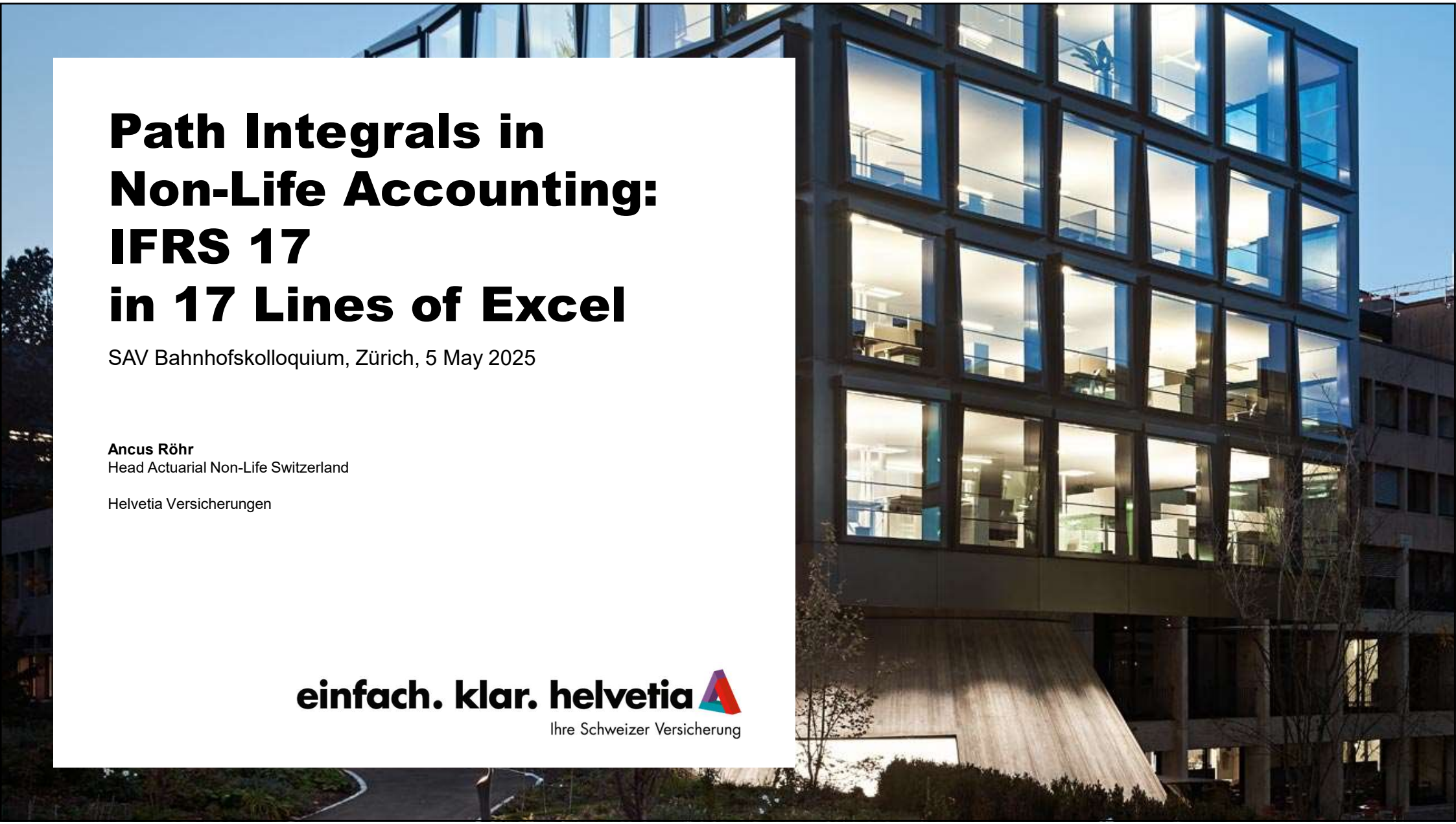

Path Integrals in Non-Life Accounting: IFRS 17 in 17 Lines of Excel

SAV Bahnhofskolloquium, Zürich, 5 May 2025

Ancus Röhr
Head Actuarial Non-Life Switzerland

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Origins of modern accounting

Luca Pacioli (1445 - 1517)

Author of "Summa de arithmetica, geometria, proportioni et proportionalita" (1494)

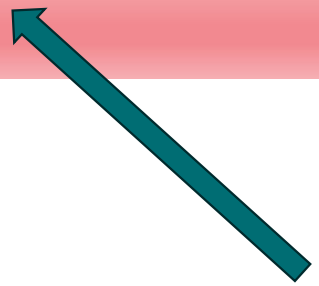
600 pages of mathematics in Italian, one chapter discusses accounting

First known write-up of the double-entry bookkeeping method (“Venetian method of bookkeeping”), very influential since.

https://upload.wikimedia.org/wikipedia/commons/2/2a/Pacioli.jpg

The balance sheet equation

Assets + Liabilities = 0



Includes Equity!

Takes a **liquidation perspective** ("= 0")

…and hence reflects **not just the past**, but also a possible **future** of the firm

Double-entry bookkeeping

Definition:

Double-entry bookkeeping := any accounting system that updates the balance sheet equation in the light of new business transactions and relevant new information.

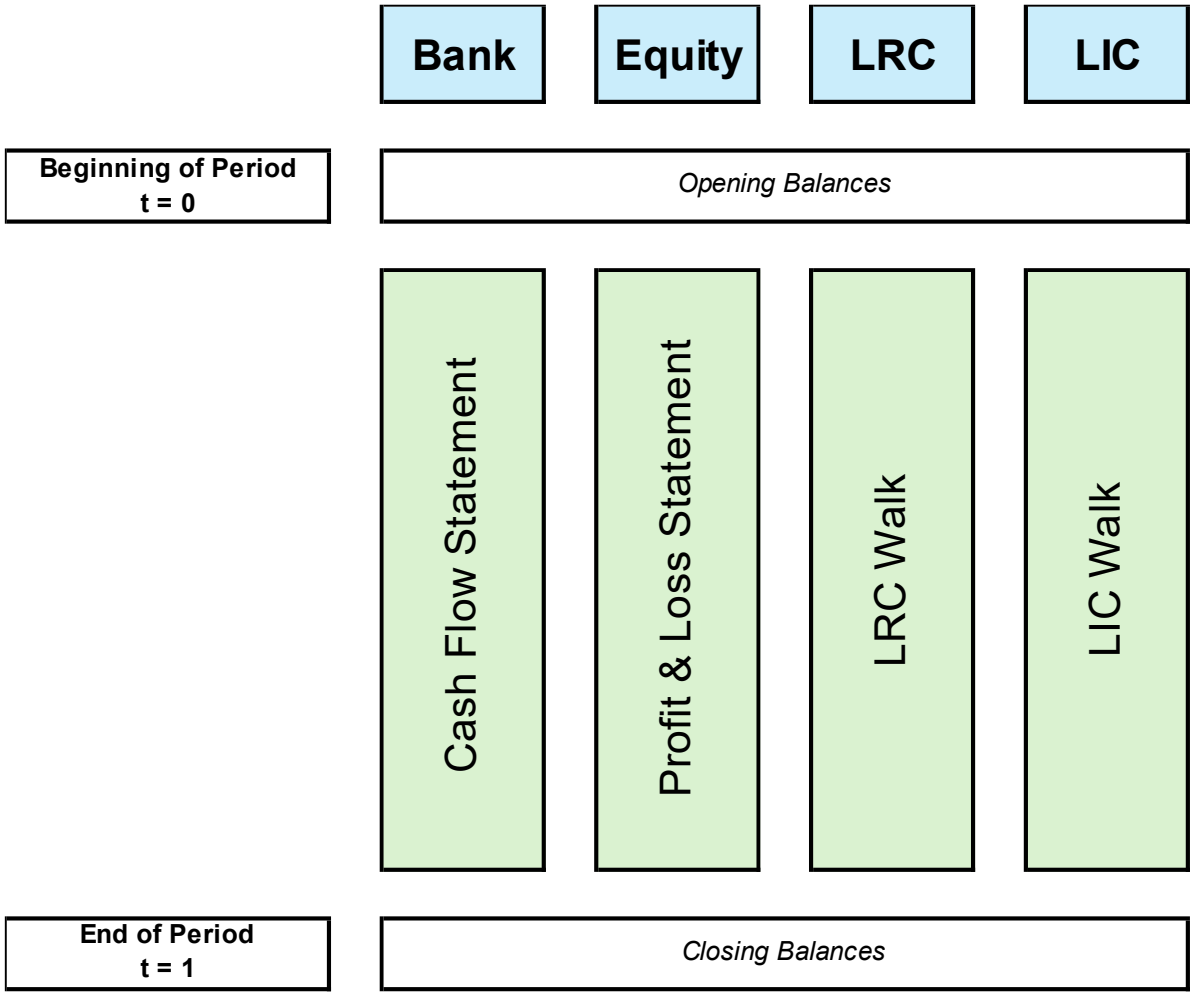
To maintain the 0 balance, any update affects at least 2 accounts … "double entry".

For any update, the sum of changes is itself 0 … "debit = credit".

Aside: Single-entry bookkeeping

Only updates "Cash" account

Only reflects the past



Updating the Balance Sheet

- The P&L statement is just the "Equity Walk"
- The cash flow statement is mandatory under IAS 7 (2001), US GAAP (1971)
- IFRS 17 introduced LIC and LRC walks
  - including CSM & OCL walks

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IFRS 17 Walks

	LRC		LIC	
in CHF million	Excl. loss component	Loss component	Pre… value of the future cash flows	Risk adjustment
Insurance contract assets as of 1 January 2024	–1.7	–	0.4	0.0
Insurance contract liabilities as of 1 January 2024	435.8	–	1,768.4	63.9
Opening balance as of 1 January 2024	434.2	–	1,768.8	63.9
Insurance service result				
Insurance revenue	–2,061.9	–	–	–
Insurance service expenses	413.4	–	1,366.5	–3.6
Incurred claims and other expenses	–	–	*1,423.1*	*17.1*
Amortisation of insurance acquisition cash flows	*413.4*	–	–	–
Adjustments to LIC related to past services	–	–	*–56.6*	*–20.7*
Losses and reversal of losses on onerous contracts	–	–	–	–
Insurance service result	–1,648.6	–	1,366.5	–3.6
Finance result from insurance contracts recognised in P&L	4.6	–	24.0	0.9
Finance result from insurance contracts	–	–	*22.9*	*0.8*
Effects from currency exchange rate differences	*4.6*	–	*1.1*	*0.1*
Changes recognised in OCI	1.3	–	32.9	2.0
Cash flows	1,745.5	–	–1,349.4	–
Premiums received	*2,122.6*	–	–	–
Claims and other insurance service expenses paid	–	–	*–1,349.4*	–
Insurance acquisition cash flows paid	*–377.1*	–	–	–
Allocation of asset for acquisition cash flows to a group of contracts	–33.4	–	–	–
Closing balance as of 31 December 2024	**503.7**	**–**	**1,842.9**	**63.2**

Source: Helvetia Annual Report 2024

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Cash Flow Items (CFIs)

- An insurance contract triggers numerous cash flows affecting a multitude of accounts over time.

Definition:

A **cash flow item** (abbrev. **CFI**) is a part of an insurance cash flow that affects at most two balance sheet accounts at any valuation date.

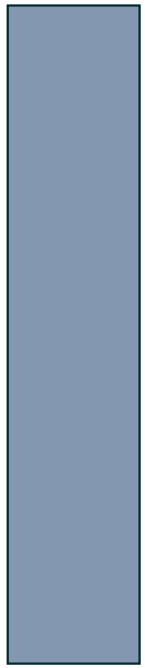
Proposition:

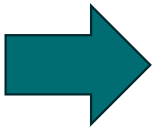
Any insurance cash flow can be broken down into a sum of cash flow items, and accounting is linear in them.

- A cash flow item is "atomic" in the sense that its accounting can not be simplified by further division.

Example of breakdown into cash flow items

CHF 1000
Annual
Premium
Received at
01.01.2025





CHF 250 rec. Q1, earned Q1

CHF 250 rec. Q1, earned Q2

CHF 250 rec. Q1, earned Q3

CHF 250 rec. Q1, earned Q4

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Aside: CSM amortization

Proposition :

Any CSM amortization method can be implemented by allocating cash flows to coverage periods.

Proof:

CSM is amortized over the time of the coverage, creating profit in each period. Since any profit can only originate from and must be traceable back to the underlying cash flows, the amortized part must stem from parts of those cash flows having been allocated to the respective period.

Walking the CFI through accounting periods

Period 2025 Jan-Mar 1st CFI (earned in q1)

Update	Bank	Equity	LRC
Opening Balance	0	0	0
New Business	-250	0	250
Coverage Provided	-250	250	0
Closing Balance	-250	250	0

Period 2025 Jan-Mar, 2nd CFI (earned in q2)

Update	Bank	Equity	LRC
Opening Balance	0	0	0
New Business	-250	0	250
Coverage Provided	-250	0	250
Closing Balance	-250	0	250

Period 2025 Apr-Jun, 1st CFI (earned in q1)

Update	Bank	Equity	LRC
Opening Balance	-250	250	0
New Business	-250	250	0
Coverage Provided	-250	250	0
Closing Balance	-250	250	0

Period 2025 Apr-Jun 2nd CFI (earned in q2)

Update	Bank	Equity	LRC
Opening Balance	-250	0	250
New Business	-250	0	250
Coverage Provided	-250	250	0
Closing Balance	-250	250	0

Walking the CFI through accounting periods

	…	Acct1	Acct2	Acct3	Acct4	…
…						
Update 1						
Update 2						
Update 3						
Update 4						
Update 5						
Update 6						
Update 7						
…						

- At each step, exactly two balance sheet accounts are non-zero (and of opposite signs)
- Walks are constructed by calculating the increments (e.g on equity, for the P&L)

CFI valuation – case of continuous updates

Consider loss amount X in a foreign currency, to be paid out at some period in the (distant) future.

v[t] = discount factor at time t

r[t] = currency exchange rate at time t

Valuation of cash flow item at time t =: F[v[t],r[t]] = X * v[t] * r[t]

	Reason of Valuation Change	Valuation Amount
Beginning of period (t = 0)	Opening balance	F[v[0], r[0]]
	Unwinding of discount	?
	FX effect	?
End of period (t = 1)	Closing Balance	F[v[1], r[1]]

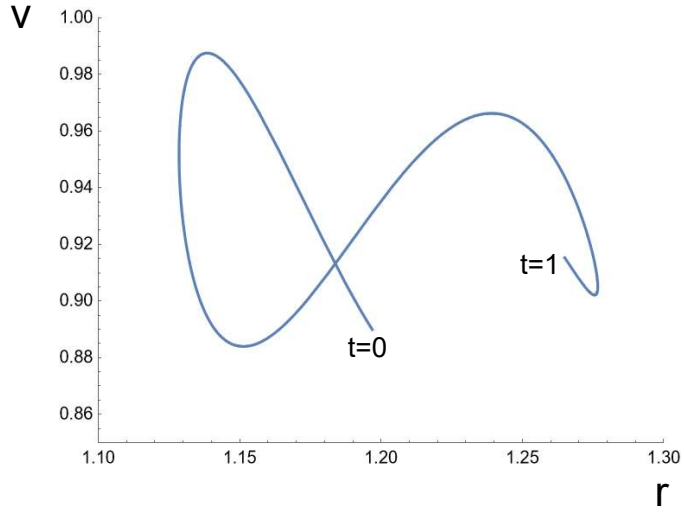
How to attribute the changes?

$$F[v[1],\ r[1]] - F[v[0],\ r[0]]$$

$$= \int_0^1 \frac{\partial F[\,v[t], r[t]]}{\partial t}\, dt$$

$$= \int_0^1 \frac{\partial F[v[t], r[t]]}{\partial v}\ \frac{\partial v[t]}{\partial t}\, dt + \int_0^1 \frac{\partial F[v[t], r[t]]}{\partial r}\ \frac{\partial r[t]}{\partial t}\, dt$$

= Unwinding of discount + FX effect



Path Integral !

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Discrete Versions of Path Integral

$$F[v[1],\ r[1]] - F[v[0],\ r[0]]$$

$$= F[v[1],\ r[1]] - F[v[1],\ r[0]]$$
$$+ F[v[1],\ r[0]] - F[v[0],\ r[0]]$$

$$= F[v[1],\ r[1]] - F\left[v[1],\ r\left[\tfrac{1}{2}\right]\right]$$
$$+ F\left[v[1],\ r\left[\tfrac{1}{2}\right]\right] - F\left[v\left[\tfrac{1}{2}\right],\ r\left[\tfrac{1}{2}\right]\right]$$
$$+ F\left[v\left[\tfrac{1}{2}\right],\ r\left[\tfrac{1}{2}\right]\right] - F\left[v\left[\tfrac{1}{2}\right],\ r[0]\right]$$
$$+ F\left[v\left[\tfrac{1}{2}\right],\ r[0]\right] - F[v[0],\ r[0]]$$

Example 1:

r changes … FX effect

v changes … Unwinding of discount

Example 2:

r changes … FX effect

v changes … Unwinding of discount

r changes … FX effect

v changes … Unwinding of discount

The result of the attribution depends on the selected path!

Choosing "Single Change" Updates

	…	Acct1	Acct2	Acct3	Acct4	…
…						
Update 1						
Update 2						
Update 3						
Update 4						
Update 5						
Update 6						
Update 7						
…						

- Updates must be chosen such that only a single factor changes! – allows attribution to that factor
- The attribution will still depend on the sequence and order of updates (the "path")

Summary of concept

- Split insurance cash flows into "atomic" cash flow items, whose accounting is maximally simple
- Choose a sequence (a "path") of "atomic" changes allowing for correct attribution of movements
- Perform the valuation of each CFI along this path, repeat for each accounting period
- Collect all balances and increments and assemble all financial reports

- **This works for any double-entry bookkeeping accounting regime, such as PAA, BBA, OR**

Required granularity of CFIs

Company	The reporting unit the item belongs to.
PartnerCompany	The partner reporting unit, if the item belongs to an inter-company transaction.
Portfolio	A portfolio of similar risks that are managed together
pInf	The time when this information is obtained (or becomes relevant).
cInf	The true-up type of the cash flow amount update. Values are
	n Information arises from recognition of new business
	t Information is a true-up on cash flows for existing business
	d Information arises from derecognition of (part of) existing business
pSgn	The period when the contract becomes bound.
pIni	The period when the contract begins. Also determines the cohort. A Portfolio plus a cohort together form a Group of Contracts.
pCov	The exposure (or coverage) period the cash flow applies to
pDue	Period when the item has been booked and marked as due in the system.
pPay	Period when payment is actually made.
pTrf	Period when portfolio transfer occurs
cTrf	The type of portfolio transfer. IN for incoming, OUT for outgoing.
cTyp	The type of cash flow (see worksheet CFType)
cSet	The "settlement type". If payment happens at the beginning of pPay, then 0, if it happens at the end, the value is 1.
BR	'R' for ceded reinsurance, 'A' for assumed reinsurance, 'B' for everything else
Currency	Transactional Currency
Amount	The amount in transactional currency. Positive, if the entity receives money.

- The cash flow type – premium, claims, acquisition costs etc. – is very important
- Next in importance are all time related fields and their position with respect to the current financial period (future? past?) – this governs much of the accounting!
- "External" information that updates the accounting is FX rates, interest rates and the onerous status

Example of implementation in Excel

Step	Single Change Item	New Value	cIntReg	cInt	cFX	cCR	is_onerous	is_recognized	rInf	rSgn	rIni	rCov	rDue	rPay	rDiv	rTrf	df	fx	cr	AmtFC	DEBIT	Use	CREDIT	TOM
0			NOMINAL	IN	IN	IN	-	-	1	-	-	-	1	1	1	1	1.0000	1.2286	1.0000	3'685.7	Dummy		Dummy	
1	cIntReg	CURRENT	CURRENT	IN	IN	IN	-	-	1	-	-	-	1	1	1	1	1.0106	1.2286	1.0000	3'724.9	Dummy	-	Dummy	Disc. eff. BS
2	rTrf	1	CURRENT	IN	IN	IN	-	-	1	-	-	-	1	1	1	1	1.0106	1.2286	1.0000	3'724.9	Dummy	-	Dummy	Ptf. Trf. 0
3	cIntReg	LOCKED	LOCKED	IN	IN	IN	-	-	1	-	-	-	1	1	1	1	0.9735	1.2286	1.0000	3'587.9	Dummy	-	Dummy	OCI
4	cFX	MID	LOCKED	IN	MID	IN	-	-	1	-	-	-	1	1	1	1	0.9735	1.2857	1.0000	3'754.8	Dummy	-	Dummy	FX eff.
5	cCR	MID	LOCKED	IN	MID	MID	-	-	1	-	-	-	1	1	1	1	0.9735	1.2857	1.0000	3'754.8	Dummy	-	Dummy	Chg. Cred. Risk
6	cInt	MID	LOCKED	MID	MID	MID	-	-	1	-	-	-	1	1	1	1	0.9824	1.2857	1.0000	3'789.3	Dummy	-	Dummy	Accr. of int.
7	cIntReg	NOMINAL	NOMINAL	MID	MID	MID	-	-	1	-	-	-	1	1	1	1	1.0000	1.2857	1.0000	3'857.1	Dummy	-	Dummy	Disc. eff. PL
8	rInf	0	NOMINAL	MID	MID	MID	-	1	-	-	-	-	1	1	1	1	1.0000	1.2857	1.0000	3'857.1	LIC	A	Equity	Exp. Adj.
9	is_onerous	0	NOMINAL	MID	MID	MID	-	1	-	-	-	-	1	1	1	1	1.0000	1.2857	1.0000	3'857.1	LIC	-	Equity	Derec. of Loss Comp.
10	rSgn	0	NOMINAL	MID	MID	MID	-	1	-	-	-	-	1	1	1	1	1.0000	1.2857	1.0000	3'857.1	LIC	-	Equity	Day 1 Loss
11	rIni	0	NOMINAL	MID	MID	MID	-	1	-	-	-	-	1	1	1	1	1.0000	1.2857	1.0000	3'857.1	LIC	-	Equity	?
12	rCov	0	NOMINAL	MID	MID	MID	-	1	-	-	-	-	1	1	1	1	1.0000	1.2857	1.0000	3'857.1	LIC	-	Equity	Earned/Incurred
13	rDue	1	NOMINAL	MID	MID	MID	-	1	-	-	-	-	1	1	1	1	1.0000	1.2857	1.0000	3'857.1	LIC	-	Equity	Booked
14	rPay	1	NOMINAL	MID	MID	MID	-	1	-	-	-	-	1	1	1	1	1.0000	1.2857	1.0000	3'857.1	LIC	-	Equity	Cash flow
15	rCov	0	NOMINAL	MID	MID	MID	-	1	-	-	-	-	1	1	1	1	1.0000	1.2857	1.0000	3'857.1	LIC	-	Equity	Earned/Incurred
16	cIntReg	LOCKED	LOCKED	MID	MID	MID	-	1	-	-	-	-	1	1	1	1	0.9824	1.2857	1.0000	3'789.3	LIC	A	Equity	Disc. eff. PL
17	rDiv	1	LOCKED	MID	MID	MID	-	1	-	-	-	-	1	1	1	1	0.9824	1.2857	1.0000	3'789.3	LIC	-	Equity	Dividend
18	cInt	OUT	LOCKED	OUT	MID	MID	-	1	-	-	-	-	1	1	1	1	0.9912	1.2857	1.0000	3'823.4	LIC	A	Equity	Accr. of int.
19	cCR	OUT	LOCKED	OUT	MID	OUT	-	1	-	-	-	-	1	1	1	1	0.9912	1.2857	1.0000	3'823.4	LIC	-	Equity	Chg. Cred. Risk
20	cFX	OUT	LOCKED	OUT	OUT	OUT	-	1	-	-	-	-	1	1	1	1	0.9912	1.3429	1.0000	3'993.3	LIC	A	Equity	FX eff.
21	cIntReg	CURRENT	CURRENT	OUT	OUT	OUT	-	1	-	-	-	-	1	1	1	1	0.9996	1.3429	1.0000	4'027.1	LIC	A	Equity	OCI
22	cIntReg	NOMINAL	NOMINAL	OUT	OUT	OUT	-	1	-	-	-	-	1	1	1	1	1.0000	1.3429	1.0000	4'028.6	LIC	A	Equity	Disc. eff. BS

- The walk does fit into (originally 17, currently 23) lines of Excel
- The "path" can be chosen almost universally, suitable for all cash flow types, but is somewhat different for each accounting regime (PAA, BBA, OR)
- An Excel macro runs through all CFIs and financial periods and collects the results from the walk(s)
- A SQL server implementation does all of the above using a database and adds SAP accounts (via lookup)

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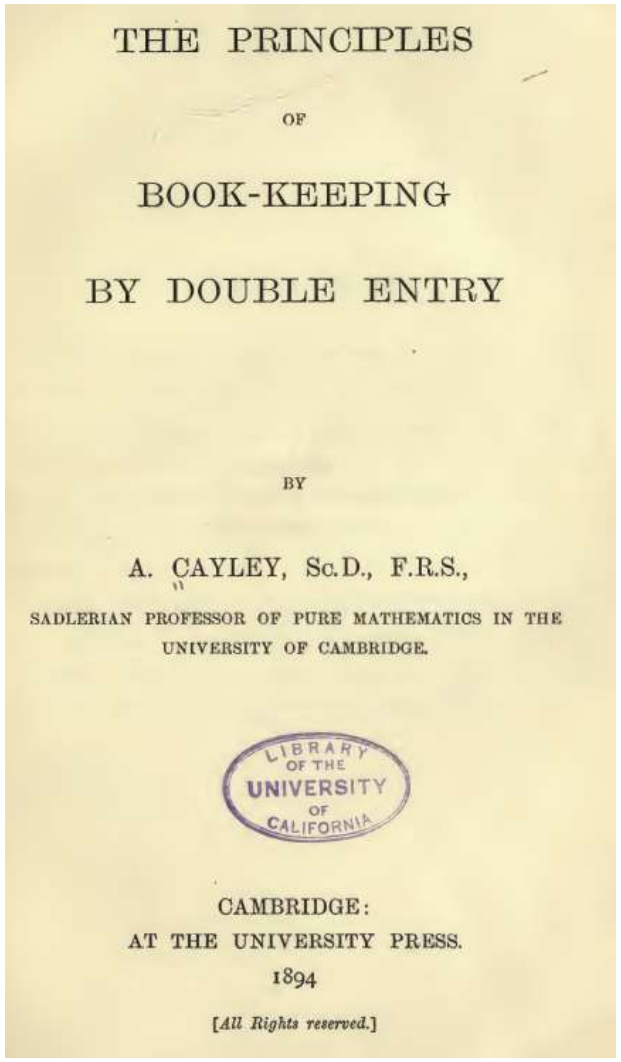
Some Final Remarks

- The challenges of IFRS 17 comprise new "actuarial" concepts such as the risk margin, discounting, but also new "walks", an accounting concept
- Prior to IFRS 17, non-life insurance technical accounting was often reduced some form of cash accounting, throwing all "IN" positions at the beginning of the period into equity, booking all "Actuals" (=cash) into equity and leaving it to the actuaries to figure out the "OUT" bookings at the end of the period
- If you ever had a (difficult) discussion about FX effects, you have noticed some effects of this approach
- IFRS 17 supports the view that the principal dichotomy of double-entry bookkeeping is not between "Balance Sheet" and "P&L", but rather between "Balances" and "Movements"
- The proposed scheme of "cash flow items" and "single change accounting walks" maintains the symmetry between all balance sheet accounts and is multi-GAAP capable



THE PRINCIPLES

OF

BOOK-KEEPING

BY DOUBLE ENTRY

BY

A. CAYLEY, Sc.D., F.R.S.,

SADLERIAN PROFESSOR OF PURE MATHEMATICS IN THE UNIVERSITY OF CAMBRIDGE.

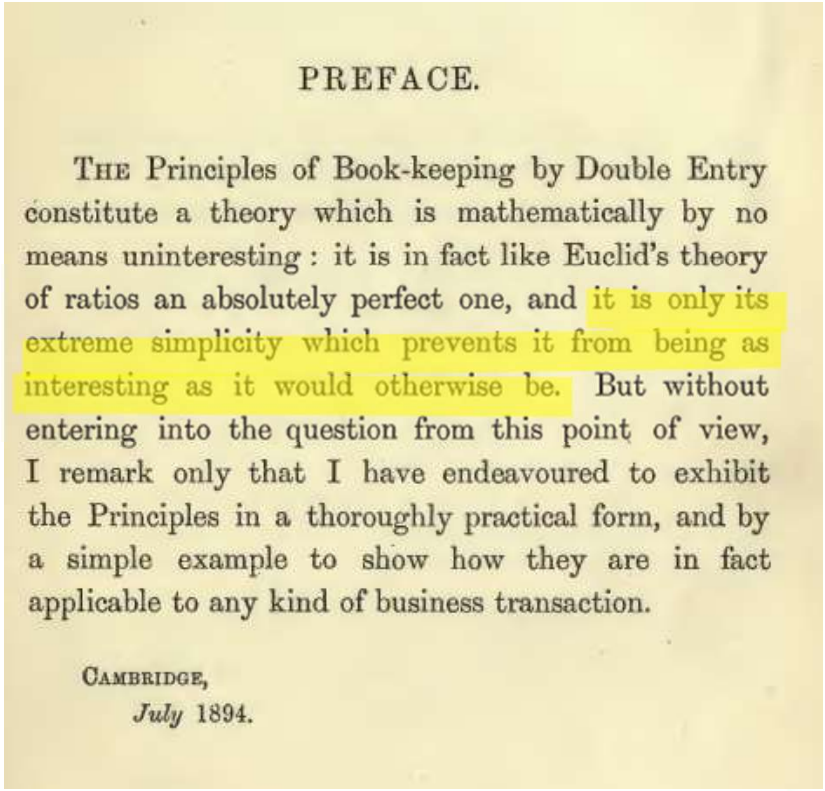
CAMBRIDGE:
AT THE UNIVERSITY PRESS.
1894

It is trivial, after all...

Arthur Cayley (1821-1895)

Cayley-Hamilton theorem in linear algebra

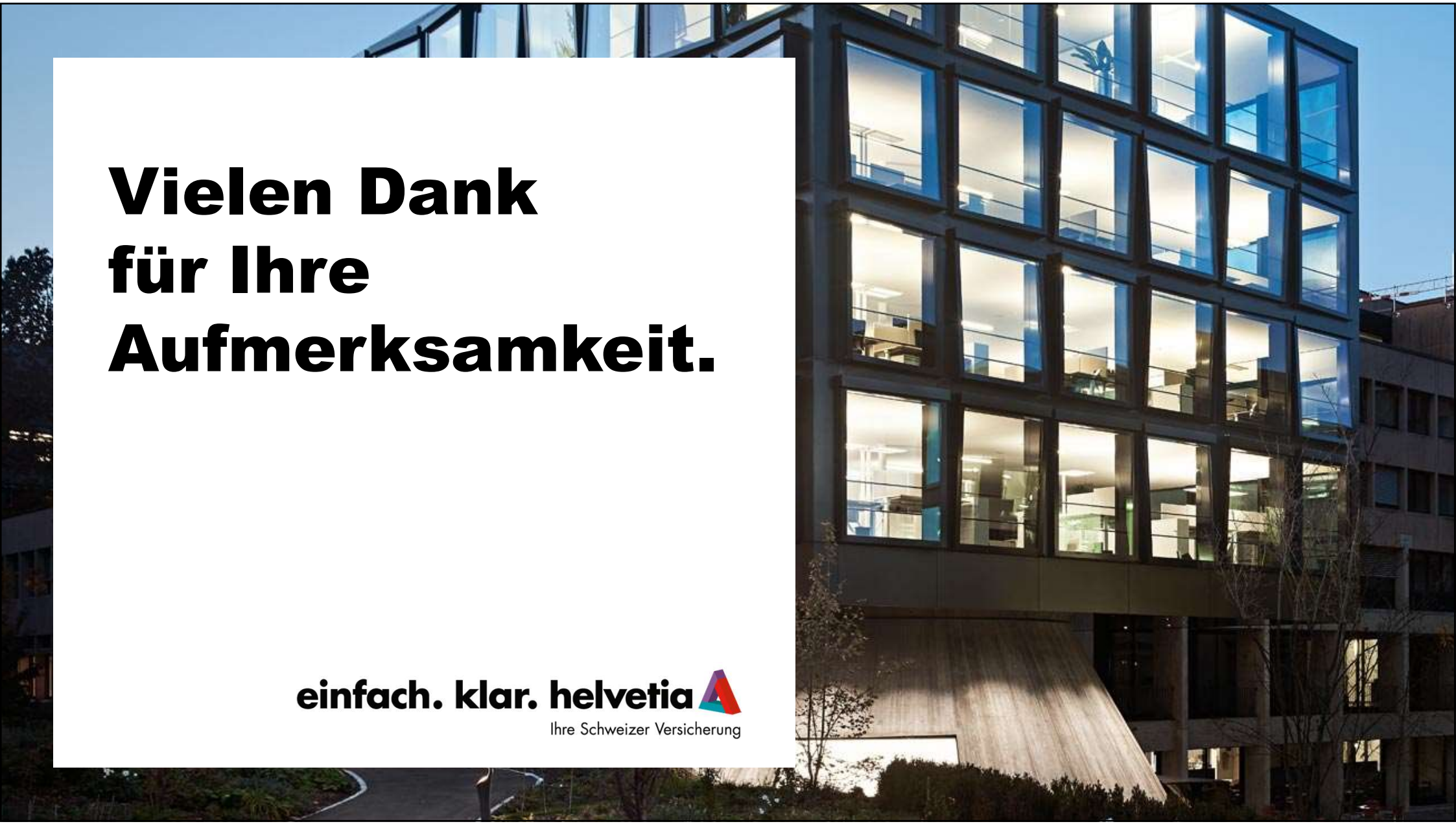
Introduced concept of "group", a cornerstone of modern mathematics



PREFACE.

THE Principles of Book-keeping by Double Entry constitute a theory which is mathematically by no means uninteresting: it is in fact like Euclid's theory of ratios an absolutely perfect one, and it is only its extreme simplicity which prevents it from being as interesting as it would otherwise be. But without entering into the question from this point of view, I remark only that I have endeavoured to exhibit the Principles in a thoroughly practical form, and by a simple example to show how they are in fact applicable to any kind of business transaction.

CAMBRIDGE,
July 1894.



Vielen Dank für Ihre Aufmerksamkeit.

einfach. klar. helvetia

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