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Long-Term Care Modeling, Part 2: First-Principles Modeling

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In the first installment of our three-part series (published in the December 2016 issue of *The Modeling Platform*), we provided an overview of long-term care (LTC) modeling and compared a claims cost approach with a first-principles approach. In this installment, we dive deeper into first-principles modeling for LTC. First-principles modeling is both more sophisticated and more challenging than a claims cost approach. There should be careful planning around model architecture and design, implementation, testing, validation and model maintenance from both a technical and an operational perspective.

MOTIVATION FOR FIRST-PRINCIPLES MODELS

The decision to convert to a first-principles model will depend on the merits of the advantages relative to the disadvantages, set out in Table 1.

BUSINESS SITUATIONS THAT MOTIVATE FIRST-PRINCIPLES MODELING

A good actuarial model is likely to improve management's understanding of their business, lead to better decision making and ultimately boost the financial health of the organization. This is because an actuarial model is a fundamental tool enabling senior management to monitor the financial status of the business and to gain insights not easily obtainable otherwise. The following business situations illustrate the value of a robust LTC first-principles model.

- **Management attempts to improve their understanding of LTC experience drivers to ensure that a closed block of business continues to break even.** A closed block of business that generates losses is undesirable. This could be addressed by improving the actuarial reporting and modeling capabilities using a first-principles model. Since the current claims cost framework utilizes existing industry claims cost tables, a company's experience drivers may not be accurately reflected within the source of earnings analysis. Implementing a first-principles structure tailored to the company's claims incurred, emergence and recovery pattern enables greater granularity and higher accuracy.
- **Companies look to enhance their enterprise risk management and control effectiveness.** A claims cost approach involves a high level of manual adjustments and regular calculations of tables that are used in the models. To reduce key-person risk and increase effectiveness of input controls,

Table 1
Deciding Whether to Convert to a First-Principles Model

Advantages	Disadvantages
More granular approach (tracking status of policyholders) facilitates better understanding of the financial drivers of results and appreciation of in-force movement	Greater complexity and computing power are required to implement and support a first-principles model
More direct sensitivity testing, for example, negates the need to go through regeneration of claims cost tables	First-principles model is more difficult and time-consuming to audit or maintain due to higher complexity
Greater consistency, streamlining of assumptions and more efficient implementation of assumption changes reduce issues associated with more traditional approaches, e.g., manually estimating claims cost	Challenges emerge in conversion to first-principles approach, such as recalculation of in-force reserves that were ascertained on a claims cost basis and the redesign of assumption tables
Users are able to calculate paid claims and decrement simultaneously, without pre-generation of payment pattern inputs	Greater focus on, and understanding of, assumptions are required for model operators (relative to claims cost table-based model)
Drivers of discrepancies in excess of materiality thresholds can be easier to identify	First-principles model requires more granular experience studies to be performed for accurate component assumption setting, which may not be available

first-principles modeling automates the data and assumption loading procedure and lowers the requirement for additional actuarial support, boosting efficiency.

- **Companies wish to improve pricing model capabilities.** Companies may benefit from adopting a first-principles approach to their pricing modeling framework to increase sophistication and modeling accuracy. For example, a stochastic first-principles pricing model allows for the generation of a full distribution of scenarios, such as the 95th percentile. This broadens the risk management capabilities of the company. Financial results can be measured with greater detail and accuracy on new and in-force business blocks, facilitating better business decision making.
- **Companies engaging in merger or acquisition activities.** There has been increasing activity in the market for selling closed LTC blocks of business. For a potential merger or acquisition, a first-principles model could be adopted by both sides of the transaction to ensure a fair and appropriate price range. On the sell side, companies may use a first-principles model to prepare for experience analyses, actuarial financial projections and the appraisal model development. On the buy side, in instances when the potential buyer believes the seller's model is not desirable or practical, a robust first-principles model may be helpful.
- **Companies wish to synchronize modeling approaches and increase modeling robustness.** Companies that have already converted to a first-principles modeling approach on their in-force block of business or pricing practice may now wish to synchronize their new-business modeling approach for consistency. In addition, companies may benefit from adopting a first-principles approach in order to have a more robust financial reporting capability. In particular, a first-principles approach lends itself to analyzing financial results by segment. This enhances management's ability to understand the drivers of results and increases consistency with existing models (e.g., consistency of in-force models with cash-flow projection models that have already been converted to first principles).

FIRST-PRINCIPLES MODELING LEADING PRACTICES: KEY CONSIDERATIONS

In setting up a first-principles model, an actuary should keep in mind the primary technical perspectives. They include, but are not limited to, the following leading modeling practices related to model architecture, conversion methodology and assumption development.

Financial Model Architecture

A company must consider numerous factors when selecting modeling software. Among them are type of system, single vs.



multiple modeling platforms, level of granularity, reinsurance model, and handling of riders, miscellaneous benefits and manual adjustments.

Type of System

This refers to whether a modeling software is designed to be an open system or a closed system. An open system allows for user customizations, which calls for tighter model governance and controls. A closed system has a defined system code that cannot be easily modified by users and, therefore, requires less formal governance. For example, in pricing new products, most actuaries would prefer an open system, as it offers customization flexibility to capture new product features, while a closed system may be preferable for a stable closed block.

Single vs. Multiple Modeling Platforms

Depending on the actuarial organization structure and the age of product, a company may find it has multiple modeling platforms to meet its business needs of each actuarial functional area. Alternatively, they may use, or strive to consolidate to, a single modeling platform that supports various business units, including valuation, forecasting, year-end testing and rate increases.

Level of Granularity

The level of granularity supported by the model can range from seriatim level to group level. This will largely be driven by how the assumptions vary and are applied in each model, how the experience analysis model must be set up to support the financial model, the input data table structure and the desired segmentation of financial analysis.

Reinsurance Model Consideration

Depending on the complexity and the type of the reinsurance treaties, companies may model their reinsurance in either separate models or the same model. A one-model approach is usually

more appropriate for coinsurance types of treaties, while a separate-model approach would be more applicable if separated premiums and assumption structures are negotiated under the reinsurance treaties.

Handling of Riders, Miscellaneous Benefits and Manual Adjustments

Historically, in modeling riders and miscellaneous benefits under a claims cost model, most companies have used simplified approaches, including (1) applying factors to the base claims cost assumption or (2) making topside adjustments. The decision to use a simplified approach is primarily due to companies' concerns about the complexity in modeling riders or benefits that produce only a small financial impact. The improvement of computational power and the robust calculation capability under a first-principles model has definitely improved companies' abilities to model many of the riders and benefits. Companies should carefully contemplate future sales expectations, financial impacts, product portfolio and marketing focus among other factors when deciding what should or should not be modeled.

In addition, the current modeling environment may require a variety of manual interventions and adjustments to determine the reported results. The modeling software chosen should be sufficiently flexible to incorporate these manual adjustments as automatic features, thereby reducing the amount of manual work required in the modeling process. This is an important consideration, as eliminating or reducing manual adjustments increases efficiency, lessens reliance on resources, speeds processing and increases accuracy.

Conversion Methodology

Once a decision is made on the system architecture, another key decision is which model conversion/implementation approach to employ.

Conversion of Different Accounting Bases and Order

Different accounting bases and order, such as best estimate, statutory/tax, and U.S. generally accepted accounting principles (GAAP), are used in LTC financial models to support a wide array of business and financial analysis activities. A company may set up separate models to support different business applications to accommodate a variety of actuarial concepts and assumption structures. In choosing the order of conversions for the various models, consideration should be given to which business activities would benefit the most from the conversion.

For example, LTC companies with first-principles models have chosen to convert the cash-flow projection model before converting their reserving models. A first-principles cash-flow projection model provides management with the benefits of robust reporting and analysis capability (e.g., better understanding of the emerging claims incidence by care location, recovery

and disabled death pattern). However, most of these companies believe the benefits of a first-principles approach are somewhat diminished when it comes to reserving, as reserving assumptions and methodologies are either locked in or prescribed. If the pre-converted reserving models are set up correctly, the post-converted models should produce exactly the same results. As alluded to in the business cases earlier in this article, if the existing reserving models are set up on a group basis that does not provide much flexibility to analyze financial results by segment, a conversion to a first-principles reserving approach would be a natural step following the conversion of the cash-flow model.

Implementation Steps

Many carriers have used a multistep “walk” approach during the conversion process. A “walk” approach enables carriers to discover errors from existing models, explain differences and understand movements. Here are a few different “walk” examples:

- **Example 1.** Company 1's pre-converted models were on a total lives claims cost basis. The approach that Company 1 has used was to first convert from a total lives claims cost model to a total lives interim first-principles model, then from a total lives interim first-principles model to a healthy lives first-principles model (two “walk” steps). The total lives interim first-principles model would enable the modeler to (1) verify that the claim assumptions are being decomposed correctly and accurately, as the only change made is the decomposing of the claims cost into its components (incidence, termination and utilization); and (2) to detect any issues that may exist in the claims cost mechanics of either the pre-converted model or the post-converted model. If both models and assumptions are handled appropriately, the results from both models should match very closely, as there are virtually no changes made besides decomposing the claims cost assumption.
- **Example 2.** Similar to Company 1, Company 2's existing models also use total lives claims cost. Company 2 first “walked” its total lives claims cost models to healthy lives claims cost and then performed another “walk” from healthy lives claims cost model to the final first-principles model. This interim step enabled the company to derive a set of interim healthy claims costs that later could be used to verify the converted healthy first-principles model claims costs. It also enables Company 2 to appreciate the impact of converting from total lives to healthy lives in isolation of the claims cost decomposition impact.

Either approach mentioned here increases the companies' abilities to identify errors and analyze results, which will result in much more reliable models. This benefit usually exceeds the cost of the additional effort.



Assumption Development

Key assumptions for the long-term care business include mortality rates, lapse rates and morbidity (e.g., incidence rates, underwriting selection factors, termination rates, utilization factors and morbidity improvements). The common assumption bases include best estimate, statutory and GAAP.

Best Estimate Assumptions

Conversion of the best estimate assumption has a multidimensional impact: (1) the use of implied assumptions vs. derived assumptions; (2) consideration of the morbidity assumptions; and (3) preservation of mortality.

The Use of Implied Assumptions vs. Derived Assumptions.

In converting best estimate assumptions, many companies have considered the choice of implied assumptions vs. derived assumptions. To avoid an abrupt change to the projection results, some companies have elected to first calculate a set of morbidity assumptions by decomposing their existing claims costs into incidence rates, termination rates and utilization factors. If all existing claims cost generators are error-free, the converted claims cost using the “implied” assumptions should match the pre-converted claims cost. However, many legacy models historically use total lives claims cost, and while decomposing claims cost may seem as easy as a pure mathematical exercise, actuaries should carefully contemplate the conceptual implications of such calculations. For example, do the relative sizes of the post-converted claims cost components make sense? Are they really an appropriate representation of the healthy lives basis claims cost? For example, a company may have previously used a set of J factors (ratios of non-claimant exposure to total exposure) to help bridge the gap between total exposure and total lives claims cost. These J factors may have varied by policy characteristic. The implied healthy lives claims cost would, therefore, vary by benefit period (product of total lives claims cost and J factors). A

technical check may not show any issues with this approach, but conceptually, is the converted claims cost appropriate?

For companies with frequently updated experience studies and well-maintained and robust assumptions, it may be intuitive to simply use a set of derived assumptions (e.g., incidence rates, termination rates and utilizations) based on the latest experience study. With this approach, companies should still make sure that the pre-converted and the post-converted claims cost match at the conversion date and into the future.

Regardless of which approach a company uses, the experience analysis framework should be structured consistently so that post-converted models can be validated periodically.

Consideration of the Morbidity Assumptions. As stated earlier, first-principles morbidity assumptions include incidence, terminations (which can be further decomposed into recoveries and disabled deaths) and utilizations. Key morbidity assumption conversion considerations include (1) ensuring no erroneous subsidies/shifts among incidence, termination and utilizations during the decomposition; (2) confirming factors and adjustments, if any, are being interpreted properly and converted accurately (for example, how should the adjustments be qualified? Should they be decomposed to have implication on incidence rates, termination rates and utilizations?); (3) verifying the original termination assumptions are preserved after being decomposed into recoveries and disabled deaths; and (4) accounting for any morbidity improvements and if they should be reconsidered separately for incidence and terminations.

Preservation of Mortality. Historically, most models use total lives mortality. This is mostly due to system and data limitations in the LTC industry.

A first-principles model is able to keep track of and, therefore, require separate mortality assumptions for healthy lives vs. disabled lives. Depending on data credibility and granularity of the experience analysis model, companies could use various approaches to develop their mortality assumptions. For example, (1) maintain existing total life assumptions, develop a set of disabled life mortality assumptions and calculate a set of implied healthy lives mortality; or (2) separately develop the mortality assumptions for healthy lives and total lives.

During the conversion, it’s important that the actuary makes sure the number of total deaths is preserved (e.g., the sum of healthy deaths and disabled deaths should equal the total deaths implied by the original total lives mortality assumptions). This is referred to as preservation of mortality. Table 2 illustrates how the preservation of mortality could be violated. Model validation and assumption calibration are common approaches to correct for any violations discovered during model validation.

Table 2
Example of How Preservation of Mortality Could be Violated

Year	Assumptions	Results
x	Total life mortality rate = 0.01 Incidence rate = 0.01 Disabled life mortality rate = 0.15 10,000 lives	Total deaths = 10 (1,000 × 0.01) Disabled lives = 10 (1,000 × 0.01) Disabled deaths = 1.5 (10 × 0.15) Expect 8.5 active deaths (10 total deaths – 1.5 disabled deaths) Mortality rate for active lives = 8.5/990 = 0.008596
y	Total life mortality rate = 0.04 Incidence rate = 0.12 Disabled life mortality rate = 0.15 700 active lives 150 disabled lives	Total deaths = 34 [(700 + 150) × 0.04] New disabled lives = 84 (700 × 0.12) Disabled deaths = (150 + 84) × 0.15 = 35.1 Expect -1.1 active deaths (34 total deaths – 35.1 disabled deaths) Observe that expected active deaths is negative, which is not plausible Preservation of mortality does not hold

Statutory Assumptions

In converting National Association of Insurance Commissioners (NAIC) reserves to a first-principles approach, major challenges to companies include the following:

1. Interpretation of the minimum reserve requirement. For financial reporting purposes, companies are required to hold reserves at or above the minimum statutory reserve levels, regardless of the approach used. However, there have been different interpretations in terms of whether the minimum reserve requirement should be applied in aggregate or at an individual policy level.
2. Interpretation of the model regulation and deciding the treatment on their NAIC valuation mortality, lapse and morbidity assumptions for the healthy lives and disabled lives.
3. Ensuring that the pre-converted projected reserves and the post-converted projected reserves match at time zero and going forward.

The statutory reserve basis cannot be changed after a policy is issued unless regulatory approval is obtained. When the regulation was written, a first-principles reserving model did not exist. Therefore, the regulation remains silent in terms of the separation of the mortality rates into healthy mortality and disabled mortality.

The following list provides some sample approaches that companies have considered in handling the NAIC model regulation during the conversion:

- **Example 1.** Treat the prescribed mortality table as the healthy life mortality table. Since the regulation remains silent about disabled mortality, a set of disabled life mortality table rates developed from the company’s own experience is used.
- **Example 2.** Treat the prescribed mortality table as the total mortality table, separately develop a disabled life mortality table and calculate a set of implied healthy mortality rates.
- **Example 3.** Ensure that the total prescribed policy termination does not change before and after the conversion. Develop a separate disabled life mortality table solely for the purpose of separating claim termination rates into disabled deaths and recoveries.

The regulation also doesn’t address the decomposition of the claims cost tables. The statutory reserving basis is not supposed to change post policy issuance. The reserving model regulation doesn’t prescribe any standard morbidity tables. For many companies’ older policies, the NAIC morbidity reserving assumptions are based on their original pricing claims costs. Some of these pricing assumptions were created when the policies were first

issued (e.g., more than two decades ago). It, therefore, would be difficult for companies to track down the claims cost components. The separation of these claims costs into the different components would, therefore, become arbitrary.

Companies have considered these two approaches:

- Use morbidity assumptions from similar policy forms for which the morbidity components are identifiable and calibrate to the converted claims cost in order to match the reserves, net premiums and/or claims cost.
- Develop a set of average-length stay of proxy and apply it to the original claims cost to back into other components of the claims cost assumptions (e.g., incidence rates).

Regardless of which approach is used to handle the issues outlined here, the post-converted reserves should match the pre-converted reserves as of the conversion date and into the future, unless errors were discovered and corrections must be made to the pre-converted model. Any reserve comparison divergence into the future should be based on reason.

Finally, it's important for management to ensure that the regulator's approval is obtained for any key methodology and assumption changes.

GAAP Assumptions

The handling of the GAAP reserve conversions is similar to the handling of the NAIC reserve conversions in that the GAAP assumptions shall be "locked in" per GAAP accounting requirements under ASC 944-60 (formerly FAS 60). During a conversion process, the "locked in" concept is challenged because claims costs are decomposed, and mortality and lapses often need to be redefined on a healthy lives basis as opposed to total lives basis. The general approaches that companies have taken are to ensure that the claims costs calculated by the first-principles model match those from the pre-converted model and that the projected reserves match reasonably well as of the converted date and into the future. Any changes to the reserves due to error discovered during the conversion should be fully disclosed.

If the Financial Accounting Standards Board's (FASB) proposed Accounting Standards Update is approved, companies will be required to update their assumptions annually. If planned carefully between model conversion and assumption analysis, the concept of "locked in" would become a moot point in this situation.

Assumption Governance and Maintenance of Assumptions

Regardless of the assumption basis, it is important to consider the governance structure in place for assumptions on a first-principles LTC model. A comprehensive governance framework would typically entail multiple levels of committee review and approval, taking into account differences in the various assumptions used in a first-principles LTC model. In addition, a centralized assumptions review and governance committee may be required in order to promote consistency of assumptions used for the LTC model and those for other business lines. High-functioning assumption governance committees typically have adequate stakeholder representation to prevent the assumption-setting process from being disproportionately impacted by a particular group. The assumption-setting process, review, approval and final basis should be adequately documented, regardless of the complexity of the business and associated modeling framework. Details of assumption governance and control will be further discussed in the third installment of this article series.

VALIDATION AND TESTING

Generally speaking, model conversion is usually a significant effort involving many functional areas, such as data warehousing, actuarial assumption setting, experience studies and actuarial modeling. After the conversion, it is crucial to ensure that there is still close integration of all components and that there is compliance with company-wide governance policies. This can be accomplished through model validation procedures and testing.

As discussed in the first part of the series, a model validation process should at minimum include model verification, model fitting and user acceptance testing. A test plan helps guide the model developer, tester and end user to track the status of model validation. These concepts generally apply to a first-principles modeling approach but with specific caveats in such a complex situation.

During the model verification step, a modeling expert would ask if validation criteria were set with sufficient granularity and in a way that captures the company's goals. The questions to ask include (but are not limited to) the following: Is the design of the model aligned with the company's objectives and goals? Did the modeling team ensure that the models are producing reasonably close results for premiums, claims and expenses? Were significant components of the models compared, and were differences attributed to the key changes made?

Similarly, when evaluating model fit, there are many questions to ask and considerations to be made. Users should check if the initial data align reasonably with historical data and if there is a smooth transition between experience and projected data. The model's limitations should be documented, and model experts should understand their impacts on results. As experience emerges, users should confirm if backtesting indicates a reasonable fit of the model to the data.

Finally, the model users should evaluate the converted model's robustness and performance relative to expectations. They will want to confirm that the model still performs as expected when certain assumptions are stressed and that data inputs are accurately captured within the model. The users should understand any modifications that must be made to model outputs. Additionally, the model's run time, efficiency and processing should be reasonable from the viewpoint of the model users.

There are many considerations in validating a converted model. While it is generally the last step during a conversion project, it is arguably the most essential to ensure that an effective model is put into production. When specifically applying these steps to LTC models, there are certain comparison items between the pre-converted model and the post-converted model that should be considered:

1. Pre-converted claims cost and post-converted claims cost (should match at the conversion date)
2. The projected cash flows
3. The projected lives by cohort (e.g., healthy and disabled versus total, disabled lives by care location, number of recoveries and disabled deaths versus number of terminations)
4. The average reserve factors
5. The pre-converted net premium and post-converted net premium
6. The projected reserves at the conversion date and into the future

The details of each of these will be discussed in our next article.

CONCLUSION

First-principles modeling of LTC products is a complicated task, requiring careful planning and foresight. We have highlighted important aspects to consider with respect to a first-principles LTC model, including model architecture, conversion methodologies and assumption-setting processes. These considerations impact the potential model uses, spanning a wide spectrum from valuation such as GAAP and statutory reserving to actuarial and financial projections, including cash-flow testing and asset liability modeling. Model validation will also play a crucial role in the conversion process by ensuring robustness and goodness of fit. Owing to the potentially significant impact of the choice between first-principles and claims cost models, the decision regarding whether to convert should not be taken lightly. ■

The views expressed are those of the authors and do not necessarily reflect the views of any member firm of the global EY organization.



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