Modern policy administration with Markov models

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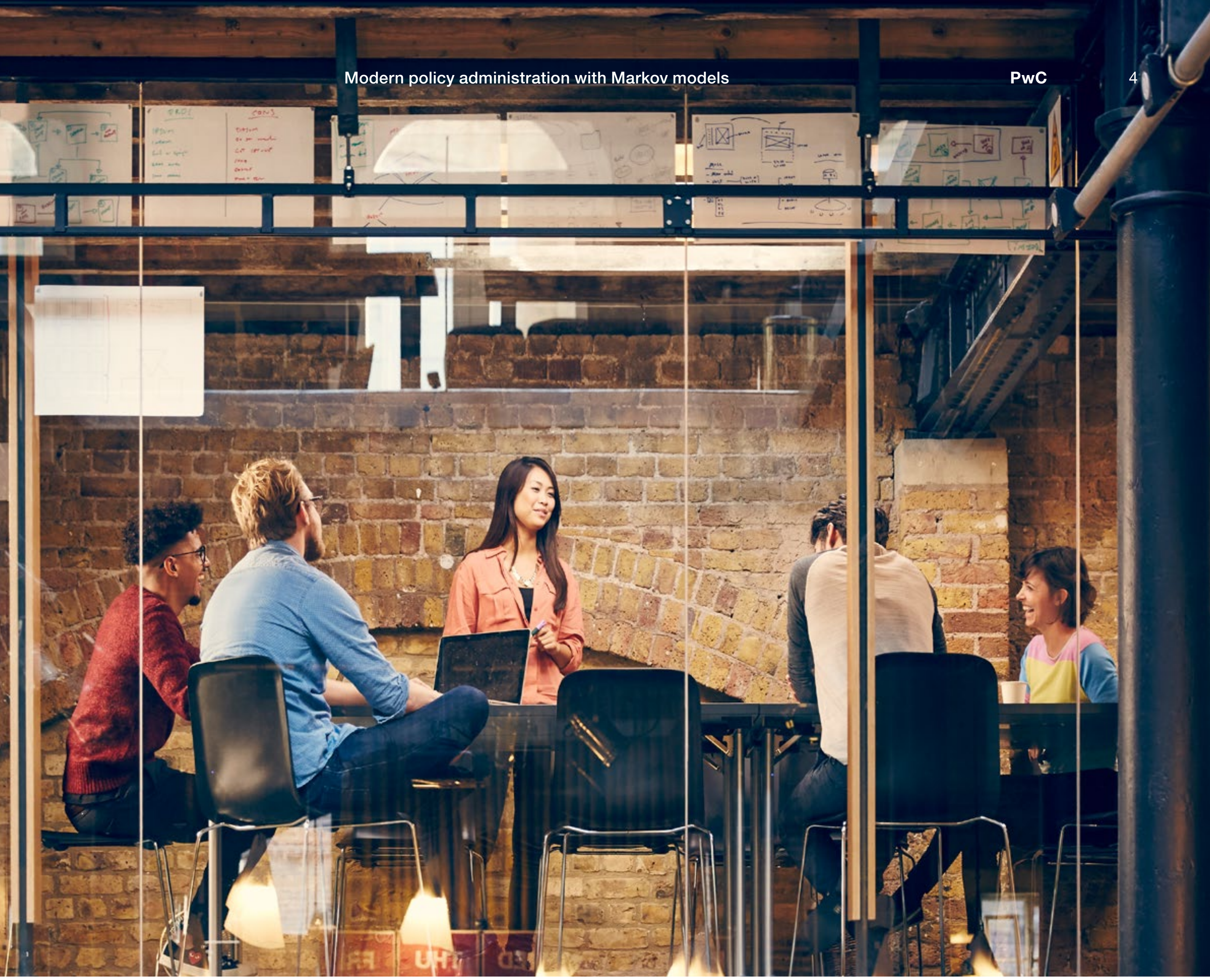
Modernisation of policy administration systems for efficient management of insurance contracts

Insurers have recognised the urgent need to modernise their policy administration systems

In the last decade, life insurers in Switzerland have been facing increasing challenges of both a macro-economic as well as regulatory and operational nature. At the same time, life insurance customers have been and are (still) searching for innovative products that offer individual insurance solutions regarding protection as well as customisable combinations of asset-based private pension schemes (pillar 3a/b). Thereby, customers wish to understand how life insurers can support them throughout their life as their insurance needs are naturally evolving. To address these requirements, to remain competitive, and to increase the customers' experience, Swiss insurers make diverse digital investments. Well-known examples are the increase of the digitalisation of the interaction with customers (e.g. chat bots, online offers, partnerships), the use of AI-driven technologies for accelerated claims handling as well as the automation of processes in general [1].

Beyond all these digital efforts, insurers have also reviewed their product landscape and started to introduce modular and highly individualised product designs to retain ageing policyholders but also to attract young customers of Gen Z. However, despite these efforts, a recurring challenge of the insurance industry remains the rigidity of outdated legacy policy management systems. These systems often prevent dynamic product designs, do not meet evolving customers' expectations, and ultimately may not support an efficient handling of complex business operations between the insurer and the insured. But these days, insureds are keen to understand the benefits that are covered by their policies under different scenarios (e.g. in the case of certain illnesses for multiple insureds) and modern hybrid unit-linked products strive for timely valuation and clarity at the policy level. In addition, insurance companies are driven to analyse performances of their life books more deeply, to meet more granular reporting requirements (e.g. experience analysis), or simply wish to reduce administration costs by increasing operational efficiencies and accelerated implementation times of tariffs.

In today's insurance industry, policy administration systems – which form the core of each company –often fail to embrace the full potential of the insurance business. To overcome these hurdles and to allow for underwriting of future-oriented products, insurers have started to recognise the urgent need to modernise their existing policy administration systems. Commonly, the systems in place only offer basic capabilities that date back to technologies employed in the last century [2]. Unfortunately, as part of major IT endeavours where risks, costs and complexity are carefully assessed, the future benefits that can be unlocked from a business perspective by either choosing to 'rearchitect' or 'rebuild' the policy management system are sometimes overlooked. Instead, a 'rehosting' or 'replatforming' in a new environment is selected to migrate more rapidly outdated systems without modifying the existing code, features and functions at seemingly lower costs – but all based on still outdated actuarial kernels for managing insurance contracts, such as commutation values, which lack the flexibility to accommodate the insured's current needs at each specific point in time [3].



Markov models for flexible valuation of insurance benefits

In this article, we outline the potential benefits of using Markov-based techniques for modelling insurance contracts in modern policy administration systems from a business perspective. We recognise that a Markov approach employs well-established recursive valuation techniques. Further, in combination with Thiele's differential equation, an iterative valuation of state-dependent insurance obligations can be performed. Applications are manifold and range from modern ratemaking and reserving, to forecasting of the insured's benefits. While we provide some theoretical background on the idea of Markov models, our focus is to look at some real-life examples for modelling life insurance contracts. Finally, our practical observations on designing actuarial kernels for policy administration systems when using Markov approaches in the context of system migrations are summarised.

01

From static actuarial tables to dynamic Markov models

For nearly three centuries, actuaries have relied on **commutation numbers** to model life insurance risks. These techniques are rooted in tabular approaches based on deterministic assumptions and have proved to be highly effective in an era of limited computational power and relatively simple product designs. A typical example is a whole life insurance, where the sum assured is fixed at maturity or in the event of death of the beneficiary. Commutation values are indeed (still) a convenient and well-tested approach to provide actuarial present values for valuation of simple traditional products that employ technical interest rates. Therefore, it is also no surprise that commutation numbers continue to underpin many core administration systems in life insurance today, especially when it comes to classical prospective calculations of reserves, benefits and premiums. These can be calculated prospectively using the well-established equivalence principle. To further reduce computational complexity, often the commutation numbers are even hard-coded in the system or stored in a data base from which these are ultimately sourced by actuarial calculation kernels.

The use of commutation tables comes at the expense of limited flexibility

Major challenges we observe when using commutation values are as follows.

Firstly, changes in underlying actuarial assumptions such as deterministic technical interest rates or non-economic assumptions (e.g. mortality rates) trigger the storage of new tables or even additional implementation efforts for modelling in-force contracts. Secondly, the calculation of time-dependent as well as various types of benefits (e.g. temporary disability insurance, critical illness) or when multiple beneficiaries are jointly insured (e.g. joint whole life insurance) requires the derivation of highly complex commutation formulas that are error-prone. Thirdly, modern life insurance contracts increasingly feature partial surrenders, premium suspensions, dynamic discounts and other 'non-linear' features. Adapting commutation models to these realities often requires complex workarounds which erodes both maintainability and transparency. Some products even require updated recursive valuation techniques (e.g. unit linked based products) which cannot be properly simulated using commutation values.

To overcome these drawbacks, a more flexible approach that allows stochastic modelling of multiple states and benefits is required. Fortunately, an alternative has existed for over a century: the **Markov model**. Originally conceived in the early 20th century, this framework offers a **dynamic, state-based approach** to actuarial modelling of insurance contracts. Historically, its adoption was limited by the same obstacle that constrained early artificial intelligence — computational power, but nowadays this constraint no longer exists.

Thanks to available modern computing power, the **Thiele recursion** now gained attraction in the actuarial community. **The Thiele recursion complements the idea of Markov and has become a powerful and viable alternative to commutation-based systems.** In the following, we'll explore how the combination of Markov processes and the Thiele recursion unlocks a new level of flexibility in life insurance policy administration, capable of mapping more personalised, modular and future-proof products in a structured fashion.

The impact of Thiele on insurance business modelling

The shift from commutation-based systems to a dynamic recursion-based framework which is based on Thiele's idea has far-reaching implications. It not only facilitates the modelling capabilities or offers another tool to actuaries and IT teams, but rather has a business enabling component of a (life[1]) insurer. The benefits span operational efficiency, performance management, customer experience and competitive agility, for which we would like to give some examples.

1. Reduced operational and maintenance costs

Legacy systems built on commutation numbers often require bespoke processes and extensive manual interventions when underlying assumptions are modified or even minor changes in the tariffs' benefits are made. We also observe that quite often a complex logic to handle exceptions is required, for example when partial surrenders or temporary premium suspensions occur. In this case, modifications or case-by-case extensions to the formula are needed to address changes in the contract conditions or payment pattern. Such changes can be very cumbersome and require time to identify relevant parts in the code to be changed, as well as potentially intensive and costly retesting of the modifications to the legacy implementations. In contrast, a Thiele-based approach enables:

- Fewer custom calculations and special-case processes,
- Streamlined process flows with less need for manual decisions,
- Reduced reliance on actuarial or technical experts to handle policy alterations.

This simplification translates into **lower maintenance costs,** better scalability and improved efficiency in policy servicing as no changes as such in the underlying formula are required.

2. Enablement of digital self-service

By modelling policy values dynamically and continuously, the Thiele recursion lays the groundwork for **real-time policy updates and self-service capabilities.** Policyholders can themselves initiate changes such as adjustments to premium levels or request partial withdrawals through standardised digital channels. These changes do not need manual recalculations or approvals as Thiele's recursion treats them as reparameterisation of expected future cash flows. Consequently, the customer enjoys:

- A more seamless digital experience,
- Faster response times,
- Significant reduction in workload for customer operations teams, while even no further action is required by the insurer due to automated processes.

[1] Not limited to life insurance.

Applications can be found in other lines of business such as health or even in non-life when future and various states of contracts are of interest, for example when analysing technical results.

3. Greater product flexibility and personalisation

Modern policyholders expect insurance products that reflect their evolving financial needs. A Thiele-based engine allows for a much more flexible design of:

- Premium schedules (e.g. temporary suspensions, variable premiums),
- Benefit structures (e.g. step-up or step-down options, partial payouts),
- Optional features and riders.

This enables insurers to offer truly customer-centric products, enhancing long-term satisfaction and retention, which is imperative to life insurers wishing to position themselves as **lifetime financial partners** for their insureds.

4. Faster time to market

In a dynamic regulatory and competitive environment, insurers must be able to quickly adapt their tariffs that are open for sale. The modular and cash-flow-driven nature of Thiele's recursion makes it significantly easier to:

1. Prototype and launch new products or riders,
2. Adjust pricing assumptions without restructuring the entire product model,
3. React to regulatory or market changes with minimal development overhead.

This agility is essential not only to stay compliant but also to **capture faster market opportunities more quickly** in a very competitive environment.

5. Facilitation of portfolio in-force management

Thiele's recursion does not provide a present value view but rather a periodical and probability-weighted representation of potential future outcomes. This allows for simplified extraction of expected cash flows, which can be compared with observed actual payments or premiums. The advantages are manifold such as:

1. Contribution to surplus analysis by risk, cost and savings process,
2. Comparison with accounting and claims data,
3. Simplified reconciliation with other actuarial projection systems.

6. Game changer for migration of policy administration systems

The idea of Thiele's recursion is to project actuarial technical reserves **recursively between the current and future states** of the policy. Thereby, forward-looking information such as agreed premiums, expected costs and periodically expected as well as maturing benefits are used in each potential future state of the insured. Due to the recursive design, Thiele's equation is quite flexible and can be used in a retrospective or prospective manner. This has profound implications for system migrations.

When migrating policies, a **reconstruction of historical policy states** is often needed. When using commutation numbers, this reconstruction can represent a resource-intensive process of reconciling the legacy calculations of technical policy modifications due to the use of helper values to overwrite and alter calculations. These efforts are exacerbated if the target system applies a fundamentally different approach in the handling of technical policy modifications. With a Thiele-based model, the **deterministic vector of reserves, guaranteed benefits and premiums at the migration date may even be a direct input.** Then, all expected values can be derived dynamically going forward, while the introduction of migration cost premium vectors permit reconciliation with the legacy system. This eliminates the need to replicate every historical step of the policy from the legacy system, hence resulting in several key advantages in the migration process:

- Significantly reduced reconciliation effort with legacy systems,
- Simplified onboarding of migrated policies, even in the presence of rounding differences or product rationalisations,
- Greater control over deviations, which can be absorbed via a migration premium spread over the remaining policy duration instead of requiring one-time reserve or benefit adjustments.

This approach is already gaining traction in the German-speaking 'DACH' region, which is supported by leading administration system suppliers. The cost savings and risk reduction from this method can be substantial when life insurers plan an overhaul of their core system. For general viewpoints on the transformation of core systems, we also refer to our study 'Die überfällige Transformation der Versicherungskernsysteme' [4].

03

So what's the issue with commutation tables?

In traditional policy administration systems, the commutation tables remain the foundation for calculating premiums, benefits and reserves which are based on actuarial present values and are derived from commutation values. These figures represent pre-tabulated present values of normalised future cash flows of size one, which are typically discounted assuming a constant technical interest rate and static mortality tables. Then the equivalence principle is used to ensuring that the present value of future benefits equals the present value of future premiums to arrive at reserves at the valuation date. This approach has several advantages, as it:

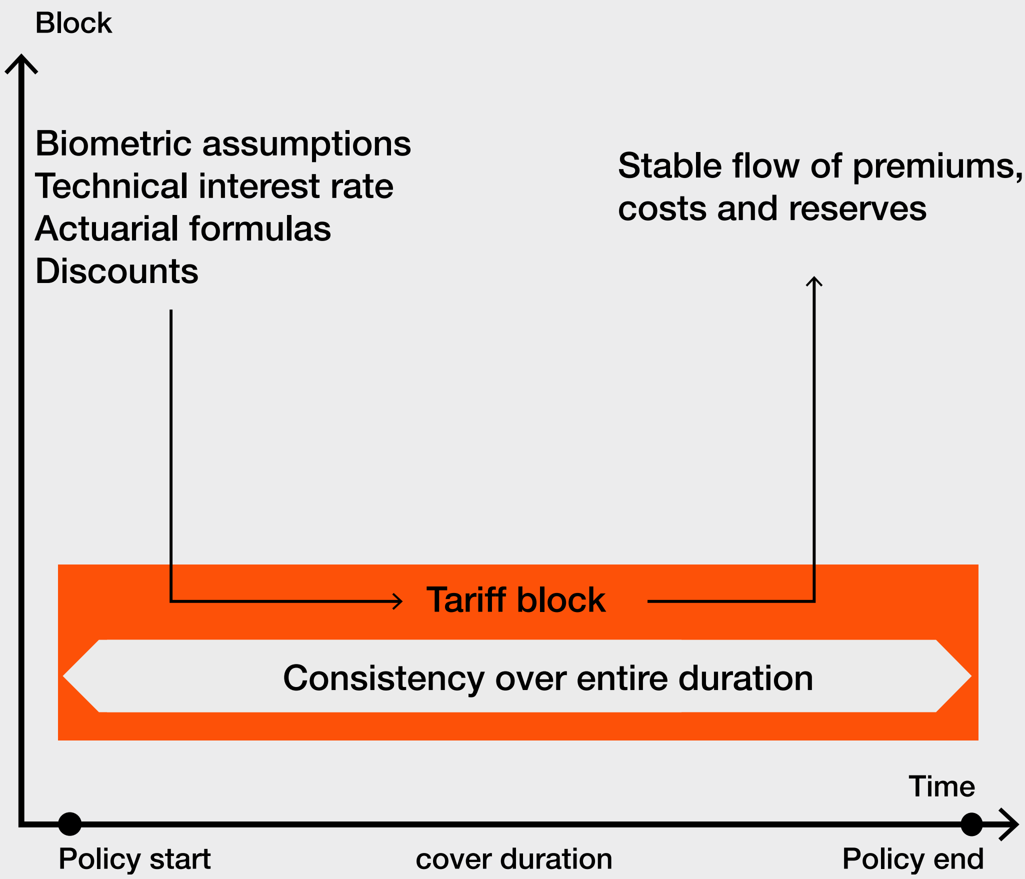
- Provides transparency as all values are internally consistent (e.g. setting premiums and calculation of tariff reserves) and traceable.
- Enables efficient implementation for simple traditional products due to the use of standard commutation values.
- Serves as a plausibility check of the calculation of reserves, since premiums and benefits are inherently tied together.

Figure 1: Illustrative example of commutation tables, as they might be hard-coded in a policy administration system.

x	q_x	ℓ_x	d_x	D_x	C_x	N_x	M_x
0	0.011687	100000	1169	100000	1132	2774172	12674
1	0.001008	98831	100	95720	94	2674172	11542
2	0.000728	98731	72	92613	65	2578452	11448
3	0.000542	98659	53	89633	47	2485839	11383
4	0.000473	98606	47	86765	40	2396206	11336
5	0.000452	98559	45	83994	37	2309441	11296
6	0.000433	98514	43	81313	34	2225447	11259
7	0.000408	98471	40	78719	31	2144134	11225
8	0.000379	98431	37	76210	28	2065415	11194
9	0.000352	98394	35	73783	25	1989205	11166
10	0.000334	98359	33	71435	23	1915422	11141

However, this tight coupling of premiums, benefits and reserves – while mathematically elegant – also introduces significant constraints. As the reserve is derived directly from the same commutation values as the premiums or benefits, any change to one element requires the recalculation of the other variables to maintain consistency (e.g. stepwise rebates). In other words, while the commutation-based approach is suitable for fixed, predictable contracts, it becomes restrictive in a world where flexibility and personalisation are increasingly essential. Another way to represent this consistency is via a tariff block, an object where a set of formulas and assumptions ensure the consistency of actuarial calculations over the entire duration of the insurance cover.

Figure 2: Modelling with commutation-based values requires consistency of assumptions at each time step



Simplification of policy administration with Thiele's recursion

In this section, we explore how Markov models, paired with the Thiele recursion, can offer a powerful and flexible alternative to traditional commutation-based methods. This approach enables actuaries to decouple reserves from strict equivalence constraints, allowing policies to be modelled dynamically instead. That is, changes to premiums, benefits or policyholder behaviour can be modelled in real time.

A forward-looking perspective

At its core, the Thiele recursion provides a **recursive reserve calculation** based on a system of differential equations. These equations reflect the transitions between different states in a Markov model such as 'active', 'disabled' or 'deceased', while using mainly **future premiums and benefits** as inputs. Crucially, this means that past policy events need not to be reconstructed or reconciled as the model focuses purely on the future trajectory of the policy which can be modelled prospectively from the recursion. This is particularly advantageous in today's product landscape, where policy features may change dynamically due to more flexible contractual conditions designed to meet policyholders' expectations of high levels of personalisation and control.

Transition states: some actuarial fundamentals

To illustrate the concept of Markov, we consider a **unit-linked endowment insurance** product. A policyholder could move through various states (Z) throughout the policy's durations with the following states and probabilities:

- A: Active
- D: Deceased
- p: Probability of remaining active

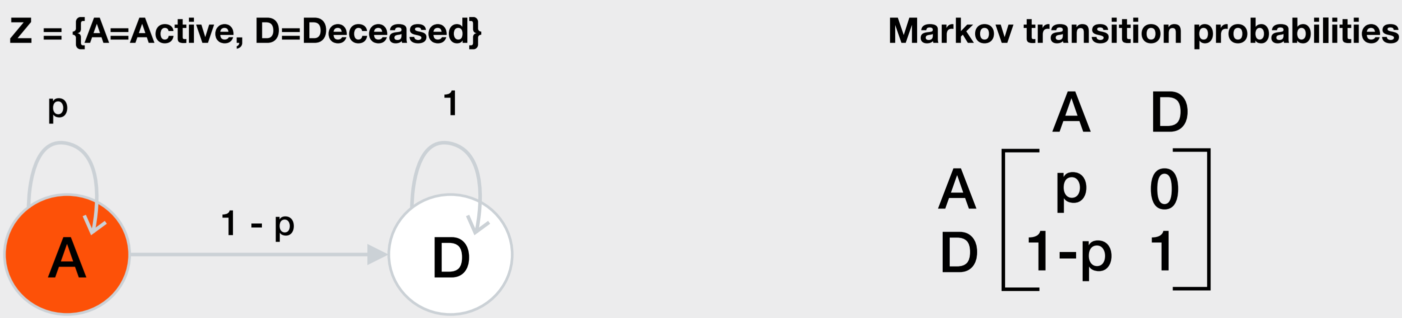


Figure 3: Illustration of transition probabilities for two states and matrix notation for Markov

This progression may seem complex, but **basic linear algebra and matrix** operations allow us to elegantly model these transitions, in particular when various states or decrements can be assumed by the insured(s) such as disability, widow's disability, time-dependent reactivation, cause-dependent death due to accident or sickness, etc.. When applied iteratively over time, these transitions naturally form a **Markov chain**, where each state depends only on its prior state but not the full history. This is called 'memorylessness of the stochastic process'.

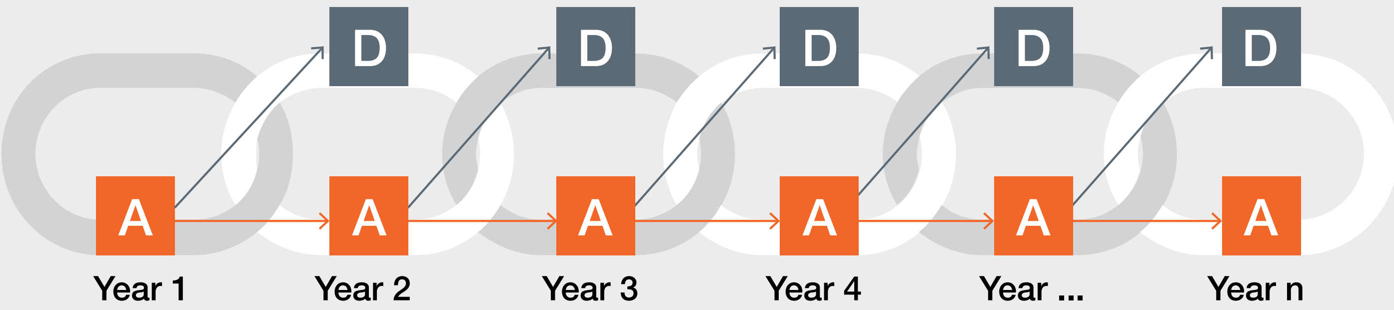


Figure 4: Illustration of a simple Markov process for a unit-linked endowment cover

From chain to recursion: practical implementation of Thiele's recursion

While the theoretical Markov chain is an elegant approach, its direct implementation in a policy administration system would be still impractical. This is where the **Thiele recursion bridges the gap between Markov and practice**. Thiele translates a transition structure into a **recursive time-discrete equation** system. This system can be solved prospectively (or retrospectively) when the following contractual information is provided:

- the reserve ${}_{m}V^{\alpha}$ in current state $\alpha \in Z$ and the reserve ${}_{m+1}V^{\beta}$ in posterior state $\beta \in Z$ or final reserve value at the end of the recursive iteration step;
- the future gross premiums π, costs C and benefits B depending on time $t= m+1, m+2, \ldots$ and in
- possible future states $\beta \in Z$ such as alive and death; and
- other policyholder's desired inputs/priority (e.g., target benefit or premium);

Then Thiele's recursion can be more generally described by

$$ {}_{m}V^{\alpha} = {}_{m}B^{\alpha} + {}_{m}C^{\alpha} - {}_{m}\pi^{\alpha} + \sum_{\beta} {}_{m}p^{\alpha,\beta} \times v \times {}_{m+1}V^{\beta} $$

In our illustrative example for endowment product, Thiele's equation can be applied as follows as only two states are possible:

$$ {}_{t}V = \underbrace{vp_{x+t} \times {}_{t+1}V}_{\text{Reserve premium / discounted maturity benefit}} + \underbrace{vq_{x+t} \times {}_{t}VS}_{\text{Risk premium / discounted mortality benefit}} + Cost\ premiums - {}_{t}\pi $$

Actual reserve ← ${}_{t}V$; ${}_{t}\pi$ → Gross premium

Reserve premium / discounted maturity benefit

Risk premium / discounted mortality benefit

Equation 1: Thiele's equation recursion for endowment

This recursive approach allows for direct adjustments to premiums or benefits without the need to introduce a set of rigid tariff blocks and correction overrides to alter the existing benefits and premiums of a policy. This enables **real-time recalculations** and is perfectly suited for modern and modular policy administration systems. Further, it opens the possibility for policyholders to perform changes directly by themselves without interacting with an agent or customer service.

For further details on Thiele and examples, we also refer to [5].

An application from practice: modelling of an endowment product

We consider a 20-year endowment policy with a base premium of CHF 1,000 per year. After 10 years, the policyholder chooses to increase the premium by another CHF 1,000 annually. The acquisition cost period lasts for 3 years, and the model assumes the policyholder has indicated a fixed premium (premium priority). The following table offers a simplified illustration of the projected benefits, premiums and reserves: high levels of personalisation and control.

Table 1: Modelled cash flows of a 20-year endowment using Thiele.

	Benefit vectors		Recursion		Premium Split				
Year	Survival	Death	Gross	Reserve	Savings	Risk	Cost	Admin	Acquisition
0	-	19,323	1,000	0	599	8	375	29	346
1	-	19,323	1,000	617	599	8	375	29	346
2	-	19,323	1,000	1,234	599	8	375	29	346
3	-	19,323	1,000	1,852	945	8	29	29	-
4	-	19,323	1,000	2,816	945	8	29	29	-
5	-	19,323	1,000	3,781	945	8	29	29	-
6	-	19,323	1,000	4,747	945	8	29	29	-
7	-	19,323	1,000	5,713	944	7	29	29	-
8	-	19,323	1,000	6,680	944	7	29	29	-
9	-	19,323	1,000	7,648	944	7	29	29	-
10	-	28,642	2,000	8,616	1,444	13	543	43	500
11	-	28,642	2,000	10,065	1,444	13	543	43	500
12	-	28,642	2,000	11,514	1,444	13	543	43	500
13	-	28,642	2,000	12,965	1,945	13	43	43	-
14	-	28,642	2,000	14,916	1,945	12	43	43	-
15	-	28,642	2,000	16,870	1,946	11	43	43	-
16	-	28,642	2,000	18,825	1,947	10	43	43	-
17	-	28,642	2,000	20,782	1,948	9	43	43	-
18	-	28,642	2,000	22,741	1,951	7	43	43	-
19	-	28,642	2,000	24,704	1,953	4	43	43	-
20	-	28,642	2,000	26,670	1,957	-	43	43	-
End	28,642	-		28,642					

Once the premium vector is defined, the recursion efficiently computes the reserve and allocates the premium split (i.e. risk, savings and cost premiums) for each future year in a single and coherent system.

Further benefits of Thiele: built-in premium decomposition

As can be seen in **table 1**, a key benefit of the Thiele recursion is that the premium decomposition comes for free. One can see from **equation 1** above that the recursive structure simultaneously determines the reserve evolution over periods and thereby incorporates the components of the gross premium with its constituent parts such as risk premium, acquisition cost, savings premiums etc. Whereas commutation-based administration systems require separate calculation efforts or additional approximations. Another benefit of the recursive approach using premium components is that in the projection changes to the premium components can be made in each future period while all dependent values (such as reserves) are implicitly calculated. These insights can be used for performance management or technical analysis on surpluses or to understand the adequacy of the tariffs' underlying assumptions.

Examples of efficient post-sale operations with Markov-based policy management systems

Further benefits of Thiele: built-in premium decomposition

To understand the differences of the business impacts when choosing between commutation- or Markov-based policy management systems, let us consider a typical endowment policy with financial guarantee and premium waiver. This is a popular product with insureds in Switzerland as it is eligible for the pillar 3a tax-advantaged framework. In the following, this product serves as our reference product to investigate the efficiency of the above-mentioned post sales operations.

While these products seem straightforward to be administered from an actuarial perspective at inception of the contract, it is important to remember the long-term nature (sometimes spanning over multiple decades) of life insurance policies. In fact, over the duration of the policy life cycle, the insured may decide to make a series of changes to the policy or activate certain rights and options enshrined in the law or within the terms and conditions of the underlying policy. Another common modification are regulatory updates regarding the increase of the maximum annual contribution limit for premiums paid to pillar 3a solutions. All these changes can be viewed as so-called 'Post-Sales Operations'. The ability to effectively and continuously manage one or even a sequence of post-sales operations may in fact pose significant actuarial challenges which may not be evident at first glance.

To fully appreciate the practical advantages of the Thiele recursion, we look at **two common post-sales key operations** that often occur after the point of sale of the policy but strain the flexibility of traditional core systems that are based on commutation values: **partial surrender** and **premium suspension**.

Example 1: partial surrender

A policyholder wishes to partially withdraw accumulated savings without altering the regular premium payments. This event typically occurs when the policyholders is purchasing a home (WEF) or in the event of divorce. Overall, in traditional administration systems the following process steps are triggered and may occur at different points in time (here we assume that all steps occur at a time of partial surrender).

With commutation numbers (3 processes, manual oversight)

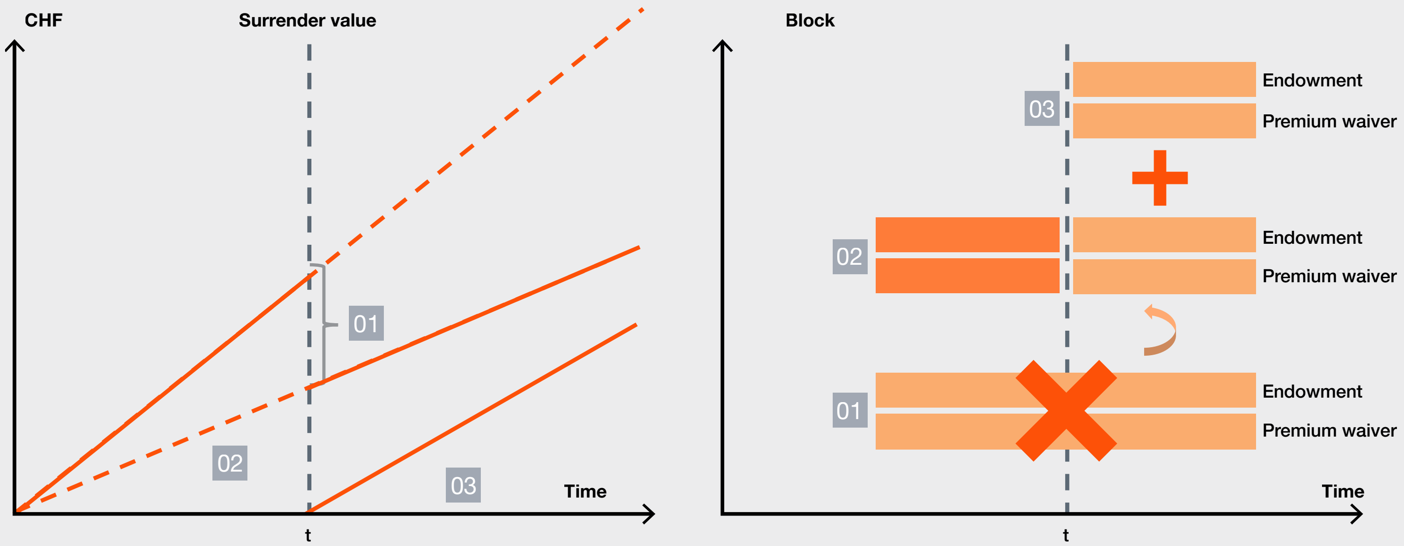


Figure 5: For partial surrender, the left-hand side shows the evolution of the surrender value over the contract duration when using commutation numbers; the right-hand side illustrates the three technical operations on tariff components on execution of the post-sale operation.

01

Partial surrender execution
The system calculates the allowed partial surrender amount, applies penalties (if applicable), and ends all affected tariff blocks.

02

Recalculation of new tariff blocks
New tariff blocks must be created for the reduced sum insured. This includes a full actuarial recalculation of actuarial components such as premiums, benefits, reserves after subtraction of the desired surrender amount from the unit linked fund.

03

Premium reversion setup
If the policyholder wishes to restore the original premium, an additional process is required to create a new additional tariff block. This often triggers a new underwriting process which hinders automation of processes. Often manual oversight is typically needed.

The final premiums, benefits and actuarial reserves result from the sum of individual tariff blocks. In this example it would correspond to the blocks from step 2 and step 3.

In contrast, for Markov-based administration systems mainly one operation is required.

With Markov + Thiele recursion (1 seamless process)

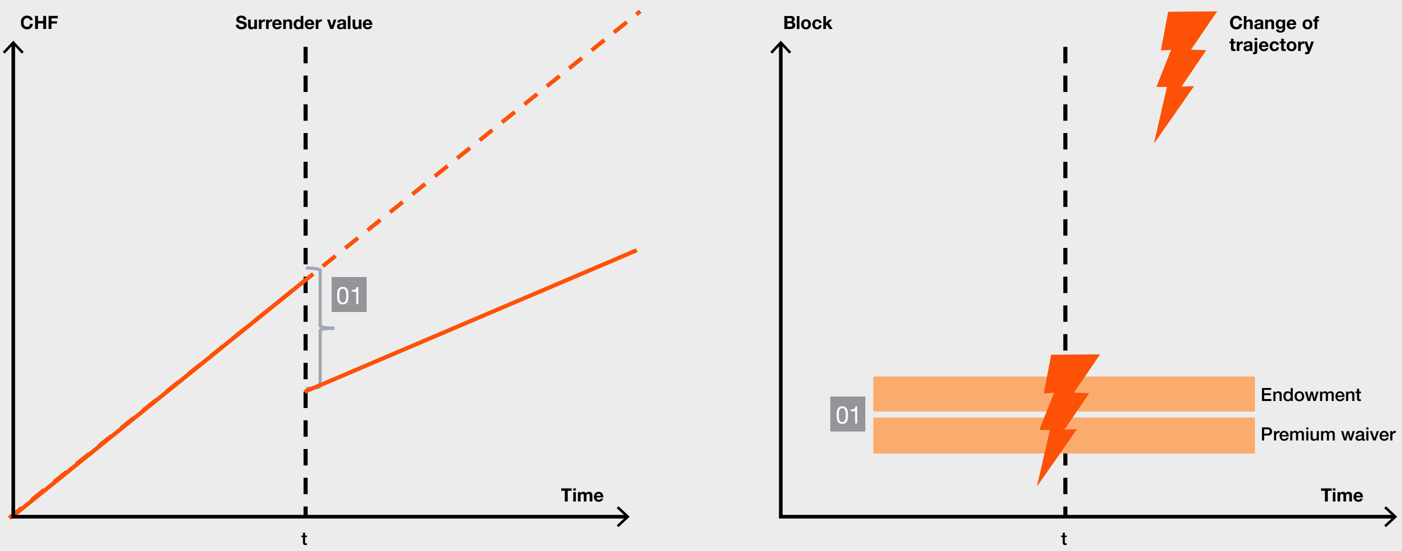
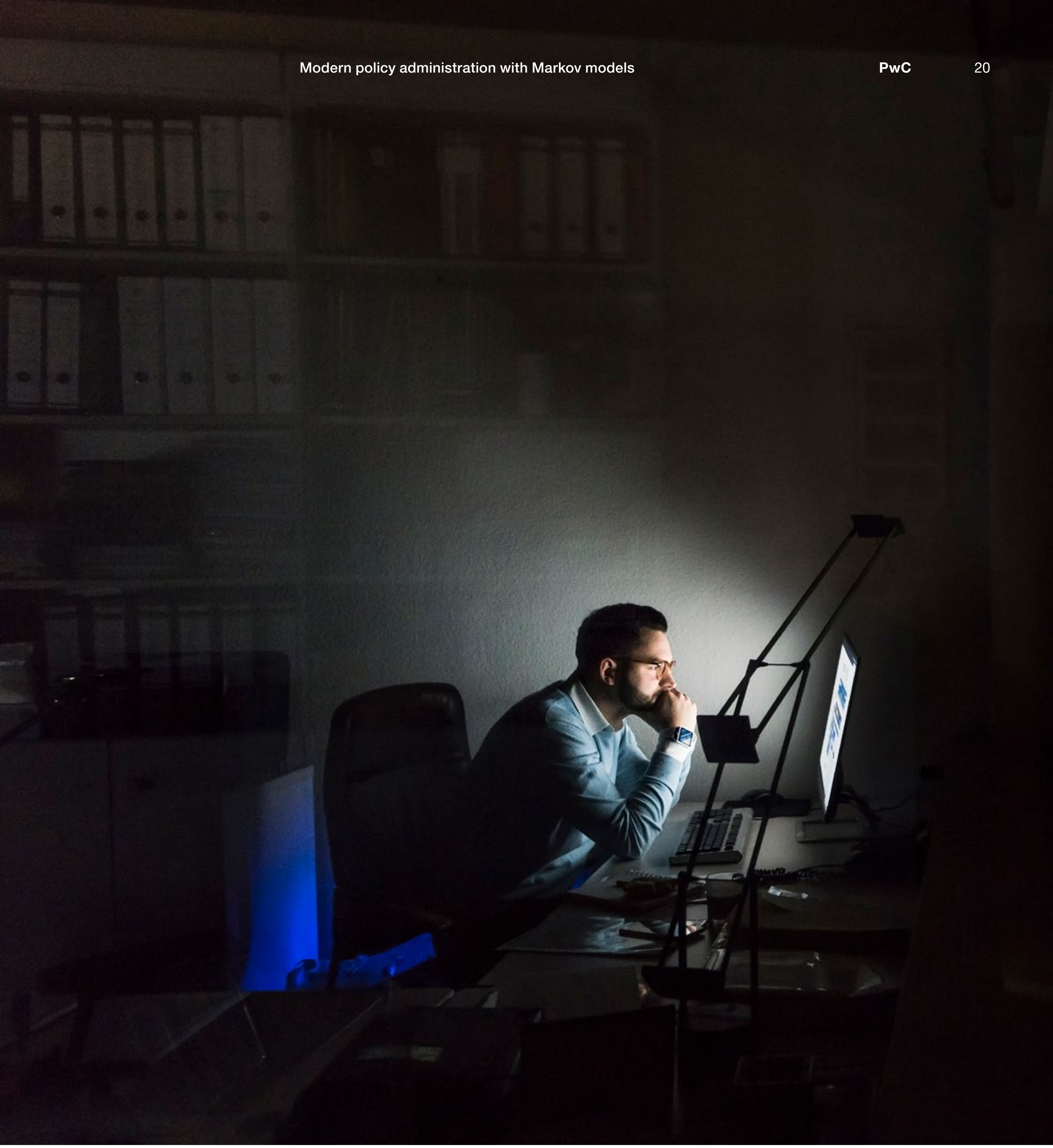


Figure 6: For partial surrender, the left-hand side shows the evolution of the surrender value over the contract duration when using Thiele's recursion; the right-hand side illustrates the single technical operations on tariff components on execution of the post-sale operation.

01

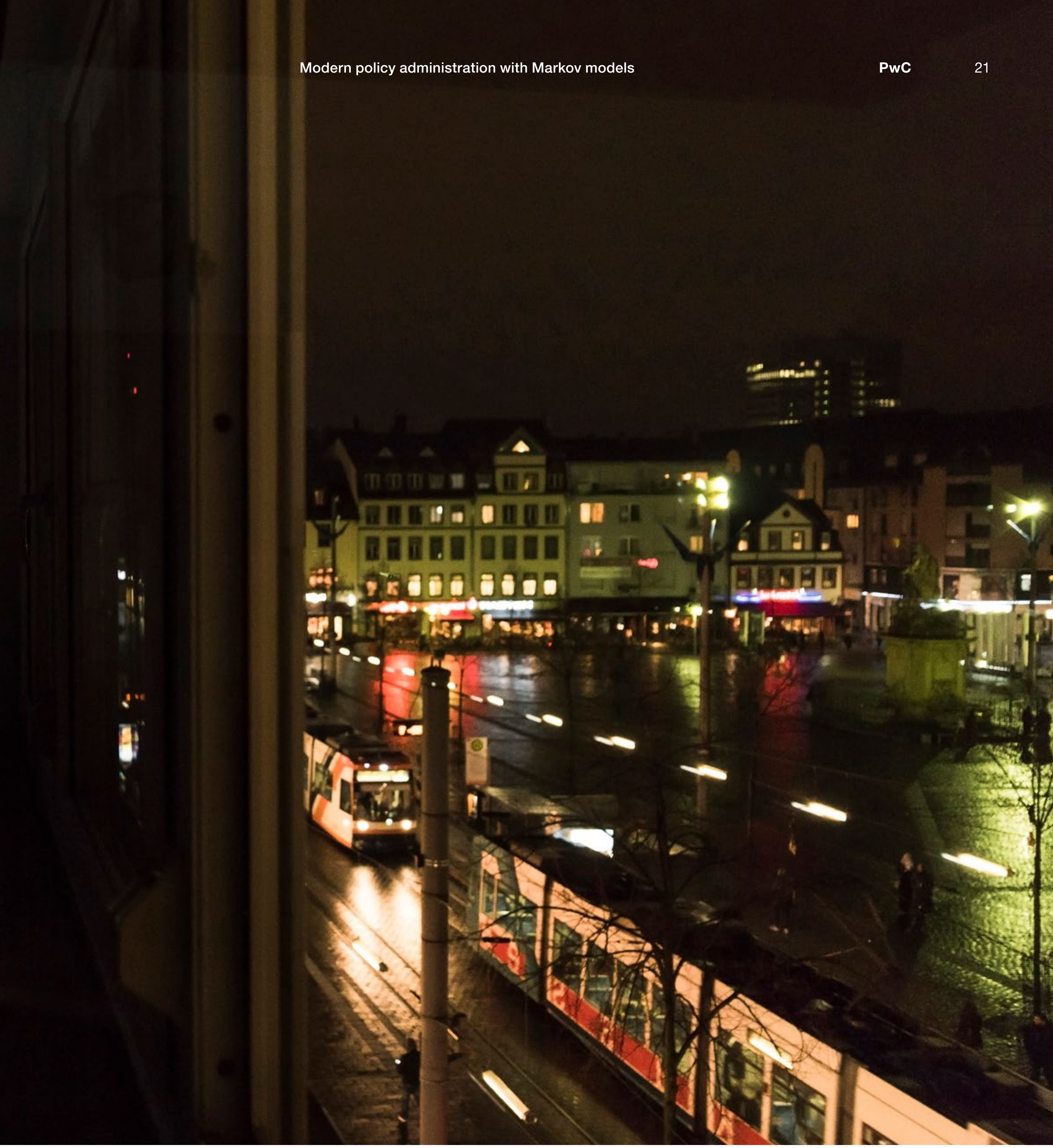
Partial surrender entry
The user enters the desired surrender amount. The system recomputes the new benefit prospectively, which changes the trajectory, but keeps the premium unchanged. The Thiele recursion dynamically adjusts future reserves and benefits without touching historical data or requiring any new tariff block.

With Thiele's approach, the initial tariff block was versioned, and the trajectory of premium and benefit vectors was changed. These changes can be made on the same tariff block with no additional adjustments.



Example 2: premium suspension

In our next example, the policyholder wishes to suspend premium payments temporarily, for example due to a situation of financial distress or entering parenthood. These premium interruptions may last over a period of one to three years. Then the following actions are performed in the system at two different points in time.



With commutation numbers (3 processes, high complexity)

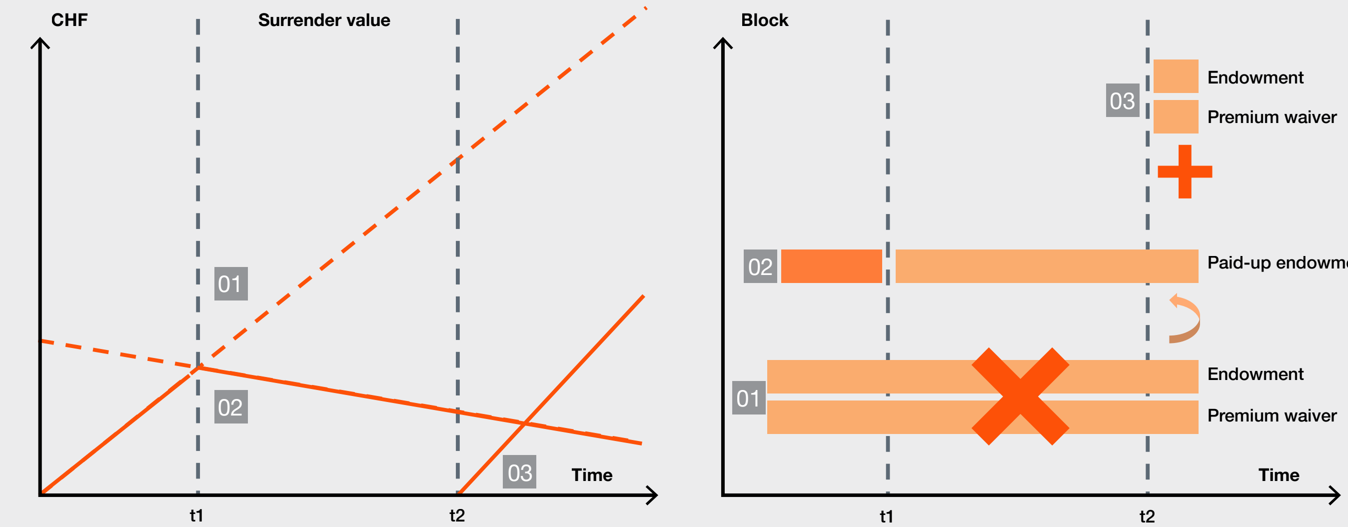


Figure 7: For premium suspension, the left-hand side shows the evolution of the surrender value over the contract duration when using commutation numbers; the right-hand side illustrates the three technical operations on tariff components on execution of the post-sale operation.

At the time of premium suspension:

01

Policy suspension
The original policy is prematurely closed, ending all associated tariff blocks.
The current surrender value is calculated.

02

Creation of paid-up policy
A new paid-up policy is created, using the surrender value from step 1 as a single premium. Actuarial calculations are re-performed based on the new structure. The system needs to administer this new 'Paid-Up Policy'.

At the time of resuming premium payments:

03

New policy for future premiums
Once the premium suspension ends, a new policy is created to resume regular premiums. This often requires a further underwriting activity and offsets for inconsistencies between the old and new contract conditions (e.g., via one-time corrections). A new additional policy is effectively issued.

In contrast, in a Markov-based environment the suspension is treated as follows on the next page.

With Markov + Thiele recursion (1 clean process)

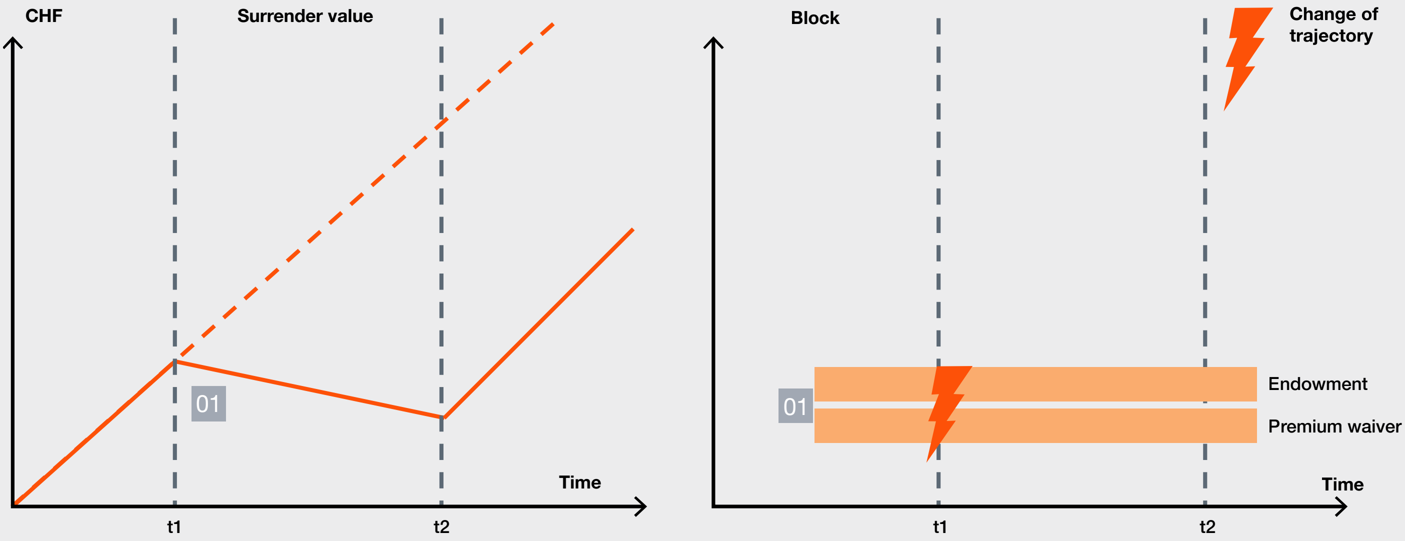


Figure 8: For premium suspension, the left-hand side shows the evolution of the surrender value over the contract duration when using Thiele's recursion; the right-hand side illustrates the single technical operation on tariff components on execution of the post-sale operation.

01

Premium suspension
The user records the premium suspension period. At this point in time the insured can indicate the time period for suspending future premium payments, say 3 years (definition of a future premium vector). Then Thiele's recursion recalculates all future reserves and benefits recursively, where the premium payments for the next 3 years are treated as zeroes in the premium vector. Once the premiums are expected to be resumed, the recursion takes it into the consideration accordingly, but already at the time of suspension and performs the projection of the expected actuarial values. The existing policy is continued.

At the time of resuming premium payments:
no operation is required if the premium payment is resumed as planned.

With Thiele's approach, the initial tariff block was versioned in t1, but no additional tariff blocks were introduced. The operation was performed by changing the trajectory of the premium vectors.

For more examples, the interested reader may also refer to [6].

Key learnings from post-sale operations

Our examples demonstrate that the use of a Markov-based approach offers several key benefits to both the insureds and the insurer. This win-win situation increases the customer's experience while at the same time the insurer enjoys more cost-efficient operational designs. One key observation we experienced is that when moving to a Markov-model while employing a Thiele recursion there is significant potential to reduce maintenance efforts. Alongside, it enables self-service features and dramatically reduces manual interventions across different potential operations. This shift in paradigm to administer policies can be summarised as follows:

Scenario	Commutation values	Markov-based
Partial surrender	3 manual processes, new tariff bocks needed	1 self-service step, real-time calculation
Premium suspension	3 manual processes, contract breakup	1 seamless update, no UW needed
Recalculation logic	Rebuild from past	Project from current state or backward recursion
Flexibility	Low – rigid structure	High – dynamic by recursive design
Automation potential	Low	High

A game changer for system migrations?

System migrations are often among the most complex and costly projects a life insurer may undertake when modernising its IT-related systems. Legacy policy administration systems which were designed decades ago and are based on commutation number logic have a rigid structure. Further, in certain situations the modelling of historical states of each policy is often required. This creates a major barrier when trying to transition to a modern core system, especially when attempting to achieve clean reconciliations without disrupting policyholder guaranteed benefits. This is another angle, where we believe that the Thiele recursion within a Markovian model may deliver a game-changing advantage.

Two principles from a regulatory standpoint

There are two principles from a regulatory standpoint that must be considered during system migrations at individual policy granularity:

1. The migration exercise may not negatively affect individual policyholders. This means that agreed premium amounts and guaranteed benefits (which would include surrender values that are based on actuarial reserves) should either stay unchanged or may be greater in the target system. This condition needs to be fulfilled when performing a reconciliation between the legacy and target system over the entire policy life cycle.
2. If benefits of individual policyholders are indeed greater in the target system, this increase may not come at the expense of policyholders within the same tariff generation community.

These two requirements suggest the need to reconcile the guaranteed benefits between the legacy system and the target system over the entire policy life cycle. Should this reconciliation not be successful, the insurer can typically rely on three different mechanisms to mitigate any potential violations: a) reduce premiums, b) increase benefits or c) increase the reserve/fund of individual policies while ensuring the second principle described above is respected. This constitutes a management decision that needs to be aligned with the function of the responsible actuary. It should be noted, that to avoid unintended **'customer confusion'**, it is typically best practice to keep the migration impact at an absolute minimum and use individual policy corrections as a last resort which may also require to inform the policyholders.

Nevertheless, despite careful planning of migrations differences between the target system and the legacy environment are commonly observed whether due to different rounding conventions, tariff rationalisations (e.g. merging multiple legacy tariffs into a unified one) or because the target system applies a fundamentally different logic for 'Post Sales Operations'. In addition, legacy systems may contain inconsistencies such as manual overrides, missing data or outright handling errors. In many instances the reconciliation of individual policies may simply be impossible.

It becomes clear that system migrations contain an additional cost component that will inevitably be carried by the insurer, both in the time-consuming analysis of the migration impact and in the allocation of the needed compensation of individual policyholders.

We believe that system migrations that are based on commutation numbers require the partial reconstruction of the actuarial history of each individual policy. This includes the recalculation of past and future expected premium payments, benefit transactions, and reserve movements. In this context, actuaries are expected to propose lean solutions that minimise such costs. We believe a Markovian approach can significantly simplify the migration.

Meet your promises and focus on the future

We assume that the vector of future benefits and premiums can be migrated to the target system. Then, moving to Thiele's recursion can overcome the dependency on historical contractual events and potential inconsistencies contained in the legacy system as

- the **reserve observed at the time of migration** is used as the true starting point,
- the **vector of future benefits and premiums** is used as an input to recompute the future actuarial reserve
- the current state of the insured.

We like to highlight that the forward-looking nature eliminates the potential **'customer confusion'** we described above. Indeed, as benefits and premiums are already jointly considered as inputs, there is no need to increase benefits or reduce premiums.

However, using the reserve observed at the point of migration may still be challenging as it may be inconsistent with the vector of expected future premiums and benefits. Indeed, the application of Thiele's recursion on the migrated vector of expected future benefits and premiums in a 'backward' recursion from the policy maturity to the migration cut-off date may still lead to a calculated reserve that is different from the one that was migrated from the legacy system. This observable difference represents the migration impact and needs to be managed. Commonly, to remove such an inconsistency a 'Migration Cost Premium' as an additional mechanism is introduced.

Migration cost premium

This so-called migration cost premium can be defined from the migration cut-off date until maturity and act as the balancing item to close the gap between the migrated reserve from the legacy system and the reserve obtained when using the backward application of the Thiele recursion.

In essence, instead of performing one-time corrections via premium reductions or benefit increase, the Thiele recursion allows us to smooth out the migration impact via an additional cost premium factor over the duration of the policy duration.

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Conclusion and some thoughts on your way forward

As life insurers continue to modernise their systems, design new products and increase customer experience, the limitations of traditional commutation-based approaches are becoming increasingly evident. While commutation numbers provided a powerful framework for managing actuarial calculations for many years, they were built for a world of rather ‘static’ products with limited flexibility. These are conditions that no longer reflect today’s insurance requirements.

We have illustrated that the Markov approach in combination with the Thiele recursion offers a forward-looking, modular and highly adaptable alternative. Thereby, it provides greater operational efficiency, enhanced customer flexibility, faster go-to-market cycles, and ultimately policy administrations systems that meet the future needs in insurance.

What makes this approach so appealing is that it doesn’t require revolutionary mathematics as the Thiele recursion has been known for decades. The **computational power and system architecture** that are now available unfold their daily benefits in the operation of an insurer which are at scale and in real time.

Leading insurers and system providers across the DACH region are already taking first steps on this technological journey. For those that are still relying on legacy technology the message is clear: now is the time to **rethink the core** – not just to keep pace but to lead.

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Thank you