Impact case study (REF3)

Institution: City, University of London

Unit of Assessment: Business & Management

Title of case study: StMoMo: improving regulation, productivity and business performance for the pension and insurance industries.

Period when the underpinning research was undertaken: 2014 - ongoing

Details of staff conducting the underpinning research from the submitting unit:

Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Prof Vladimir Kaishev	Professor of Actuarial Science	2002 – present
Dr Pietro Millossovich	Senior Lecturer in Actuarial Science	2012 – present
Dr Andres Villegas	Senior Lecturer UNSW	2010 – 2015 PhD student Cass BS

Period when the claimed impact occurred: 2015 - ongoing

Is this case study continued from a case study submitted in 2014? No

1. Summary of the impact (indicative maximum 100 words)

Modelling and forecasting human mortality is crucial to pensions, life insurance, demography, healthcare and finance. Using a unifying framework, Professor Vladimir Kaishev, Dr Pietro Millossovich and Dr Andres Villegas developed the R package *StMoMo* which implements the most significant mortality projection models and performs fitting, testing goodness-of-fit and forecasting. *StMoMo* has been used worldwide by regulators, (re-) insurance and consulting companies to improve confidence in forecasts and to assess risk, allowing organisations to improve regulation of the pension and insurance industry, increase productivity and enhance business performance. Beneficiaries include regulators of the insurance and private pension markets of Canada, Peru and the EU (with market valuation of 5241 billion €) and leading global reinsurance companies and actuarial consultancies.

2. Underpinning research (indicative maximum 500 words)

During the last two centuries developed countries experienced a continued increase in life expectancy at an approximate pace of three months per year. This increase, though a sign of social progress, poses a significant challenge to governments, private pension plans and life insurers because of its impact on pension and health costs. Actuaries and demographers have recognised the implications of an aging population and rising longevity and have devoted much attention to the development of statistical techniques for the modelling and projection of mortality rates.

The StMoMo framework incorporates core mortality projection models such as the parsimonious model proposed by Lee and Carter (1992) and extended by Professors Steve Haberman and David Blake from Cass Business School, City, University of London, and the full age range model by Plat (2009). These models are known as the Renshaw-Haberman model, the Cairns-Blake-Dowd (CBD) model and the Plat model (see [3.4], Cairns et al. (2006) and Plat (2009)).

The first significant and novel research contribution of Prof Kaishev, Dr Millossovich and Dr Villegas was that they introduced the unifying generalized age-period-cohort (GAPC) modelling framework (see [3.1], [3.5]). The GAPC modelling framework incorporates the majority of the existing models used by researchers and practitioners such as the Renshaw-Haberman model, the age-period-cohort model, the CBD family of models and many others that fall within the class of generalized linear or non-linear models. As a second research contribution, Prof Kaishev, Dr Millossovich and Dr Villegas implemented the GAPC

framework in the StMoMo R package. This package allows users to build and apply all the above-mentioned models in a highly efficient manner. Users can also construct new mortality models customised to their needs, which is a completely novel feature not present in any of the existing mortality modelling software. Furthermore, the StMoMo package provides tools for fitting, simulating, analysing and forecasting mortality trends, allowing experienced and less sophisticated users to perform advanced modelling.

The development of the StMoMo package was preceded by work on a project aimed at assessing basis risk in index based longevity transfers, commissioned by the Life and Longevity Markets Association (LLMA) and the Institute and Faculty of Actuaries (see Haberman et al. (2014) [3.3] and Villegas et al. (2017). [3.2]). The results of this work have provided useful mortality model implementations, insights and ideas that have later been used by Prof Kaishev, Dr Millossovich and Dr Villegas in the development of the StMoMo package.

The research that underpins the development of the StMoMo mortality projection software has contributed to the establishment of the Cass Business School's longstanding research recognition for modelling of mortality and longevity.

3. References to the research (indicative maximum of six references)
1. Villegas A., Millossovich P. and Kaishev, V. (2018). StMoMo: An R Package for Stochastic Mortality Modeling. Journal of Statistical Software, 84(3), 1-38. doi:http://dx.doi.org/10.18637/jss.v084.i03
   (previously available in preprint version as Villegas, A., Kaishev, V. and Millossovich, P., StMoMo: An R Package for Stochastic Mortality Modelling (December 3, 2015). 7th Australasian Actuarial Education and Research Symposium. Available at SSRN: https://ssrn.com)
2. Villegas A., Haberman S., Kaishev V. and Millossovich P. (2017). A Comparative Study of Two-Population Models for the Assessment of Basis Risk in Longevity Hedges. ASTIN Bulletin 47, no. 03, 631-79. https://doi.org/10.1017/asb.2017.18.
3. Haberman S., Villegas A., Millossovich P., Kaishev V., Baxter S., Gaches A., Gunnlaugsson S. and Sison M. (2014). Longevity Basis Risk A Methodology for Assessing Basis Risk Report. Institute and Faculty of Actuaries and the Life and Longevity Markets Association, available at https://www.actuaries.org.uk.
4. Renshaw A. and Haberman S. (2006). A Cohort-Based Extension to the Lee-Carter Model for Mortality Reduction Factors, Insurance: Mathematics and Economics 38, no. 3, 556–70. https://doi.org/10.1016/j.insmatheco.2005.12.001.
5. Villegas A., Millossovich P. Kaishev V. (2016). StMoMo: Stochastic Mortality Modelling. R package version 0.4.1. https://cran.r-project.org/package=StMoMo.

Research was published in journals that apply a stringent peer-review process prior to accepting articles for publication and are the leading publications in their field such as Journal of Statistical Software (IF 22.737 - 1/105 Comp. Sci. Interd. App) and by leading organisations such as the Institute and Faculty of Actuaries.

4. Details of the impact (indicative maximum 750 words)
   The research and the resulting R package StMoMo are having ongoing impact on financial services regulators, insurance and reinsurance companies, pension funds, consulting firms, universities, research centres and individual users within these institutions, worldwide.

Informing Regulation

   StMoMo is used by the European Insurance and Occupational Pensions Authority (EIOPA), an independent advisory body to the European Commission, the European Parliament and the Council of the European Union. EIOPA guides the regulation of the European insurance market, of size 1213 billion € in terms of total premiums as of 2017, and the European private pension market, of size 4028 billion € of assets held.

EIOPA has used and cited StMoMo in their paper "EIOPA-CP-17-006 Consultation paper on EIOPA's second set of Advice to the European Commission on specific items in the Solvency II Delegated Regulation" [5.1]. EIOPA used StMoMo to estimate and simulate life expectancies using two key models for 11 European Economic Area (EEA) countries: France, Germany, Netherlands, Italy, Poland, Spain, United Kingdom, Belgium, Denmark, Sweden and Greece. As noted in the paper, this ensured that more than 80% of the EEA population was taken into account. EIOPA used these simulated life expectancies in order to stress test the effect of increasing/decreasing life expectancy on longevity/mortality risk. The aim of this procedure was to assess the solvency capital of insurance undertakings, including insurance and reinsurance companies and pension funds, as part of the broader Solvency II framework.

StMoMo is used by regulators:
1. AMF - Financial Markets Regulator/Autorité des Marchés Financiers (Québec, Canada), which regulates Québec's financial sector valued at 20 billion CAD. StMoMo was used to successfully challenge work of actuaries regarding mortality improvement tables and was praised for assisting actuarial analysts in achieving better mortality improvement analysis with minimal effort [5.2.1].
2. Financial and Insurance Supervisory Authority of Peru for the construction of mortality tables for the Peruvian Private Pension System and also in the development of the Risk-based Capital Requirements framework for the Peruvian insurance market [5.2.2, 5.2.3].

StMoMo was also used by Statistics Offices in preparing national population mortality projections:
1. [text removed for publication], from the Research Department of Statistics Norway, confirms that the use of *StMoMo has led to "…increased productivity (efficiency) of our modelling work"* [5.3.1].
2. [text removed for publication] from the Hungarian Central Statistical Office indicates "…*The description of the package and the study of Villegas et al. (2016) are easy to understand and excellent programming aid. These accelerated my work, and I was able to examine several methods in a short time....I consider the StMoMo package an extremely useful development.*" [5.3.2].

Enabling Efficient Professional Practice

The StMoMo package also impacted the work of insurance and reinsurance companies and consultancies, including Hannover Re, SCOR, Reinsurance Group of America (RGA) and Pacific Life Re, respectively the 3rd, the 4th, the 8th and the 25th largest reinsurance companies in the world, according to total premiums written in 2018. Among financial services companies and consultancies we highlight, Legal and General Group, the 10th largest investment management firm in the world, the second largest institutional investment management firm in Europe, and first in pension fund management in the UK managing €782.7bn in pension assets; Milliman, the second largest consulting firm in the world for health and life insurance in terms of loss reserves, amounting to $16 billion in total.

The package has been used extensively at Hannover Re where it has been acknowledged that *"…StMoMo aids the transition from closed-source black-box solutions towards more transparent and flexible techniques, which arguably leads to better understanding of risks and thus to better risk management."* [5.4.1].

The feedback from RGA and SCOR is explicit: [text removed for publication], Senior Vice President and Head of Global Research and Development with RGA Reinsurance Company and members of his team, confirm that "*We find it (StMoMo) a very quick and easy tool to use and it has saved us considerable time in implementing the various stochastic projections. As an organisation RGA has written in excess of £10bn PV of Pension Risk Transfer Business, and so being able to generate extreme scenarios and price non-proportionate deals is a substantial financial and risk management benefit.*" [5.4.2].

Multiple members of the R&D team at SCOR mention the significant gains in efficiency and time when, for example, they use StMoMo to implement new mortality models and conduct comparisons of their forecasting performance [5.5]. At Pacific Life Re they also use StMoMo leading to substantial efficiency gains as confirmed by [text removed for publication], Director R&D. [5.6].

Legal and General acknowledged that: "*Using StMoMo meant we stopped using a proprietary software for the last 2 years, which resulted in considerable savings to our team's budget.*" [5.7].

At Milliman, the Head of R&D indicated that the package has been adopted for use in its R&D work, for student projects between the company and French universities and for illustration for courses on mortality/longevity risks modelling at French universities. The results achieved were better knowledge of mortality and longevity risks, increased scientific productivity and better client services [5.8].

StMoMo has also been used by some of the largest insurance companies in Europe, including UnipolSai. Feedback from [text removed for publication], one of their data scientists, states "*I choose StMoMo since it is the only open source package that combines in a structured approach the most important mortality models…It has been used to estimate final mortality tables for actuarial purposes (annuity pricing)…It has eased my work since I do not need anymore to use different packages and write custom functions…*" [5.9]

The impact of the StMoMo package is extensive both in terms of reach and significance and goes well beyond the realm of the pension and life insurance business and its regulation. It has been downloaded over 35,500 times worldwide, referenced, cited and utilised to conduct research in over 90 publication outputs. [5.10]

5. Sources to corroborate the impact (indicative maximum of 10 references)

[5.1] "EIOPA-CP-17-006 Consultation paper on EIOPA's second set of Advice to the European Commission on specific items in the Solvency II Delegated Regulation", section 3 "Recalibration of mortality and longevity risk", p.65
https://eiopa.europa.eu/Publications/Consultations/EIOPA-18-075-EIOPA_Second_set_of_Advice_on_SII_DR_Review.pdf

[5.2] Testimonials from supervisory bodies of Canada and Peru from:
1. [text removed for publication], Actuarial Analyst, Financial markets regulator (Autorité des marchés financiers), Quebec, Canada, [text removed for publication]
2. [text removed for publication], ASA, DEPARTAMENTO DE SUPERVISIÓN ACTUARIAL Superintendencia de Banca, Seguros y AFP Central Telefónica [text removed for publication] http://www.sbs.gob.pe/
3. In Spanish: http://www.sbs.gob.pe (on the right side, go to "Documento Técnico") or directly to: http://www.sbs.gob.pe/tmortalidad/documento_metodologico.pdf"

[5.3] Testimonials from statistics offices of Norway and Hungary from:
1. [text removed for publication], Researcher at the Research Department, Statistics Norway. [text removed for publication]
2. [text removed for publication] Hungarian Central Statistical Office, [text removed for publication]

[5.4] Testimonials from Hanover Re and RGA Reinsurance Company via e-mail from:
1. [text removed for publication], Actuary, Life & Health, Biometric Analyses, Hannover Re, Germany. [text removed for publication] www.hannover-re.com
2. [text removed for publication] Senior Vice President and Head of Global Research and Development, RGA Reinsurance Company [text removed for publication]

[5.5] Testimonials from: [text removed for publication], SCOR Global Life | Actuarial & Risks | Head of Health & Longevity R&D. [text removed for publication]
- [text removed for publication], SCOR Global Life | R&D Department | Actuary of Long-Term Care R&D Centre. [text removed for publication]

- [text removed for publication] SCOR Global Life Americas | Statistician. [text removed for publication]

[5.6] Testimonials from [text removed for publication], Director R&D, Pacific Life Re, [text removed for publication]

[5.7] Testimonial [text removed for publication], Longevity Risk Research Specialist, Longevity Risk Team, Legal & General Retirement – text removed for publication]

[5.8] Testimonial from [text removed for publication], Senior Consultant - Head of R&D, Milliman, France. [text removed for publication]

[5.9] E-mail from [text removed for publication], Data Scientist, UnipolSai Assicurazioni S.p.A, Group Research And Development.

[5.10] List of papers and other sources citing and/or utilising StMoMo or the underpinning research.