Analyzing Risk in Long Term Care Insurance Markets
by
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An honors thesis submitted in partial fulfillment
of the requirements for the degree of
Bachelor of Science

Undergraduate College
Leonard N. Stern School of Business

New York University

May 2018

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Abstract

Assessing the distribution of long-term care claims far out into the future is difficult in part because of aggregate risk. Life insurance companies find it particularly difficult to assess and have therefore dropped out of the market or provided packages that do not adequately fulfill the consumers’ needs. The present research tries to measure some of the causes of aggregate risk in the long-term care market, and to determine whether risk sharing is feasible across nations. It is accomplished first by using a principal components analysis on long-term care expenditure, and then through multiple regressions that test the sensitivity of the spending to the principal components. The three sections indicate that there is a benefit to be gained from insuring across nations. All the data is from the Organization of economic co-operation and development.
Acknowledgements

First, I would like to thank my thesis advisor, Professor Ralph Koijen, for his oversight on my paper. I was only able to pursue this research with his help and patience. It was an honor to work with professor Koijen and I am grateful for all his help in the past year.

I would also like to thank Professor Marti G. Subrahmanyam and Jessica Rosenzweig for overseeing the Honors Thesis Program and for allowing me to be part of it.
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Introduction

Insurance companies are often reluctant to enter into long-term contracts for life insurance. Previous research has indicated that this is because of adverse selection and excessive regulation. Those likely to have long term losses are the most eager to purchase long term care insurance and public policy such as Medicaid crowds out the market. More recent studies have indicated the importance of intertemporal risk.¹ When insuring far out into the future, the risk is larger because of unforeseen medical technologies or changing mortality rates. When insuring multiple cohorts, if risks are correlated then the ability to share risk across cohorts is diminished. If the risks are uncorrelated, then the payments can be predicted over time. However, even if the risks are uncorrelated the potential payments can be very large and can potentially push the company into bankruptcy. Bankruptcy costs prevent the company from providing long term care insurance because the potential loss will be worse than a larger gain.²

Currently, life insurance companies provide indemnity insurance. Indemnity insurance pays out a specified amount at a triggering event such as entering a nursing home. It does not cover recurring risks the way that service coverage could. 70% of people admitted to nursing homes are over the age of 75, and since insurance is sold around 65, there are several unforecastable risks in that time. If aggregate risk factors could be identified, it could potentially be easier to share the risk across nations.³

Risk sharing opportunities have in the past been applied to GDP sharing. Using a CARP model, contracts were designed to create markets that hedge against the uncertainty of individuals income. World income components were defined from eigenvectors of a variance

¹ Cutler, David M. 1996. “Why Don't Markets Insure Long-Term Risk?”.
² Ibid.
³ Ibid.
matrix of individual incomes from per capita world income. Using a three-level income model of world shocks, country shocks (uncorrelated), and spatial country shocks (correlated), they were able to explain the variance. The paper found that country size, spatial arrangement, and variations in standard of living can be used to design swaps between the different countries.  

There are several variables that have a great impact on long-term care expenditure. The first is the number of dependent people in the population. To study the number of dependent people in the population, life expectancy at birth and per capita health care spending can be used to estimate the decline in dependency ratio at specific age groups. According to the healthy aging hypothesis, the population maintains the same percentage of dependent people, but the dependency is pushed later in life as life expectancy rises. The greater the amount of dependent people in the population, the more the country is likely to spend on health care spending.

Around 70-90% of those who provide care are family members. In several countries, the informal care supply greatly exceeds the formal care supply. There is evidence that the size of the informal elderly care supply is associated with female labor force participation. Therefore, the informal care supply can be studied by measuring the labor force participation rate of women over 50. Female labor force participation has in the past been proven to be a reliable proxy.

The Baumol effect is when there are rising wages in a sector without gains in productivity. Rising costs in other areas can lead to rising costs of LTC. Weak productivity in a nation can be measured by tracking care staff salaries. LTC does not achieve substantial

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productivity gains,\textsuperscript{8} so high wages of care givers can lead to much higher LTC expenditure. Similarly, as real income and GDP per capita rise, care can be directed at higher quality services.\textsuperscript{9} The relative price of LTC rises with increasing GDP and income.

Financing schemes, population structure, and geographic location can also lead to LTC expenditure variance. Population structure, such as more people over the age of 65 when the contracts for long-term care are normally bought, would be expected to have a great impact on the amount that a country spends on long-term care.

There are several different financing schemes among the OECD countries. Most of them have collective finance schemes for nursing-care costs. The Nordic countries have universal coverage as part of a tax-funded social-care system and Germany, Japan, Korea, the Netherlands, and Luxembourg have dedicated social insurance schemes. Belgium arranges for long-term care costs in their health system. In total one third of the countries have universal coverage. Some countries do not have a long-term care system but have universal care benefits in cash or in kind. These countries include Austria, France, Italy, Australia, and New Zealand. Two countries have a safety-net system for LTC costs. These countries are the United Kingdom and the United States.\textsuperscript{10}

\textbf{The broad question/issue /hypotheses}

Long term Care insurance companies find it difficult to assess the distribution of long-term care claims in the future. This led to many long-term care insurance companies experiencing losses and dropping out of the market in the early 2000’s. Health shocks are not only controlled by idiosyncratic risk, but also aggregate risk. Changes in aggregate risk have often been omitted in academic and policy debates. Factors such as government policy and behavior vary significantly from nation to nation and can create entire nations that are higher or lower risk.

I am studying the aggregate risk in the long-term care insurance market and the feasibility for risk sharing across nations to diversify country-specific risk. This paper seeks to find what the factors are that cause nations to have similar risk profiles. The first section will be a principal components analysis on the long-term care spending, followed by regression analysis to figure out the factors that contribute to the different components. The regression should show the sensitivity of the long-term care spending to the principal components. This will be followed by an analysis of the aggregate risk and idiosyncratic risk that can be used to divide and share the different kinds of risk. Risk sharing would be made possible by analyzing the risk profiles of the different nations, and then creating contracts that would allow countries to proportionately divide and share the risk.

Data

Data was collected from the organization for economic co-operation and development and the World Health Organization. The data included is long-term care expenditure, life expectancy, healthcare spending, GDP per capita, female labor force participation, and population structure.
The long-term care expenditure includes 32 countries over 15 years. It is in per capita and in 2010 base year USD. Missing values in all the data sets were replaced with the average value for that country over the years. The data had a mean of 458.3, median of 391.6, minimum value of 4.2, maximum value of 1623.4, and standard deviation of 389.1. Long term care expenditure has been slowly growing in the countries over the last 15 years.

Life expectancy data contained 14 years of data and 32 countries. The data had a mean of 79.23, median of 80.1, minimum value of 70.1, maximum value of 83.9, and standard deviation of 2.899. The values were life expectancy at birth.

Healthcare spending data contained 14 years of data and 32 countries. The data had a mean of 3020.6, a median of 3036.3, a minimum value of 605.6, a maximum value of 6493.8, and a standard deviation of 1336.9. The values are in USD, constant prices, 2010 purchasing power parity.

GDP data contained 14 years of data and 32 countries. The data had a mean of 35478.4, a median of 35543.7, a minimum value of 11602.7, a maximum of 91280.1, and a standard deviation of 13280.1. The values are in USD, constant prices, 2010 purchasing power parity. It is measured per capita.

Labor force participation of females over the age of 65 contained 14 years of data and 32 countries. The data had a mean of 44.6, a median of 46.1, a minimum value of 11, a maximum of 85.3, and a standard deviation of 16.7. It is measured as a percentage of females between 55-64 years old.

Population structure is the percentage of people over the age of 65. Population structure contained 14 years of data and 32 countries. The data had a mean of 15.3, a median of 15.8, a minimum value of 6.6, a maximum of 26.6, and a standard deviation of 3.3.
Principal components analysis creates a variance matrix that can find the nations that move together. It reduces the dimensions of the data to k-1 and enables the user to find the components that contribute to most of the variance. Principal axes are made that coincide with directions of maximum variation. The variance is removed, and the process is repeated. The line of maximum variation creates projected values corresponding to the original data points called principal component scores. If all the countries have the same variation that would mean that risk sharing is not possible because they all contain the same risk factors. In this case, there would be one component and the risk would not be able to be diversified. If there is more than one component, there is an indication that the risk can be diversified across the nations that are uncorrelated. The principal components analysis was conducted using the computer programming language Matlab.

To figure out the contributing factors to the principal components, multiple regressions were used. The factors influencing the exposures have been chosen through review of previous research. The factors determined to be important through previous research are life expectancy,
population structure, health care spending, labor force participation of women over 50, and GDP per capita. Long term care spending can be used as the response variable in a regression against the time series data of the principal components according to the formula:

\[ \lambda_{CT} = \alpha + (Y_0 + Y_1X_{CT}) F_{1T} + (\delta_0 + \delta_1X_{CT}) F_{2T} + e_{CT} \]

In this equation F represents the first and second principal components. X is the factor such as life expectancy, which interacts with the principal components. Y and \(\delta\) represent the regression coefficients and \(\lambda\) is the long-term care expenditure. This regression can show how the factor contributes to the variance through the interaction with the principal component data.

The different factors can be standardized to make the data comparable according to the formula:

\[ X_{CT}^Z = (X_{CT} - \bar{X}_T)/SD_z(X_{CT}) \]

By comparing the different values, you can see the change in sensitivity of spending to the different principal components. The higher the regression coefficient of the interaction between the principal component and the factor, the more sensitive the long-term care expenditure is to that principal component. The data was compiled and organized on Microsoft Excel, and then exported to Windows software Minitab. The regressions were performed in Minitab.

Using the regression data, a set of contracts can then be made to share and divide the risk. The first contract can be used to divide the aggregate risk. There is a piece of the risk that cannot be shared which is equal to:

\[ \lambda_t = Y_0F_{1T} + \delta_0F_{2T} \]

The payment that each country would be required to pay would be equal to:

\[ (Y_1X_{CT}/N_{CT}F_{1T}) *N_{CT} + (Y_1X_{CT}/N_{CT}F_{1T}) *N_{CT} \]
N is equal to the number of people in each country and is used for the size adjustment. The payments were organized in Microsoft Excel. The data was pulled from the regression equations previously calculated.

The second contract is used to share the idiosyncratic risk. The payments and exposures can be seen in the formula:

$$\sum C N \lambda_{CT} = \alpha + \sum C N + \sum C e_{CT}$$

All the data was created in Minitab and then organized in Microsoft excel. Using the residual values found through the regressions, the payments, exposures, and long-term care expenditure after insurance can be calculated. The volatility changes were computed using Microsoft Excel.

**Principal Components Analysis**

![Principal components](image)

**Figure 2:** Principal components that explain the variability in the long-term care expenditure data.
The previous graphs were made using the computer programming language Matlab. The sample is 32 nations with 15 years of long term care expenditure. Figure 2 shows the principal components that explain the variability in the sample. The first principal component explains approximately 75% of the variability and the second one explains approximately 15%. Since all the variance is not explained by the principal components there is a positive indication for the possibility of risk sharing. In this case, there seem to be two main factors explaining the risk, as well as some that is unexplained by a major principal component.

Figure 3 shows the loading factors that correlate the nation (variable) and the principal component. The blue lines are correlations between the variable and the first principal component, and the yellow lines are the correlations between the variable and the second
principal component. The variables can be grouped based on their loading factors to see which ones share similar risk which explains the variance. The ones with the largest loading factors have the most exposure to the principal component. The countries with positive values for principal component 1 are Australia, Austria, Belgium, Canada, Czech Republic, Estonia, Finland, France, Germany, Hungary, Iceland, Ireland, Israel, Japan, Korea, Latvia, Luxembourg, Netherlands, New Zealand, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, the United Kingdom, and the United States. The countries with positive values for principal component 2 are Austria, Belgium, Canada, Estonia, Finland, France, Germany, Greece, Iceland, Ireland, Japan, Latvia, Netherlands, New Zealand, Poland, Portugal, Spain, Sweden, and the United States.

**Regressions**

To figure out the factor(s) that contributes to the sensitivities of spending to the principal components, regressions were run using the time series data of the principal components. The regressions were run according to the following equation.

\[
\lambda_{CT} = \alpha + Y_0 F_{1T} + Y_1 X_{CT} F_{1T} + \delta_0 F_{2T} + \delta_1 X_{CT} F_{2T} + e_{CT}
\]

In Figure 4, X is the factor that contributes to the principal component, \(Y_1\) is the coefficient of the interaction between the factor and the first principal component, and \(\delta_1\) is the coefficient of the factor and the second principal component.
The first regression with the two principal components and life expectancy according to the previous formula yielded a $Y_1$ value of 0.06871 and a $p$ value of .000. The correlation of life expectancy and the second principal component was not significant. This shows that countries sensitivity to principal component one varies with life expectancy and that the countries sensitivity to principal component 2 does not vary significantly with life expectancy. The values in red are not statistically significant and do not vary with the principal component.
Figures 5-9 show the coefficients of multiple regression according to the formula:

$\lambda_{CT} = \alpha + Y_0F_{1T} + Y_1X_{CT} F_{1T} + \delta_0F_{2T} + \delta_1X_{CT} F_{2T} + e_{CT}$

**Risk Sharing Contracts**

The long-term care risk can be divided into aggregate risk factors and country specific idiosyncratic risk, which could be shared via a pooled insurance scheme. The aggregate risk factors are those used in the regressions and the idiosyncratic risk is the value that is not explained by the regression equation. The equation to represent this is:

$\Lambda_{ct} = \beta c F_t + e_{ct}$

In this equation, $\Lambda$ represents the long-term care expenditure of a country, $\beta$ is equal to the regression coefficient, $F$ is the aggregate risk factor and $e$ is the country specific risk to be shared. The equation is analogous to the one used in the multiple regression section to test the
sensitivity of the expenditure to the principal components. If that equation is rearranged, the following equation can be formed:

$$\lambda_{CT} = \alpha + (Y_0 + Y_1 X_{CT}) F_{1T} + (\delta_0 + \delta_1 X_{CT}) F_{2T} + e_{CT}$$

This equation shows the aggregate risk and the country specific risk. The factor in the equation, $X_{CT}$, is standardized and has an average of zero. So, for every country with a positive value of $X_{CT}$ there is a country with a negative value of $X_{CT}$ which can turn the portion of the equation $Y_1 X_{CT}$ to equal to zero. The equation can then be simplified to:

$$\lambda_{CT} = Y_0 F_{1T} + \delta_0 F_{2T} + e_{CT}$$

The different factors such as labor force participation, GDP per capita, population structure etc. cannot be shared in a way that makes the exposure to the risk factor disappear. However, these factors can be effectively divided up. It is divided up between nations in a way that makes every nation carry a proportional burden of the risk relative to the nations size by changing the amount of volatility.

The country specific risk factor is idiosyncratic risk and can be risk shared. The idiosyncratic risk is unsystematic risk that is found in one country but not likely to be found in all.

If the covariance of the country specific risk is zero, and the value of the number is constant over time, then there is possibility for a pooled insurance scheme that diversifies this risk.

$$\text{Cov}(e_{it}, e_{jt}) = 0$$

$$\frac{1}{N} \sum_{N}^{N} e_{CT}$$
A set of contracts can be made to divide and share the risk of the nations. The first contract would divide the aggregate risk factors of the nations. Every country that is being studied is not equal in size, so a country the size of the United States will not be able to divide the risk equally with a country such as Estonia. After comparing the risk profiles of different countries such as sensitivity to certain aggregate risk factors and the size of the nation, the risk can then be divided between the different nations. The aggregate risk can be defined as:

$$\lambda_{CT} = (Y_0 + Y_1 (X_{CT})) F_{1T} + (\delta_0 + \delta_1 (X_{CT})) F_{2T}$$

In this equation $X_{CT}$ demeaned so that the sum of $X_{CT}$ is equal to zero. Since long term care expenditure is in per capita, the total long-term care expenditure in each country is equal to:

$$L_{CT} = \lambda_{CT} N_{CT} = [(Y_0 + Y_1 (X_{CT})) F_{1T}] N_{CT} + [(\delta_0 + \delta_1 (X_{CT})) F_{2T}] N_{CT}$$

Simplifying the previous formula gives the following formula:

$$L_{CT} = N_{CT} (Y_0 F_{1T} + Y_1 F_{1T} X_{CT}) + N_{CT} (\delta_0 F_{2T} + \delta_1 F_{2T} X_{CT})$$

The total long-term care expenditure across countries would be:

$$L_T = \sum C L_{CT} = (\sum C N_{CT}) Y_0 F_{1T} + Y_1 F_{1T} \sum C X_{CT} + (\sum C N_{CT}) \delta_0 F_{2T} + \delta_1 F_{2T} \sum C X_{CT}$$

Since the sum of $X_{CT}$ is equal to zero because the values are standardized, the previous formula simplifies to:

$$L_T = \sum C L_{CT} = (\sum C N_{CT}) Y_0 F_{1T} + (\sum C N_{CT}) \delta_0 F_{2T}$$

The per capita long-term care expenditure across countries is:

$$L_t / \sum C N_{CT} = \lambda_t = Y_0 F_{1T} + \delta_0 F_{2T}$$

The total long-term care expenditure without risk sharing is:
\[ \lambda_t = (Y_0 + Y_1X_{CT})F_{1T} + (\delta_0 + \delta_1X_{CT})F_{1T} \]

The total long-term care expenditure with risk sharing is:

\[ \lambda_t = Y_0F_{1T} + \delta_0F_{2T} \]

The insurance payment per country would be:

\[ P_{CT} = (Y_1X_{CT}F_{1T})^*N_{CT} + (Y_1X_{CT}F_{1T})^*N_{CT} \]

These equations show that there is a portion of the aggregate risk that cannot be divided. All countries face an exposure that is equal to \( Y_0F_{1T} + \delta_0F_{2T} \). However, since the countries do not have equal values of \( X_{CT} \), there will be some countries that are exposed to increases in long-term care expenditure for a fixed level of \( F \), and other countries where long-term care expenditure will decrease for a fixed level of \( F \). This portion that varies with \( X_{CT} \) can be divided among the different countries, and the values of the payments are shown in Table A.

The second contract to be made would share the idiosyncratic risk. If the error factors are constant over time, then the risk can be mitigated through diversification between the nations. This risk factor does not affect all the nations studied and is unpredictable. The negative impact of this risk can be minimized through diversification and hedging. In any given year, each country has risk \( e_C \) which has a mean of zero across countries. If the countries are equal in size, then the total risk is the sum of \( e_C \) and everyone would pay the same share. The average of \( e_C / I \) would converge to a value of zero.

\[ 1/C \sum_i^C e_{CT} = 0 \]
As \( C \) (number of countries) becomes infinitely large, the value of \( e_{CT} \) becomes closer to 0. Thus the payment made by each country would also equal 0 and the payment required by each country in each period would be:

\[
P_{CT} = \frac{1}{C} \sum^C e_{CT} - e_{CT} \]

\[
\sum^C P_{CT} = 0
\]

Therefore, the value of long-term expenditure after pooling the risk is:

\[
*\lambda_{CT} = \lambda_{CT} + P_{CT} = \alpha + \frac{1}{C} \sum^C e_{CT}
\]

To adjust for the size differences, every country would pay a premium that is proportional to their size. The payment could be found using the following formula:

\[
\sum^C N_C \lambda_{CT} = \alpha + \sum^C N_C + \sum^C N_C e_{CT}
\]

The benefit of a pooled insurance scheme can be seen by calculating the volatility of the long-term care spending before and after the risk sharing contract. As seen in table B in the appendix, the volatility decreased after the risk sharing contracts were drawn. Figures 10 and 11 show two countries with clear gains from the decrease in volatility from the risk sharing contracts. The transfer payments are shown in table C in the appendix.
Figure 10: Long term care spending in the Netherlands before and after contract 2.

Figure 11: Long term care spending in the United Kingdom before and after contract 2.

Conclusion
The principal components analysis, regressions, and risk sharing contracts indicate that there is a benefit to be gained from insuring across nations. The principal components analysis indicated that one aggregate risk factor did not account for all the variability in long-term care expenditure over time and across nations. PCA showed that there were two main risk factors. The regression analysis showed that exposure to the first and second aggregate risk factor varies with certain measures such as GDP per capita and life expectancy. The different exposures to the risk factors could be modified by using transfer payments to divide a portion of the aggregate risk. A pooled insurance contract showed that it was possible to share the idiosyncratic portion of the risk in a way that reduced the volatility of the long-term care expenditure over time.

**Challenges and issues with collection of data**

The analysis of aggregate risks is difficult because there are so many factors that influence the amount that is spent on long term care. The type of care the elderly are receiving is often difficult to measure. The effect of certain factors such as government policy may be hard to judge.

**Challenges and issues with empirical analysis**

Some behaviors are very hard to quantify. Societal trends such as young people living with their parents are very difficult to measure and can have a large impact on the informal care force. In some cultures, it is more common to have parents living with their children until an old age and in others it is more common for the elderly to live on their own. Finding the informal
care supply is difficult and can best be proxied by measuring the labor force participation of women over the age of 50.
References

- Cutler, David M. 1996. “Why Don't Markets Insure Long-Term Risk?”.
## Appendix

### Table A: Transfer payments by country to divide aggregate risk

<table>
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*Table B: Volatility of countries long term care spending before and after contract 2*
| Year | Australia | Austria | Belgium | Canada | Czeh Republic | Denmark | Estonia | Finland | France | Germany | Greece | Hungary | Iceland | Ireland | Israel | Italy | Japan | Korea | Latvia | Luxembourg | Luxembourg New Zealand | Norway | Poland | Portugal | Slovak Republic | Spain | Sweden | Switzerland | United Kingdom | United States |
|------|-----------|---------|---------|--------|-------------|---------|---------|---------|--------|---------|--------|---------|---------|---------|--------|------|------|------|------|-------|-------------|----------|--------|--------|----------|-------------|------|------|-----------|-------------|----------|--------|
| 2001 | 0.014052  | 0.0308324 | 0.015772 | 0.0225866 | 0.007396 | 0.00342636 | 0.014052 | 0.0553264 |

**Table C: Transfer Payments made by each country.**

| Year | Australia | Austria | Belgium | Canada | Czeh Republic | Denmark | Estonia | Finland | France | Germany | Greece | Hungary | Iceland | Ireland | Israel | Italy | Japan | Korea | Latvia | Luxembourg | Luxembourg New Zealand | Norway | Poland | Portugal | Slovak Republic | Spain | Sweden | Switzerland | United Kingdom | United States |
|------|-----------|---------|---------|--------|-------------|---------|---------|---------|--------|---------|--------|---------|---------|---------|--------|------|------|------|------|-------|-------------|----------|--------|--------|----------|-------------|------|------|-----------|-------------|----------|--------|
| 2002 | 0.910741  | 0.0308324 | 0.015772 | 0.0225866 | 0.007396 | 0.00342636 | 0.014052 | 0.0553264 |

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