markets, that model update may come with higher expected loss estimates for some CAT bond deals. So, hedgers looking to issue their CAT bonds using the most favorable model possible may have an incentive to systematically avoid models that encourage explicit ENSO risk management.

Funds understand the danger of model arbitrage and now routinely model their own risk using multiple firms' models. To the extent that funds continue to have a financial stake in correctly modeling outcomes (i.e. to the extent that they avoid the pass-through model common in mortgage-backed derivatives before the crash, where funds who theoretically should police model arbitrage actually encourage that arbitrage as they hold an ever smaller portion of the resulting risk), then such model averaging will check incentive problems that might undermine rational risk management, including ENSO hedging.

Service provider interviews: Climate researchers

The data that would underlie any ENSO market would come from measurement networks operated by national meteorological services (NMS). NOAA and ABM provide the most watched forecasts. I visited each and interviewed the climatologists in charge of issuing their El Niño/La Niña forecasts. Much of those discussions focused on methodology, data, and climate science. (See chapter 3 for additional methodology.) However, we also went over four key issues regarding the relationship between those NMS and any eventual risk markets using their data:

- Data release policy - the procedures NMS follow as they release data to the public;
- Transparency on data quality - full and timely disclosure of any issues that may compromise the quality of NMS data;
- Clear contingencies - alternative procedures for calculating key indexes in the event that expected data are not available or are of poor quality;
- De-politicizing forecasts - the way that markets can provide a benchmark for policy makers that frees NMS from the political pressure to alter, temper, or delay sensitive forecast warnings.

Data release policy

Currently both ABM and NOAA attempt to release monthly SST measurements on a set schedule through their websites. However,

controls on data release fall well short of those for other sensitive economic data. If a reporter, for example, is particularly interested in discussing forecasts in the days leading up to that release, NMS might discuss the numbers with those reporters so that their forecasts are taken seriously and interpreted correctly as soon as they are released.

If ENSO markets allow for continuous trading based on such information, then it is imperative NMS revisit their data release protocol and put in place safe guards to ensure that all market participants have equal access to public data. The same applies to the relevant Peruvian authorities, although Peruvian data tends to focus on the Peruvian coast and would have less relevance to settlement than either NOAA or ABM. The ABM in particular was enthusiastic about standardizing data release.

Transparency on data quality

ENSO markets will settle on monthly SST averages. As straightforward as that may sound, taking an average over a whole month for a large swath of the Pacific Ocean is not simple. Take for example, satellite buoys. They may go off-line occasionally. If a malfunctioning buoy is in a closely monitored part of the Pacific, then the missing data can be safely and accurately interpolated. If, however, the malfunctioning buoy is located in a part of the Pacific with relatively low measurement density, that missing data can materially alter monthly numbers.

NOAA does a remarkable job with transparency. NOAA's National Buoy Center[49] allows the public to see recent data and even pictures from buoys throughout the TAO network that provides most ERSST SSTs. (Chapter 3 explains the difference between ERSST's in-situ measurements and the parallel satellite based dataset, OISST.) However, as ENSO markets focus the attention of new motivated parities on SST data, new transparency issues will almost certainly arise.

[49] http://www.ndbc.noaa.gov/

Clear contingencies

Data quality and quantity problems will inevitably arise in ENSO markets. In those cases, someone besides NOAA would have to take responsibility for providing settlement numbers according to a predefined contingency plan. Moreover, they would have to accept the legal liability for providing those number on-time as specified. In return for taking on this responsibility, the settlement index provider would receive a small royalty on every transaction settled based on their numbers.

Based on my discussions with multiple individuals involved in the launch of new derivatives, these royalties will be enough to pay for

staff time to develop and maintain the index. However, they are unlikely to produce substantial revenues beyond that. Only a select group of highly watched financial indexes, like the Case-Shiller housing indexes and the S&P 500, provide sufficient royalty income to sustain more than the basic staff required to maintain them. I believe that the chances of an index of SSTs, which only diverges slightly from public data, generating substantial revenue are slim. The index will consist almost exclusively of NOAA measurement figures issued publicly and will only differ from those figures when there are unusual contingencies in the data.

Nevertheless, index provision will provide modest revenue to someone. My personal hope is that NOAA itself could find a means of collecting those royalties by setting up a public-private partnership. That would employ one additional climatologist specializing in analyzing the quality of NOAA's SST data and any additional revenues would go back to the NOAA offices responsible for issuing the SSTs. I talked with NOAA scientists about that possibility and they were uncertain about whether current NOAA rules allowed the agency, or an agency-endorsed public-private partnership, to accept revenues and take on liabilities.

If NOAA does not take advantage of this opportunity to collect royalties on the numbers it issues, then there are a handful of private data providers that would step in to provide the index.

De-politicizing forecasts

In Australia in particular weather forecasting is highly politicized. The climatologist I interviewed at the ABM told the story of a famous politician from an arid rural district that attempted to stop the ABM from forecasting drought. The climatologist bristled at the idea that a politician, particularly an outspoken ideologically motivated one, was interfering with a evidence-based forecasts. However, the climatologist said that he had largely changed his mind after hearing the politician describing the dire consequences for individual farm households who might simply give up on their lives in the face of another year of drought.

While he sympathized with the humanitarian reasons for tempering that forecast, he was excited by the idea that a market might insulate his work forecasting El Niño/La Niña from political calculations.

The ABM has worked to switch Australia's reference point for monitoring ENSO from the SOI index to Pacific SSTs. Australians now use the SOI index as their primary indicator of ENSO related precipitation and it is so well known that the index often appears in weather forecasts alongside temperatures. However, the index is subject to

volatility that is unrelated to the ENSO cycle, such as with the recent arrival of Tropical Cyclone Yazi. The ABM expert I interviewed was enthusiastic to hear that markets might be the primary reference point going forward, since that might allow him to issue forecasts without the added pressure of those forecasts being perceived as definitive by Australian politicians.

Other climate groups

Beyond NMS's data provision the climate science community will also have the chance to support ENSO markets through their research and analysis. Risk modelers hire climate scientists, but generally their work involves linking economic losses to weather, climate, and natural disaster data. That work is distinct from climate modeling and basic research on natural disasters, which still comes from academics and government scientists.[50] Industry does support that work through initiatives like the Willis Research Network and the Bermuda Institute of Ocean Sciences' Risk Prediction Initiative. Hopefully, ENSO market users can similarly support basic research into the need for and value of ENSO protection.

[50] The National Center for Atmospheric Research (NCAR) is a large government supported research institution with particular relevance to ENSO.

Service provider interviews: Exchanges

If ENSO markets launch as exchange-traded derivatives, then one of the two large US derivatives exchanges, the CME Group or the Intercontinental Exchange (ICE), will certainly be involved.

The CME Group today accounts for 80 percent of US futures trading and hosts all the standardized weather derivatives contracts in the US. That makes the exchange the most likely venue for ENSO risk. Indeed, as part of this research I spoke with a CME staff member who believes the risk fits well with their existing weather suite and hopes to leverage this research to launch ENSO contracts soon.

The ICE is a less likely destination for ENSO risk. However, ENSO's connection to energy markets, ICE's specialty, means there may be some synergies that would entice the smaller exchange into supporting ENSO markets. Trading on the ICE is dominated by energy firms. That focus has made ICE the more profitable exchange over its short history. However, the focus has also meant that ICE has a more conservative stance on new contracts. The exchange prefers to launch products that can tap into existing liquidity, such as their recent agricultural contracts that are clones of CME futures, actually settling based on CME prices.

Marketing new contracts

Virtually all of my interview subjects with background in exchange-traded derivatives agreed on one important point: neither exchange will provide a marketing budget sufficient for ENSO to reach liquidity. Hedgers, brokers, and even exchange employees agreed that the marketing budgets for new contracts were insufficient to educate hedgers. To the extent that such markets succeed, it is because brokers and other service providers take it upon themselves to educate clients and encourage trades.

How rational is that laissez faire attitude toward new markets? Chapter 5 tells a nuanced story. On one hand, contracts that are approaching a volume of 10,000 or on a growth path to reach that threshold, are worth supporting.

On the other hand, it also shows why exchanges' current innovation strategy might be profitable. In the last decade, contracts tended not to fail outright. In fact, despite high rates of innovation, the marginal prospects of contracts remains remarkably stable. One interpretation of that result might be that exchanges like the CME and ICE should not bother to support new contracts, since the marginal prospects for contracts have been robust across time.

I do not accept that interpretation at face value, since the evidence in chapter 5 does not speak to the key counter-factual: what would have happened to contracts had they received plenty of marketing support? Especially since the work in chapter 5 presages predictive models of contract success which could target marketing investment, it would be a mistake to dismiss the hypothesis held by so many contract innovators: that their creations would have benefited from higher marketing budgets.

Exchanges and CAT bonds

If ENSO markets launch as CAT bonds, then exchanges like CME and ICE will not have much influence on their prospects. However, CAT bonds do use a different kind of exchange. The Bermuda Stock Exchange (BSX) lists almost half of the CAT bonds currently outstanding. Unlike derivatives exchanges, the BSX is not meant to be a venue for trading. Instead, the BSX enforces accounting and business conduct standards, such that listing on the exchange gives investors assurance about the integrity of the underlying issue. In that limited role, the BSX may be involved in an initial CAT bond issue.

Conclusions

I interviewed over 35 climate and finance experts on their views about key questions surrounding the launch of ENSO risk markets. Based on those interviews, there are motivated hedgers to drive early demand for formal ENSO coverage. Those early adopters include Peruvian fisheries, a few parastatal power companies in Australia, US energy firms, and international agribusiness firms, particularly those reliant on southern Brazil and Argentina.

I initially believed that ENSO products could be sold as hedges to reinsurers and ILS funds to offset hurricane losses. My interviews suggested otherwise. Those groups are unlikely to hedge in ENSO markets, thanks to entrenched business models and the basis risk inherent in hurricane hedging via ENSO.

Many hedgers' ENSO trades will offset one another. But I found that there will be plenty of speculative interest, particularly from ILS and weather funds, to correct any hedging imbalance. That finding was echoed both in my qualitative interviews and in my quantitative survey.

Despite my initial inclination toward exchange-traded derivatives, convincing me that the sturdiest foundation for successful ENSO markets will be a robust trade in bespoke hedges - either OTC derivatives or, more likely, CAT bonds. My discussion with a broker that spearheaded the CME's hurricane derivatives was particularly influential in shaping that conclusion.

While I was initially skeptical that CAT bonds could create the same social value as exchange-traded derivatives, my interviews also suggested ways to promote equitable access to CAT bond markets, boosting their positive externalities. John Seo of Fermat Capital proposed a liquidity facility that could bridge the gap between those specialized markets and social enterprises. That facility would offer small hedgers highly customizable contracts in small denominations. Those contracts would be priced using information from secondary CAT bond trading. All of the risk from the resulting portfolio of contracts would be hedged, so the facility would operate at no net cost to the host institution. This should help smooth ENSO hedgers' eventual transition to exchange-trading.

Hedgers and speculators alike need the support of analytical tools, branded by catastrophe or weather modeling firms, that link ENSO to specific business losses. Also, the national meteorological services that provide the data for contract settlement need help improving their data release procedures and converting raw data to tradeable index.

Most importantly, ENSO markets need the support of motivated brokers. The brokers willing and able to provide that support are

firmly anchored in the world of reinsurance and ILS. That may be the single best reason to favor CAT bonds for ENSO risk in the short-term. Most of those brokers would be reluctant to support exchange-traded ENSO derivatives, and exchanges themselves are unlikely to make up for the loss of those brokers.