Dynamic Stochasticity in the control of liquidity in Asset and Liability Management (ALM) for pension funds

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Abstract.

System dynamics may enhance Asset and Liability Management (ALM) capability in order to be risk oriented. Many integrated ALM problem for pension funds has been modeled to address, among others, liquidity control. The purpose is to provide long-term liquidity control prognoses for investment decisions as a way to forecast long-term scenarios and to develop an integrated policy for assets and liabilities.

Key words: system dynamics; asset/liability management (ALM) uncertainties; ALM risk management; social security; risk factors models; subjectivity; pension funds

Introduction

Asset and liability management economic models are recognized by the literature as a balance sheet oriented approach and aims to represent the wealth of an organization in terms of its assets tied to its long term liabilities. As a factor based model, requires a great amount of information and a well-known knowledge of organization processes and policies to better manage asset allocations portfolio optimization and to establish some well done equilibrium assumptions, based on liabilities prognosis of the uncertain future.

Many biometric, demographic, economic and administrative factors in asset and liability management models involve uncertainty. Actuaries, directors and economists in pension funds must interact to each other to decide over allocation processes based on variable liability. This paper focuses on ALM´s liquidity control based on conceptual issues assigned to ALM variables, the uncertainties involved and a system dynamic model to manage and control liquidity in a pension fund.

System dynamics (SD) may amplify asset and liability management (ALM) methodology capability to be risk oriented. The complex problem is how to make the allocation process connected to uncertainties of the actuarial assumptions.

Uncertainties mean risks that must be defined in tangible operational terms. Pension funds need to produce a high-income return to correspond to actuarial expectations and to pay different kind of benefits. Its underlying assets non-financial nature and long-term liabilities dictate the nature of liquidity risk management.

In a changing and complex environment, pension funds wealth management needs a more robust investment allocation approach, than the static mean-variance analysis. In this context, a dynamic ALM approach may provide some advantages.

Finally, since decisions under uncertainty become complex especially because of the low comprehension of system long term best interests as a whole, system dynamics methods may provide an holistic overview to the uncertainties of an ALM analysis results. The combination may improve the managers ability to explicit tacit knowledge, understand complexity, plan under uncertainty and design better operating policies enhancing, this way, the discussions and learning about businesses strategies in pension funds.

1 Context - Social Security and Pension Funds

The Social Security policy is considered an efficient way to promote social transfers and thus get social justice and welfare. It must protect workers and their families against social risks like sickness, incapacity, death, involuntary unemployment, advanced age, maternity and prison. Current trend regarding social security systems is the shift from pay-as-you-go schemes to funded schemes that may be well defined as:

> Pension funds are managed provisions made by corporations and their employees in order to fund the future payments of pensions to the later. This system differs from the pay as you go system to the extent that the contributions paid are invested in securities for very long periods of time, typically forty years. Therefore the provisions made will depend non-solely on the level of contribution but also on the return of the investment portfolio. (BOULIER, MICHEL and WISNIA, 1996).

In Brazil, a complementary private pension entity is authorized to administrate pension-based defined benefit (DB) or defined contribution (DC) benefit plans. They are controlled by specific legislation, chiefly by Complementary Acts 108 and 109, Resolution 3.121 of the National Monetary Council (CMN) and other rules issued by the Complementary Pension Secretariat (SPC) and by the Complementary Pension Management Council (CGPC). Given the total invested capital and the great quantity of participantes, during the last decade, pension funds in Brazil are a growing segment of more than US$ 146 billion (feb/2006) and shared interests among different segments of the Brazilian economy.

As a non-financial institution and with non-speculative nature, assets and liabilities management is different than those of financial institutions. So is the risk management. DAS (1997, p. 551) points out the underlying assets as “real assets, such as properties, plant and equipment, intangible assets such as goodwill (surplus on acquisition), intellectual property and brand names, as well as financial assets in the form of equity or other investments”. For workers and corporations who pay contributions to a pension fund, the liabilities may be linked to pensions released when of the workers retirement. This long-term nature of financial assets implies many risks that must be dealed.

These are inherent risks to benefit plans and represent its liabilities. Its mission is to structure many investment policies looking for an optimal allocation strategy and to act seeking sustained growth and a socially responsible behavior. Their complex goal is to offer benefit plans and obtain an adequate income return to maintain an actuarial equilibrium.

Indeed, the corporate governance of a pension fund includes a set of practices that may optimize its performance and protect economic agents involved: investors, employees, sponsors and other interested parties. By structuring many investment politics and acting seeking sustained growth and a socially responsible

behavior, their goal is to offer benefit plans and obtain an income return accordingly to the actuarial expectations. Thus, their offer is related to the protecting of the participants against social risks like sickness, incapacitate, death, involuntary unemployment, advanced age, maternity and prison. These are inherent risks to benefit plans.

2 Risk Management

An organization's risk management program must be tailored to its overall objectives and should change when those objectives change. As stated by OCDE (2007),

> risk management is not new in fundamental concepts although as a specialist management approach or process it is still developing. Over the last few years, it has become increasingly preferred by organizations to assist them in reducing risk exposures to new products, advanced technologies and global market competition, and to enable them to allocate and use their scarce resources as efficiently and effectively as possible (OCDE, 2007).

The term ’risk management’ can be somewhat misleading as ’management’ tends to imply some ability to influence or ’control’ events and this is not always the case. In reality risk management is a formal process whereby risk factors for a particular context are systematically identified, analyzed, assessed, ranked and provided for. It is a proactive, systematic analysis of possible events and responses to them rather than a mere reaction mechanism to those limited events that are detected. It is about managing the future rather than administering past events.

Das (1997, p. 548) lists several factors to the increased focus on risk management:

- The deregulation of financial markets;
- The increasing role of securities and derivative products in financial intermediation;
- The increase in the risk profile of organizations, with increased emphasis on activities which require the assumption of risk, deliberately;
- The volatility of markets and its impact on financial institutions;
- The pressure from capital market investors for returns related to the relative riskiness of their investments; and
- The regulatory requirements for a risk management framework.

For a pension fund, Chaim (2006) connected typical actions to inherent risk factors, as may be show in table 1.

Table 1: Inherent risks by maturity stage of a benefit plan

PF phase	Decisions drivers	Inherent Risk Factors	Typical Actions
Accumulation	↑Strategic asset allocation	↑ High-income (market risks); ↓ low-solvency (liquidity risks) ↑ Higher returns	- A portfolio with more risky assets is structured because the need of credibility and participants expectations; - Interest on new adhesions to reduce costs and get more income. - Loans and other facilities to add value to participants
Maturity	(Strategic asset allocation Punctual payments	↓ low-income (market risks); ↑high-solvency (liquidity risks) ↓ lower returns	- A portfolio with less risky assets is structured to assure liquid yields to pay liabilities; - The adhesions generally are closed; - The loans follow a historical behavior to maintain credibility
All stages	Authorize new benefits plan Better manage the assets Low Costs Good Solvency Higher yields	- Legal risks: out of the limits fixed by the regulation - Compliance - Legal obligations and schedule - Bad corporative governance Reducing transaction costs	- Market monitoring - Actuarial assessments - Emphasis on actuarial constraints and the plan equilibrium. - A program to maintain good internal controls is desirable to assure better corporate governance Economies of scale through volume of transactions and controlling the information flow to better decide and act accordingly the needs.

Source: Chaim (2006)

3 Liquidity Control

Financial activity is a set of processes to assure asset-liability equilibrium. It should be stressed that no transaction should be affected when in disagreement with the corporate purposes. Since a pension fund is a service organization, the goal of risk management will be to protect business present value against individual risk factors (reputation/image, market volatility, solvency, liquidity and credit) in order to maintain a good client perception.

Financial risk management includes the assumption, management and pricing of different classes of risks: credit, market, liquidity and operational. DAS (1997, p. 547) defines each of them:

- Credit risk: refers to the risk of loss arising from the default of the counterparty, i.e. the failure to honor and meet its legal obligation;

- Market risks: refers to the risk of loss sustained as a result of changes in the values of market prices or factors used to value financial instruments;

- Operational risk: refers to the risk of loss from a broad range of risks including: operational (processing failure); technology (systems failure); legal (non unenforceability of contracts); and regulatory (breach of regulatory requirements);

- Liquidity risk: refers to the risk of loss arising from either inability to make payments or the inability to re-finance obligations as and when they mature or the inability to re-finance at anticipated rates.

As a broad concept, liquidity may be defined as:

> Although commonly used in monetary, banking and financial parlance, the term 'liquidity' is understood in different ways. In the macroeconomic context, it refers to overall monetary conditions, reflecting the extent of mismatch between demand and supply of overall monetary resources. In the context of financial markets, it is rather narrowly defined as the ease of undertaking transactions in financial assets at narrow bid-ask spreads (REDDY, 2002).

As stated by OCDE (2000),

> liquidity risk arises when a bank cannot obtain sufficient funds to meet demand, either by increasing liabilities or by converting assets promptly. When a bank has inadequate liquidity, its profitability can be affected and, in some cases, insufficient liquidity can lead to the insolvency of a bank. The purpose of liquidity management is thus to ensure that a bank is able to meet its contractual commitments fully. The Committee maintains that the elements of strong liquidity management include good management information systems, central liquidity control, analysis of net funding requirements, diversification of funding sources, and contingency planning.

> The analysis of net funding requirements involves the construction of a maturity ladder and the calculation of cumulative net excess or deficit of funds at selected maturity dates. A bank's net funding requirements are determined by analyzing its future cash flows based on assumptions of the future behavior of assets, liabilities and off-balance-sheet items, and then calculating the cumulative net excess over the time frame for the liquidity assessment. Banks are advised by the Committee to construct a maturity ladder that will be used to compare a bank's future cash inflows with its future cash outflows over a series of specified time periods (OCDE, 2000)

Thus, much attention has been paid to ALM for pension funds in last years as a way to analyze net funding requirements and control, among others, liquidity risks.

4 Dynamic Asset/Liability Management (ALM)

A balance-sheet oriented methodology can help managers to better known the debt structure, the comprehension of the business expand, the results of assets allocations and the wealth of the company. Balance sheets allow them to identify and analyze trends. "It affects the entire scope of the operations including lending, marketing, product pricing, investment analysis, cash management, internal controls and data processing". (LEE, 2005).

Pension funds have to decide periodically how to allocate the investments over different asset classes and what the contribution rate should be in order to fund its liabilities. Because of its long-term obligations, Pension Funds' planning horizon is large. The solvency of the fund must be guaranteed by acceptable investment and contribution policies. The process requires a great amount of information about the organization, its operations and market performance.

It comprises: (1) better understand the wealth of the organization by evaluating balance sheet; (2) executing actions to control credit, liquidity and market risks (3) based on statistical and mathematical methods, predict, forecast or foresee how the future should be in order to define a finite number of scenarios to model uncertainty.

In a deterministic way, ALM is always combined to one or more mean-variance models or techniques to quantify financial risks: Markowitz portfolio theory, Capital Asset Pricing Model (CAPM), Asset Pricing Theory (APT), Value at risk - V@r, Sharpe, Duration and many others. Generally attempting to predict the future based on past behavior or to take the present value of a future position, they try to know more about time series and thus mitigate uncertainty.

A stochastic programming model for ALM processes of a pension fund is dynamic since the information on the actual value of uncertain parameters is revealed in stages. For Drijver, Haneveld & Vlerk (2002), it is assumed that:

(1) Because of the risks of under funding, decisions on asset mix, contribution rate and remedial contributions are made once a year;
(2) Uncertainty is modeled through a finite number of scenarios given by a scenario tree. Each scenario demands a complete set of decision variables at each time period:
    - Total asset value
    - The portfolio market value given the value of investments in each asset class
    - Total value of liabilities

Cariño et al (1994) proposed a multistage stochastic dynamic ALM model that includes stochastic controls and shortfall penalties. Also, techniques like Bayesian analysis and brownian motion have been used in search of better results (KAUFMANN, 2005).
Boulier(1996) considers that “stock returns are uncertain in efficient markets, so stochastic control would help in finding the optimal investment policy, as well as the adequate level of contribution” (CARIÑO et al 1994). Kaufmann (2005) used stochastic volatility models with jumps to estimate quartiles of financial risks for two week period.

Due to uncertainty, it’s difficult to quantify risk, especially in some special cases. This way, Aderbi, Nordio & Sirtori (2006) studied the properties of expected shortfall from the point of view of financial risk management. “As a measure for assessing the financial risks of a portfolio”, they conclude that “expected shortfall appears as a natural choice to resort to when v@r is unable to distinguish between portfolios with different riskiness” (ADERBI, NORDIO & SIRTORI, 2006). Expected shortfall may be defined as “the average loss when value-at-risk is exceeded” giving “information about frequency and size of large losses” (KAUFMANN, 2005).

The use of system dynamics in combination with asset-liability management model (ALM) represents an opportunity to amplify its capability to become risk oriented. Thus, macroeconomics, biometrics and actuarial classes of variables must be holistically considered and allow the model to incorporate risk factors and constraints when there is a shortfall. Table 2 synthesizes the benefits of combining SD and ALM.

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Table 2: Benefits of combining SD and ALM

ALM	System Dynamics	ALM combined to SD
Balance sheet oriented approach. Offers a static view from a dynamic reality.	Represent complexity and the interrelationship between the variables of the model.	Enhance ALM capability to be risk oriented and allows it to produce and test theories about the dynamic relations in a pension fund.
Factor model. Uses correlation, linear regression and structural equations to manage complexity.	Focused on causations and circular relationship between variables.	It is possible to simulate the future behavior of the model and analyze these projections impact over the system.
In assets side, is based on econometric theories and methods to optimize the risk and return relations and to estimate the volatility and sensibility of markets. In liabilities side, the estimates are based on actuarial methods and assumptions.	Based on general systems theory and control theory and system thinking, lead analysts to explain behavior based on mathematical relations between variables.	Make it easier to foresee and foresight the behavior of the system to better understand information delays and their influence over expected results and to do analysis based on assets and liabilities stochasticity.

Boulier (1996) states that “portfolio management and contributions scheme are clearly interdependent”. Thus, causal loops relations may represent the uncertainty and may predict the impact of each of it in the system as a whole.

5 Dynamic liquidity

An exploratory and descriptive research was conducted by the author to verify how System Dynamics may be applied to Asset and Liability Management (ALM) in order to manage, in a systemic approach, the information of risk factors in Pension Fund assets and liabilities management processes.

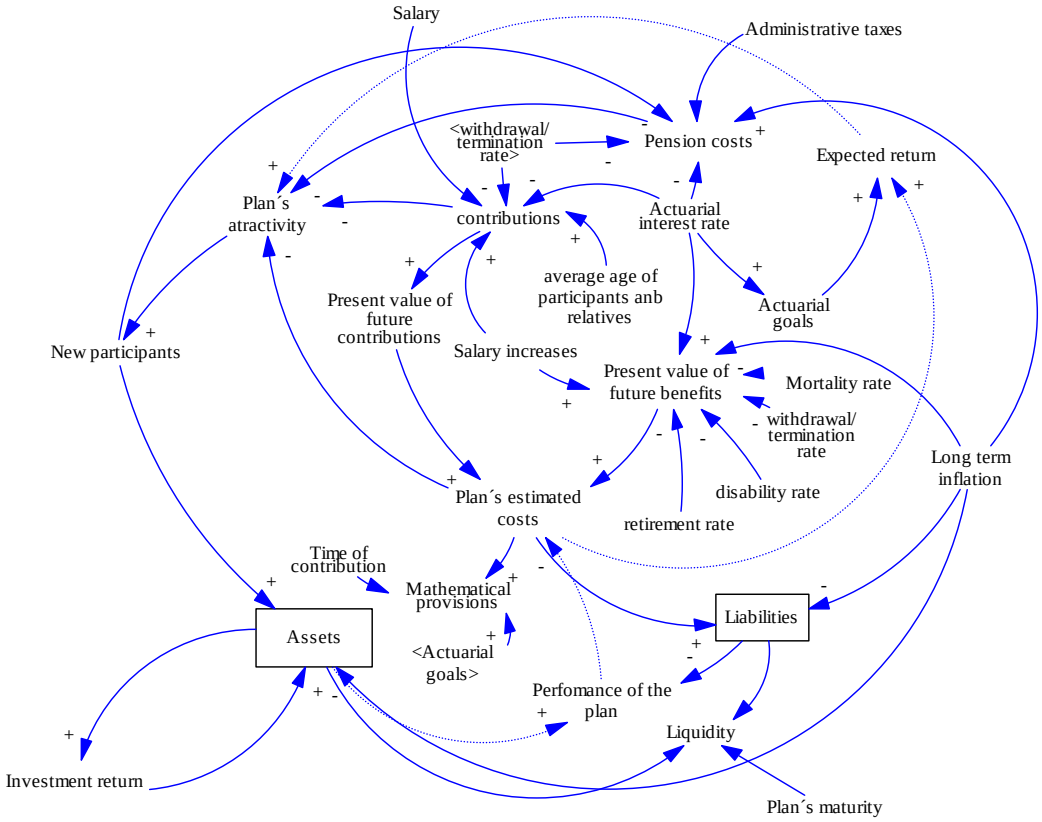
Twenty-five Brazilian pension funds were picked out of 313, in order to supply actual required data. Their characteristics were described, risk factors used by ALM were identified to describe their information management and to represent their cause and effect relations. Financial managers were interviewed and, by the application of Delphi technique, questionnaires were submitted to actuaries. Based on their opinion, the portfolio’s systemic dynamic administration of assets was

represented in order to get a function of their expenses and the actual and future payments of the retirements. As stated by (SANTOS, 1992),

> to use computational based models it is necessary to define world in terms of variables ... “To imagine the world in terms of variables, to understand rates of change, to think at a system level and to understand causation in a system.

Thus, appendix 1 shows the factors identified by the research, their inter-relation and causation between variables. Based on it, data were collected and complexity and causation between variables were represented at figure 1 to a generic pension fund.

Figure 1: Actuarial factors and their interrelationship in an ALM Model



Risk factors attempt to maximize the benefit or minimize the loss for the amount of uncertainty assumed. There are many actions based on a forward-looking statement that involves risk and uncertainty. The risk factor may be related to a particular pension fund or to the segment as a whole. Risk analysis may differ to risk management because the latter must consider the inter-relationships among operations, investments and financing, each carries risks alone: operations drive revenue and expense; investments assure wealth growth, discounted costs; and,

financing are related to how the organization is capitalized and how to manage market risks.

Risk, risk analysis and risk management are different and inter-related concepts. The former needs to identify and detail the events and their impact over the organization. The second need to quantify their impacts over business and use historical information, scenarios analysis and previous behavior to estimate it and predict future consequences. The latter, require plans and discussions by decision makers about business strategic perspective. Therefore, it is important to consider:

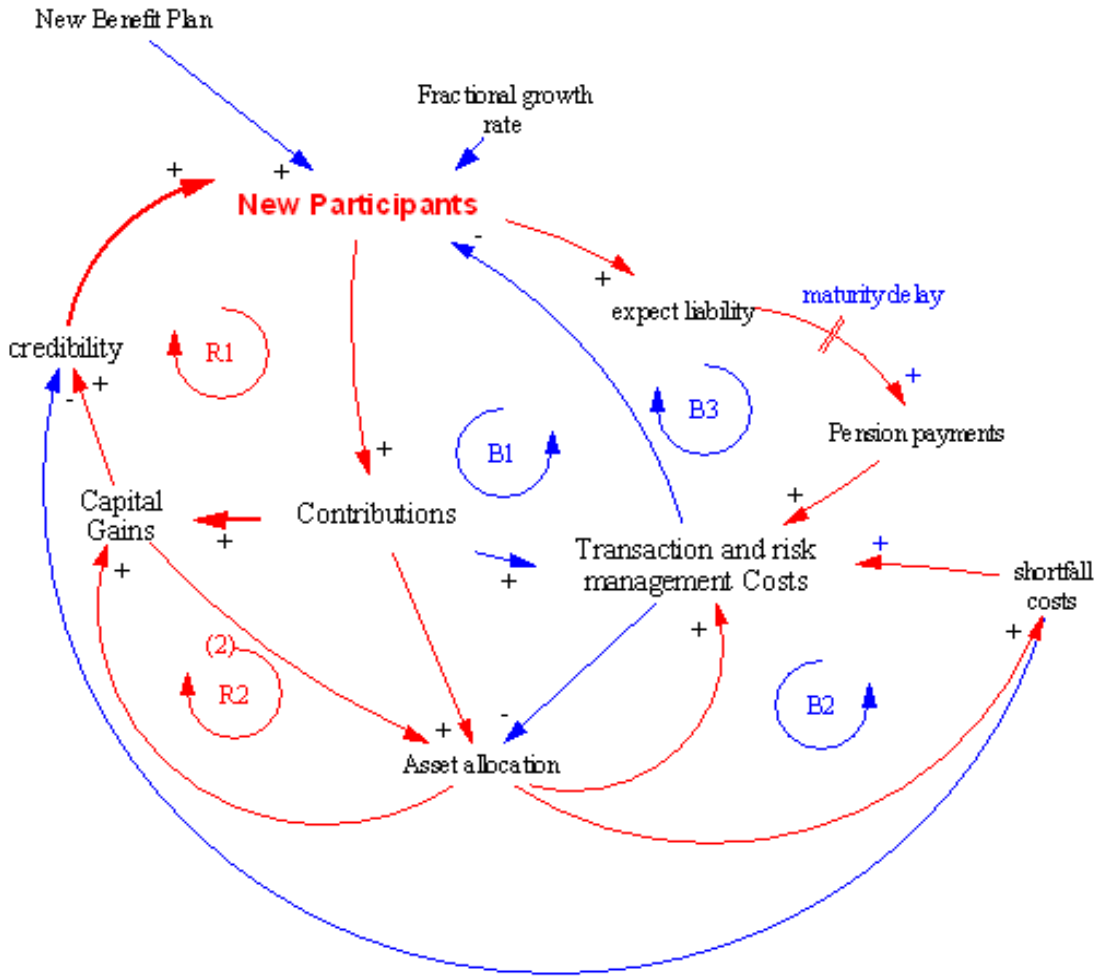
- It's necessary to structure many dynamic hypothesis based on risk events. They must be modeled as causal loops to better predict their impact over the system and to encourage people to identify the elements of dynamic complexity normally absent from mental models;

- The liabilities and shortfalls must be managed. The structure of the system (and thus their behavior) must be represented in SD mental model. Shortfall means controls over the uncertainty and a way to control variances. By computing the amounts out of the estimates, they act like constraints imposed to the model and become a way to quantify it;

- The scenarios must consider the complexity of the system and their implications. SD simulations may be a good way to determine the probabilities and to test their impact over a quantified risk factor.

Thus, figure 2 shows the dynamic of implementing new benefit plans and the organizational processes involved. Each new participant represents a deposit income. The future cash flow must be projected and is associated with each account. The liability management decisions must consider the uncertain outcomes of events relevant to the company's business environment: regulation, multiple accounts, multiple horizons for different goals, provisions for end effects, the uncertainty of future assets and liabilities.

Figure 2: The dynamic of implementing new benefit plans



R1 – Credibility is a subjective factor that takes place as assets management treats well market volatilities and generate more capital gains. Good governance and internal control practices gives more maturity to pension fund processes.

R2 – Accumulation is the situation where money produces money. Capital gains means more money to invest.

B1 – Costs and risks. There are many expenses and it may decrease the amount of money available to investments. Also, if there are many costs it may influence the rates of new participants.

B2 – Shortfall costs the way to materialize different kind of risks.

B3 – Benefit payments describes the process accumulating the funds and paying the payments. It include the control of liquidity and the solvency of the pension fund..

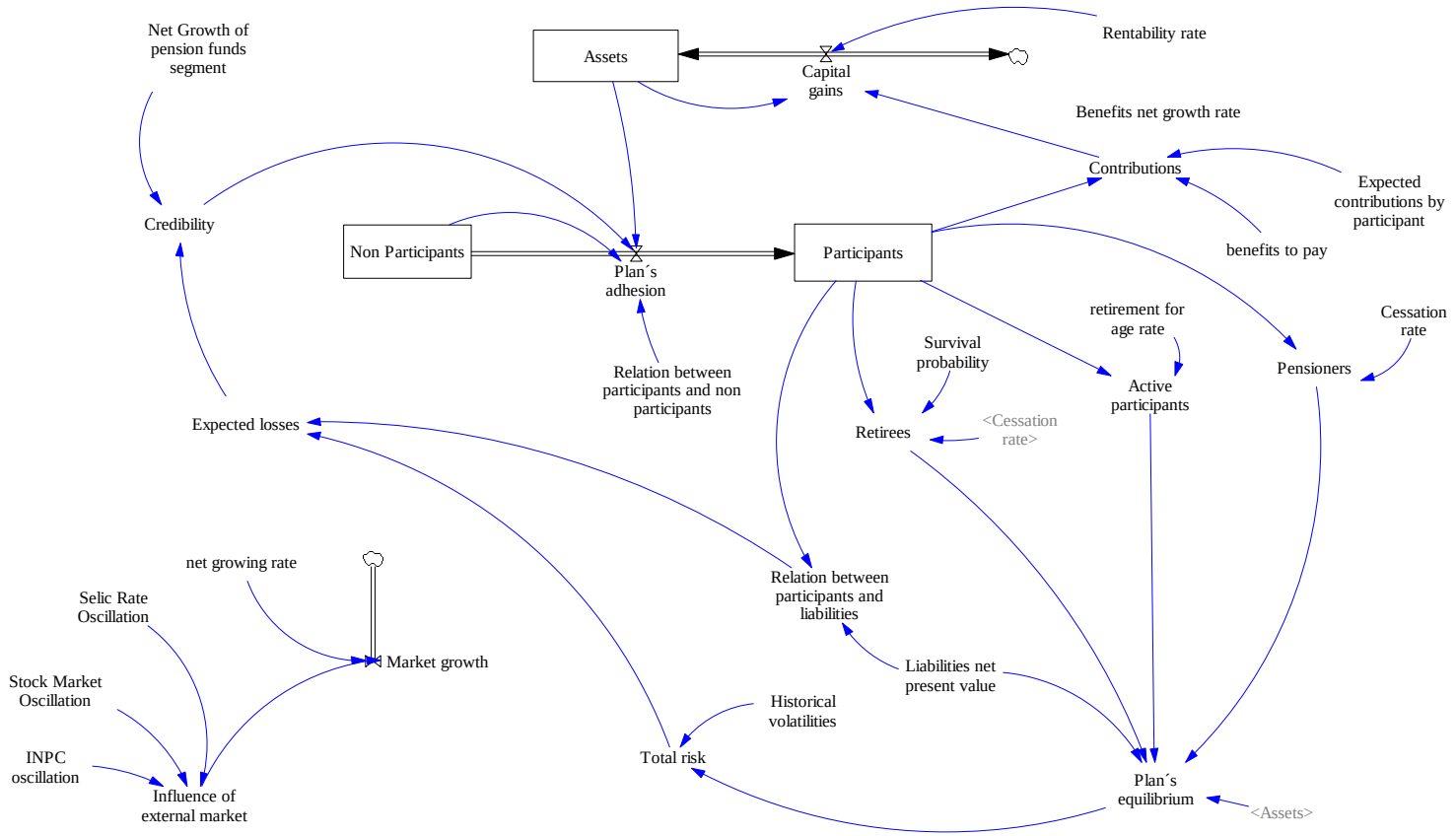
Loop R1 and R2 reflect exponential growth and represent the expected Pension Funds `power` of accumulating income over time. If the asset allocation is not efficient it can generate fewer capital gains, which may affect the pension fund credibility.

The literature recognizes ALM as a bottom-up model and, consequently, needs a great amount of information and that have traditionally been used for investment analyses. Uncertainty is usually addressed by a baseline, an optimistic and a pessimist scenario assigned with likely occurrences and many probabilities even liabilities one. Once identified the average and variability and the probability distributions that may give a good description of the stochastic processes governing the pension fund, as liabilities and the allocations may move between high and low scenarios over time.

The better and the more pro-active a risk management program is the better the asset allocation, which implies in more credibility to pension fund. The worst it is, more costs it may generate, affecting credibility. Fewer participants mean less wealth.

Figure 3 shows a conceptual model that can represent the dynamic of transforming potential participants in participants. The model represents Pension Funds' mission expressed by Boulier et al (1996) as an important principle: "Workers and sponsors' pay contributions to a pension fund, which invests them over a very long period of time and releases them when the workers retire, in the form of pensions".

Figure 3: Stock and flow conceptual diagram including risks restrictions



As stated by Winklevoss (1977, p. 10), “Pension plan participants in active service are exposed to the contingencies of death, disablement, early withdrawal from employment, and retirement, while nonactive members are exposed to death”. So, figure 3 shows that an equilibrium by assets and liabilities may be accompanied by a liquidity ratio.

Liquidity ratios of an organization have the aim to measure its ability to meet its contractual commitments fully. Liquidity Ratios are ratios that come off the Balance Sheet and hence measure the liquidity of the company as on a particular day i.e. the day that the Balance Sheet was prepared. These ratios are important in measuring the ability of a company to meet both its short term and long term obligations. At least two kinds of liquidity must be controlled on a pension fund:

(a) First liquidity ratio: Divide the total current assets of a company by its total current liabilities. The ratio is regarded as a test of liquidity for a company. It expresses the 'working capital' relationship of current assets available to meet the company's current obligations.

Current Ratio = Total Current Assets/ Total Current Liabilities

(b) Second liquidity ratio (debt to equity ratio): The ratio measures how the company is leveraging its debt against the capital employed by its owners - participants and sponsors in a Pension Fund case. If the liabilities exceed the net worth then in that case the creditors have more stake than the shareowners.

Debt to Equity Ratio = Total Liabilities / Owners Equity or Net Worth

Rodrigues (2004) establishes that the value of mathematical provisions of benefits to be paid of a participant with age x is represented by the equation RMx = VABFx – VACFx and its value will be:

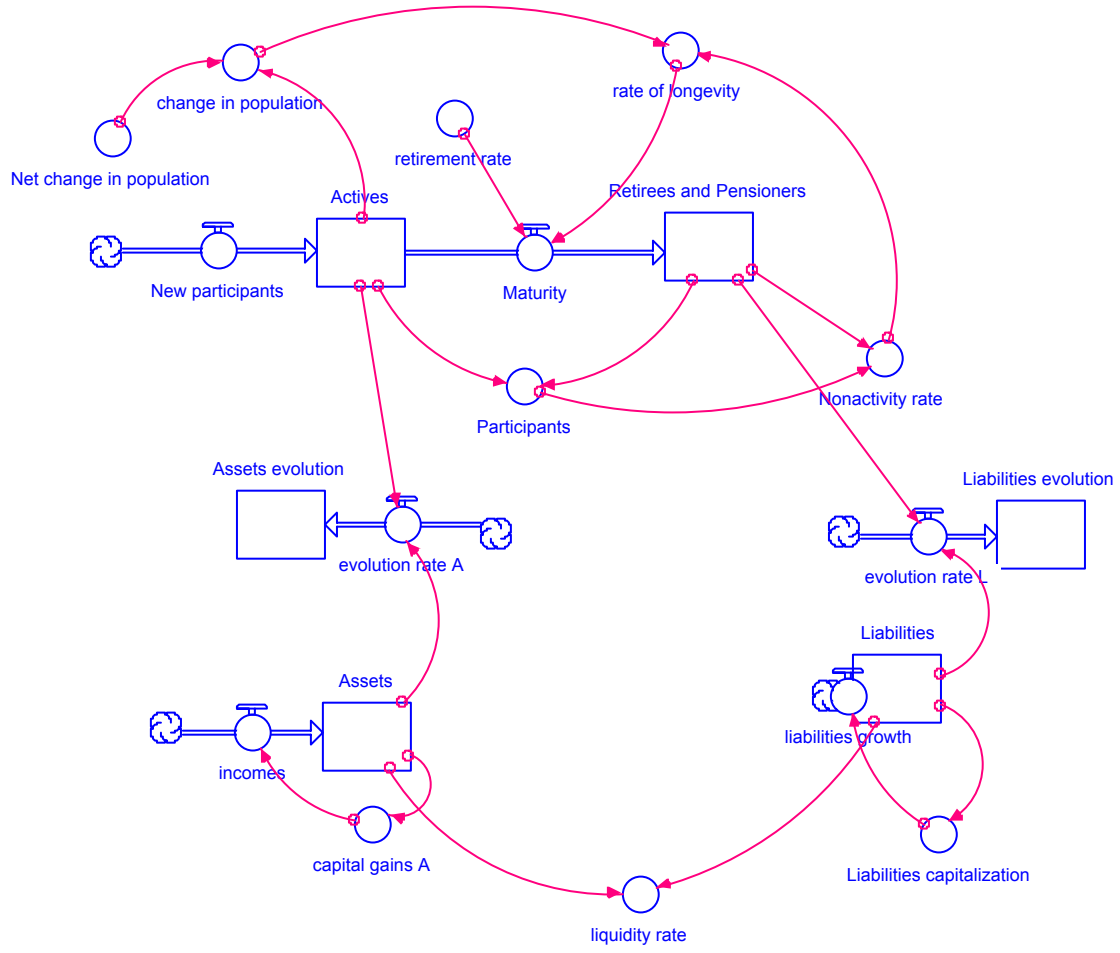
$$RM_x = FCS.[S_x.(1+CS)^{r-x}._{r-x}p_x^{aa}.\ddot{a}_r.v^{r-x} - (S_{x\to r}.CN(\%).\ddot{a}_{x:r-x}\neg]\{x<r\}$$, where

The uncertain parameters identified by Rocha(2001) are interest rates, administrative taxes, capacity factor of salaries and benefits and the rates of increase of salaries. After assigning maximum and minimum values along with a random distribution over which to vary them to see their impact on model behavior. One parameter, since like interest rates, could be selected to see how sensitive model behavior is to one parameter.

Stochastic differential equations have been used to solve many problems in pension fund stochastic lifetime studies and tried to describe the factors that must be considered to better manage a pension fund. System dynamic model must represent a way using historical data to fit statistical parameters by using calibration or reality check techniques.

A key feature of dynamic systems is the ability to do multiple simulations on a model under different conditions, test the impact of different policies and predict the side effects and the reactions provoked by many decisions over the system. Although that was not an aspect explored in this article, it is possible to consider a model enhancement that would generate an efficient set of alternate balance sheets. It will be possible to explore the price of risk associated with the trade-off between investment and underwriting opportunities. Regulators, by contrast, would be able to observe useful information about the firm's ability to mediate risky managerial decisions and risky economic environments. Figure 4 shows population dynamics and its influences over liquidity control.

Figure 4: The dynamic of population influences of assets and liabilities and the control of the liquidity



The difference between defined contribution and defined benefit plans is the lower cost of the former because of losses sharing among participants. There are many risk factors for each of these situations. SD methods may aid to simulate these particularities.

There are many particular risk factors that explain the system behavior since a defined benefit plan reaches maturity. As the number of active participants decrease and pension payments increase, it becomes more important to hedge against liquidity risks. The complexity of maintaining the Pension Fund solvency in this stage implies to obtain more interest return. ALM served an important role in eliciting requirements to better elaborate benefit and investment plans' or to review the predictions underlying choice preferences. It had a significant impact on the structure and parameterization of the final simulation model.

In order to analyze a business decision problem, it is necessary to compute the distribution or expectation of a function, use a probability diagram to decompose a problem into separable problems and identify a set of conditional distributions that explains variables being modeled.

6 Conclusions

Many authors recognize that ALM is more art than science and is a developing area of practice. System dynamics may provide important tools to actuaries and financial managers as well as the board of directors and administrative council. In Brazil, because the stability of the economy, ALM is growing and technicians in a pension fund is expanding their knowledge base to do more work in it. Accordingly to the promise a pension fund does, they are trying to foresee or forecast asset adequacy, maintain it segregated and diversified and connected to the evolution of the liabilities.

ALM is not yet a top priority of management and there is a lack of efficient dynamic models that may represent long-term liabilities and the risks involved. Some assumptions and practices must be well documented, quantified and understood in order to better manage the communication between the board of directors, the administrative council, actuaries and financial managers to assure that PF politics may be well managed.

There are many ways to do ALM. In a portfolio basis, people can approach ALM from the balance sheet liability side, from the asset side where the portfolio is easier to adjust than the liabilities or from credit strategy point of view. Because it is management, the practices revealed that actuaries must be involved in assets portfolio allocation decision and must manage assets and liabilities much more closely with financial managers and cooperate more to each other.

Concerns to better manage corporate governance are changing this kind of organization and their management practices. Informational systems are evolving and become to inform about how to manage the liabilities and assets, and how to coordinate them. The assets allocations decision must be based on many scenarios and on a liability appraisal, which can give hypothesis about investment returns and the liabilities behavior. Annuities must be managed by realistic rates

that reflect compensations in the short run. Securities and other hedge options for the assets must be considered on the board members level.

The need to anticipate the regulatory environment, and factors movement lead to dynamic models that may show in a stochastic way their risks characteristics and may anticipate some issues that are likely to evolve. The portfolio must be managed against relevant benchmarks that must reflect yield targets, spreads, convexity, duration, quality and liquidity.

Stochastic liquidity processes should:

- Reflect the short-term cash flow movements, representing the asset and liabilities values;
- Exhibit some long-term mean reversion characteristics, reflecting the solvency of the pension fund and the equity equilibrium;
- Utilize available market data from market models and methodologies that express volatility;
- Maintain possible cross-correlations between other sources of stochastic variables and actuarial influences of deterministic factors;
- Reflect long-term uncertainties

The mathematical relations between dynamic asset and liability model variables must consider different risks according to different maturity stages of a pension fund.

Because most decisions are made without advance knowledge of their consequences, it is sometimes still difficult to a manager to obtain precise information on the right timing at a low cost. This way, heuristics have been made based on tacit business knowledge.

As we see, causal thinking may be used to identify risk factors and quantify their impacts on the system. The basic modes of behavior in system dynamics like exponential growth, goal seeking, and oscillations created by positive or negative feedback with time delays or not, are potential sources of risk that may be considered in an ALM analysis, amplifying it capability to be not just balance-sheet but also a risk oriented approach.

Since the decisions under uncertainty become complex, specially because the low comprehension of the long term best interests of the system as a whole, it is possible to say that ALM combined to SD methods is useful to provide an holistic overview to the analysis of a pension fund liquidity and to forecast and foresight different scenarios. Thus ALM may help managers to improve their skills to consider complex, driving the formulation of better business strategies.

Stochastic liquidity analysis may provide a way to manage liquidity risks in many scenarios. The crucial feature here is the extent to which the information of the liquidity corresponds to the compromises of benefit plans. Maturity phase is totally

liquidity constrained. At accumulation phase, a participan may prefer to save even more and supplements the mandatory savings with additional free savings.

In maturity phase people prefer not to save at all, his rate of time preference is extremely high; future income is practically of no value for him. Actual workers are a mixture of the two, both in person and in distribution. Young workers may be relatively shortsighted, and seriously liquidity constrained, so that the second model dominates. Old workers are close to retirement, more mature, and less liquidity constrained so that the first model might be more relevant.

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Appendix 1: Factors identified by the research and their inter-relationship.

	Actuarial interest rate	Actuarial goals	Performance of the plan	Plan´s estimated costs	Mathematical provisions	Pension costs	Contributions	Salary increases	Administrative taxes	Long term inflation	Rates of mortality, with-drawal, disability and retirement	Salary	Expected return	Plan´s maturity	New participants	Average age of participants and relatives	Time of contribution	Plan's atractivity	Investment return	Liquidity	Total
Actuarial interest rate	0	1(+)		1(-)		0	1(-)	0										1(-)			4
Actuarial goals													1(+)								1
Performance of the plan																					
Plan's estimated costs		1(+)		0									1(+)								2
Mathematical provisions																					0
Pension costs						0															0
Contributions				1(-)	1(+)		0														2
Salary increases			1(-)	1(+)	1(-)	1(+)	1(+)	0					1(+)								6
Administrative taxes									0												0
Long term inflation				1(-)		1(+)				0									1(+)		3
Rates of mortality, withdrawal, disability and retirement				1(-)	1(+)						0									1(+)	3
Salary												0									0
Expected return													0								0
Plan's maturity														0							0
New participants			1(+)	1(+)	1(-)	1(-)					1(+)		1(+)		0					1(+)	8
Average age of participants and relatives			1(+)	1(-)																	2
Time of contribution					1(+)																1
Plan's atractivity																		0			0
Investment return			1(+)	1(+)		1(+)	1(+)												0		4
Liquidity																					
Total	0	3	4	11	7	6	4	0	0	0	1	0	5	0	0	0	0	2	1	0	

Work supported by FINATEC. Acknowledgments to Brazil chapter of Dynamic Systems, DATAPREV, Getulio Vargas Foundation and University of Brasília.