A System Dynamics Approach to Modelling Business Activities of Ukrainian General Insurers

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Abstract

In this paper, a system dynamics model of a Ukrainian general insurer is presented. The aim of the study is to examine the potential feedback effects related to the dynamics of profitability of an insurance company. The developed model follows the managerial accounting logic, which combines a traditional accounting approach with non-financial elements. The model structure consists of twelve interconnected modules, each representing a relatively detached sphere of insurer operations. The major feedback loops that determine the dynamic behavior of the model are based on a combination of different business activities. These loops produce both reinforcing and counteracting effects that influence the financial performance of an insurance company and are centered around insurance rate, insurance premiums ceding, and investing. The test of model responses to different demand shocks allowed to corroborate the prominent feedback impacts and outline possible implications for managerial practice.

Keywords: general insurance, business modelling, managerial accounting, cash flows, balance sheet, underwriting, reinsurance, reserving, investing, financial results, Ukraine.

Introduction

The objectivity and reasonableness of business decisions in general insurance companies have always been in the spotlight of both corporate managers and governmental officials. The former are mainly interested in high business performance, whereas the latter are concerned about solvency of companies. In times of crises, the soundness of corporate administration activities becomes even more urgent since it largely

determines the ability of a firm to endure adverse operational conditions and continue as a going concern.

It appears that the effectiveness of management in Ukrainian general insurers has been rather low. Indeed, the National Commission for Regulation of Financial Services Market of Ukraine (NCRFSM) reports that the crisis of 2008-2009 has shown that many insurance companies (as well as other companies in the financial sector) were unable to cope with unexpected difficulties, high rates of bankruptcy being a logical consequence. According to NCRFSM data, during 2005-2008, the number of registered general underwriters rose from 348 to 396, and by the end of September 2014 their number decreased further to 331. The mean drop-out rate for the last 5 years has been above 6%.

The main reasons for the rising number of bankruptcies of insurance companies are low profitability and depletion of cash stocks. The NCRFSM's online register shows that most Ukrainian general insurers had their licenses suspended and nullified due to the large and recurring proportion of non-settled claims. Insufficient cash levels cause insurers to become insolvent, which is the primary indicator for the state regulator to initiate bankruptcy proceedings. For instance, one of the functioning Ukrainian general insurers, PJSC "Etalon" insurance company" has faced problems with settling insurance claims in 2014 and, as a consequence, temporary administration in the company was enforced by the state regulator (NCRFSM). However, viewing insolvency as a sole cause of insurance company means neglecting the real roots of this problem that lie in the structure of insurer business processes. For example, the problem might be connected with poorly managed financial flows due to flawed corporate policies.

Limited scientific and practical attention to the specifics of Ukrainian general insurers business hinders the comprehension of key causal relationships that influence the problematic behavior of the companies. Many domestic scientific works have been aimed at theoretical discussion on financial health of insurers, yet many them either suggest utilizing outdated or irrelevant methods, or simply rely on

overviewing such methods (Dobosh, 2009; Kryvytska, 2012). Fewer works have been dedicated to predicting financial crises in insurance companies, however, they do not present clear guidelines on how to cope with identified undesirable conditions (Lee and Urrutia, 2006; Kleffner, et al., 2009; Shpitzhluz, 2013; Zhuravlova, 2013). Finally, even fewer authors in Ukraine have addressed the need of establishing holistic frameworks for managing complex business systems of insurers (Barlas et al., 2000; Klepikova, 2011).

General insurance business has several peculiar features stemming from the nature of its main operations. Firstly, insurers are corporations that provide financial services and, therefore, do not have a common inventory (Hamankova, 2007; Zweifel and Eisen, 2011). Secondly, the amount of contractual obligations of general insurance companies is probabilistic, thus they have to deal with more significant risks comparing to companies in other industries (Zweifel and Eisen, 2011). Finally, the activities of insurance corporations are subject to strict state supervision and regulation due to the uniqueness and importance of services they provide (Hamankova, 2007; NCRFSM).

Both the distinctive characteristics of insurance business and the gaps in scientific knowledge in general insurance sphere make the research on insurance company business processes quite topical. System dynamics should be a promising instrument to be applied in the research on the problem due to several reasons. Firstly, the dynamics of the financial performance of insurance companies appears to be complex and non-linear, extending beyond simple “gather premiums – pay claims” algorithm and depending on numerous internal financial restrictions (Hamankova, 2007) that might imply feedback effects. Secondly, the factor of time has quite a significate influence on cash flows of insurers: premiums take time to be fully earned, investment instruments have to mature before they can yield income, etc. (Hamakova, 2007; Zweifel and Eisen, 2011). Finally, the management policies in general insurers can be associated with mental models the influence of which has to be examined to determine their real effect on the financial condition of the companies.

The aim of this work is to develop a model of a Ukrainian general insurance company based on the available insurance corporation theory, accessible firm data, and relevant legislative regulations in order to determine the key feedback relationships responsible for the dynamics of profits or losses and their effect on cash accumulation in general insurer activities. The built model should both facilitate the traditional analysis of financial condition of insurance companies and promote better management decision making.

Overview of the Model

The developed model reflects most major activities of Ukrainian general insurers. Just as the other enterprises, general insurance companies perform three main types of activities, namely operating, investing, and financing ones, and it is the content of these activities that distinguishes insurers from other types of businesses (Hamankova, 2007; Klepikova, 2011).

The operating activities of an insurer consist of underwriting, reinsurance, reserving, and claim settlement. Underwriting includes signing insurance contracts with a specified insurance sum based on the capital available. If the company cannot retain the proposed risk, reinsurance is used. Part of gathered premiums are reserved to ensure the ability to settle claims in form of payouts.

However, unlike firms from other industries, insurance companies have a stronger imperative to accumulate and multiply funds gathered through insurance operations. Investing serves a major role in business activities of a general insurer since it can provide the required addition of funds. Insurance companies can invest both free funds and technical reserves, but the latter are subject to strict regulations by the government.

Financing activities represent insurers' flows related to attracting and returning financial resources to/from both equity and liabilities, as well as show payouts to owners in form of dividends.

Despite the fact that typical statement of cash flows presents financial flows within the mentioned three activities, we suggest

departing from a solely accounting approach during the modelling process. Forrester states that financial information "does not form an integral part of decision-making functions" and "the skeleton framework of primary effects within the organization can often be represented without financial and accounting information"(1961, p. 335-336), yet the financial dimension is extremely important for proper management in insurance companies. To take into consideration both financial and nonfinancial aspects of insurance business, the managerial accounting perspective was chosen for modelling.

Management (or managerial) accounting is "the part of accounting devoted to providing information useful to the management of an organization, (…) contrasted with the process of producing official accounts"; it "involves the collection and processing of information which will help in actually running a firm" and "includes checking on stocks to ensure that enough are kept to avoid running out." (Black et al., 2012, p. 193).

Managerial accounting information appears to be most suitable for purposes of business modelling due to several reasons. Firstly, unlike pure accounting data, management accounting information provides a broader view on the activities of the company and, thus, enables the analysis of core causes in dynamic business behavior. Secondly, this kind of information implicitly or explicitly accounts for managerial mental models that are built in the business model of an enterprise. Finally, obtaining such information is feasible (in contrast to perfect market information, which virtually cannot be gathered and utilized in decision-making).

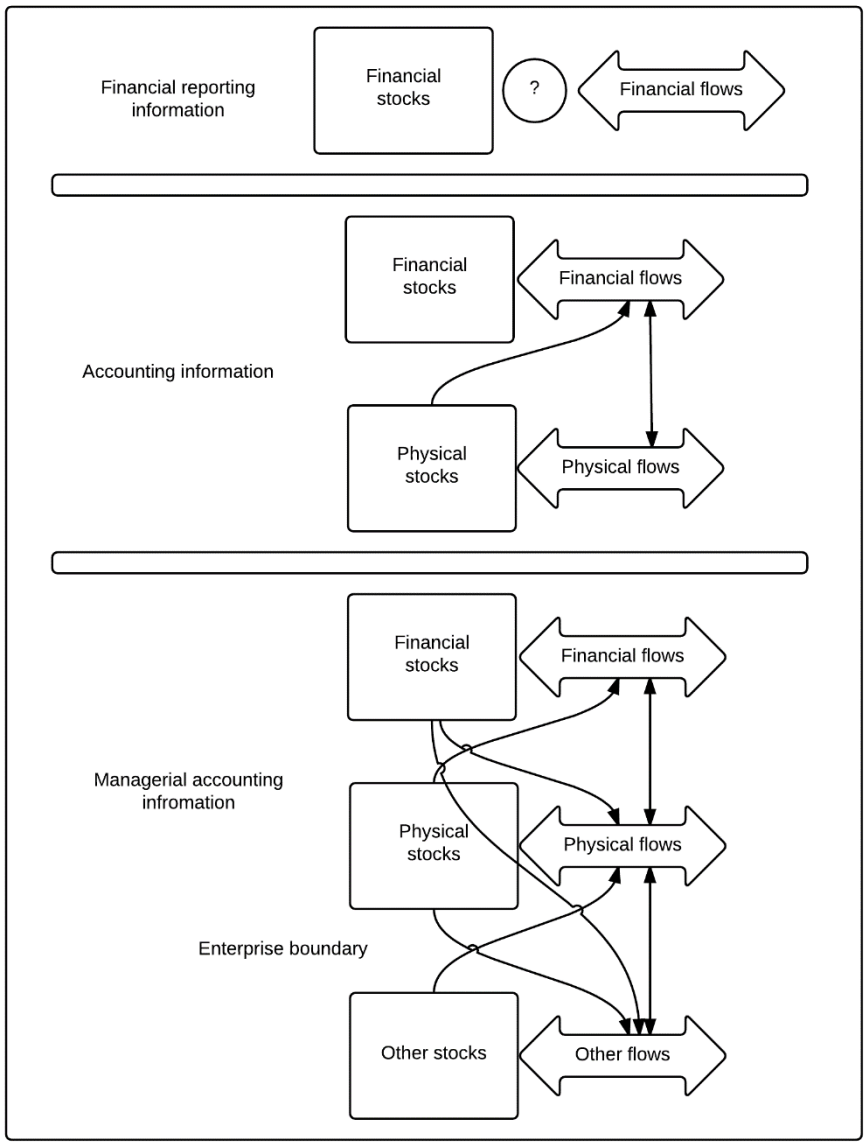


Figure 1. Corporate financial statements information structure from different reporting perspectives

Moreover, the managerial accounting perspective largely coincides with the system dynamics viewpoint on the problem (See Fig. 1). Financial reporting data mostly presents financial statements disregarding any stock-flow relations between them. Accounting information, which is more detailed, includes a broader view on financial statement formation: the dynamics of flows influencing stocks can be examined. Yet, the accounting approach limits its scope only to direct causal relationships.

By contrast, management accounting perspective does not suffer scope problems and can provide enough reasoning not only on causal, but also on the feedback effects in corporate activities.

The developed general insurance company model currently consists of twelve modules, each representing a relatively detached sphere of corporate activities. Most modules are interconnected, showing that either information or financial flows are shared between them. The modules included in the model are the following:

- *Actuarial* (insurance rate calculation),
- *Underwriting* (insurance product sales),
- *Reinsurance* (calculation of allowed retention and reinsurance related financial flows),
- *Claims* (keeping track of contracts, contractual liabilities settlement),
- *Reserving* (formation, investing, and returning of insurance reserves),
- *Human resources* (track of sales and administrative staff and their productivity),
- *Investing* (investing and returning of free funds),
- *Fixed assets* (track of fixed assets),
- *Equity* (formation of retained earnings / accumulated losses, track of statutory capital and equity),
- *Tax calculation* (calculation of tax),
- *Financials* (calculation of aggregate asset, equity, reserve, and liability statements, evaluation of financial ratios),
- *Cash* (track of cash, incorporation of all cash flows).

Figure 2 shows the outlay of the modules. The color scheme was applied in order to simplify spotting of feedback loops between the spheres of insurer activities (inputs within each module are presented in corresponding colors).

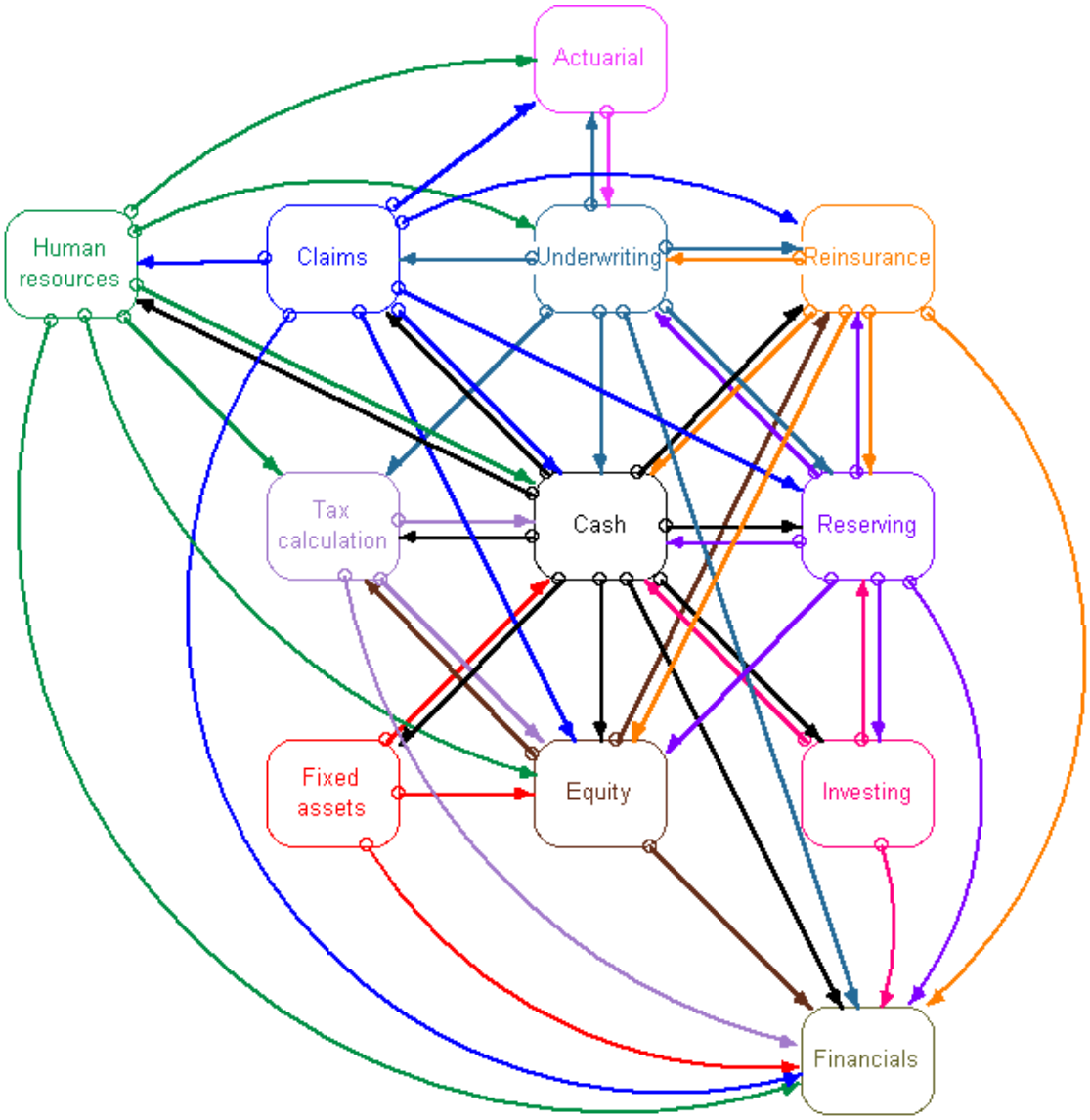


Figure 2. The proposed activity structure of a general insurer

Our approach to accounting operation presentation is largely based on the works of Yamaguchi (2003) and Melse (2006). The insurer activity framework follows the legislative base on insurance market regulation (NCRFSM) and studies on insurance economics (Hamankova, 2007; Zweifel and Eisen, 2011).

A general insurer attempts to satisfy the demand for insurance products by supplying its services at a price of gross insurance rate (*Actuarial*) based on the available sales workforce (*Human Resources*)

and fixed capital (*Fixed assets*). The gross insurance rate is formed with taking into account the anticipated costs associated with underwriting and claim settlement, the risk premium, and the historical insurance loss rate. Insurance rate formation premium process is presented in Fig. 2.

The sales of an insurer are its gross premiums written (*Underwriting*). Every general insurance company has to maintain an unearned premium reserve, which is calculated based on premiums written for three previous quarters (*Reserving*).

Yet not all written premiums belong to the company. Based on the allowed retention, certain amount of gross premiums has to be ceded, which influences the actual amount of sales pertaining to the insurer (*Reinsurance*). The reinsured part of premiums is also taken into account in the unearned premium reserve as a claim right to a reinsurer (*Reserving*). The exclusion of premiums ceded combined with the period change in the unearned premium reserve results into net premiums earned, which are the actual amount of an insurer's revenue that is taxed at a 3% rate (*Underwriting*).

A general insurer keeps track of active, settled, pending, and expired contracts. When claims are presented to an insurance company, their validity is checked and the amount is compared to the insurance sum; after this, an insurer proceeds to making payouts (*Claims*) if there is enough cash (*Cash*). Reinsurers compensate part of claims based on the share of ceded premiums in gross premium written (*Reinsurance*). The amount of premiums that was previously reserved into the unearned premium reserve is returned from reserves if the corresponding contract has been settled or has expired (*Reserving*).

If there is free cash (not reserved and not used for other payments), it is invested into different assets in order to produce additional non-insurance revenues (*Investing*). Likewise, insurance reserves are invested into different types of assets, however, reserve investing is highly regulated legislatively (*Reserving*) regarding maximum shares of assets, their liquidity, security, yields, and diversity. Tax to be paid (*Tax calculation*) is calculated based on insurance revenues (*Underwriting*),

other kinds of income (*Cash*), and salaries (*Human Resources*). The total tax is presented as a separate outflow due to the highest priority of this payment.

The retained earnings / accumulated losses are calculated based on all cash and non-cash flows and constitute a part of total equity of a general insurer (*Equity)*. Insurance and other liabilities (mainly backlogs on each cash outflow), as well as assets are aggregated into financial statements. Additionally, financial ratios that can be used in evaluation of financial health of an insurer are calculated (*Financials*).

The central and summarizing module of the model is *Cash* which contains the general cash stock as well as all inflows and outflows that affect it; additionally, cash stock is an input to many modules. Due to the space limitations, most flows to and out of cash stock had to be aggregated where possible.

The main inflows to cash stock are *Insurance and reinsurance premium revenues*, presented as a separate flow due to the specifics of taxation (3% tax is imposed on premiums earned). Other revenues (as well as non-operating losses) are counted in the *Other revenues or losses* flow, which includes *Insurance payouts compensated* (by reinsurers), *Other reinsurance related revenues* (ceding fee and gainsharing), *Investing result* (from investing of both free funds and insurance reserves), and *Fixed asset sales.* It should be noted that investing results are taken net of investing losses. All income presented in this flow is taxed at a different, 18 % rate.

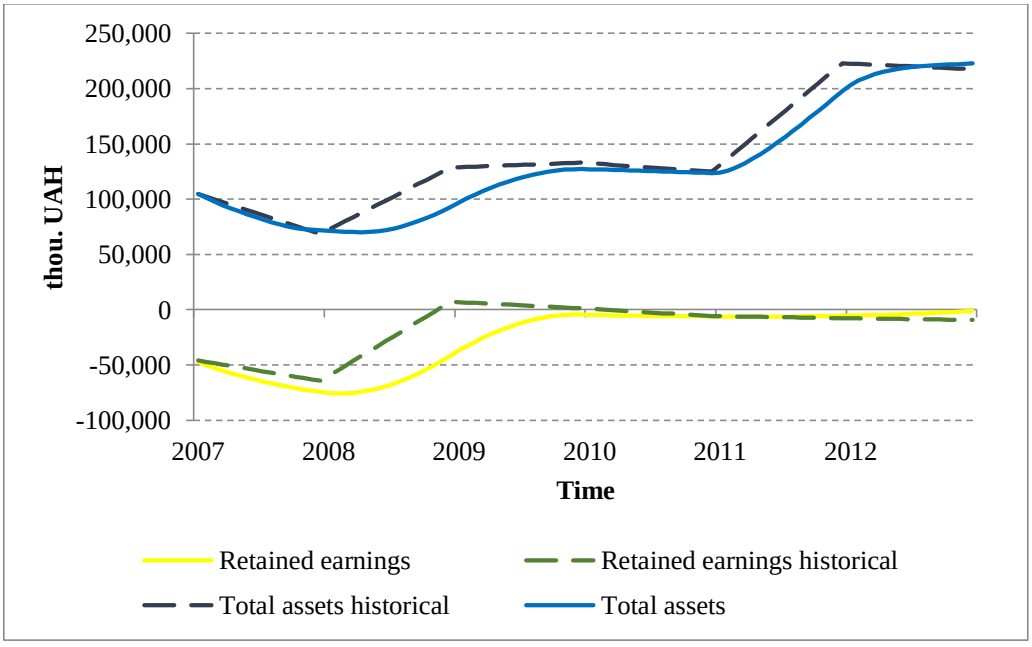
Other major flows are *Reserving and returning UPR, Reserving and returning RBNS, Reserving and returning IBNR,* and *Reserving and returning ER*. These four flows correspond to maintaining the unearned premium reserve (UPR), reported but not settled claims reserve (RBNS), incurred but not reported claims reserve (IBNR), and equalization reserve (ER). Insurance reserves are kept at desired levels, any excess funds being returned to the cash stock. Like reserving, *Investing and returning* is a biflow to cash that shows the movement of free funds from the general stock into certain types of investment assets and vice versa.

The main operating expense of a general insurer is *Insurance and reinsurance payouts*. Another operating outflow form cash stock are *Insurance premiums ceded* which denotes the sum of gathered premiums that was reinsured. *Costs and expenses* (salaries and other costs), *Tax payment* (insurance premium tax, income tax, and social tax on salary fund), and *Fixed assets purchases* are the other outflows.

It must be noted that cash collection cycle has been simplified by omitting accounts receivable (we assume that cash is collected right away). In this case, it is possible to account for financial results based on actual, not hypothetical cash flows. On the other hand, we have included accounts payable into the model because their amount can be significant in calculation of financial arrears.

Stock-flow diagrams for selected modules, as well as respective equations are presented in the Appendix.

The developed model produced behavior which is really close to actual. The comparison of reference mode and simulation results are shown in Graph 1.



Graph 1. Reference mode and model simulation result

Testing Main Feedback Effects

The model contains several important feedback loops that determine its behavior. Most of these loops extend beyond a single module and include elements of different kinds of general insurer activities. Fig. 3 contains the diagram with the main reinforcing and balancing loops.

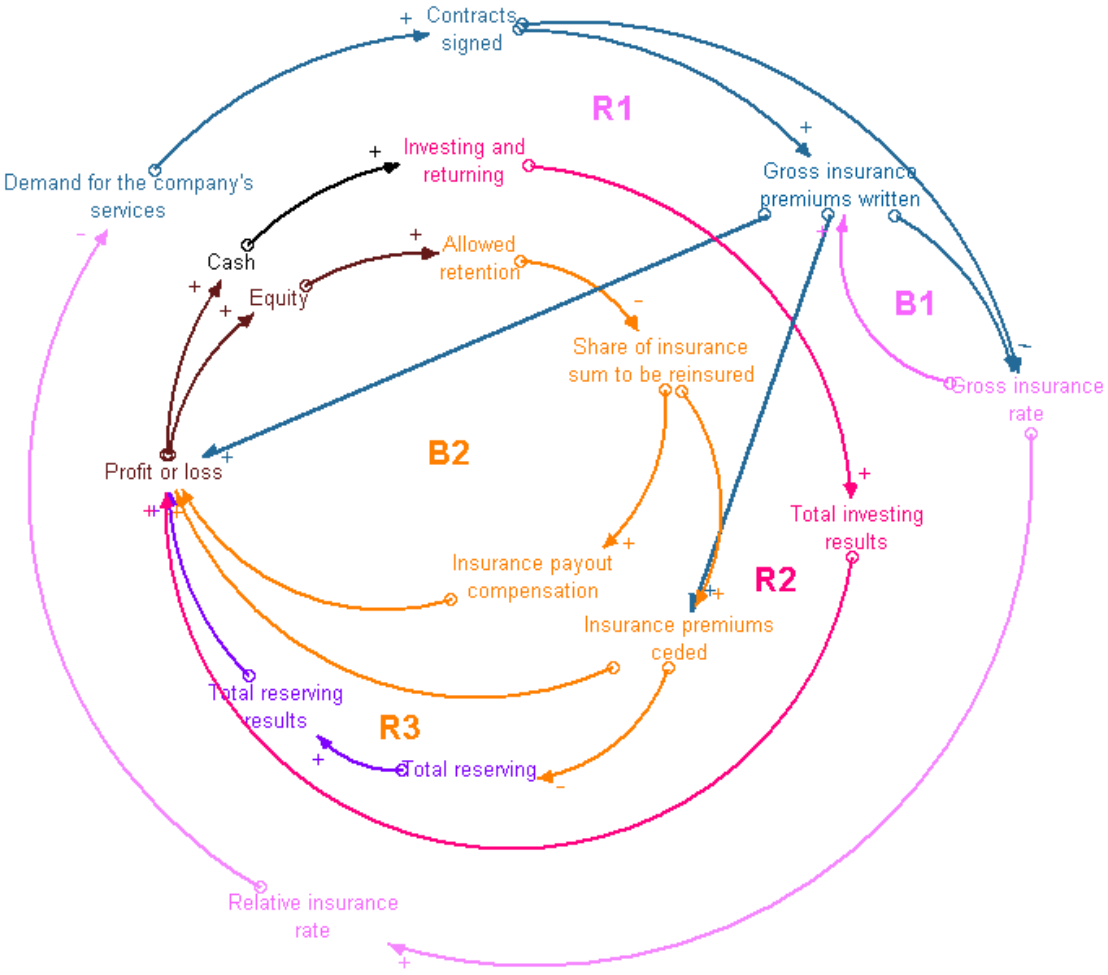


Figure 3. Major feedback loops in the model (CLD)

The **R1** reinforcing feedback loop shows the mutual influence between the price of insurance product (gross insurance rate) and the demand. The rise in demand for the services of an insurer positively affects the number of signed contracts, increasing gross insurance

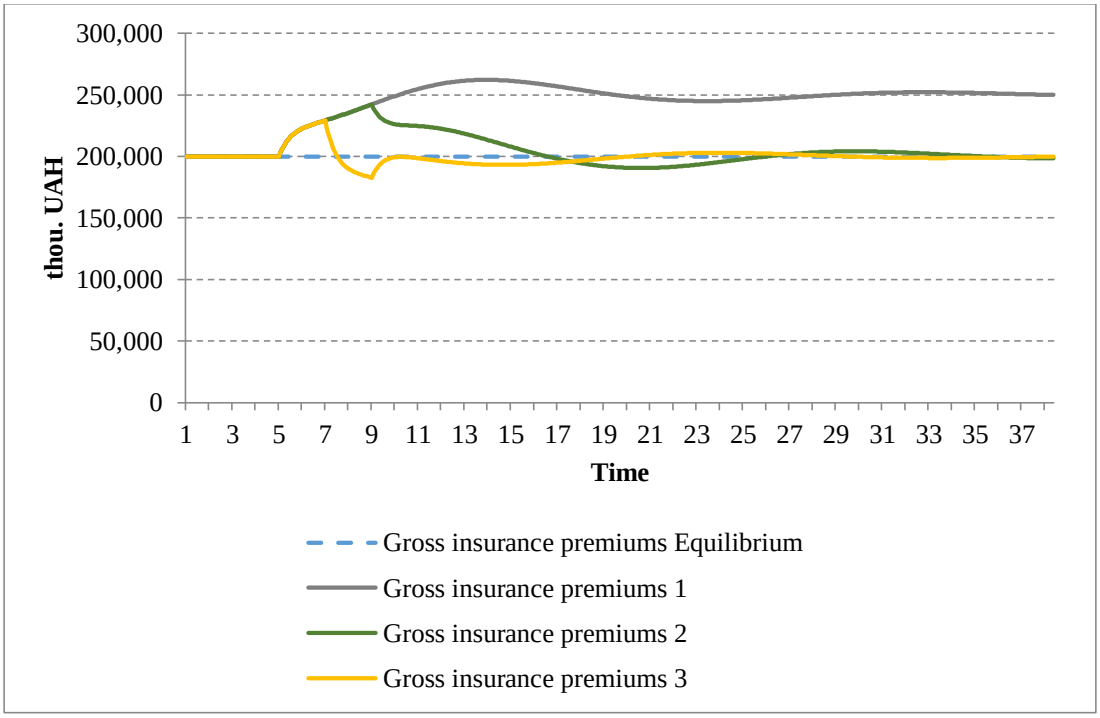
premiums. Higher sales allow insurers to reduce the net insurance rate because of the falling loss rate, which, in turn, drives more customers to the insurer's products.

At the same time, gross premiums written can also rise not because of an increase in contract signing but from the additions in product price. The balancing loop **B1** represents this feedback effect.

To demonstrate the feedback effects in the model, we propose several tests. In order to examine the influences of **R1** and **B1** loops, the ratio between the company's insurance rate and the average market insurance rate was changed as follows:

1. Average market insurance rate rises by 25% in Q4;
2. Average market insurance rate rises by 25% in Q4, and falls back to the initial level in Q8;
3. Average market insurance rate rises by 25% in Q4, drops by 25% in Q6, and then comes back to the initial level in Q8.

Simulation results are presented in Graph 2.



Graph 2. Response of gross insurance premiums written to changes in insurance rate

As it can be seen from the graph, the adaptation of insurance rate to the average market level or loss rate enables the insurer to use this as an instrument of rising its revenues in both auspicious and adverse market conditions.

The second major reinforcing loop is based on the effect of investing onto the cash multiplication. The **R2** loop shows that the more cash an insurer has available for investment, the greater will be the financial results of such investments. This, in turn, increases the amount of free cash that can be once again used in investing process. Alternatively, the extra cash can be directed to other outflows according to their priority.

Reserving activities also include similar loops that show the multiplication effect of investments. The major difference between the investment of free cash and investment of reserved cash lies in restrictions on investment shares and the need of maintaining the required level of total reserves. The reserve investing reinforcing loops are presented in Fig. 4.

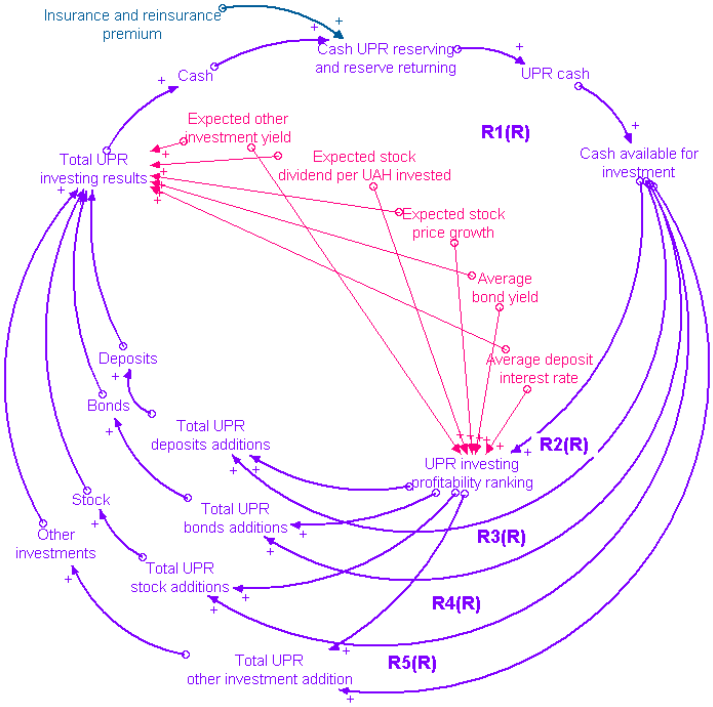
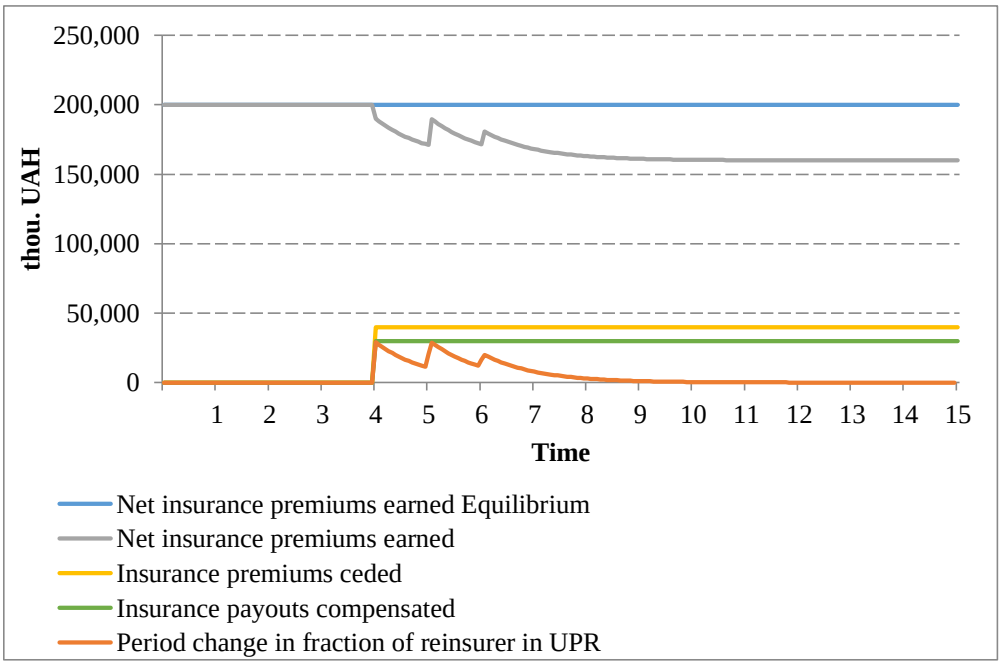


Figure 4. Reinforcing loops within unearned premium reserving (UPR) activities

The loop **R1** characterizes the reinforcing effect on profitability ranking through multiplying cash**.** At the same time, feedback loops **R2(R),.., R5(R)** characterize the multiplying effects of reserve investment in different assets (deposits, bonds, shares, and other) on the reserve investing returns and cash. Since the effects of these reinforcing loops are straightforward, testing is not conducted.

Another important reinforcing feedback loop presents the effect of reinsurance on a general insurance company performance. The **R3** loop denotes that an increased premium ceding may lead to weaker operational results, which negatively affects the equity of a company. At the same time, equity is inversely related with the allowed retention, meaning that premium ceding will increase the need to cede even further.

Apart from this, a major balancing loop **B2** is connected with reinsurance activities. Ceding premiums enables insurers to reduce the required cash outflows related to insurance payouts, which positively influences the operational financial result resulting into lesser need for ceding insurance premiums. In order to test the effects of these loops, we suggest changing the obligatory ceding norm from 0% to 20%. The results are shown in Graph 3.



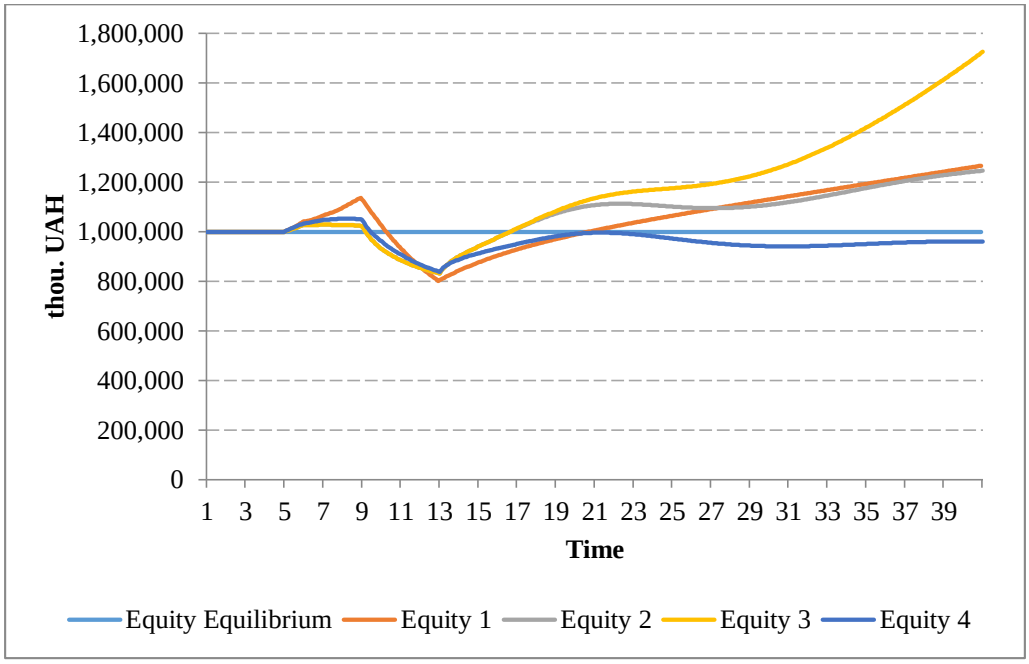
Graph 3. Effects of change in ceding norm on insurance premiums earned and insurance payouts compensated by the reinsurer

The graph shows the introduction of mandatory reinsurance practice lowers the actual insurance revenues of the company. At the same time, the level of its claim expenses is lowered too.

The effects of all the abovementioned loops can be utilized in management practice to find more effective decisions as a response to market shocks. The reinforcing effects are useful in growth strategies, whereas balancing ones may help to reduce expenses. We propose testing several different managerial responses to the following shock in market demand: rise in demand by 50% for a year with consequent decrease by 50% from the initial value for a year, and returning to the initial demand. Such management responses were tested:

1. The company does not respond at all;
2. The company adjust the insurance rate;
3. The company adjusts the insurance rate and invests;
4. The company adjusts the insurance rate, invests, and intensifies reinsurance.

The results of simulation are shown in Graph 4.



Graph 4. The effect of different management steps on equity in response to demand fluctuation

As it can been seen, the adjustment of insurance rate has a smoothing effect on retained earnings, and thus on equity. It allows managers to reduce losses when demand drops, but it also slows the income growth. Adding investing to the policy enables reinforcing equity growth. The effect of reinsurance is mixed: on the one hand, it limits the losses, yet at the same time reducing the possibilities of growth.

Conclusions. The developed system dynamics model describes the major spheres of Ukrainian general insurer activities from the managerial accounting perspective. The structure of the model contains their activities (underwriting, claim settlement, reserving, reinsurance, investing, and other), accounting and reporting elements (asset, equity, insurance reserve, and liability stocks), as well as financial health indicators.

The behavior of the built model is largely determined by the feedback effects of the main reinforcing and balancing loops.

Insurance rate has a double-sided effect on the company's financial performance: on the one hand, its growth provides higher revenues, but on the other hand, market demand may fall due to an extremely high relative insurance rate. Additionally, when insurance revenues rise, insurance rate drops because of the adjustment effect, which brings it to the loss level.

Free funds and reserve investing have a reinforcing influence on profitability and equity dynamics. Investing more cash means more investment income and more funds available for investing in the next period. This feedback effect largely determines the growth possibilities for general insurers.

Other major loops characterize the importance of reinsurance on company performance: on the one hand, ceding premiums can reduce the payout pressure on the insurer; on the other hand, using reinsurance deprives insurers of a part of earned premiums.

Testing of feedback effects presented in the model has shown that they can be utilized in management practice as a means of affecting the financial condition of the insurer.

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Data sources:

National Commission for Regulation of Financial Services Markets of Ukraine (NCRFSM): http://nfp.gov.ua

Reporting data of PJSC “Etalon” insurance company”, available at: http://etalon.ua

Appendix

Equation excerpts for selected modules

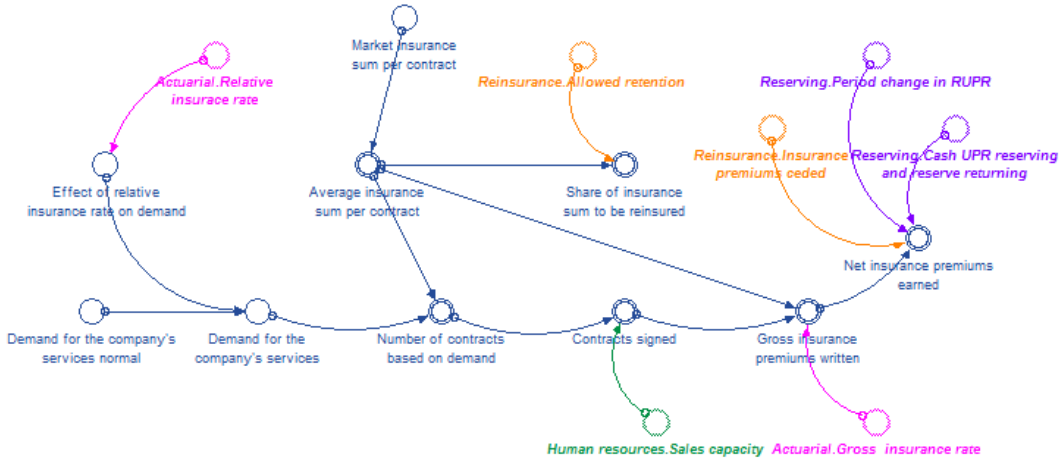

Figure A1. Stock-flow diagram of *Underwriting* module

Equations:

Average_insurance_sum_per_contract = Market_insurance_sum_per_contract
Brand_INPUT_FROM_MARKETING = 1
Contracts_signed =
min(Human_resources.Sales_capacity,Number_of_contracts_based_on_demand)
Demand_for_the_company's_services =
Demand_for_the_company's_services_normal*Effect_of_brand_on_demand*Effect_of_relative_insurance_rate_on_demand
Demand_for_the_company's_services_normal = 1000000
Desired_share_of_insurance_sum_to_be_reinsured = 0
Effect_of_brand_on_demand = Brand_INPUT_FROM_MARKETING
Effect_of_relative_insurance_rate_on_demand =
smth1(1/Actuarial.Relative__insurace_rate,1)
Gross_insurance__premiums_written =
Contracts_signed*Average_insurance_sum_per_contract*Actuarial.Gross__insurance_rate
Market_insurance_sum_per_contract = 1000+step(4000,10)*0
Net_insurance_premiums_earned = Gross_insurance__premiums_written-Reinsurance.Insurance_premiums_ceded-Reserving.Cash_UPR_reserving_and_reserve_returning+Reserving.Period_change_in_RUPR
Number_of_contracts_based_on_demand =
Demand_for_the_company's_services/Average_insurance_sum_per_contract

Share_of_insurance_sum_to_be_reinsured =
(max(0,(Average_insurance_sum_per_contract-
Reinsurance.Allowed_retention)/Average_insurance_sum_per_contract))

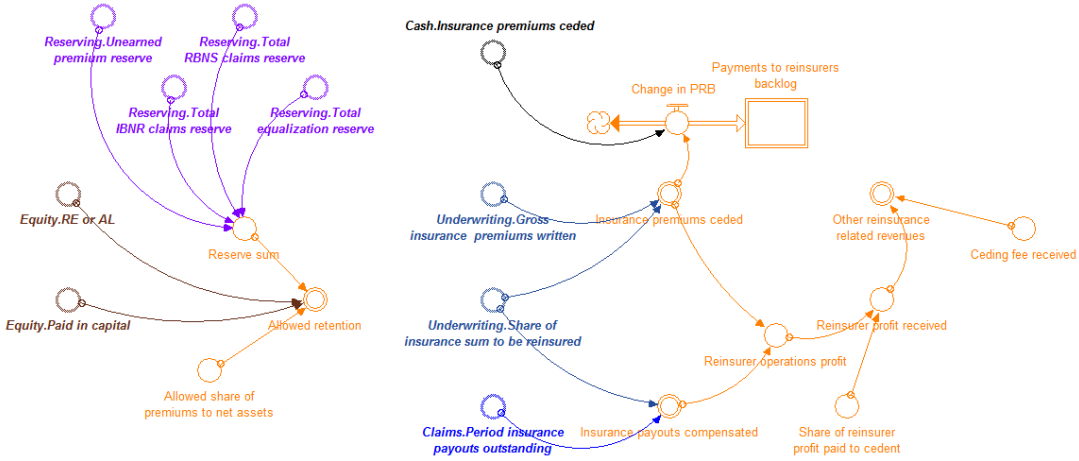

Figure A2. Stock-flow diagram of *Reinsurance* module

Equations:

Payments_to_reinsurers_backlog(t) = Payments_to_reinsurers_backlog(t - dt) +
(Change_in_PRB) * dt
INIT Payments_to_reinsurers_backlog = 0
INFLOWS:
Reinsurer_operations_profit = Insurance_premiums_ceded-
Insurance_payouts_compensated
Reinsurer_profit_received =
max(0,Reinsurer_operations_profit)*Share_of_reinsurer_profit_paid_to_cedent
Share_of_reinsurer_profit_paid_to_cedent = 0
Change_in_PRB = Insurance_premiums_ceded-Cash.Insurance_premiums_ceded
Allowed_retention = (IF ((Equity.RE_or_AL+Equity.Paid_in_capital)>=0) THEN
max(0,(Insurance_reserves+Equity.RE_or_AL+Equity.Paid_in_capital)*Allowed_sh
are_of_premiums_to_net_assets) Else 0)*0
+max(0,(Insurance_reserves+Equity.RE_or_AL+Equity.Paid_in_capital)*Allowed_s
hare_of_premiums_to_net_assets)
Allowed_share_of_premiums_to_net_assets = 0.1
Ceding_fee_received = 0
Insurance_payouts_compensated =
Claims.Period_insurance_payouts_outstanding*Underwriting.Share_of_insurance_su
m_to_be_reinsured

Insurance_premiums_ceded =
Underwriting.Gross_insurance__premiums_written*Underwriting.Share_of_insurance_sum_to_be_reinsured
Insurance_reserves =
Reserving.Total__equalization_reserve+Reserving.Unearned_premium_reserve+Reserving.Total_IBNR_claims_reserve+Reserving.Total_RBNS_claims_reserve
Other_reinsurance_related_revenues =
Ceding_fee_received+Reinsurer_profit_received

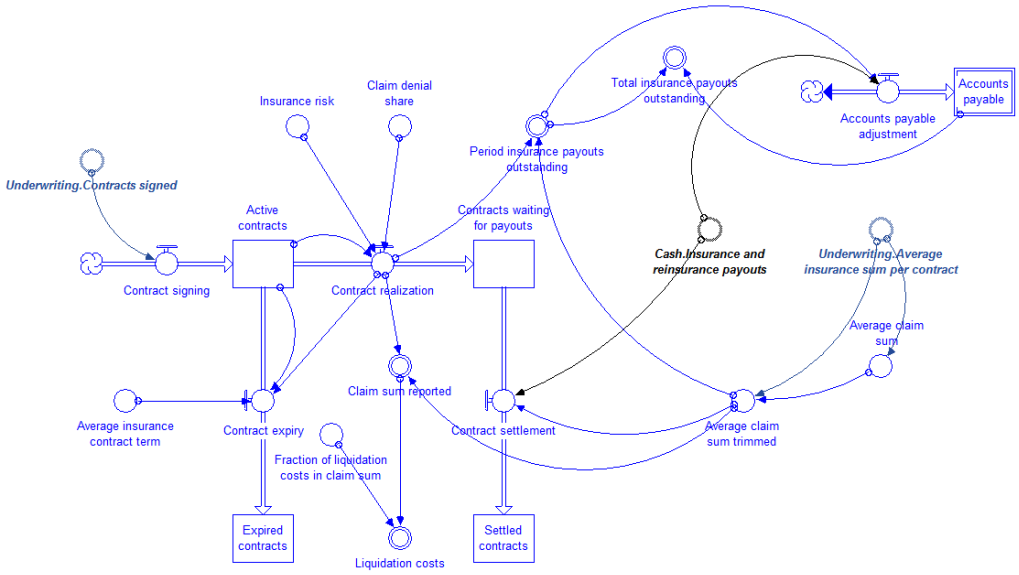

Figure A3. Stock-flow diagram of *Claims* module

Equations:

Accounts__payable(t) = Accounts__payable(t - dt) + (Accounts_payable_adjustment) * dt
INIT Accounts__payable = 0
INFLOWS:
Accounts_payable_adjustment = Period_insurance_payouts_outstanding-Cash.Insurance_and_reinsurance_payouts
Active__contracts(t) = Active__contracts(t - dt) + (Contract_signing - Contract_expiry - Contract_realization) * dt
INIT Active__contracts = Average_insurance__contract_term*Contract_signing
INFLOWS:
Contract_signing = Underwriting.Contracts_signed

OUTFLOWS:
Contract_expiry = Active__contracts/Average_insurance__contract_term-
Contract_realization
Contract_realization = Insurance_risk*(1-Claim_denial__share)*Active__contracts
Contracts_waiting__for_payouts(t) = Contracts_waiting__for_payouts(t - dt) +
(Contract_realization - Contract_settlement) * dt
INIT Contracts_waiting__for_payouts = 0
INFLOWS:
Contract_realization = Insurance_risk*(1-Claim_denial__share)*Active__contracts
OUTFLOWS:
Contract_settlement =
Cash.Insurance_and_reinsurance_payouts/Average_claim__sum_trimmed
Expired__contracts(t) = Expired__contracts(t - dt) + (Contract_expiry) * dt
INIT Expired__contracts = 0
INFLOWS:
Contract_expiry = Active__contracts/Average_insurance__contract_term-
Contract_realization
Settled__contracts(t) = Settled__contracts(t - dt) + (Contract_settlement) * dt
INIT Settled__contracts = 0
INFLOWS:
Contract_settlement =
Cash.Insurance_and_reinsurance_payouts/Average_claim__sum_trimmed
Average_claim_sum =
smth1(Underwriting.Average_insurance_sum_per_contract*1.2,1)
Average_claim__sum_trimmed =
min(Underwriting.Average_insurance_sum_per_contract,Average_claim_sum)
Average_insurance__contract_term = 4
Claim_denial__share = 0.25
Claim_sum_reported = Average_claim__sum_trimmed*Contract_realization
Fraction_of_liquidation_costs_in_claim_sum = 0.001
Insurance_risk = 0.05
Liquidation_costs =
Claim_sum_reported*Fraction_of_liquidation_costs_in_claim_sum
Period_insurance_payouts_outstanding =
Contract_realization*Average_claim__sum_trimmed
Total_insurance_payouts_outstanding =
Period_insurance_payouts_outstanding+Accounts__payable

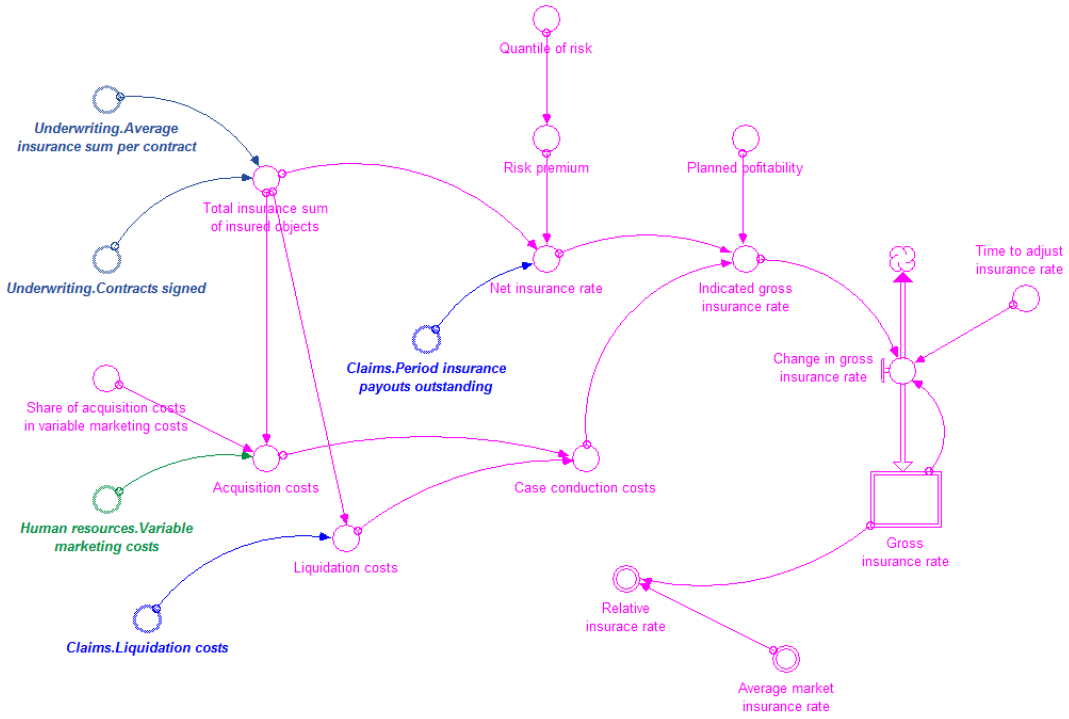

Figure A4. Stock-flow diagram of *Actuarial* module

Equations:

Gross__insurance_rate(t) = Gross__insurance_rate(t - dt) + (Change_in_gross_insurance_rate) * dt
INIT Gross__insurance_rate = 100*0.15/(100-0.265-24.735)
INFLOWS:
Change_in_gross_insurance_rate = (Indicated_gross__insurance_rate-Gross__insurance_rate)/Time_to_adjust_insurance_rate
Acquisition_costs = Human_resources.Variable__marketing_costs*Share_of_acquisition_costs_in_variable_marketing_costs/Total_insurance_sum_of_insured_objects*100
Average_market__insurance_rate = 0.2
Case_conduction_costs = Acquisition_costs+Liquidation_costs
Indicated_gross__insurance_rate = 100*Net_insurance_rate/(100-Case_conduction_costs-Planned_pofitability)
Liquidation_costs = Claims.Liquidation_costs/Total_insurance_sum_of_insured_objects*100

Net_insurance_rate =
(Claims.Period_insurance_payouts_outstanding/Total_insurance_sum_of_insured_objects+Risk_premium)
Planned_pofitability = 24.735
Quantile_of_risk = 0
Relative__insurace_rate = Gross__insurance_rate/Average_market__insurance_rate
Risk_premium = 1.2*Quantile_of_risk
Share_of_acquisition_costs_in_variable_marketing_costs = 0.1
Time_to_adjust_insurance_rate = 1
Total_insurance_sum_of_insured_objects =
Underwriting.Average_insurance_sum_per_contract*Underwriting.Contracts_signed

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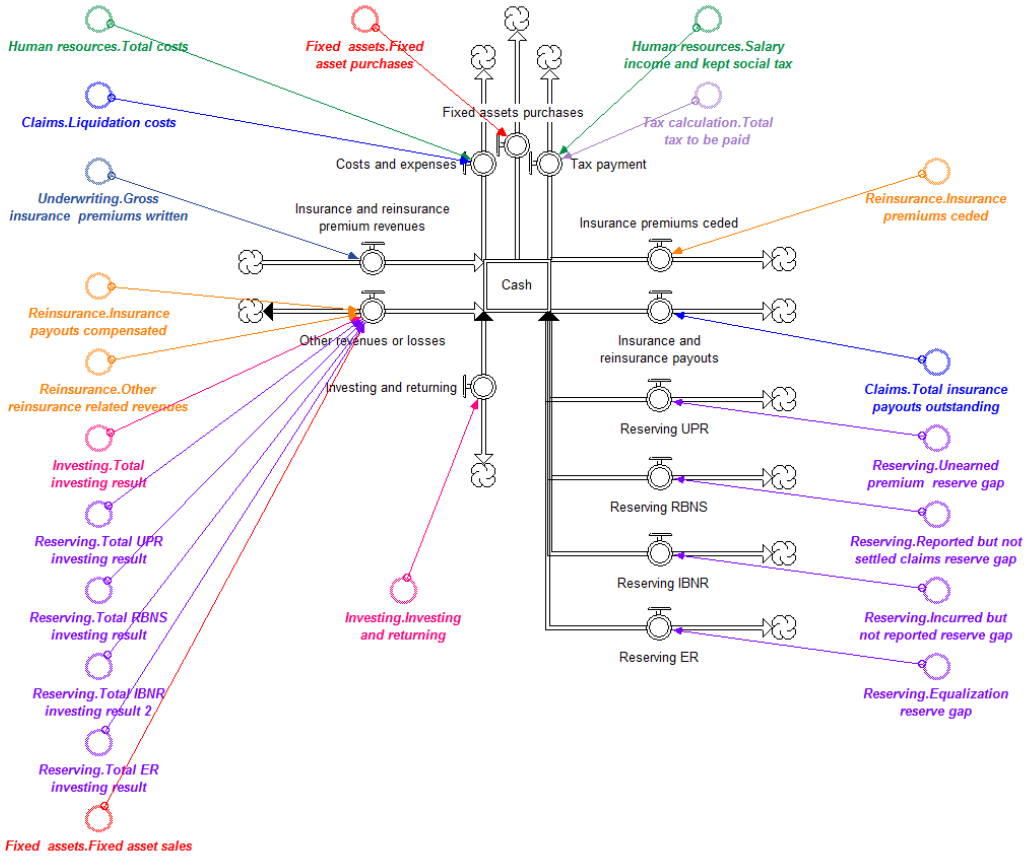

Figure A5. Stock-flow diagram of *Cash* module

Equations:

Cash(t) = Cash(t - dt) + (Insurance_and_reinsurance_premium_revenues + Other_revenues_or_losses - Insurance_premiums_ceded - Tax_payment - Reserving_UPR - Reserving_RBNS - Reserving_IBNR - Reserving_ER -

Costs_and_expenses - Insurance_and_reinsurance_payouts - Investing_and_returning - Fixed_assets_purchases) * dt
INIT Cash =
Costs_and_expenses+Fixed_assets_purchases+Tax_payment+Insurance_premiums_ceded+Insurance_and_reinsurance_payouts+Reserving_IBNR+Reserving_ER+Reserving_RBNS+Reserving_UPR
INFLOWS:
Insurance_and_reinsurance_premium_revenues =
Underwriting.Gross_insurance__premiums_written
Other_revenues_or_losses =
(Fixed__assets.Fixed_asset_sales+Investing.Total__investing_result+Reserving.Total_UPR__investing_result+Reserving.Total_RBNS__investing_result+Reserving.Total_IBNR__investing_result_2+Reserving.Total_ER__investing_result+Reinsurance.Other_reinsurance_related_revenues)+Reinsurance.Insurance_payouts_compensated
OUTFLOWS:
Insurance_premiums_ceded = Reinsurance.Insurance_premiums_ceded
Tax_payment =
Tax_calculation.Total_tax_to_be_paid+Human_resources.Salary_income_and_kept_social_tax
Reserving_UPR = Reserving.Unearned_premium__reserve_gap
Reserving_RBNS = Reserving.Reported_but_not_settled_claims_reserve_gap
Reserving_IBNR = Reserving.Incurred_but_not_reported_reserve_gap
Reserving_ER = Reserving.Equalization_reserve_gap
Costs_and_expenses = Human_resources.Total_costs+Claims.Liquidation_costs
Insurance_and_reinsurance_payouts = Claims.Total_insurance_payouts_outstanding
Investing_and_returning = Investing.Investing_and_returning
Fixed_assets_purchases = Fixed__assets.Fixed_asset_purchases

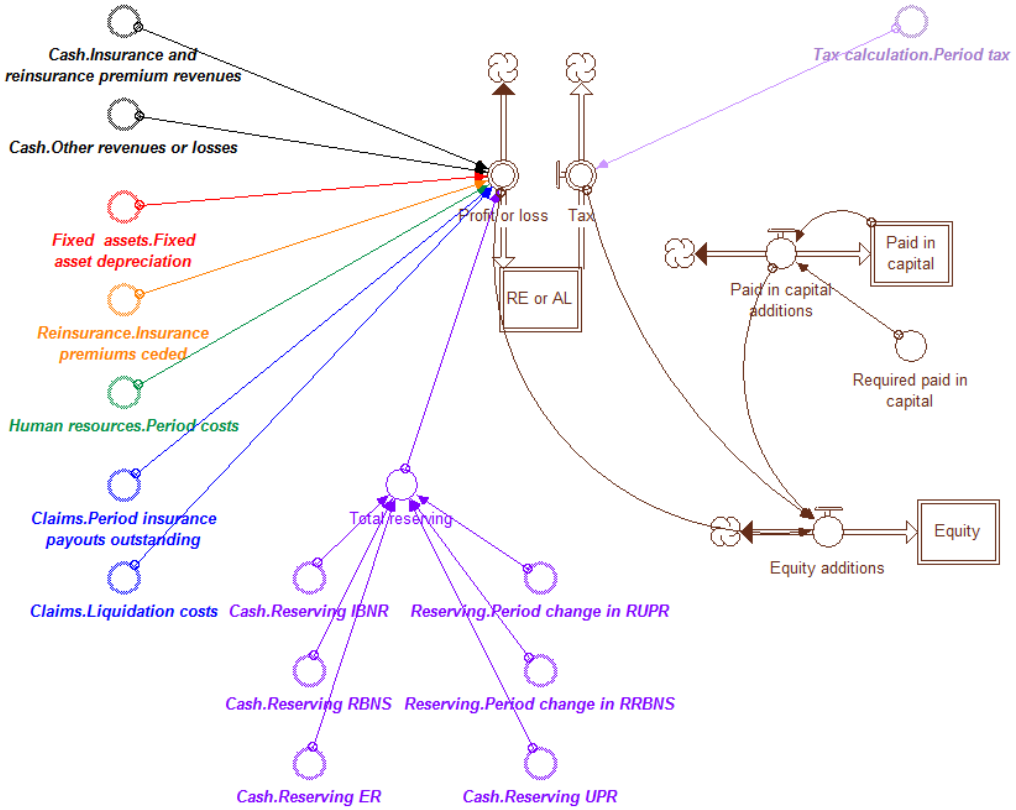

Figure A6. Stock-flow diagram of *Equity* module

Equations:

Equity(t) = Equity(t - dt) + (Equity_additions - Equity_withdrawal) * dt
INIT Equity = Paid_in_capital
INFLOWS:
Equity_additions = Paid_in_capital_additions+Profit_or_loss-Tax
OUTFLOWS:
Equity_withdrawal = Dividend_decision
RE_or_AL(t) = RE_or_AL(t - dt) + (Profit_or_loss - Tax) * dt
INIT RE_or_AL = 0
INFLOWS:
Profit_or_loss = -
Fixed__assets.Fixed_asset_depreciation+Cash.Insurance_and_reinsurance_premium_
revenues+Cash.Other_revenues_or_losses-
Claims.Period_insurance_payouts_outstanding-Human_resources.Period_costs
-Reinsurance.Insurance_premiums_ceded-Claims.Liquidation_costs-
Total_reserving_results
OUTFLOWS:
Tax = Tax_calculation.Period_tax
Paid_in_capital(t) = Paid_in_capital(t - dt) + (Paid_in_capital_additions) * dt

INIT Paid_in_capital = Required_paid_in_capital
INFLOWS:
Paid_in_capital_additions = (Required_paid_in_capital-Paid_in_capital)
Dividend_decision = 0
Required_paid_in_capital = 1000000
Total_reserving_results =
Cash.Reserving_IBNR+Cash.Reserving_RBNS+Cash.Reserving_UPR+Cash.Reservi
ng_ER-Reserving.Period_change_in_RUPR-Reserving.Period_change_in_RRBNS