Extreme Mortality Bonds

Romain Bridet
IAA Life Colloquium, Munich 2009

September 9, 2009
Agenda

Transaction Objectives
Financial Structure
Mechanism Overview
Underlying Risk
Pandemic Modeling
EMB Pricing
2009 influenza A/H1N1
Agenda

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Transaction Objectives

For issuers

- Protection against extreme mortality risk
  - Systemic risk
  - Exclusion from traditional reinsurance
  - Cover duration

For Investors

- New class of securities
  - Higher spreads
  - Non-correlation
Agenda

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Mechanism Overview

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Financial Structure

(Re)insurer \rightarrow (Re)insurer

Swap Counterparty

fixed interest rate \downarrow

premiums + floating interest rate

SPV

floating interest rate \uparrow

premiums

Cash proceeds

Debt investors
Agenda

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Mechanism Overview

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2009 influenza A/H1N1
Mechanism Overview

Mortality Index

- Based on age and gender weighted death rates
- Based on national index(es) of mortality

<table>
<thead>
<tr>
<th>VITA III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sponsor</td>
</tr>
<tr>
<td>Year</td>
</tr>
<tr>
<td>Mortality Index</td>
</tr>
<tr>
<td>62.5% United States</td>
</tr>
<tr>
<td>17.5% United Kingdom</td>
</tr>
<tr>
<td>7.5% Germany</td>
</tr>
<tr>
<td>7.5% Japan</td>
</tr>
<tr>
<td>5% Canada</td>
</tr>
<tr>
<td>Risk Period</td>
</tr>
<tr>
<td>Index Calculation</td>
</tr>
<tr>
<td>Trigger / Exhaustion Levels</td>
</tr>
<tr>
<td>(A: 125% / 145%)</td>
</tr>
<tr>
<td>(B: 120% / 125%)</td>
</tr>
<tr>
<td>(C: 115% / 120%)</td>
</tr>
<tr>
<td>(D: 110% / 115%)</td>
</tr>
</tbody>
</table>

Source: Swiss Re
Mechanism Overview

Reduction in outstanding Principal of the Bond

- Index < Attachment point → Principal repayable in Full
- Index > Exhaustion point → Principal completely exhausted
- Linear Reduction between Attachment point and Exhaustion point
Mechanism Overview

$n$ the duration of the bond and $m = n - 1$ the number of measurement periods

$I_t$ the value of the mortality index measured at time $t = 2...m$

$A$ the attachment point

$E$ the exhaustion point

At the end of the measurement period $t = 2...m$, the reduction in principal is:

$$R_t = \max \left( \frac{I_t - A}{E - A} - R_{t-1}; 0 \right) \quad (R_1 = 0)$$

With the constraint that the cumulative principal reduction cannot exceed 100%:

$$\sum_{i=2}^{t} R_i \leq 100\%$$

At time $t$, the outstanding capital is equal to: $100\% - \sum_{i=1}^{t} R_i$
Mechanism Overview

Life Catastrophe Excess of Loss vs. EMB

- EMB Structure close to a stop loss cover
- Indemnity vs. parametric (i.e. basis risk for EMB)
- Duration
- Pandemics completely excluded from Life Cat XL
Agenda

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Mechanism Overview
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Underlying Risk

Events
- Pandemic disease
- Terrorism event
- Natural disaster
- Heat wave
- Industrial accident
- Conventional/Nuclear war

Risk profile
- Index based (parametric and not indemnity)
- Low frequency
- High severity
Underlying Risk

An Epidemic is a disease that appears as new cases in a given human population, during a given period, at a rate that substantially exceeds what is “expected”, based on recent experience.

A Pandemic is an epidemic that spreads worldwide, or at least across a large region.
Underlying Risk

31 pandemics since 1580 (according to the WHO)

<table>
<thead>
<tr>
<th>Year</th>
<th>Name</th>
<th>Deaths</th>
<th>Lethality rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1918-1919</td>
<td>Spanish flu</td>
<td>~ 50 million</td>
<td>~ 10%</td>
</tr>
<tr>
<td>1957-1958</td>
<td>Asian flu</td>
<td>~ 2 million</td>
<td>~ 0,37% (US)</td>
</tr>
<tr>
<td>1968-1969</td>
<td>Hong Kong flu</td>
<td>~ 1 million</td>
<td>~ 0,19% (US)</td>
</tr>
<tr>
<td>1977</td>
<td>Russian flu</td>
<td>10 000 in US</td>
<td>?</td>
</tr>
<tr>
<td>2003</td>
<td>SARS</td>
<td>299 in HK</td>
<td>up to 71% in HK</td>
</tr>
</tbody>
</table>
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Pandemic Modeling

Approach: Frequency * Severity

- **Frequency**: 7.4% per annum based on 31 influenza epidemics over the last 420 years

- **Severity**: exponential curve calibrated with 5 historical data points which are the 5 last pandemic events
Pandemic Modeling

Severity curve

\[ \text{Severity} = a \cdot \exp\left( -b \cdot \sqrt{r} \right) \]
\( si \; r > 0.005 \)

\[ \text{Severity} = TAN(90 - c \cdot r) \cdot \frac{\pi}{180} \]
\( si \; r \leq 0.005 \)
Pandemic Modeling

Paul Valéry

“What is simple is always wrong, what is complex is unusable.”

Limits

- pandemic risk is very uncertain and unpredictable
- many parameters not taken into account (like location of outbreak, vaccine production, pandemic lifecycle,...)
Agenda

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Financial Structure

Mechanism Overview

Underlying Risk

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2009 influenza A/H1N1
EMB Pricing

Pricing a priori with Monte Carlo Simulations

\( x = 1 \ldots X \) Simulation No \( t = 1 \ldots T \) time \( n = 1 \ldots N \) class No

\[
R_{t,n} = \frac{I_t - A_n}{E_n - A_n}
\]

\[
C_{t,n} = \begin{cases} 
R_{t,n} & \text{si } t = 1 \\
\text{Max}(R_{t,n} - C_{t-1,n}) & \text{si } t > 1
\end{cases}
\]

\[
PFL_n = \sum_{x} \delta_{(C_{t,x} > 0)} \frac{1}{X} \delta_{(C_{t,x} > 0)} = \begin{cases} 
1 & \text{si } C_{t,n} > 0 \\
0 & \text{si } C_{t,n} = 0
\end{cases}
\]

\[
PE_n = \frac{\sum_{x} \zeta_{(C_{t,x} = 1)}}{X}
\]

\[
v_n = \begin{cases} 
1 & \text{si } C_{t,n} = 1 \\
0 & \text{si } C_{t,n} = 0
\end{cases}
\]

\[
EL_n = \sum_{x} \sum_{t} v_{s,t,n} \]

Estimation for each class of Notes \( n \):

\( EL_n \) the Expected Loss
\( PFL_n \) the Probability of First Loss
\( PE_n \) the Probability of Exhaustion

\[
CEL_n = \frac{EL_n}{PFL_n}
\]

the Conditional Expected Loss
EMB Pricing

Spread and E(L) dependence measured a posteriori

EMB at issuance (unwrapped)

Spread at issuance (bps)

E(L) (bps)

Expensive (for Issuer)

Economical (for Issuer)

Frontier
EMB Pricing

Spread Variations

Spread

- Spread at issuance
- Spread at December 31, 2007
- Spread at July 31, 2009

Financial crisis

VITA II B  VITA II C  VITA II D  VITA III A  VITA III B  OSIRIS B  OSIRIS C  OSIRIS D
Agenda

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2009 influenza A/H1N1
2009 influenza A/H1N1

Low excess mortality but possible future evolution

- Mutation
- Drug Resistance

Source: WHO, CDC
## 2009 influenza A/H1N1

<table>
<thead>
<tr>
<th>Mortality Bond</th>
<th>OSIRIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mortality Holder</td>
<td>Axa</td>
</tr>
<tr>
<td>Issue date - Maturity</td>
<td>January 2006 - January 2010</td>
</tr>
<tr>
<td>Index of Mortality</td>
<td>60% France, 25% Japan, 15% US Weighted by age and gender</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Class</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attachment Point</td>
<td>114%</td>
<td>110%</td>
<td>106%</td>
</tr>
<tr>
<td>Exhaustion Point</td>
<td>119%</td>
<td>114%</td>
<td>110%</td>
</tr>
<tr>
<td>Spread at issuance</td>
<td>120 bp</td>
<td>285 bp</td>
<td>500 bp</td>
</tr>
<tr>
<td>Rating at issuance (S&amp;P)</td>
<td>A-</td>
<td>BBB</td>
<td>BB+</td>
</tr>
</tbody>
</table>

**OSIRIS Index**

<table>
<thead>
<tr>
<th>Fatality rate / Infection rate</th>
<th>5%</th>
<th>10%</th>
<th>30%</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.05%</td>
<td>100%</td>
<td>101%</td>
<td>102%</td>
</tr>
<tr>
<td>0.10%</td>
<td>101%</td>
<td>101%</td>
<td>104%</td>
</tr>
<tr>
<td>0.50%</td>
<td>104%</td>
<td>107%</td>
<td>122%</td>
</tr>
<tr>
<td>1.00%</td>
<td>107%</td>
<td>115%</td>
<td>145%</td>
</tr>
</tbody>
</table>

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*Seasonal flu*

*Attachment reached*
PartnerRe
Pandemic Modeling

Age shape depending on Pandemic’s virulence

U shaped Distribution

Low virulence

W shaped Distribution

High virulence
EMB Pricing

Spread at issuance & risk parameters

\[ \text{Spread} = E(L) + EER \]

\[ EER = \gamma (PFL)^\alpha (CEL)^\beta \]

(NatCat Bonds Approach)

\[ \alpha = 0.68 \]
\[ \beta = 0 \]
\[ \gamma = 1.5 \]