The Potential and Limitations of Index-based Weather Insurance

Mali and Peru

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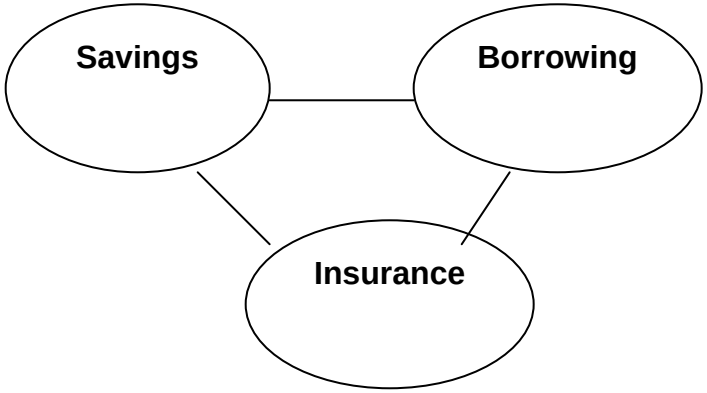
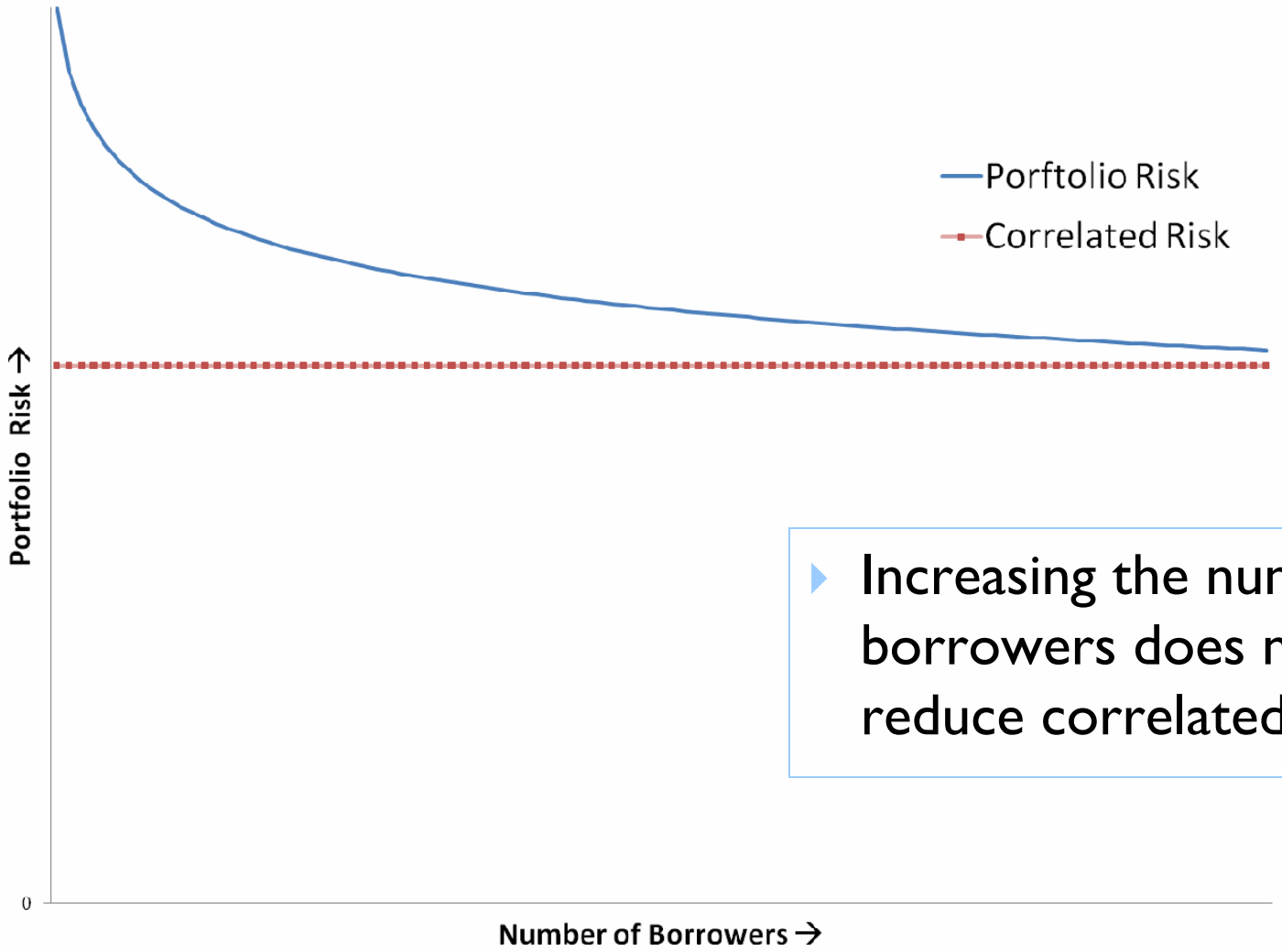
One Reason Poverty Traps Persist — Lack of Rural Finance Markets

Well-Developed Rural Financial Markets

- Saving and Insurance occurs before the event occurs
- Borrowing can be a response after the event occurs
- Delivering banking and insurance services is expensive — Cost is largely fixed making access to small and poor households even more difficult

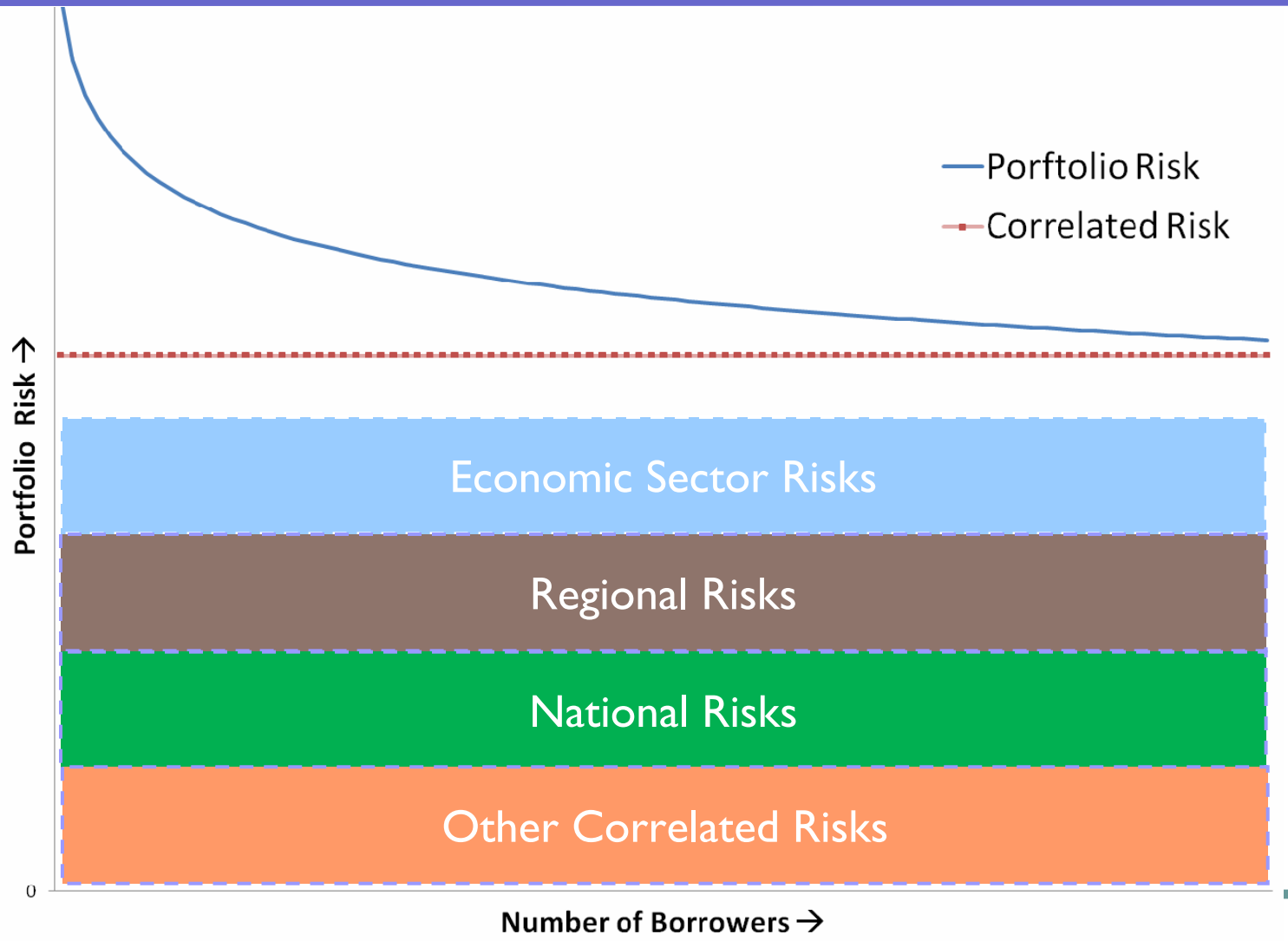


Correlated Risk in the Lending Portfolio

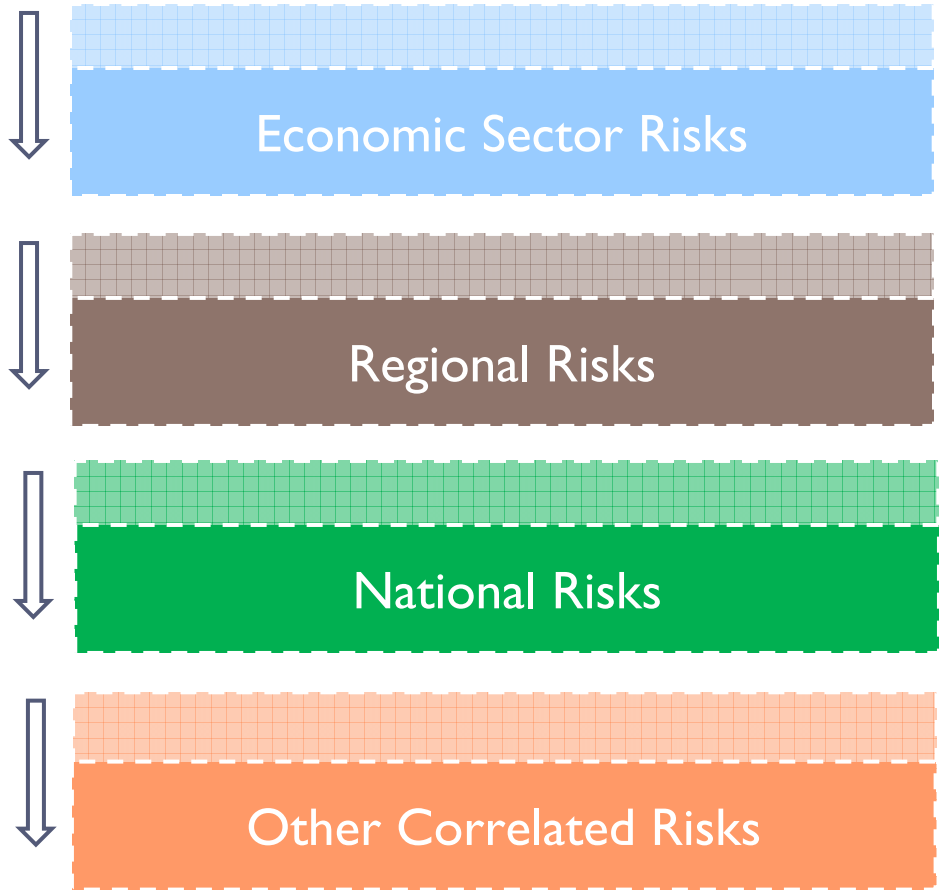


- Increasing the number of borrowers does not reduce correlated risks

Correlated Risk in the Lending Portfolio

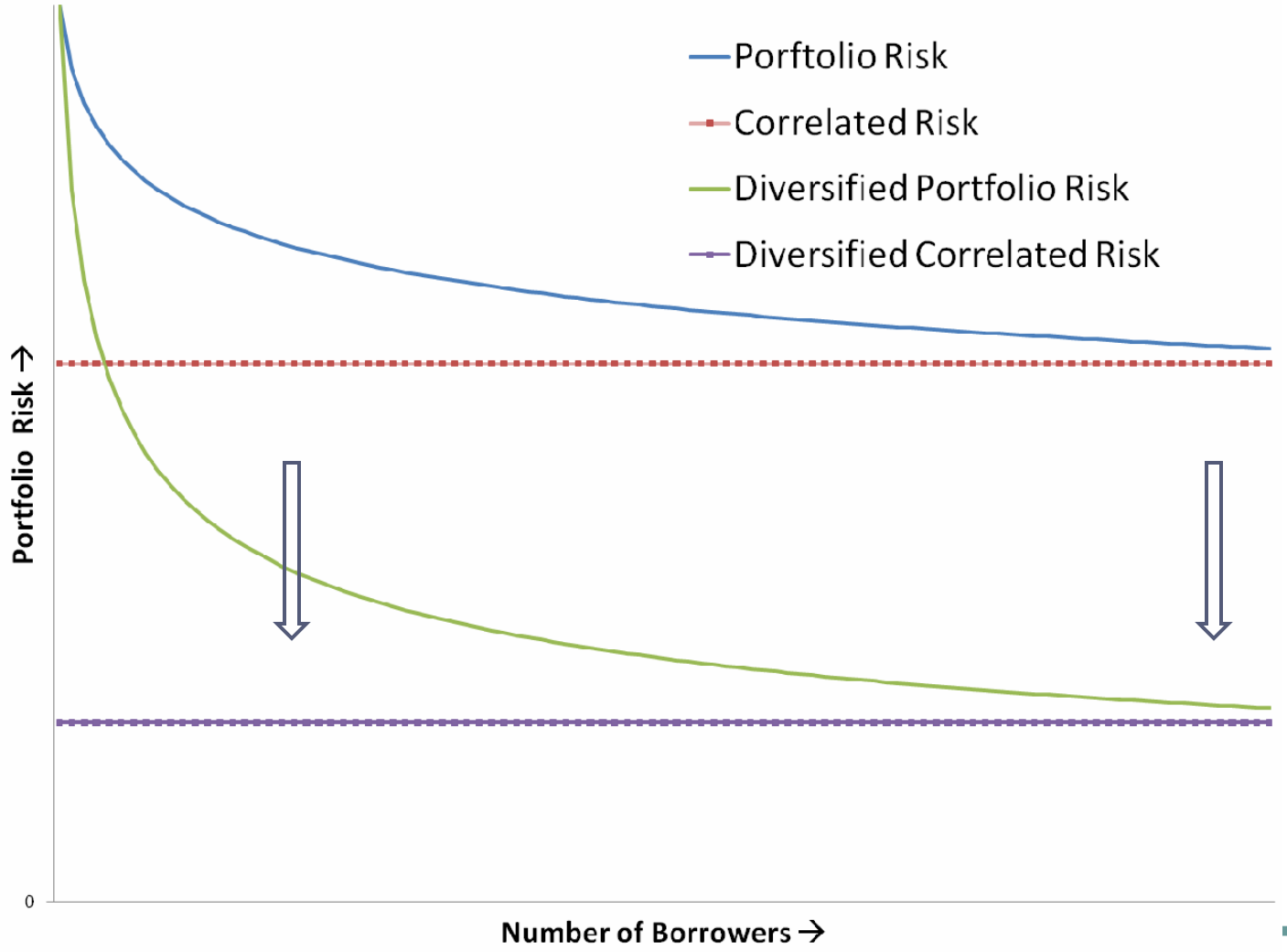


Diversification Can Reduce Correlated Risks



- Lend to several economic sectors
- Operate in several regions
- Operate internationally
- Hold assets in several currencies

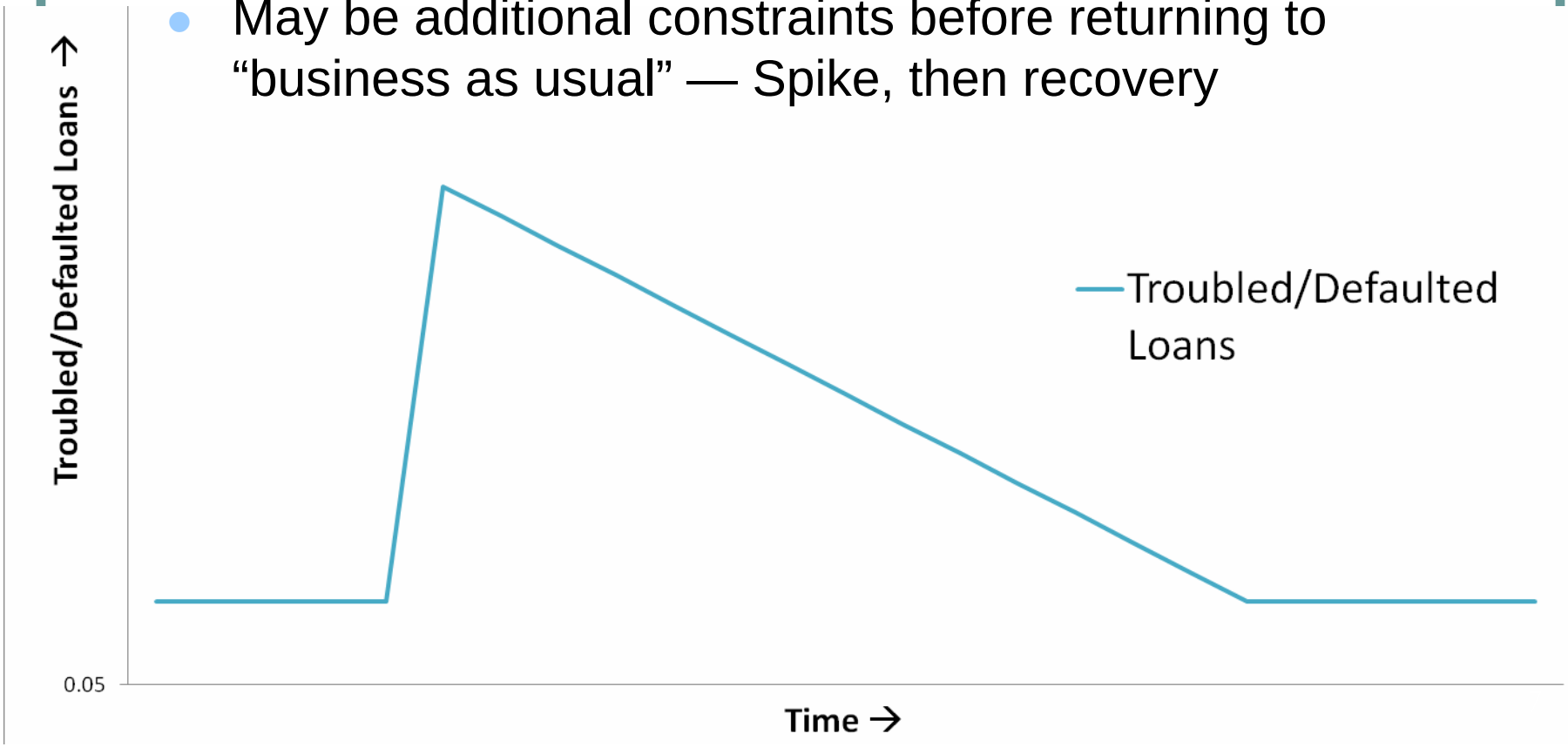
Diversification Can Reduce Correlated Risk in the Portfolio



Managing Specific Correlated Risks

Risk Assessment

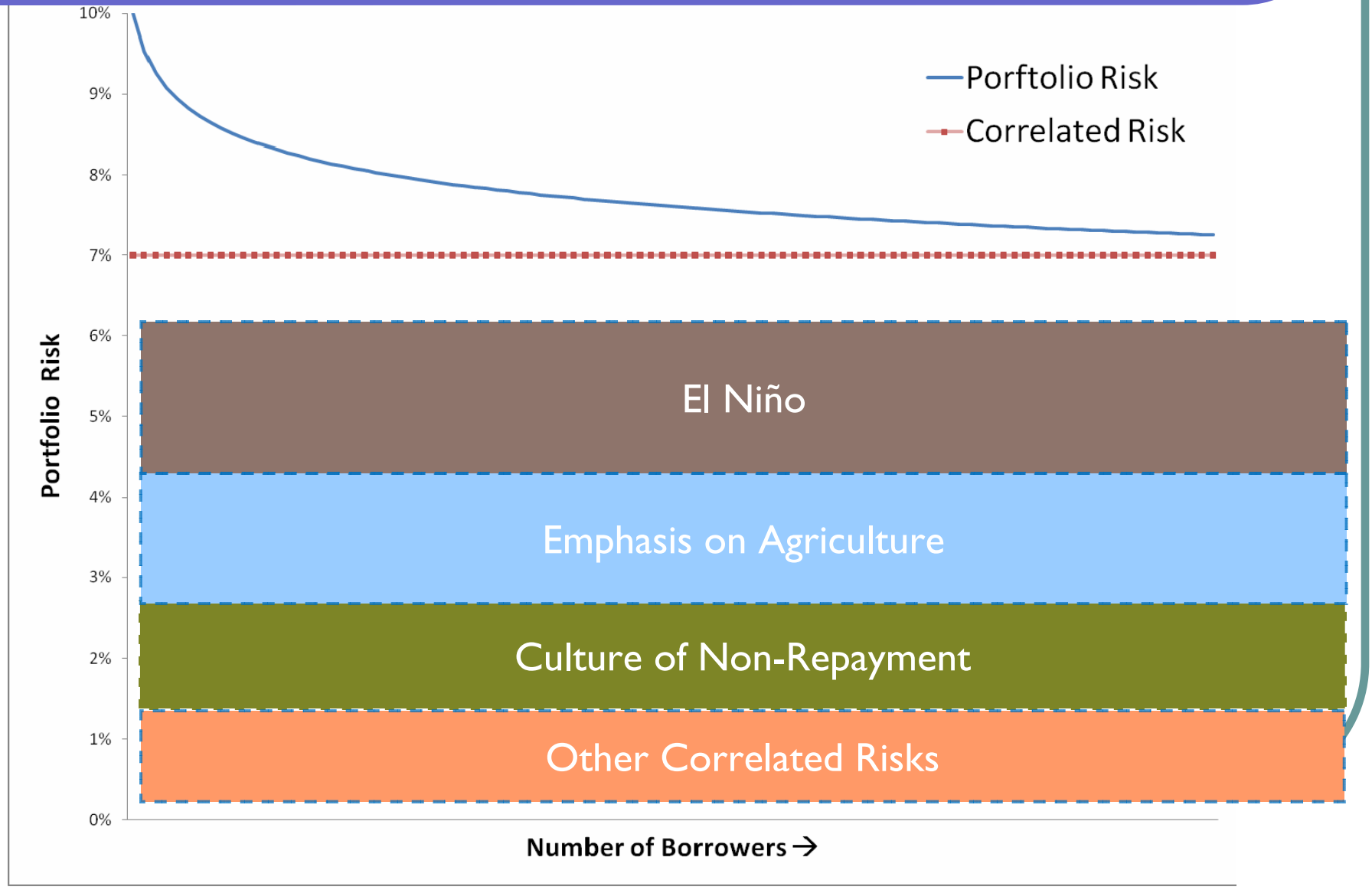
- If risk event expected to cause a up to a 10% loss, 10% is the maximum probable loss trying to manage
- May be additional constraints before returning to "business as usual" — Spike, then recovery



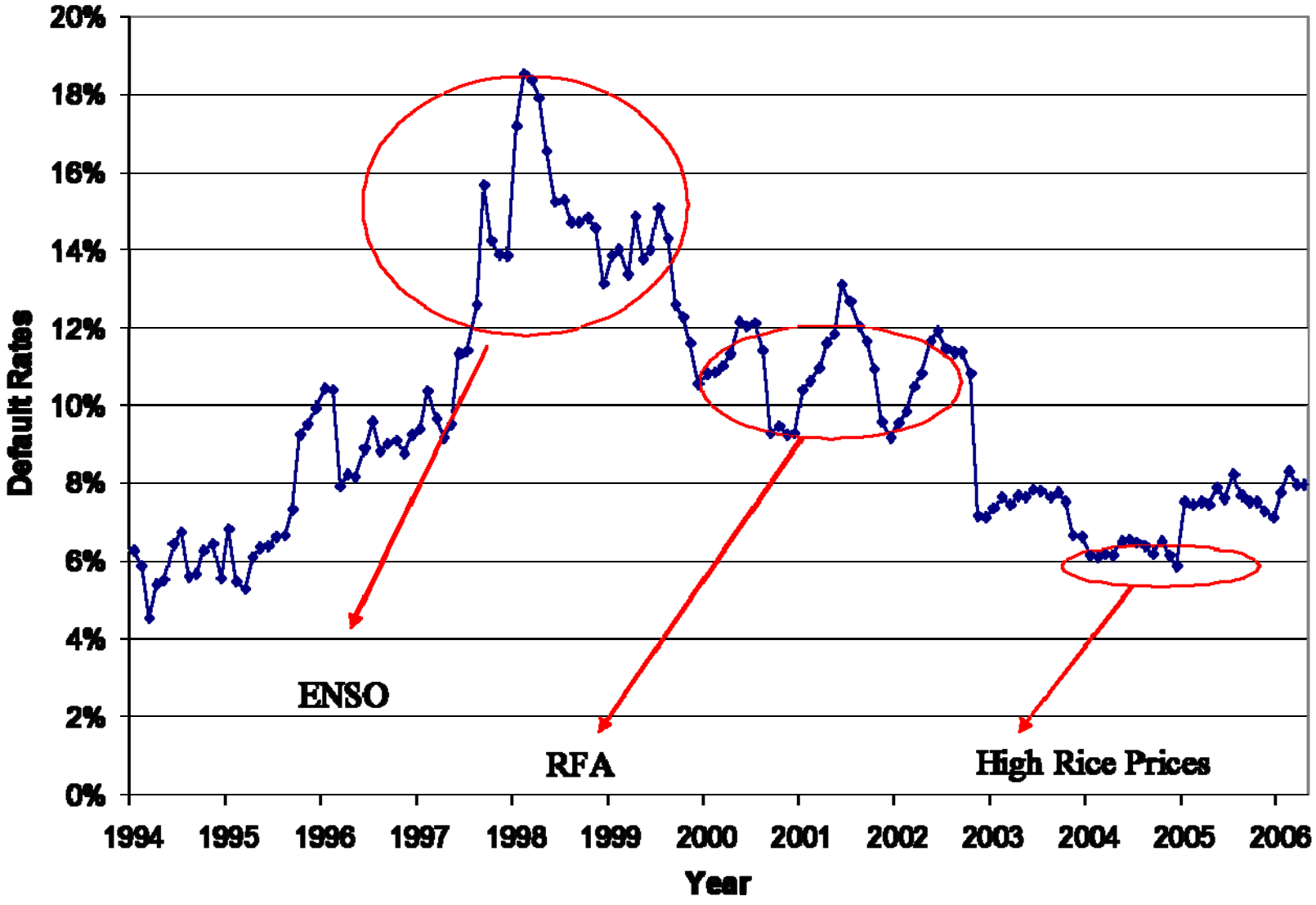
Peru Example

- GlobalAgRisk working in northern Peru (Piura)
  - Catastrophic flooding from extreme El Niño is a major regional correlated risk
  - GlobalAgRisk designed El Niño Insurance for lenders
- Puzzling through hypothetical case to illustrate benefits of insurance
- Hypothetical bank portfolio during the last severe El Niño (1997-1998)
  - Diversified portfolio has default risk of 7%
  - Diversified across economic sectors and somewhat regionally

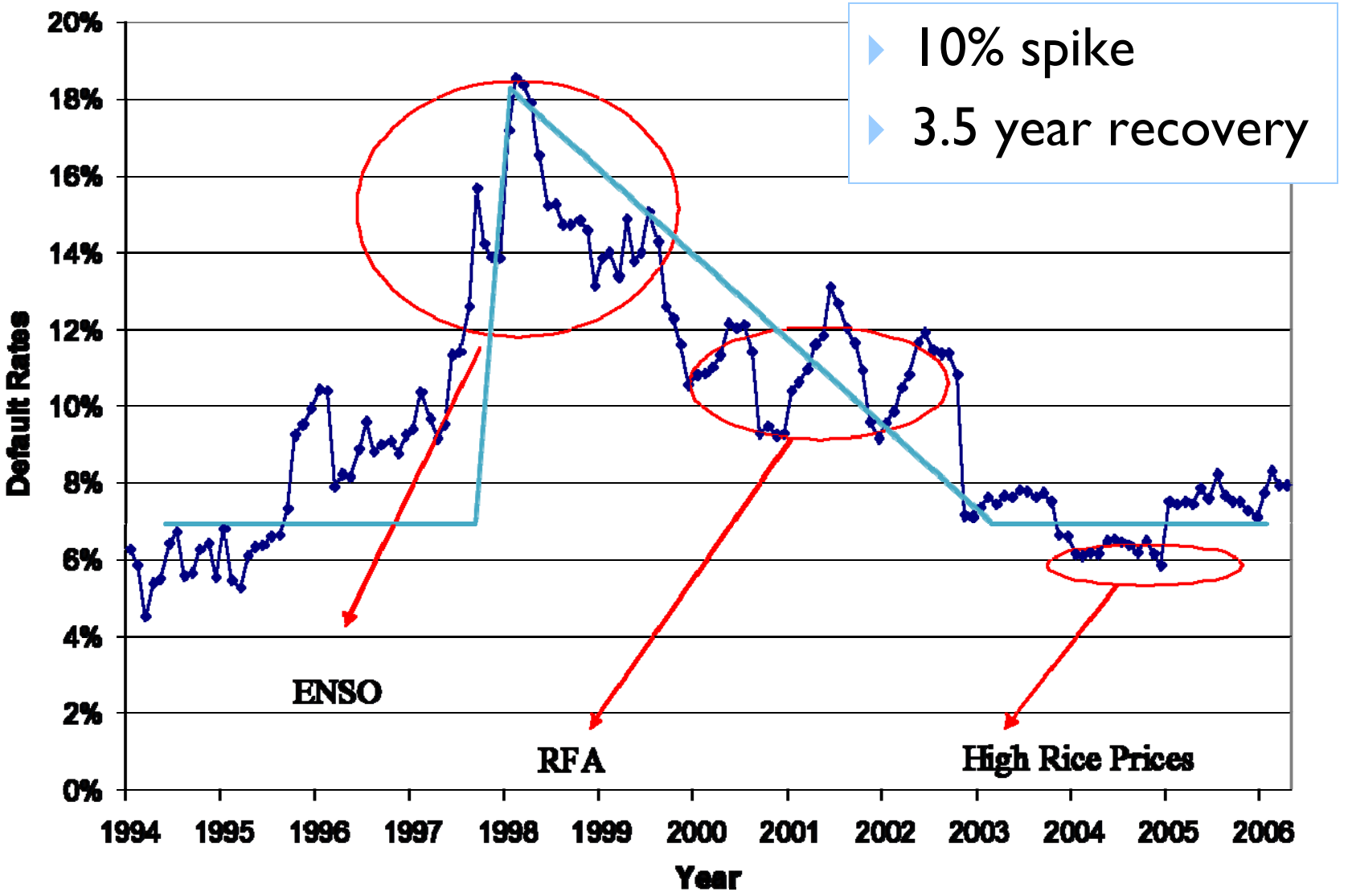
Hypothetical Bank and Correlated Risk



1997-1998 El Niño and Default Rates in Piura, Peru



1997–1998 El Niño Spike and Recovery

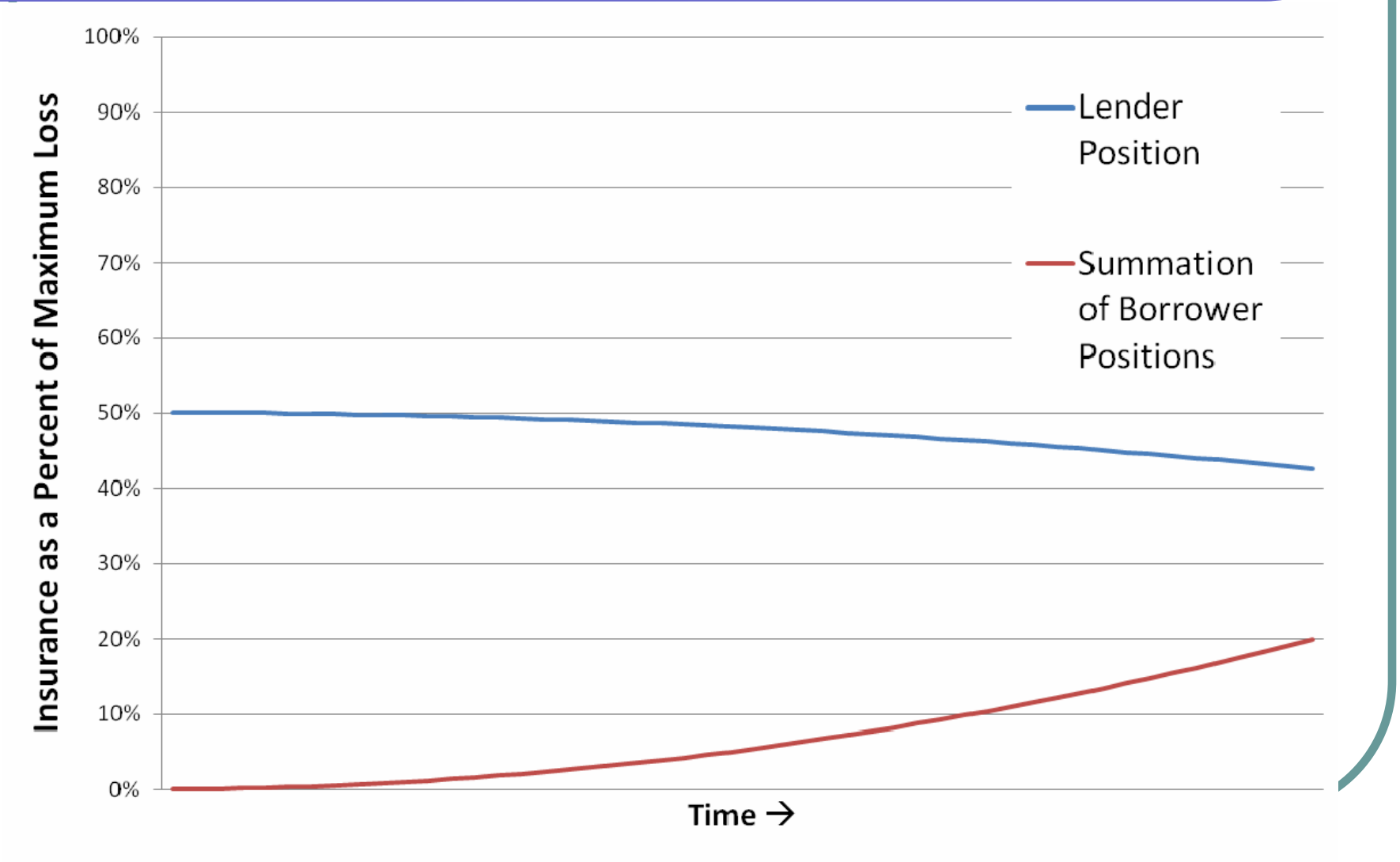


- 10% spike
- 3.5 year recovery

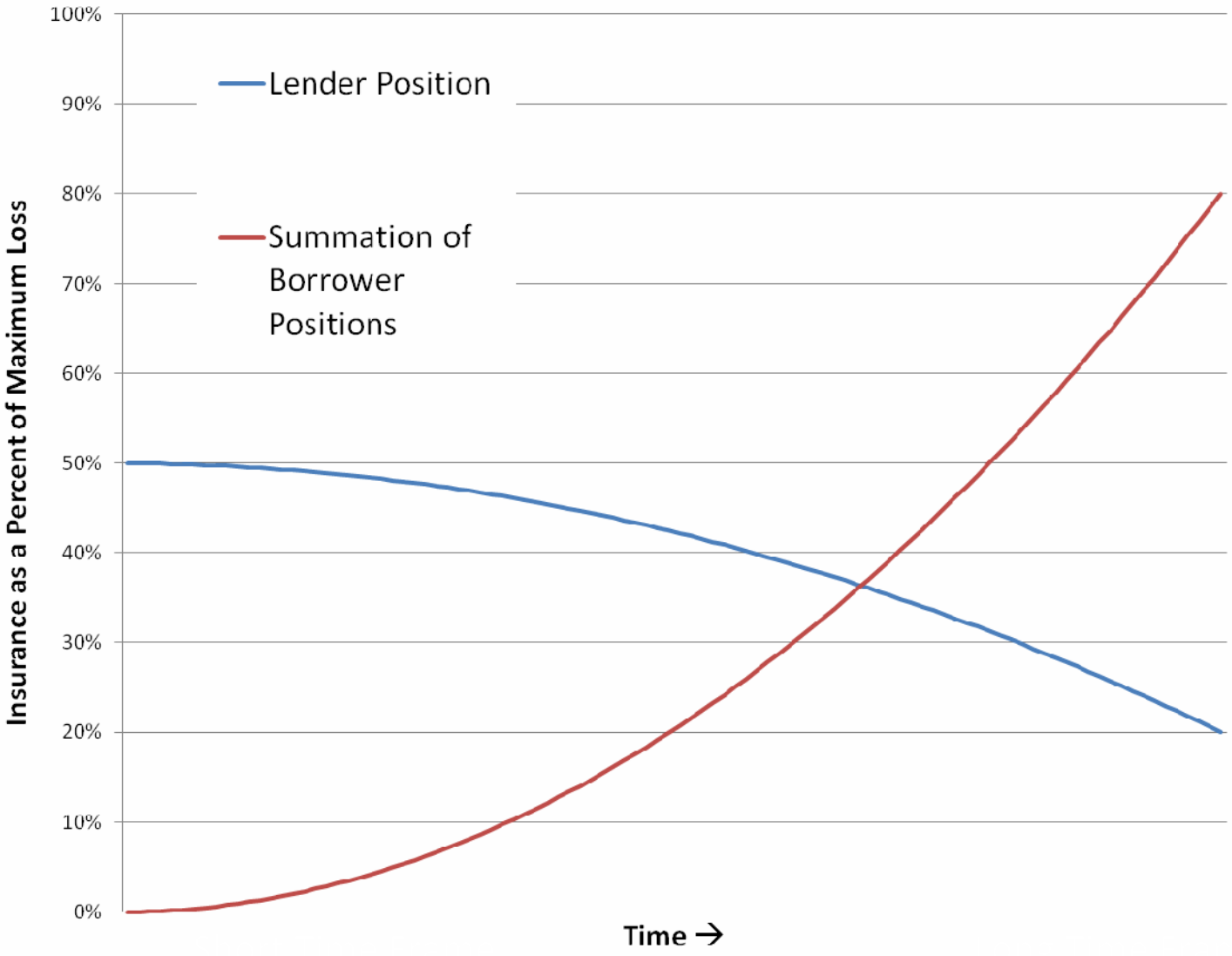
El Niño Insurance and Portfolio Risk Management

- El Niño Insurance should reduce the size of the spike
  - Leads to quicker recovery time
  - Improves portfolio performance in years following the event
- Protects the bank does not protect borrowers
- Suppose the insurance were offered to borrowers, should banks still purchase the insurance?

Insurance as a Percent of Maximum Probable Loss: *Short Time Frame*



Insurance as a Percent of Maximum Probable Loss: *Long Time Frame*

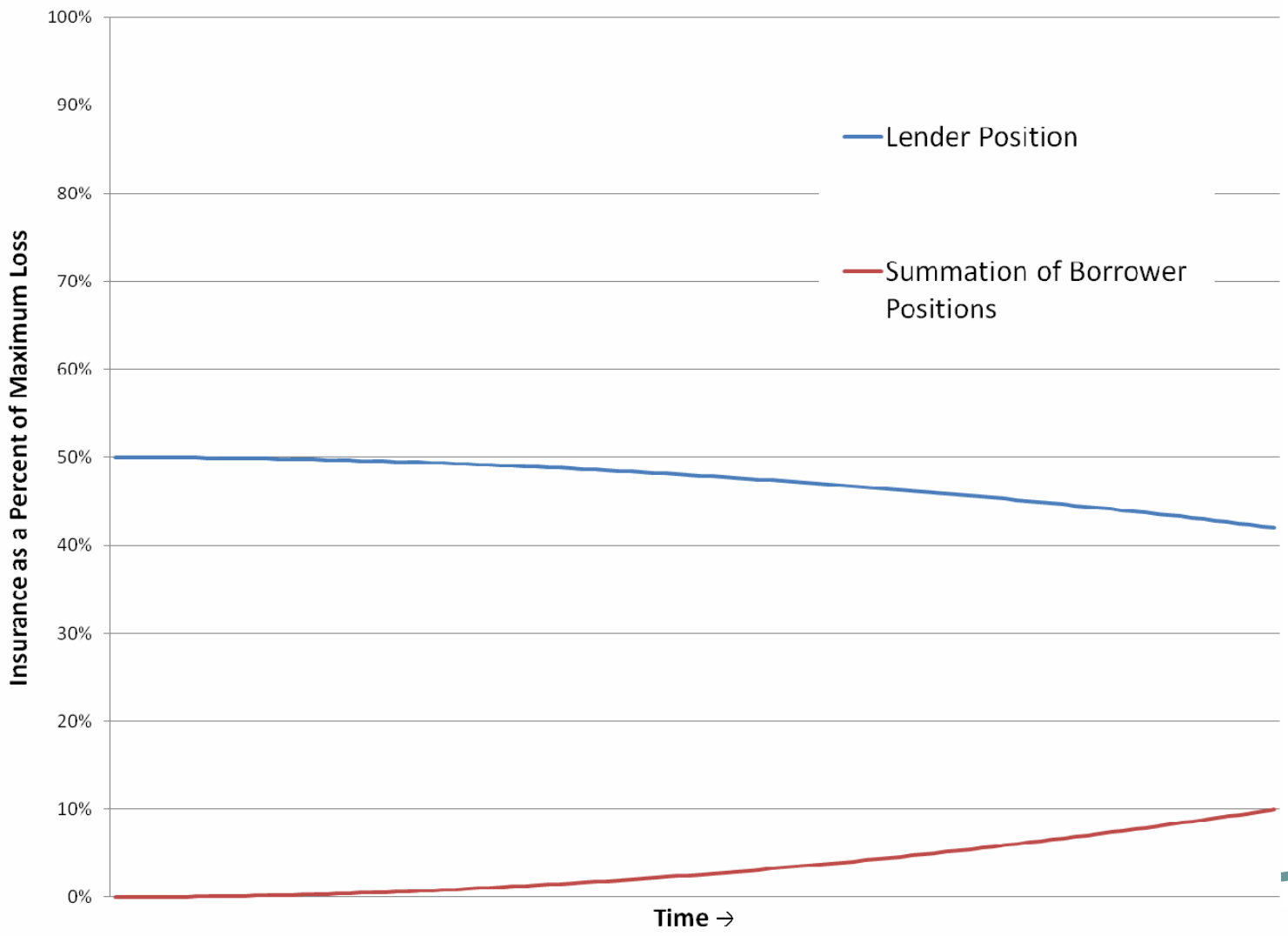


- where’s example a?

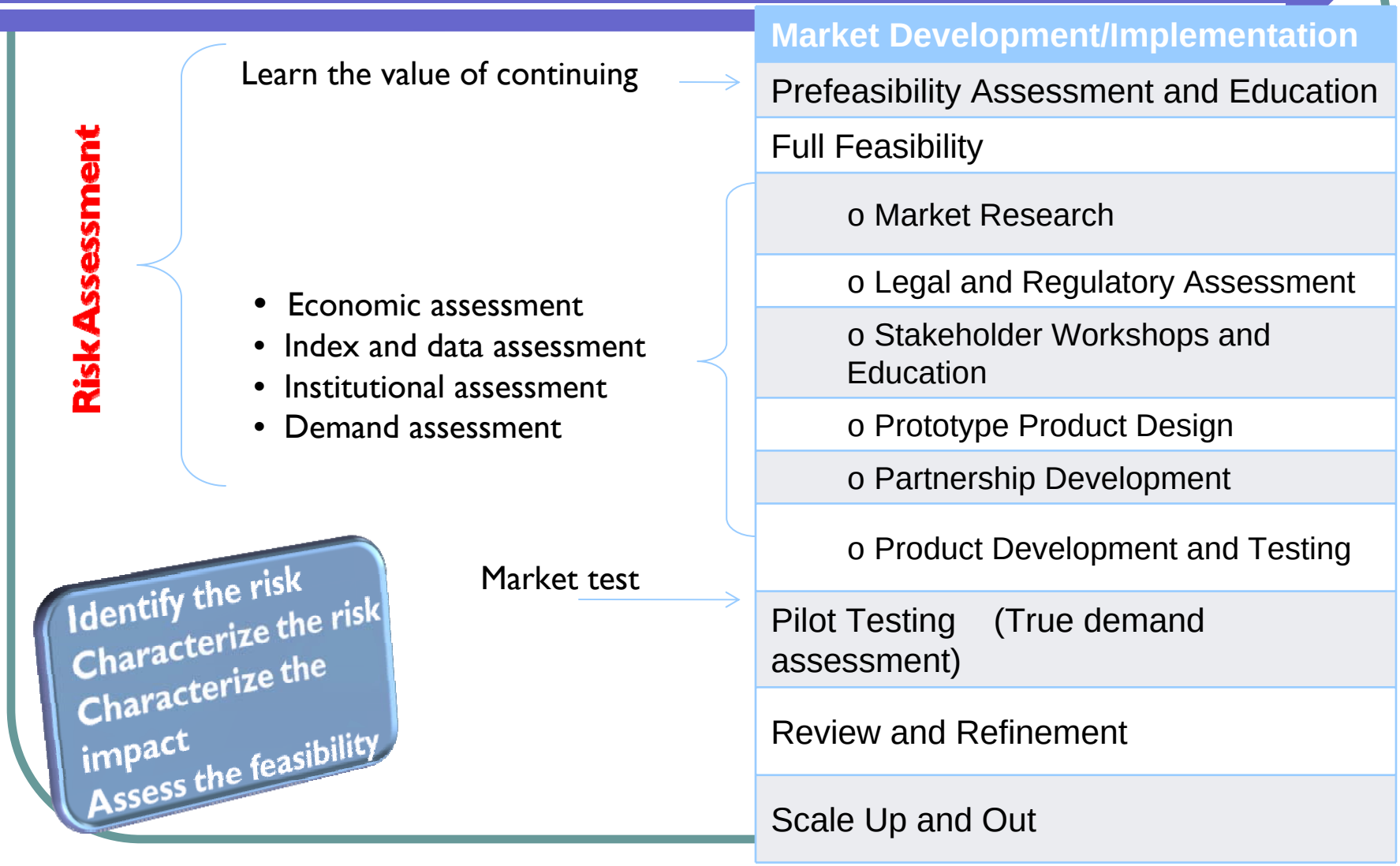
Example B: *Long Time Frame*

Short Time Frame

Example C: *Long Time Frame*



Market Development Model Overview



Index Insurance Preconditions

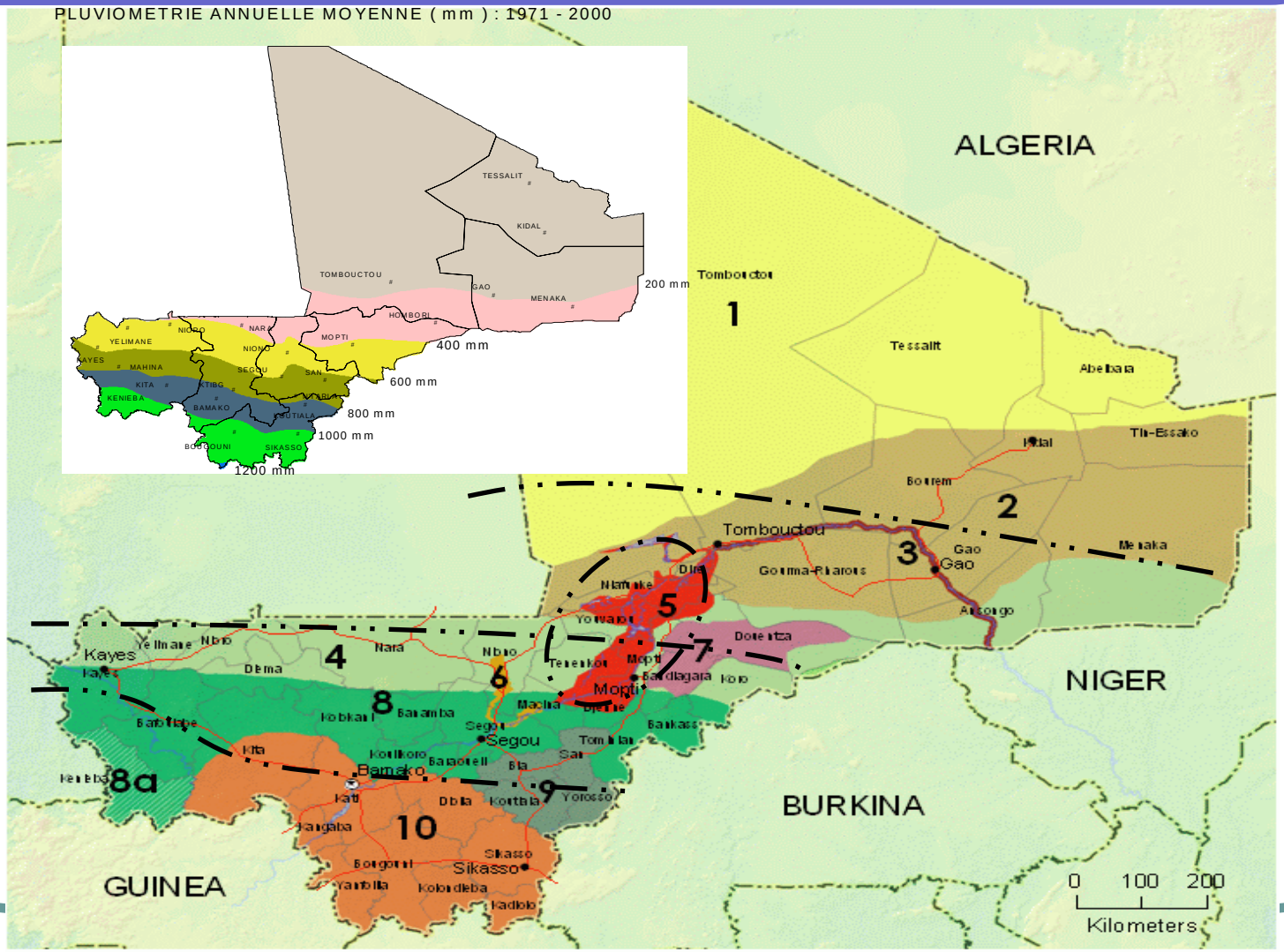
- Weather event must create correlated losses
- Index must be good proxy for losses
- Event must be observable and easily measured with a transparent, objective, and reliable source of data for the index measurement
- Measurement of weather variable should involve a third party
- Reliable, historic data must exist to price the risk (30 years or more is ideal)
- Enabling and supportive regulatory environment
- Acceptance of the concept by potential users
- Interest and enthusiasm among participants / stakeholders

Mali Prefeasibility Study Area

- Population 12m – 70% involved in agriculture
- Small-scale traditional and subsistence farming dominates

- < 2% of rural households have access to formal credit
- Southern half is arable / agro-pastoral
- Primarily manual labor technologies
- Farm size dependent on mechanization: 2-7 hectares manual / ~30 with traction
- Millet, sorghum, maize, rice, cotton, fonio
- Among largest cotton producers in Africa
- Cotton area declined after 2005 with low prices and CMDT parastatal collapse
- Sorghum and maize expanding into land formerly planted to cotton

Agro-Ecological Zones and Livelihoods



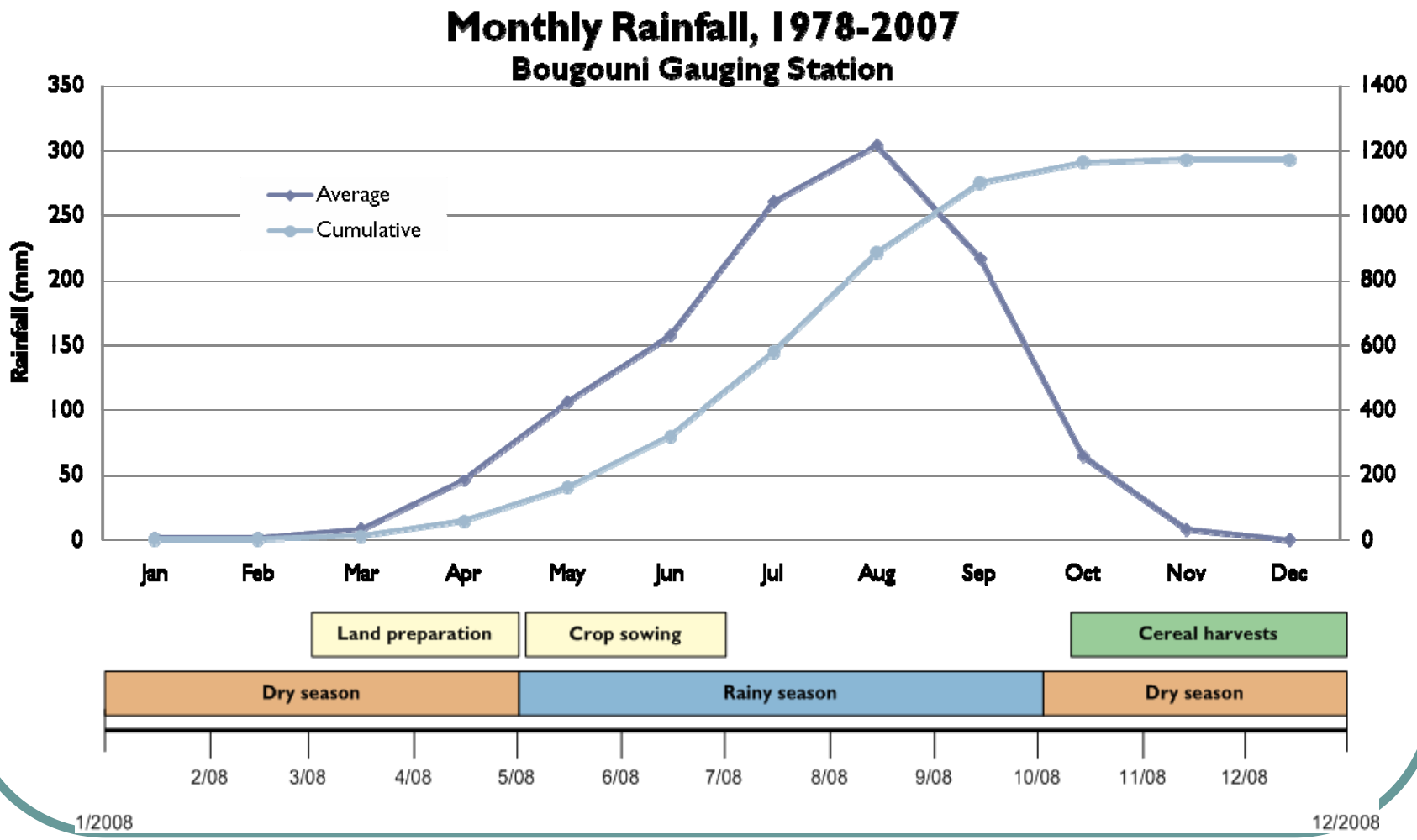
Maize, Lending, & Weather Risk

- Maize expansion limited by fertilizer affordability & ability to borrow
- Soro Yiriwaso (one of several regional MFIs) developed a maize production loan for male farmers that has generated strong demand among former cotton growers
- Rural lenders have difficulties in attracting capital when portfolio is highly exposed to correlated weather risk
  - Lack of sufficient collateral among rural borrowers
  - Perceived high level of risk in agricultural lending

Query:

Can index based weather insurance help individual farmers or rural lenders release the credit constraint and protect their livelihoods?

Rainfall / Production Interaction



Weather Station Infrastructure and Data

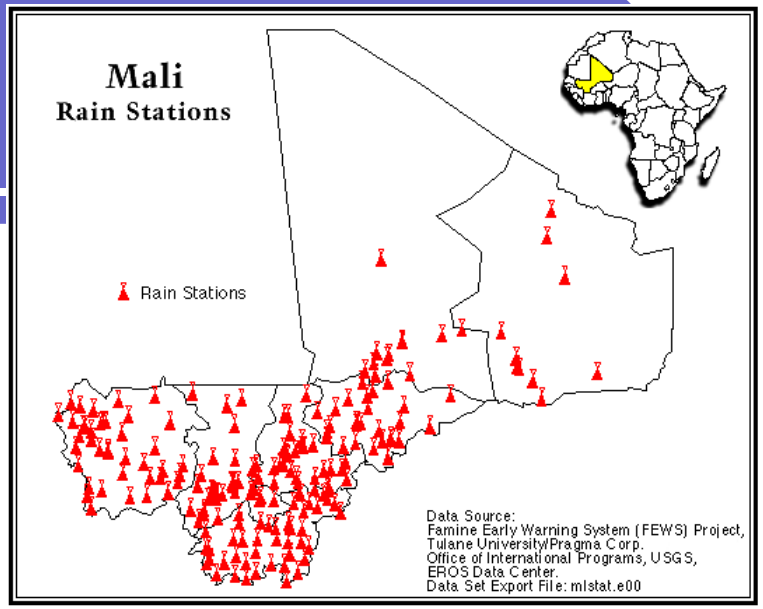
Rain Gauges, Bougouni

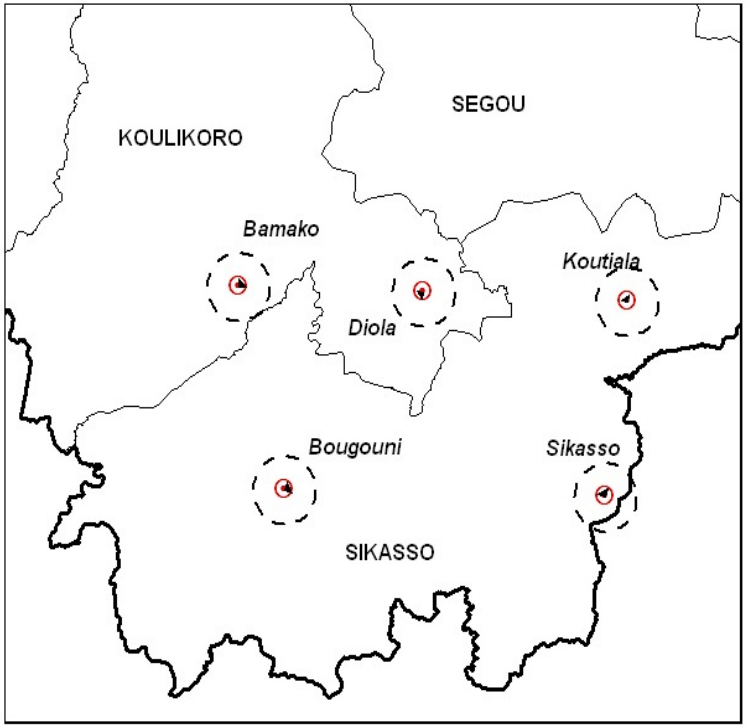
Needs

- Minimum historical record: 30 + years
- Minimal missing values
- Sufficient density of recording stations in the vicinity of cropping
- Standardized collection, verification, reporting
- Near real-time reporting
- Third-party settlement (i.e., no financial interest)

National Meteo Service

- Weather station infrastructure
- Officially: Bamako and South
  - 4 synaptic stations
  - 13 agro-climate stations
  - 57 rainfall station
- Most stations not current and have significant gaps
  - 5 active stations
  - Daily rainfall 1954-2007 for Bougouni & Sikasso stations





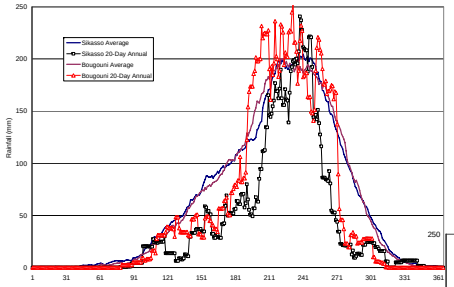
Spatial Correlation of Rainfall Events

- Is there strong correlation in weather patterns across geography? Two station data: Bougouni and Sikasso
- Different levels of looking at the correlation
  - Daily average rainfall correlation: 87%
    - The two stations on the same rainfall isohydral
  - Critical period cumulative
    - May 52%; June 65% (slow onset risk)
    - July 27%; Aug 20% (mid-season risk)

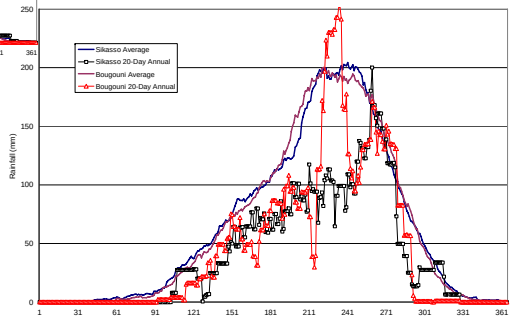
Rainfall Pattern Identification

20-day moving average / average annual rainfall

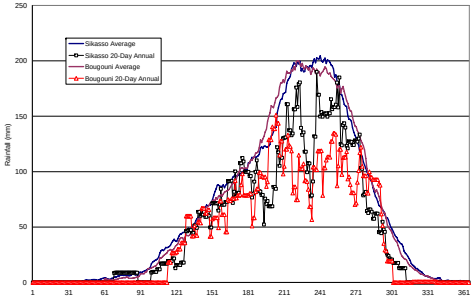
1. Low early and late season rainfall



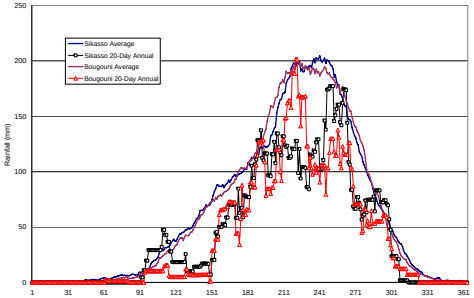
2. Below normal until late in the season



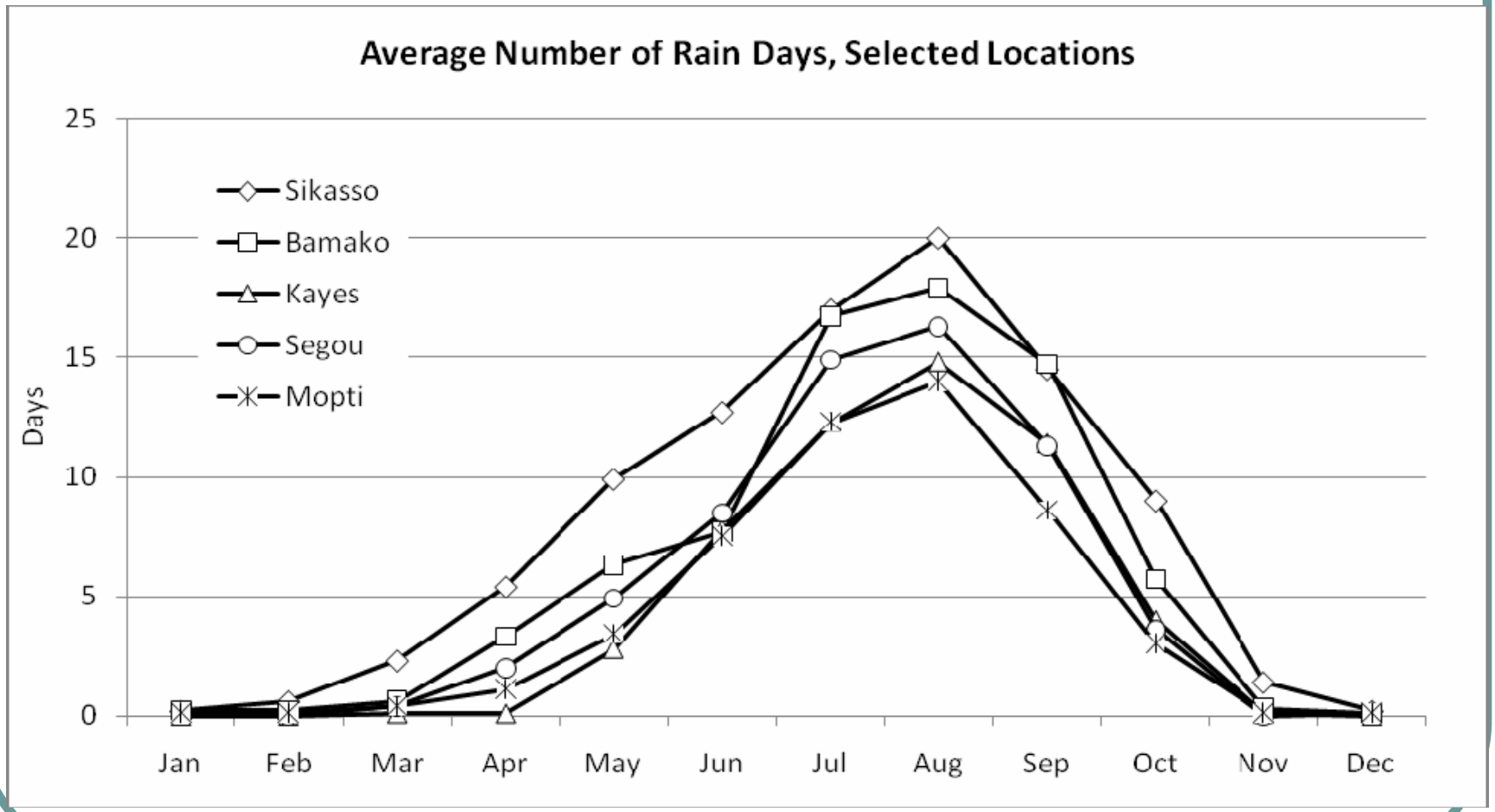
3. Below normal mid-season



4. Low early and below normal mid-season

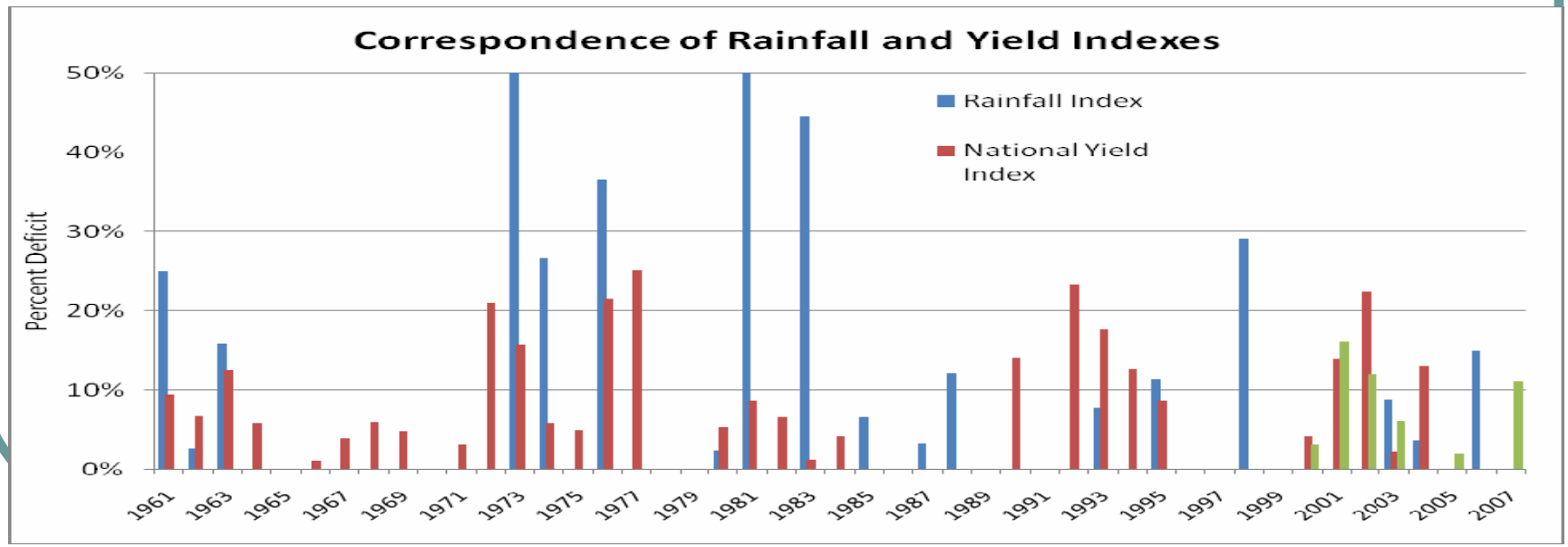


Rainfall Frequency



Correspondence for Catastrophic Loss

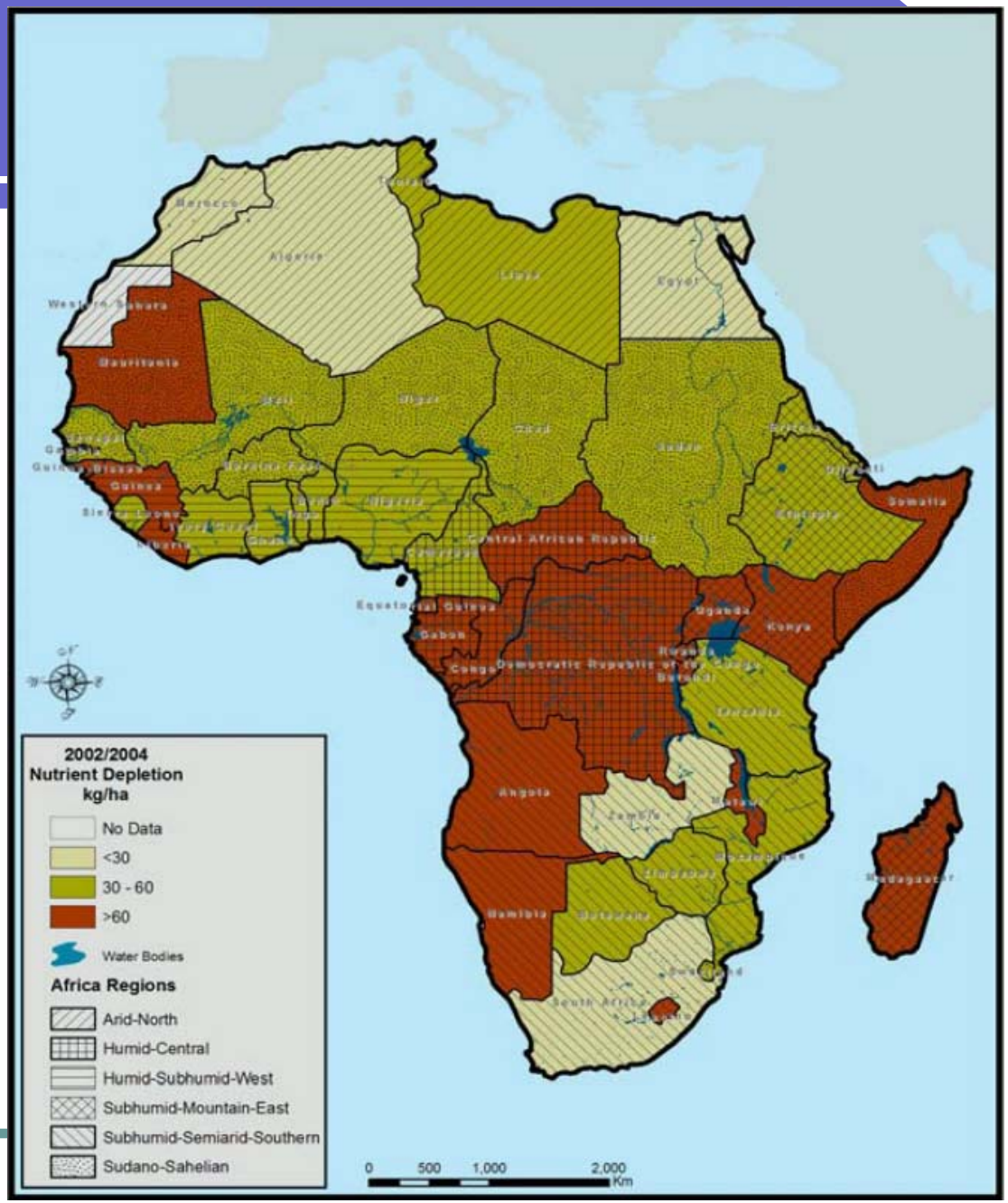
- Search available data for any possible relationships between rainfall shortfalls and yield shortfalls
- 10 monthly rainfall deficit contract between April and August for both available weather stations.
- Very little correlation: Why?



Explanation: Back to Basic Agronomy

- Soil degradation trends are such that soil organic matter is nearly depleted
- Organic carbon rich soil acts as a moisture reservoir and buffer
  - Reduced water infiltration
  - Reduced water retention properties
  - Contributes to fertilizer and further soil erosion
  - Plant growth even more dependent on the timing of rainfall
  - Rainfall intensity is more likely to be idiosyncratic
- Documented loss of SOC in African soils
  - Randomness of yield outcomes to rainfall outcomes
  - Explain why drought and flood are both mentioned as risks
- Developing rainfall-based weather index insurance a challenge

Nutrient Depletion 2002/2004



Pre-assessment: Agricultural Practices and Weather Risk in Mali (Bougouni)

Agricultural Cropping Calendar

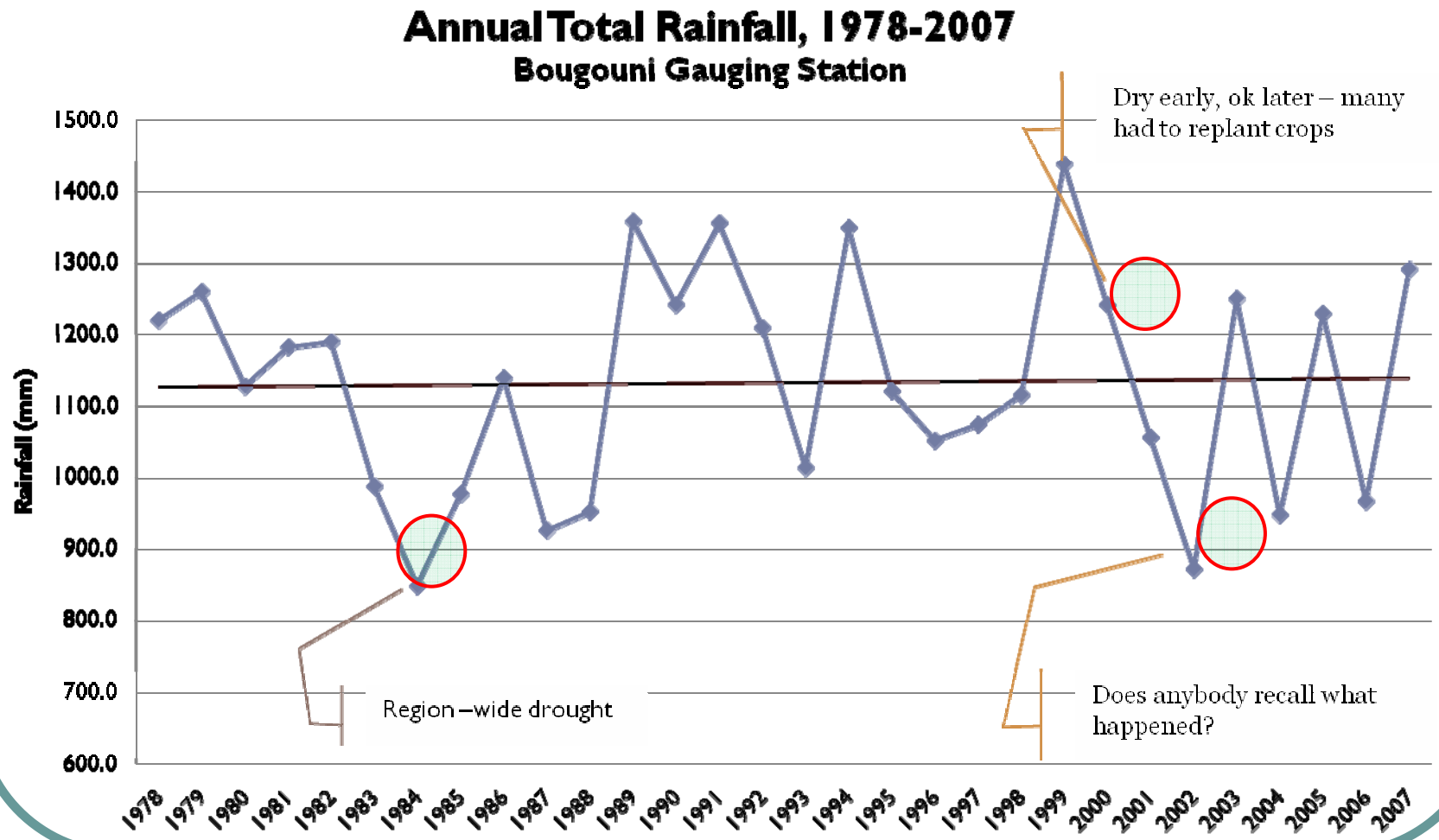
- Critical production and growth stages for important crops
- Impact of weather events on these production stages
- Production response to weather disruptions

Financial Impact

- Costs incurred by household when a weather disruption occurs
- Household strategy to cope with additional cost
- Impact on household credit repayment
- Impact on MFI non-performing loans
- Impact on MFI financing

Weather Characteristics and Interaction with Production Activities

Total Annual Rainfall at Bougouni Station



Lenders and Agricultural Risk Exposure

This is more than getting a farmer to buy insurance

- Risk assessment, risk management and possibly risk transfer
- What are the portfolio challenges of managing agricultural risk?
  - Regulations with regard to lending and reserving requirements?
  - Cash flow and the cropping systems of farmers?
  - How is the lender incorporating risk into lending interest rates?
  - How is the lender incorporating risk into collateral deposits?
  - What other choices do they have to manage risk?
  - Has the lender truly experienced the impact of a natural disaster on their portfolio clients?
- Then ask….if some of the risk could be transferred, how would that create a more efficient way of delivering financial services?
- That will help reveal the *value* of risk transfer….

Understand the Financial Impact

Lending Exposure & Farm Level Exposure

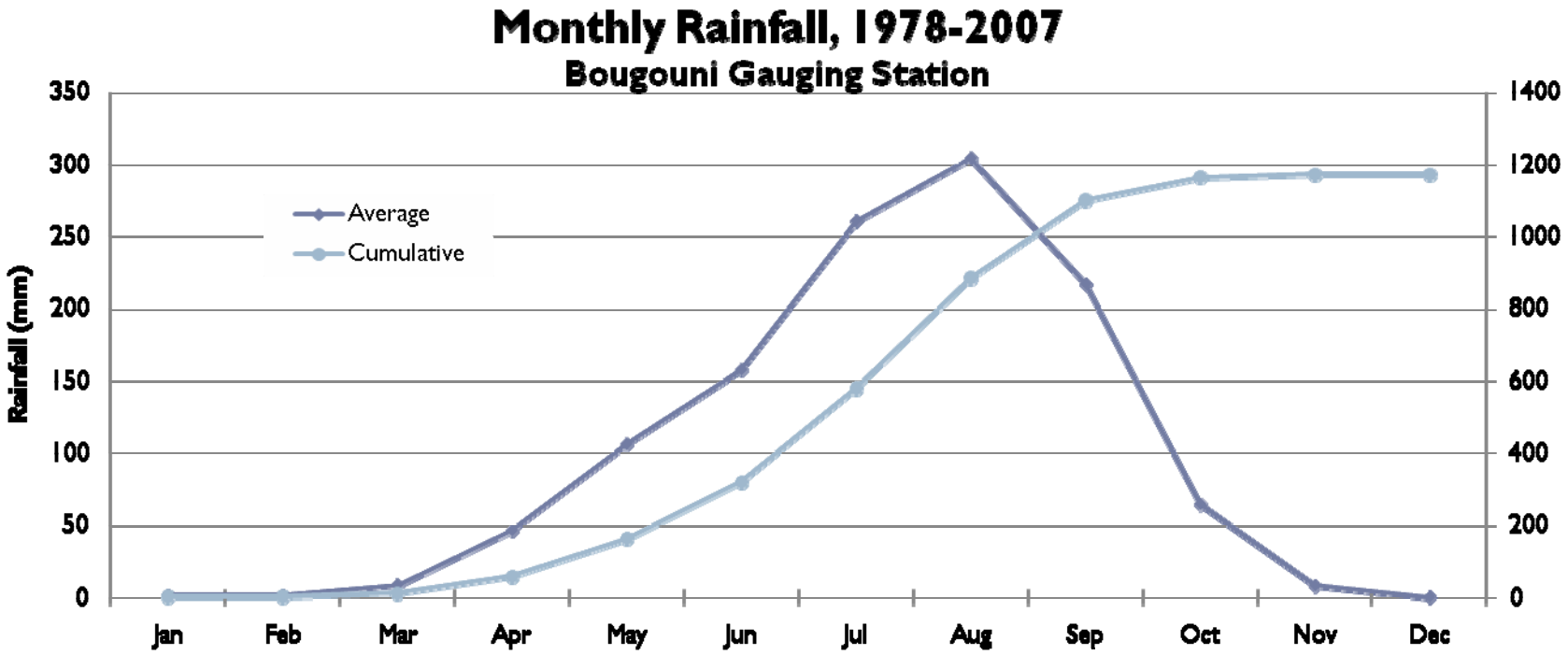
Maize Producers (Bougouni)

- Drought in phase 1
  - Replanting increase total production cost by 50-60%.
- Drought in phase 2 or 3
  - Near total crop loss
- What does this mean in terms of over all household welfare and repayment ability? Not all the impacts are readily observed
  - 2008 maize crop was down by 1/3; Some farmers are worried about repaying

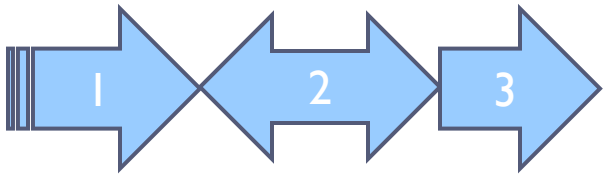
Possibilities to Consider

- Crop Specific Index Product
  - Useful for producers of that crop
  - Useful for lenders providing input credit for produces of the crop
  - Useful for value chain participants of that crop
- Area Yield Product
  - Yield statistics must meet the prefeasibility test
  - But, confounded results when there are serious constraints in the credit and input markets
- Livelihoods Insurance for Households
  - HHs buy a certain level of liability that pays whenever the insured catastrophic weather risk occurs
  - Benefits over index insurance for a specific crop
    - More inclusive of household income sources
    - More inclusive of the landless poor
  - Delivery and data problems make household products challenging

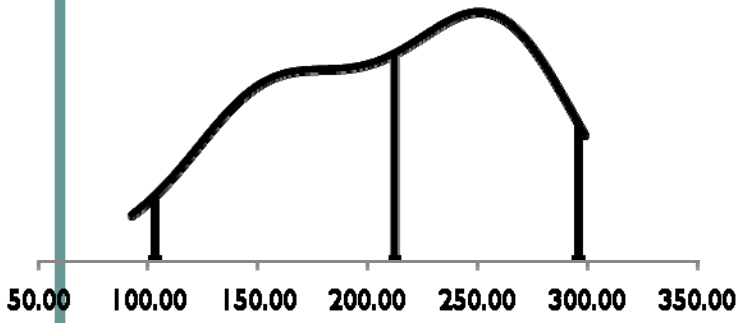
Rainfall and Critical Maize Growth Phases



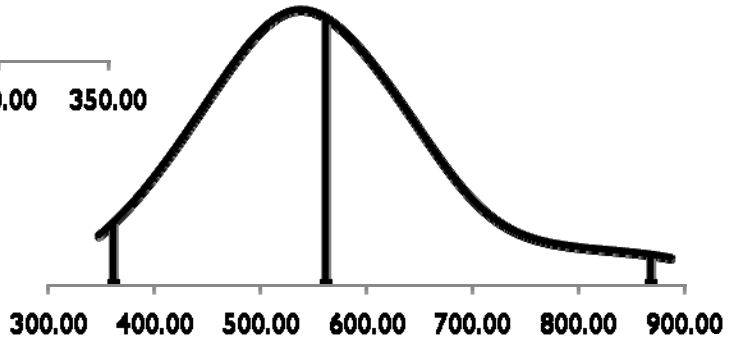
1. Emergence and establishment
2. Growth and flowering
3. Kernel development & harvest

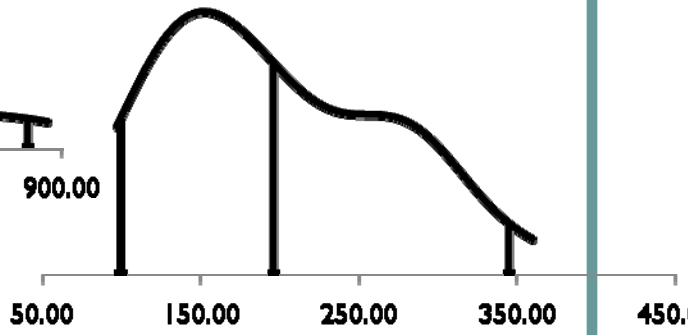


Maize Growth Phase and Rainfall Distribution



PDF Approximation





Phase 1

Mean =212mm

Phase 2

Mean =561mm

Phase 3

Mean= 196mm

198
4
347.1

El Niño in Peru

- El Niño has more negative effects in Peru than any other country in the world!
- Some regions have extreme flooding; others have extreme drought
- Agriculture, homes, fishery catches, infrastructure, transportation, markets, exports, small trade, and the overall economy of Peru are all negatively affected
- The 1997/98 El Niño affected 200,000 hectares across Peru

ENSO Business Interruption Index Insurance
Our Focus First — Business Interruption of Lenders

Covers lost profits or extra costs due to extreme flooding as indicated by high average sea surface temperatures in November–December

- Liquidity risk…
- Savings are being withdrawn
- Decrease in certificates of deposits
- Loans are being refinanced
- Cost of capital will increase
- Defaults will follow
- Increased need for more capital for provisioning

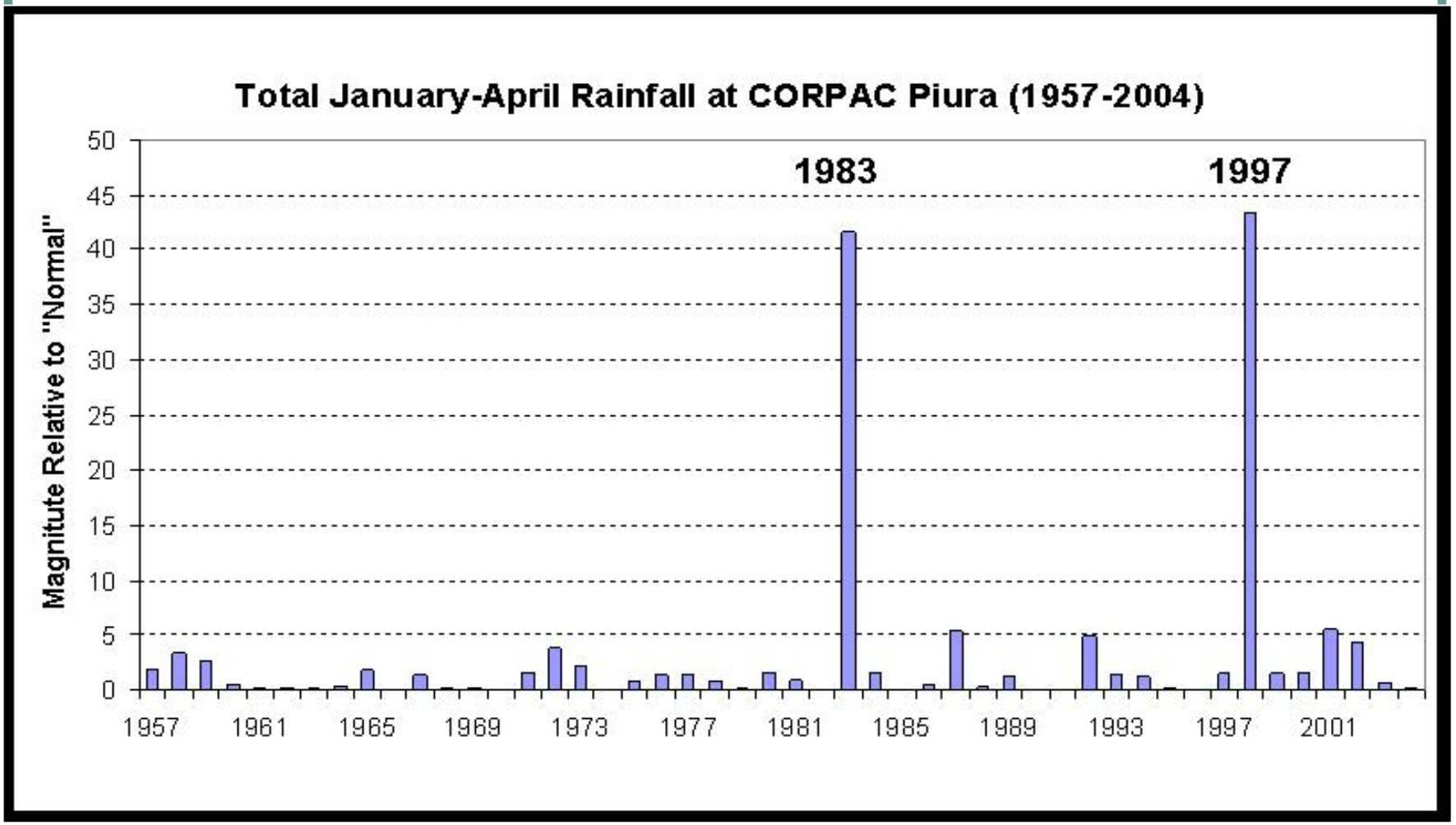
Farm Households Vulnerable to Extreme Flooding During Growing Season

- Households are engaged in a variety of labor-intensive activities susceptible to extreme rainfall and flood risk
- To cope with the effects of a disaster
  - Households rely on family and friends
  - Some sell livestock
  - These strategies are not effective when an entire community is affected such as with El Niño
- The use of savings and credit to smooth cash flow problems is not commonly used by smallholders

Extreme Flooding and El Niño

- Extreme flooding in Piura is directly tied to El Niño
  - Warm Pacific trade winds meet cold air coming down Andes Mountains
  - Results in extreme, prolonged rainfall
  - Severe El Niño occurs roughly 1 in 15 years
- Most recent severe El Niño events: 1982/83 and 1997/98
  - Rainfall was 40x normal for January to April
  - For 1997/98, volume of Piura River was 41x median value
  - For 1982/83, volume of Piura River was 36x median value
- El Niño is by far the biggest risk event for agriculture

En un evento “Niño” severo aumenta
la cantidad, frequencia y cobertura espacial de las precipitaciones —
pueden sobrepasar 40 veces el nivel normal!



El Niño Trends

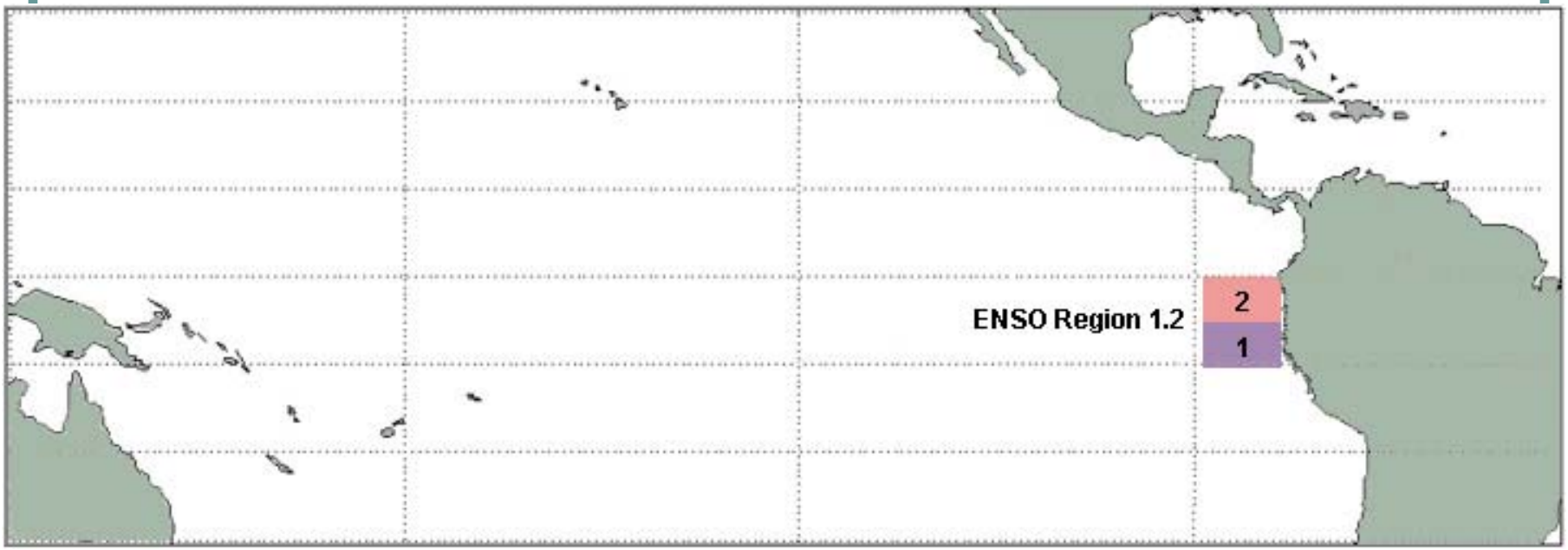
- Data from past 30 years, El Niño events may be increasing in frequency and severity
- In last 100 years, 4 strongest El Niño events have occurred since 1980
- While there is no consensus among scientists, there are some who believe global warming may be contributing to the increased frequency and severity
- 1982/83 and 1997/98 events may occur 1 in 15 years
- Increased upstream deforestation is likely responsible for increased flooding making the situation in Piura even more of a concern

ENSO Business Interruption Index Insurance (EBIII)

- Rainfall insurance not viable due to limited data
  - Short time period, sparse, difficult to interpret
  - Weather stations destroyed during previous catastrophic events
- ENSO 1.2 index of sea surface temperatures
  - Monthly average sea surface temperature (SST) from two areas off the coast of Peru
  - Published by the U.S. National Oceanic and Atmospheric Administration (NOAA) using a consistent and reliable methodology
  - ENSO 1.2 can be used to predict extreme flooding associated with El Niño

ENSO 1.2

- Measured and reported by the NOAA Climate Prediction Center for over 50 years
- ENSO Region 1.2
  - (0°-5°S, 90°W-80°W and 5°S-10°S, 90°W-80°W)



Developing ENSO Business Interruption Index Insurance

- Measure is fully transparent to all parties
  - Can be made free of moral hazard and adverse selection
- Concept for ENSO Insurance approved by SBS in 2005
- Work performed in 2009 indicates
  - Average ENSO 1.2 value for November–December captures the extreme event with high confidence
  - A contract using ENSO 1.2 values for November–December pays for the same years at nearly the precise same values
  - Correlations between November–December and January–March are 91% for ENSO 1.2 values that are above the median
  - Indemnity payments could be made as the business interruptions are accelerating (in early January)

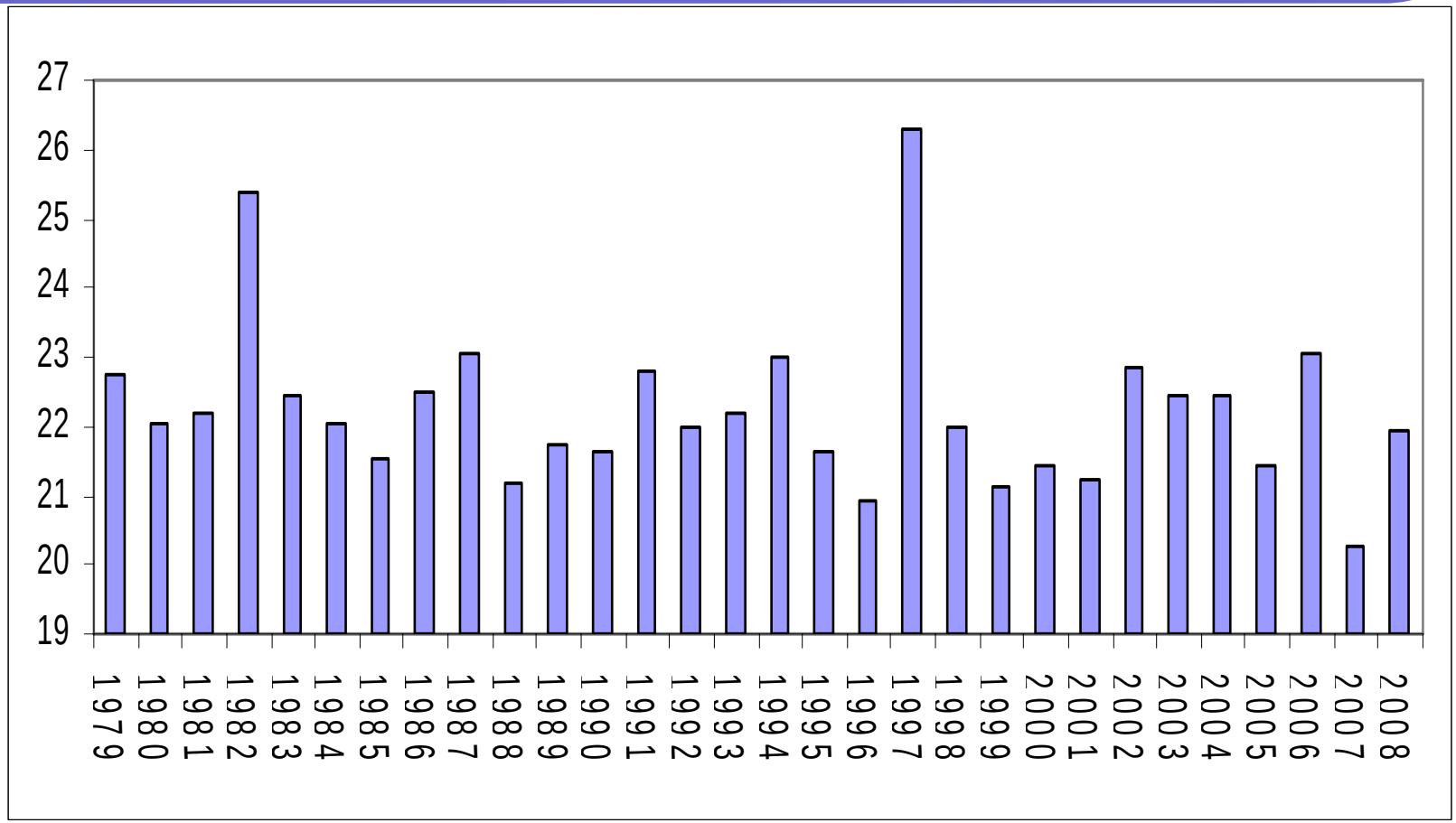
Easing Regulatory Concerns about Using an ENSO Index

- Classifying as business interruption insurance eases regulatory concerns
  - ENSO 1.2 serves as proxy for loss for those with insurable interest
  - Enhances indemnity process — pre-agreed metric for payouts rather than complicated loss adjustment process to estimate business interruption costs

$$\frac{\overline{ENSO\ 1.2}_{November} + \overline{ENSO\ 1.2}_{December}}{2}$$

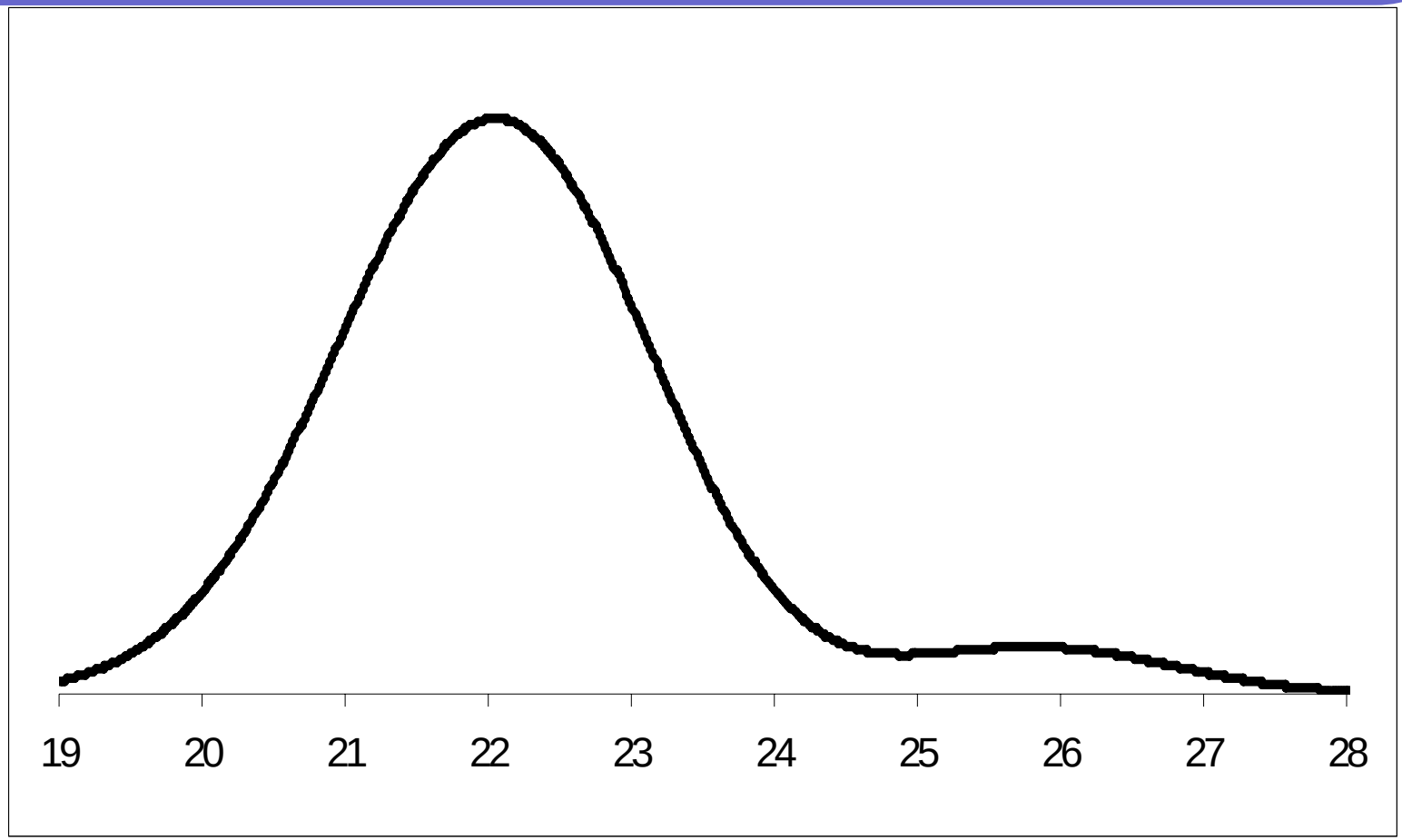
- ENSO Index

ENSO Index from 1979 to 2008



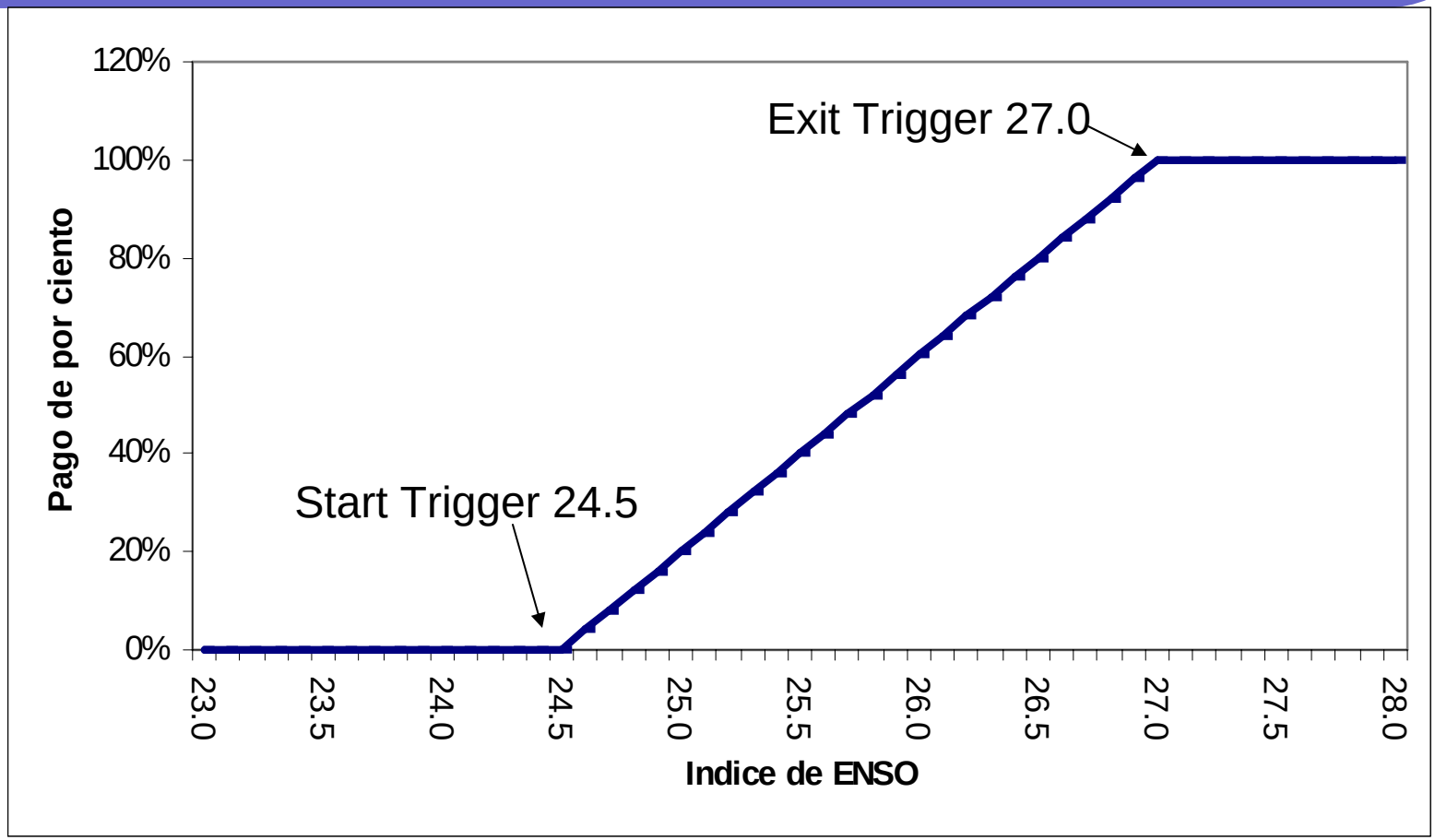
1982 payment rate = 34 percent; 1997 payment rate = 71 percent
Start Threshold = 24.5; Exit Threshold = 27

Estimated Probability Density Function for ENSO Index Using Data 1979 to 2007



Events in excess of 24 may occur as frequently as 1 in 11 years

Payout Structure



Linear payout so that if temperature is ½ the way between 24.5 and 27 or 25.75, the payout rate is 50 percent

Payout Structure: La Positiva Is Offering Product with Start Trigger of either 24.0° C or 24.5°C)

$$\text{EBIII Payment} = \min\left\{\text{MSI} * \left(\frac{\text{ENSO Index} - \text{ST}}{\text{ET} - \text{ST}}\right) \text{ or MSI}\right\}$$

MSI – Maximum Sum Insured
ST – Start Trigger (24.5° C) (24.0° C trigger is also available)
ET – Exit Trigger (27° C)

For example for 1997/98 El Niño,

if MSI = USD 1 million

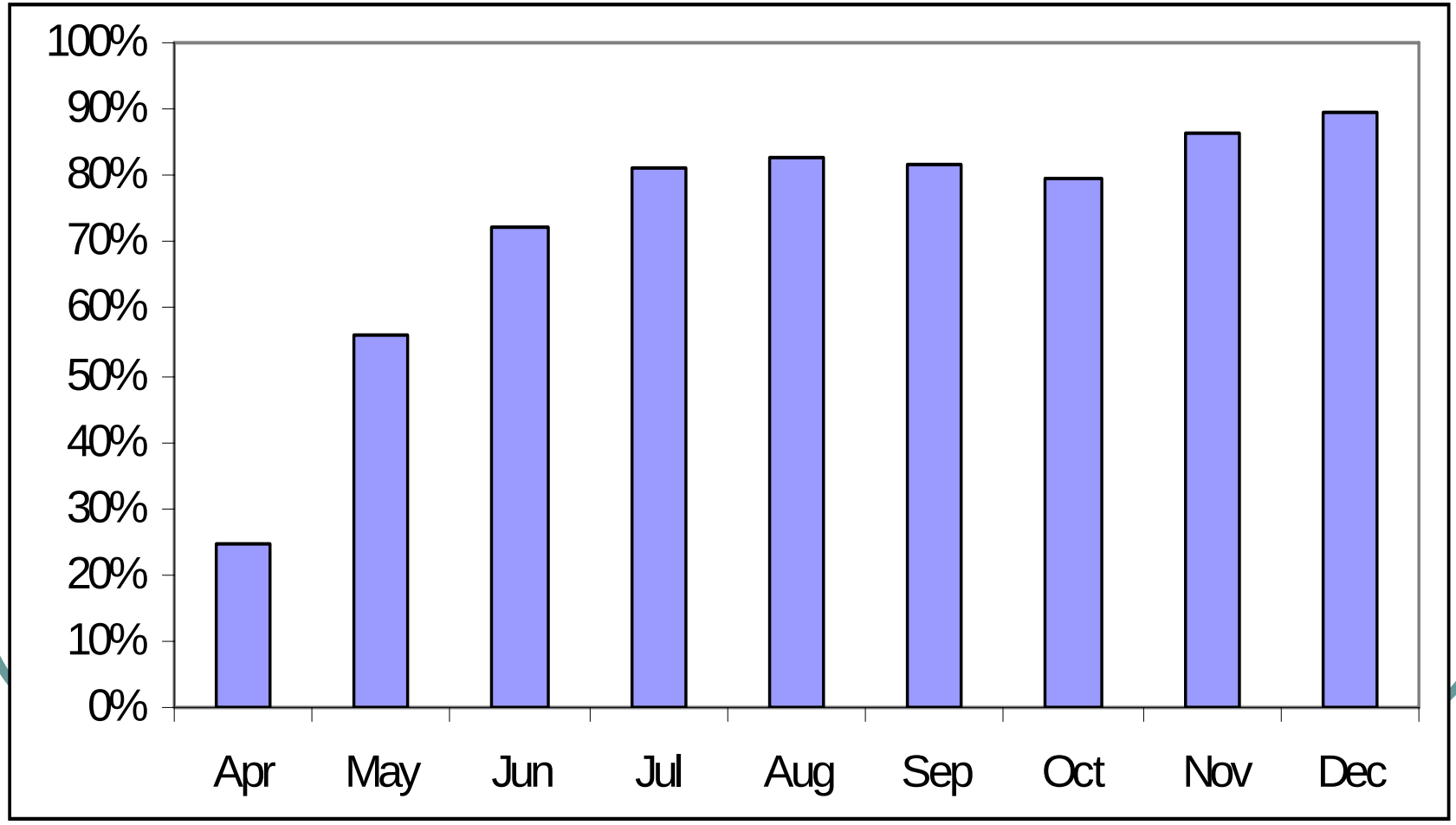
$$\text{EBIII Payment} = 1 \text{ million} * \left(\frac{26.38 - 24.5}{27 - 24.5}\right)$$

$$= 1 \text{ million} * (0.71)$$

$$= \text{USD } 710{,}000$$

ENSO Forecast Can Be Made as Early as April

Simple correlation between Jan–March ENSO 1.2 and previous year by month using only Jan–March ENSO 1.2 average values above the median



Timing of the Contract

Year 1			Year 2	
February–April	**May–October**	**Nov–Dec**	**Early January**	**February–April**
Marketing period with a sales closing date of April 30	The EBIII is in force for possible upcoming severe event	SST data from ENSO 1.2 is used to calculate payments	Payments can be made ***before*** flooding as lenders begin to incur costs	Catastrophic flooding in the region

- Sales closing date must occur before buyers can predict an El Niño — target April 30
- Insurance contract covers ENSO 1.2 (Nov–Dec)
- Payments will be made in early January as business interruptions are occurring

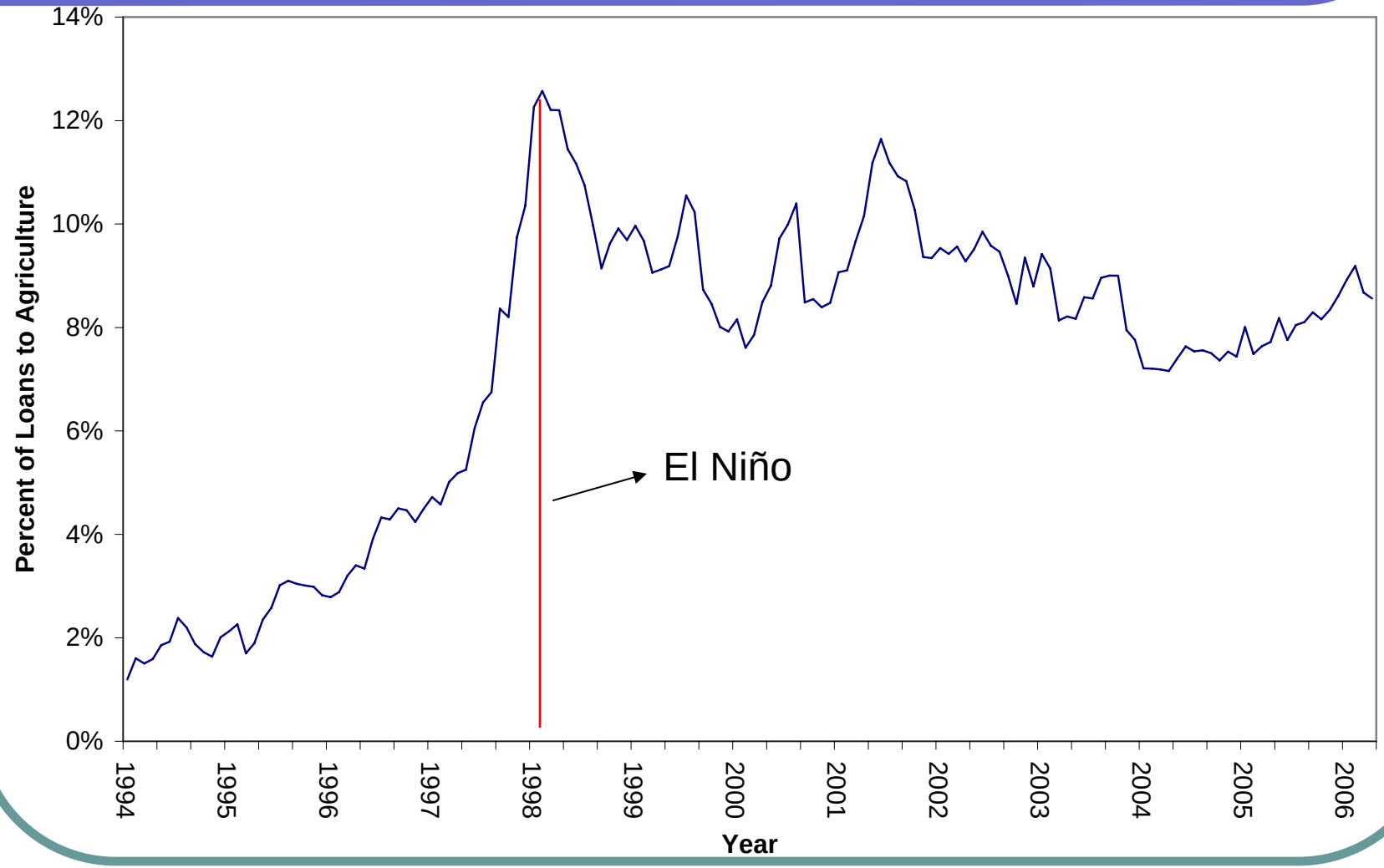
Regulatory Issues for Index Insurance

1) Does the purchaser have an insurable risk?
2) Will the index represent a reasonable proxy of loss?
3) Is there a clear plan to educate the user?
4) Is there a clear plan to educate the sale force about the unique features of the index insurance?
5) Is there a plan to protect the insurance industry form the risk of insolvency that may accompany insuring a correlated risk?
6) Is there assurance that the insured will be paid as the event and losses are described in the contract?

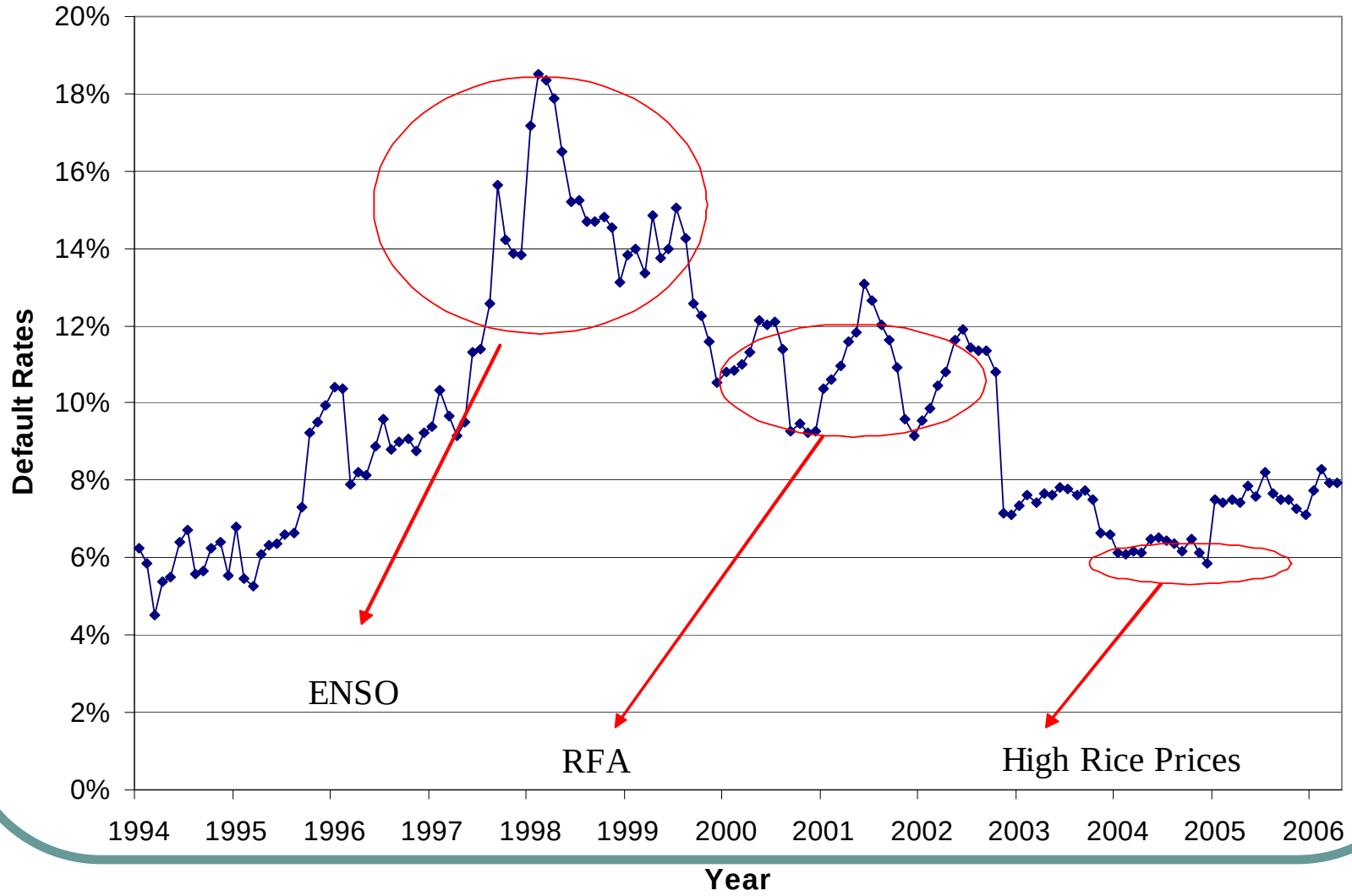
Our First Focus: Business Interruption Insurance for Lenders (Cajas and Others)

- Business Interruption Insurance pays for loss profits or added expenses when there is an insurable event
- Lenders in Piura will have significant disruptions to their business as early as January
- Major concern – Access to capital will be heavily constrained when everyone knows that El Niño is coming
  - Liquidity risk…
  - Savings are being withdrawn
  - Decrease in deposits
  - Loans are being refinanced
  - Cost of capital will increase
  - Defaults will follow
  - Increased need for more capital for provisioning

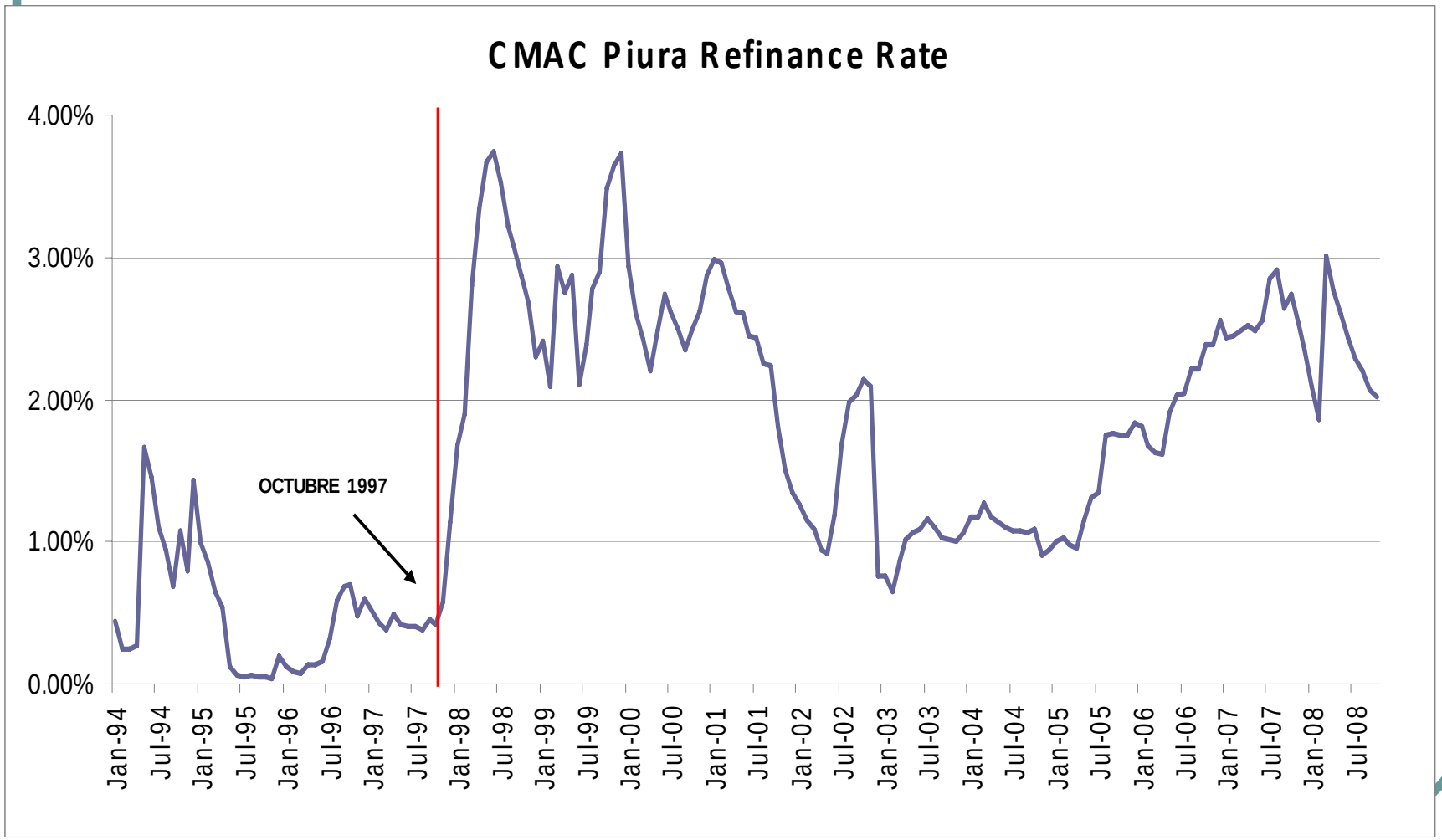
Historical Pattern of Agricultural Lending in Piura 1994–2006



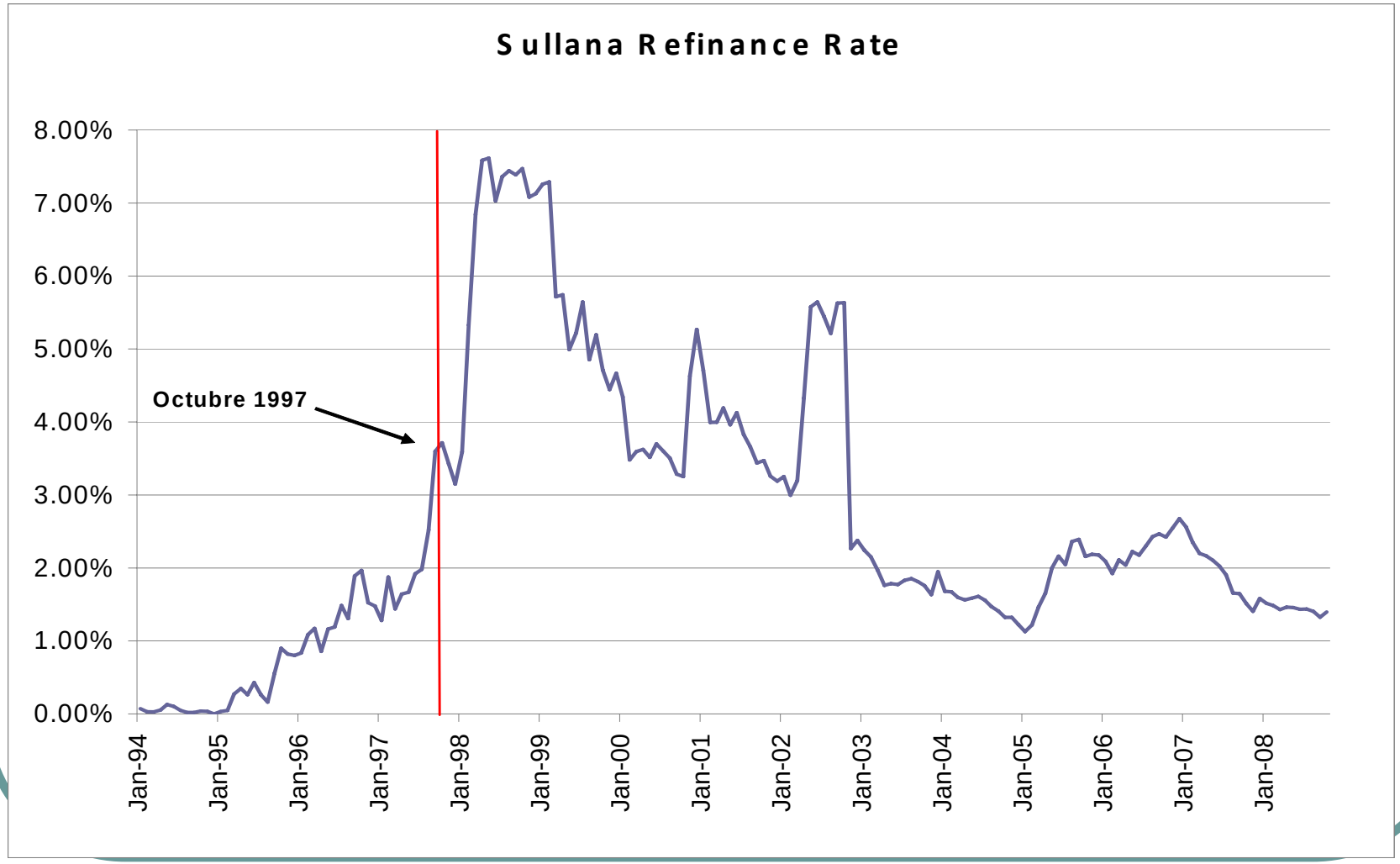
Default Pattern on All Loans in Piura, 1994–2006



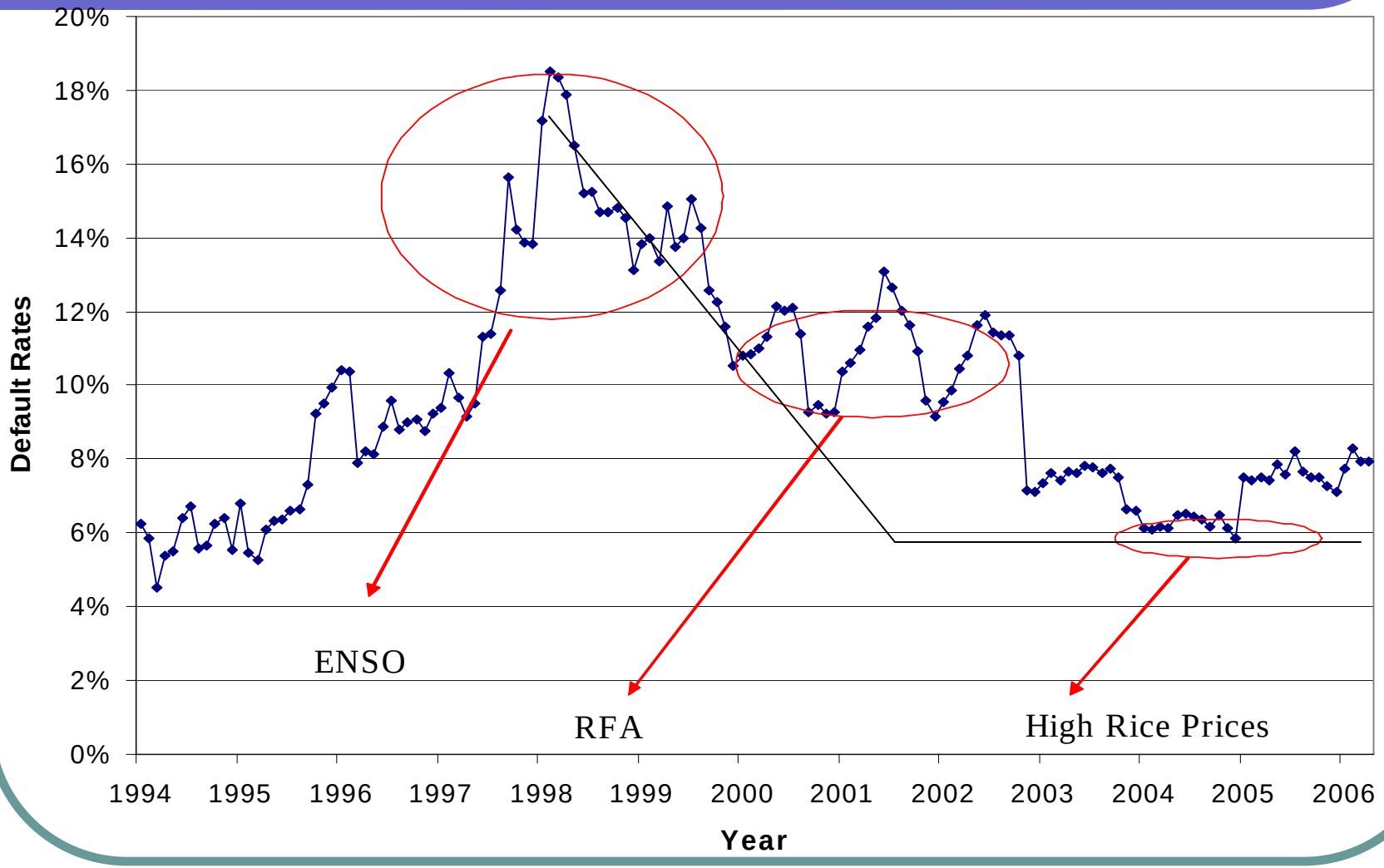
CMAC Piura Refinance Rates, 1994–2008



CMAC Sullana Refinance Rates, 1994–2008



Tiempo posible de recuperación de un El Niño en ausencia de RFA = 3.5–4 años



Longer Vision: Agricultural Lending in Piura

Lenders in Peru cite El Niño risk as preventing them from making agricultural loans

- Agricultural lending has not kept pace with other lending
- From 1998 to 2003, MFIs in Piura increased total lending by 350% but agricultural lending has declined
- Since the last El Niño agricultural lending decreased from 30% to 10 % of the portfolio
- Lenders have told us they have ‘fixed the problem’ by not making production loans when they see El Niño coming
- There is both a lender response and a farmer response
  - 70% report access to credit
  - Yet only 28% use formal credit
  - 25% report no access to credit

Estimate of the Risk Loading

$$\pi = p(1+i)L - (1+r)L$$

$$i = \frac{1+r}{p} - 1$$

π – expected profits
p – exogenous probability of non-default
i – interest rate
r – lender's opportunity costs
L – amount of funds loaned

Example (no default risk)
r = 10%
p = 100%

$$i = \frac{1+0.10}{1} - 1 = 0.10$$

Example (10% default risk)
r = 10%
p = 90%

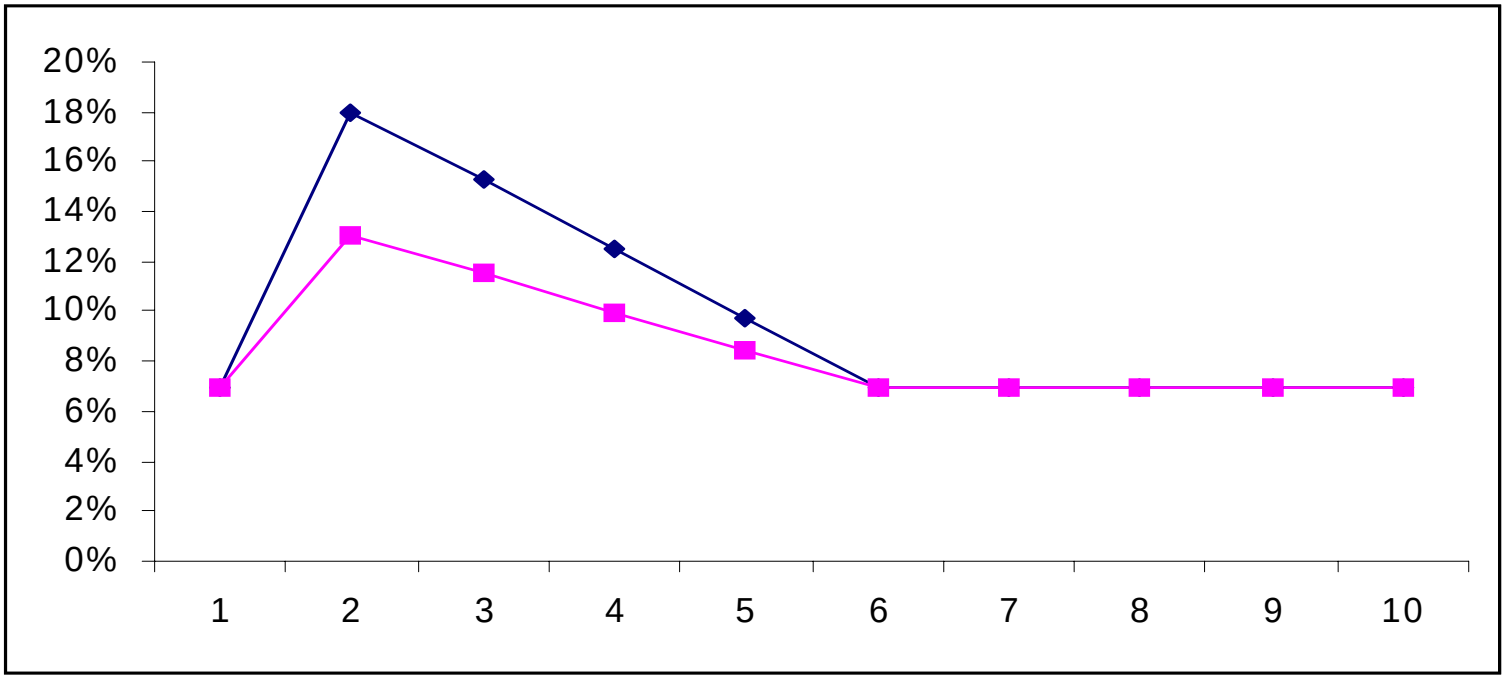
$$i = \frac{1+0.10}{0.90} - 1 = 0.22$$

Extending the Cost of Capital Formulas to El Niño Risk

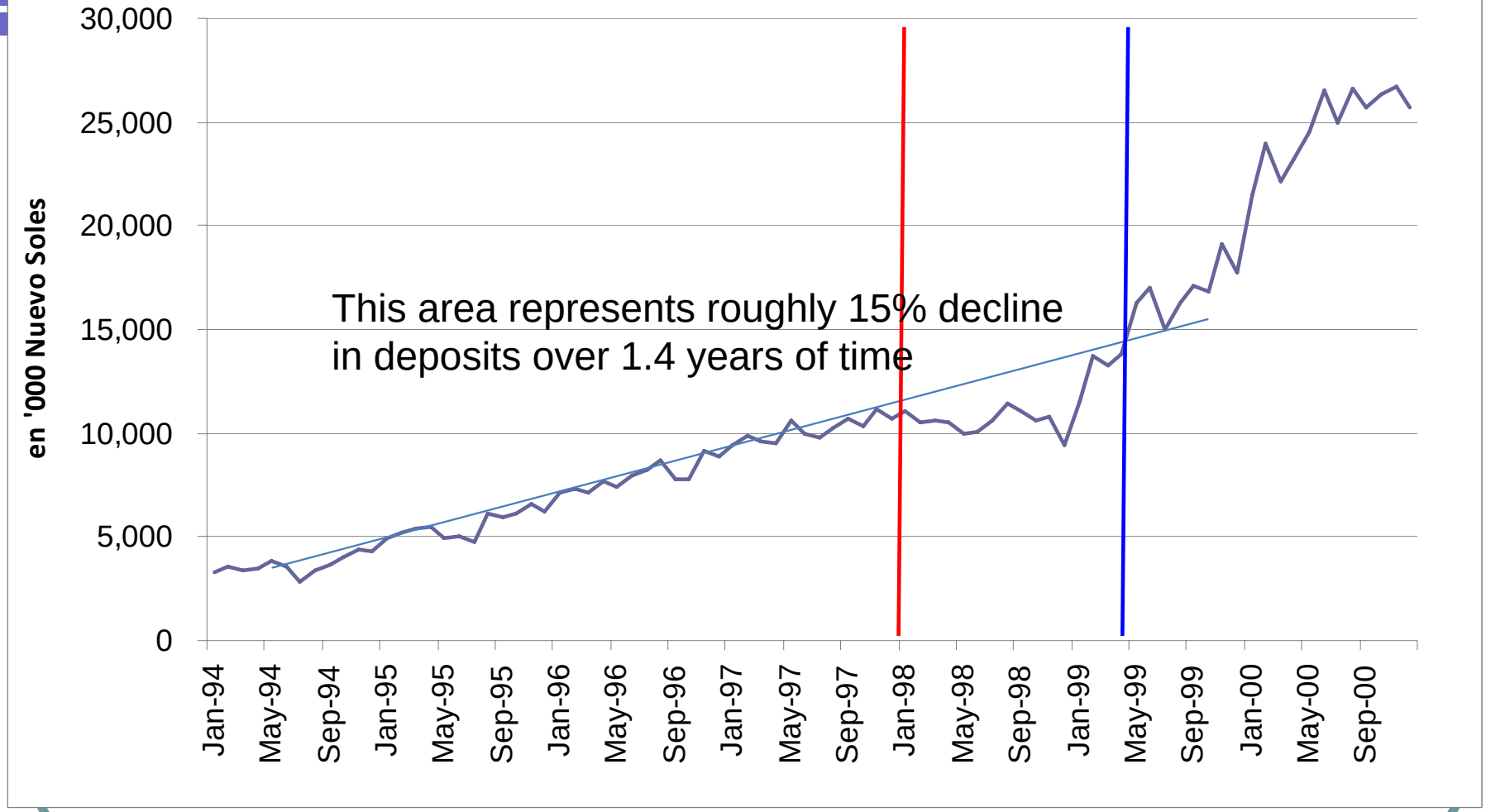
Costo de préstamos a los agricultores →	40%
Costo del capital →	-10%
Costo administrativo →	-20%
Costo de carga de riesgo? →	-10 (puntos porcentuales)

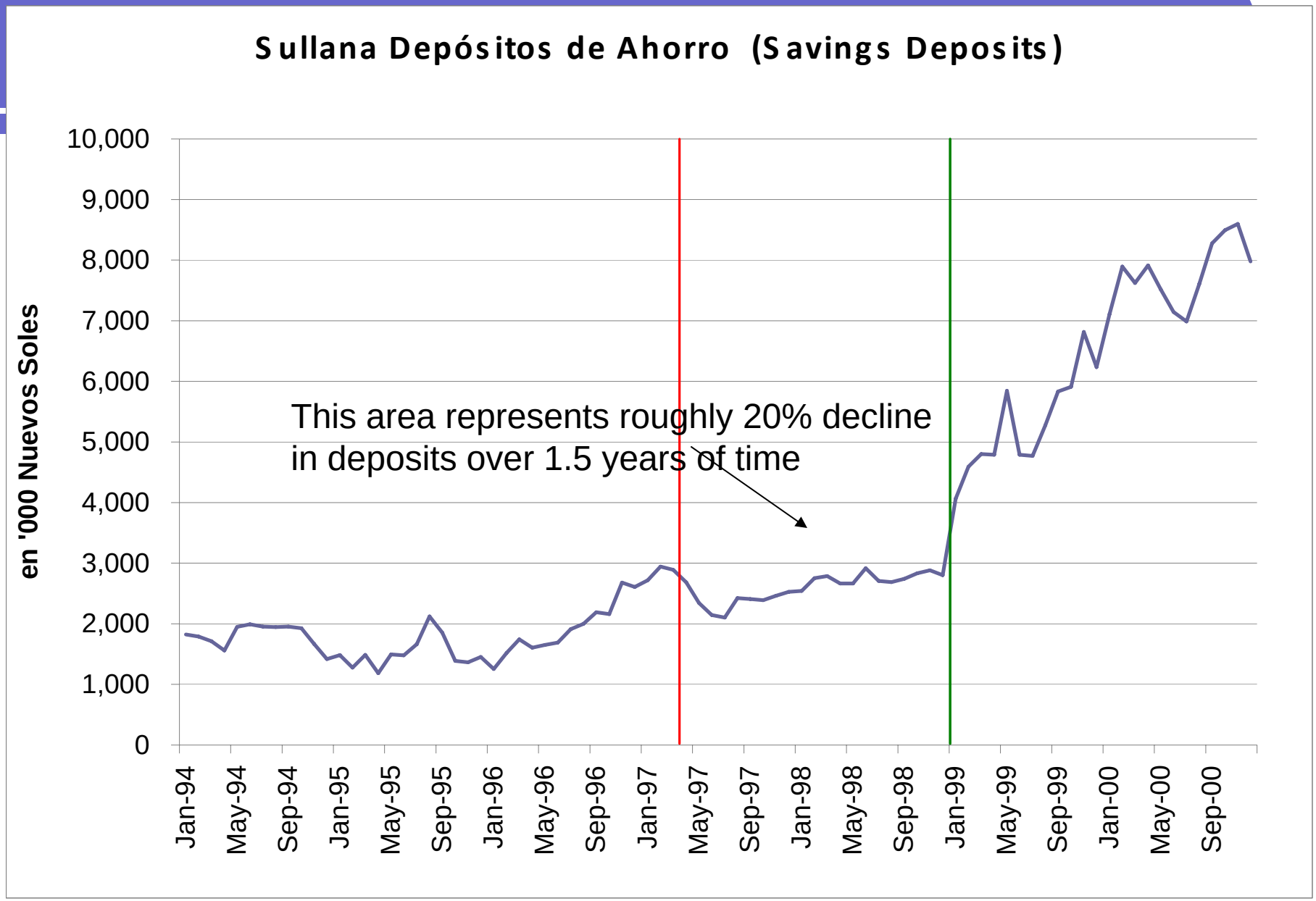
- This example and numbers match with the current environment for Cajas if we assume the average default rate is 7 percent and that this default rate spikes to 18 or 20 percent due to El Niño and it takes 4 years to return to the equilibrium default of 7 percent
- Without El Niño, *costo de carga de riesgo* would decline from 10 percentage points to 7 percentage points
- Average interest rates would decline from 40 to 37 percent

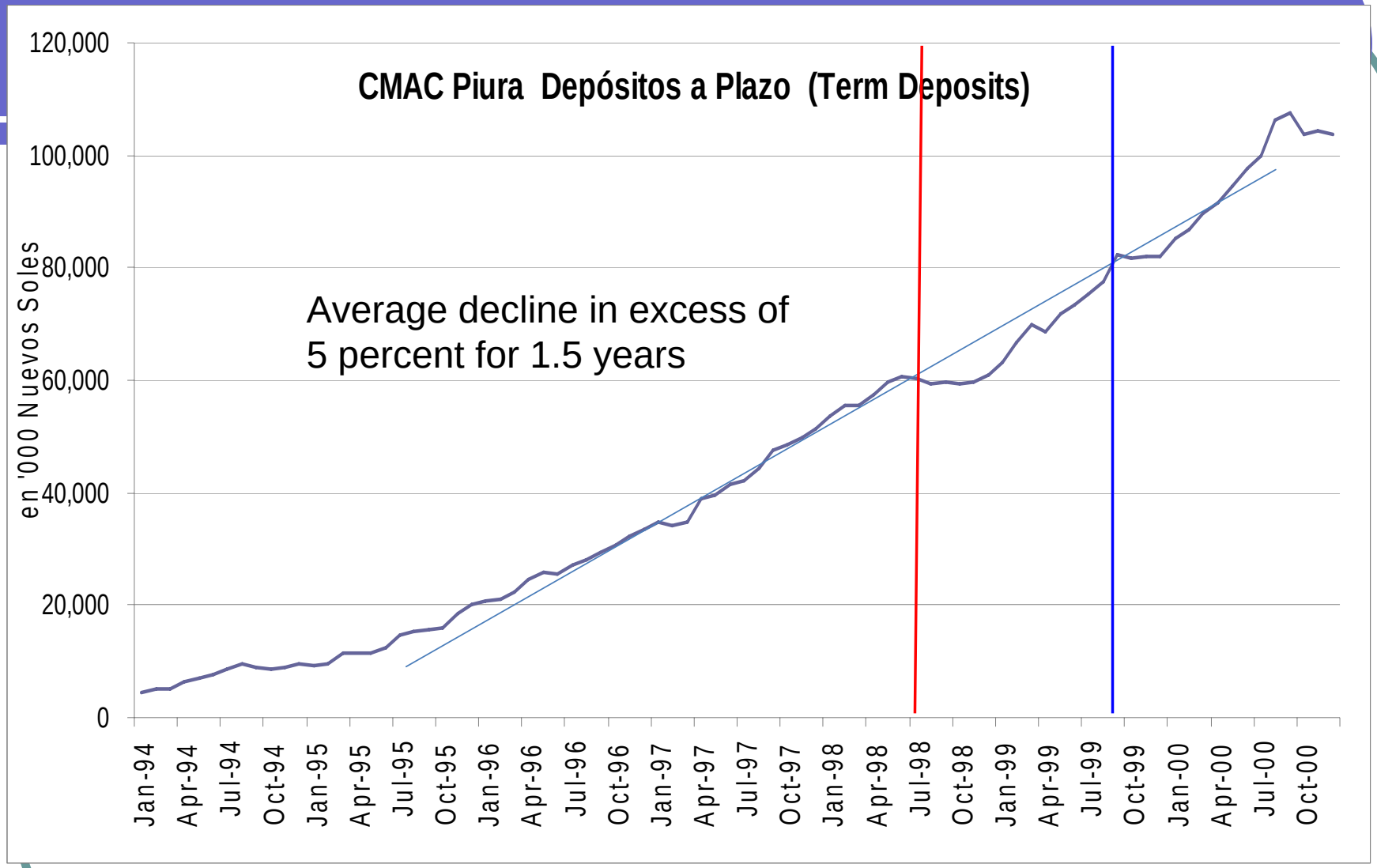
Expected Value of Using USD 5 Million of the Payout to Reduce Default Rates



On a USD 100 million portfolio, the area between the two lines represents up to USD 13 million of potential savings. If you could do this only 1 in 20 years, the expected value of this benefit would pay for USD 0.7 million of premium


Piura Depósitos de Ahorro (Savings Deposits)
en '000 Nuevo Soles
30,000
25,000
20,000
15,000
10,000
5,000
0
This area represents roughly 15% decline
in deposits over 1.4 years of time
Jan-94
May-94
Sep-94
Jan-95
May-95
Sep-95
Jan-96
May-96
Sep-96
Jan-97
May-97
Sep-97
Jan-98
May-98
Sep-98
Jan-99
May-99
Sep-99
Jan-00
May-00
Sep-00


Sullana Depósitos de Ahorro (Savings Deposits)
en '000 Nuevos Soles
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
This area represents roughly 20% decline
in deposits over 1.5 years of time
Jan-94
May-94
Sep-94
Jan-95
May-95
Sep-95
Jan-96
May-96
Sep-96
Jan-97
May-97
Sep-97
Jan-98
May-98
Sep-98
Jan-99
May-99
Sep-99
Jan-00
May-00
Sep-00


CMAC Piura Depósitos a Plazo (Term Deposits)
Average decline in excess of
5 percent for 1.5 years
en '000 Nuevos Soles
120,000
100,000
80,000
60,000
40,000
20,000
0
Jan-94
Apr-94
Jul-94
Oct-94
Jan-95
Apr-95
Jul-95
Oct-95
Jan-96
Apr-96
Jul-96
Oct-96
Jan-97
Apr-97
Jul-97
Oct-97
Jan-98
Apr-98
Jul-98
Oct-98
Jan-99
Apr-99
Jul-99
Oct-99
Jan-00
Apr-00
Jul-00
Oct-00

Initial Estimate of Lost Capital

- Assumption – roughly 70 percent of the capital needs come from savings and certificates of deposit
- For a Caja with USD 100 million portfolio
  - USD 10 million in savings
  - Lost savings = .20% x 10 = USD 2 million
  - USD 60 million in certificates of deposit
  - Lost CDs = .05% x 60 = USD 3 million
- What is the opportunity cost of losing USD 5 million in savings and certificates of deposits for up to 1.5 years (keep in mind that this must be put in expected value terms assuming that the event will occur 1 in 15 years)

Crude Estimate of the Value of Having an Indemnity Payment using USD 100 Million Portfolio

- Cost of less capital due to withdrawal of savings and cut back in certificates of deposit
  - Estimated opportunity cost = USD 0.2 million
- Some estimate of value of using funds to ease the default and restructuring rates
  - Estimated cost = USD 0.7 million
- Crude estimate of the extra cost of capital is some significant percentage of the extra cost of interest due to El Niño Risk
  - Some portion of 30 percent x 3 percent increase in interest rates up to = USD 0.9 million?

Credit Risk Managers Must Consider the Many Business Interruption Costs of El Niño to Know the True Value!

Major concern — Access to capital will be heavily constrained when everyone knows that El Niño is coming

- Liquidity risk…
- Savings are being withdrawn
- Decrease in deposits
- Loans are being refinanced
- Cost of capital will increase
- Defaults will follow
- Increased need for more capital for provisioning

Next Steps

- Significantly more work is needed to decompose the potential value of this special form of insurance of Cajas and Banks in Piura and in Peru
- Significant thinking is needed about how to most effectively use the indemnity payments to mitigate and adapt to a period where the Cajas and Banks know that they will be incurring more cost and facing lower profits in the coming months
- Significant thinking is needed to sort out solutions for the borrowers — for example those who are told they cannot borrow when El Niño is coming — can you promise them more access to consumption loans and new production loans later — as the risk of flooding eases?

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Thank You

Please visit www.microlinks.org/afterhours for seminar presentations and papers

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