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ALM in market risk management

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ABSTRACT

Asset-liability management is the continual process of defining, implementing, monitoring and reviewing of the strategies regarding the balance sheet items with the objective of reaching the financial goals while considering the given risk attitude. Its ultimate goal is to preserve and enhance the shareholder value. There are several asset-liability management models used in practice. The objective of this article is to introduce and to classify the basic methods of asset-liability management.
(Keywords: asset-liability management, duration, optimisation)

ALM a piaci kockázat-elemzésben

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Összefoglalás

Az eszköz-forrás menedzsment a vállalati mérlegtételekkel kapcsolatos stratégiák megfogalmazásának, implementálásának, monitorozásának és felülvizsgálatának ismétlődő folyamata, melynek célja a pénzügyi célok elérése adott kockázatviselési hajlandóság mellett. Végső célja a tulajdonosi érték megtartása és növelése. A gyakorlatban számos eszköz-forrás menedzsment modell használatos. A cikk célja az eszköz-forrás menedzsment alapvető módszereinek bemutatása és rendszerezése.
(Kulcsszavak: eszköz-forrás menedzsment, átlagidő, optimalizálás)

INTRODUCTION

The basic idea of **asset-liability management** (ALM) is due to *Redington* (1952) who proposed the holistic treating of assets and liabilities in evaluation and the determination of the strategy, and suggested the adaptation of duration and immunization[1]. Asset-liability management is the continual process of defining, implementing, monitoring and reviewing of the strategies regarding the balance sheet items with the objective of reaching the financial goals while considering the given risk attitude. In some ways it is a part of the corporate risk management[2], as stated by a number of authors, although it also exceeds it as well considering its value-based and strategic aspects.

[1] More on the subject in: *Karvalits and Kálmán* (1994). On asset-liability management for banks, its development, basics and on the measurement and handling the interest rate risks see: *Ligeti and Sulyok-Pap* (1998).
[2] According to *Ong* (1998) the ALM is the most important function of corporate risk-assessment, Society of Actuaries (2003) also defines it as the part of the corporate risk management.

The basic aims of asset-liability management are as follows[3]:

- The retention and expansion of the **shareholder value**.
- The quantification and analysis of the **risks** of the balance sheet.
- To support the **reserve** management.
- To support the **liquidity** management.
- To determine the optimal **capital structure**[4].

An ultimate and most important goal is to preserve expansion of the shareholder value, all other goals are subordinate and only appear as subgoals to this one.

There are many asset-liability management models in the practice. *Bradley and Crane* (1972) created a stochastic linear programming model for banks. *Kusy and Ziemba* (1986) developed a multiperiod, 5 year planning horizon linear programming model for the Vancouver City Savings Credit Union, which was proven to be better than the deterministic model. *Carino et al.* (1994) developed a multistage stochastic programming model for Japanese insurers, which is known as the Russell-Yasuda Kasai model. This model resulted in 79M $ extra profit in the first two years of its introduction (1991 and 1992). *Mulvey* (1994) developed a model for the Pacific Financial Asset Management Company. *Boender* (1997), and *Boender et al.* (1998) created a hybrid simulation / optimization ALM model for Dutch pension founds. For one of these founds the annual profit increased with more than USD 100 million.

The objective of this article is to introduce and to classify the basic methods of asset-liability management. We will use a basic classification according to both **static** and **dynamic** methods. As dynamic methods are considered we will make the subdivisions **passive** and **active** processes, and as active processes are considered we will further divide it according to if they are **value** or **return** driven.

STATIC METHODS

The static methods of asset-liability management have the assumption that balance sheet and cash-flow data are fixed, and will not change even in the future. Normally they only cover for risks of **small changes**. Even though this assumption is clearly unrealistic, we will introduce the possible problems of these methods in the next chapter.

The most important static asset-liability management methods are:

- Cash flow payment calendar;
- Gap analysis;
- Segmentation;
- Cash flow matching.

The **cash flow payment calendar** is widely used and applied in the practice. It shows the daily, weekly, etc. cash incomes and expenditures. It helps the applier to detect the period of financing demands or surpluses, and provides with a guideline for **investing** the liquid assets. Prior to applying we need to be sure that a significant part of the cash-flow can be well planed as for expiration as well as for the volume[5].

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[3] Based on *Ong* (1998). *Albrecht* (2001) in opposite comes up with only two aims: financial stability and profitability.

[4] According to a study of the Canadian Institute of Actuaries (2002) ALM is not only used for interest rate risk management. Most of the questioned companies also use it for liquidity, credit risk, stock market risk and foreign exchange risk management.

[5] More on the method see: *Ostaszewski* (2002). You can find a dynamic model in: *Szarvas* (1998).

Gap analysis is mostly used by the bank sector. It helps us to analyze the effect of the **interest-rate changes** on the profit. The definition of the gap is the difference between the interest-sensitive assets and the interest-sensitive liabilities calculated for given maturities. Some companies calculate the gap rate instead of the gap, which show the relationship between the amounts in a quotient form instead of a difference form. According to the theory a positive gap or a gap rate larger than one means that an upward shift of the yield-curve results in more income on the asset side than expenditure on the liability side when renewing the fall-due items[6], so the profit for the analyzed – and also for the later – periods are increasing. A downward shift of the yield-curve decreases the profit of the given period and also the long term results. In case of a negative gap or a gap rate less than one we have opposite effects. If the gap is zero – this means a gap rate is equal to one –, the changes in the yield curve does not affect the profitability, in theory.

As we can suspect in **practice** the gap analysis does not always work as theory forecasts. One of the reasons of inconsistency is that even for similar maturities we can not be sure that the degree of the yield changes will be similar for two balance sheet items at given changes of the interest rate – let's think of the differences in risk or the possible options embedded in the items, such as the effect of the possibility of an earlier redemption. Another reason could be that this method would not count for the changes in the value of the equity, so the effects of the prices of the balance sheet items caused by yield-curve changes, which is also important from a practical point. Third, it only examines the changes at a given time point and is unable to consider the dynamic effects, such as multiple interest rate shifts[7].

Segmentation is best suited for insurance companies[8]. We categorize the liabilities of the firm and then we **match** a group of asset to each category. Doing this we try to guarantee that the matched assets have similar features as the liabilities. This method is fairly simple and general, but because of these hard to adopt in practice, apart from direct applications like unit-linked products[9].

The following method is illustrated in *Figure 1*.

In theory **cash-flow matching** can rule out all the risks of the financial negotiator. As a first step we estimate all future cash-flows generated by the liability side. As the second step we create an asset portfolio which generates **exactly** the same cash-flow both in volume and maturity. Using this method we certainly need to consider the value of our existing assets[10]. This method can be seen as an expansion of the cash flow payment calendar or the gap analysis, since it terminates all cash flow differences and gaps. But while the above models are only descriptive, cash-flow matching is a normative one[11].

The main **problem** of the practical application of cash-flow matching is the accuracy of the cash-flow forecasts on the liability, but even more on the asset side. Another problem is the identification of the cheapest adequate asset-portfolio. Further

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[6] Supposing a parallel yield curve change the periodical additional profit is Gap * Δr.

[7] More on gap analysis see: *Smink* (1995).

[8] According to *Schroeder* (2000) 25% of the German insurers use this method in their ALM.

[9] One variant of this method is the investment-generation, when we match such assets only with the new liabilities of the period. Another variant of it is transfer-pricing, where the process happens through an ALM-profitcenter. More detailed see: Society of Actuaries (2003).

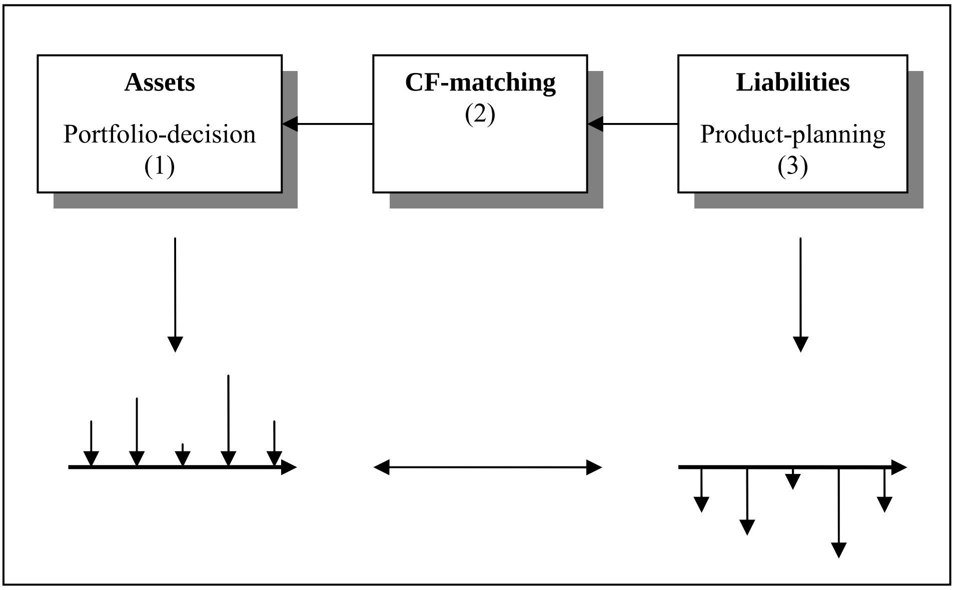
[10] Here we have a linear programming problem, where the bounds are wealth and investment related.

[11] According to *Schroeder* (2000) 50% of the German insurers use this method in their ALM.

problem can be the low product availability of the money- and the stock-market[12], the lack of liquidity and the non zero non-payment risks[13].

Figure 1

The pattern for cash-flow matching



Source (*Forrás*): According to *Rosen and Zenios* (2001) (*Rosen and Zenios* (2001) alapján)

1. ábra: A Cash-flow összefüggései

Eszközök, portfolio döntések(1), Cash-flow(2), Követelések, termék-tervezés(3)

For the above reasons companies do not force the matching, they only apply the so-called **dedication**. This method is mostly used in cases when there are no appropriate assets for the exact matching, or the appropriate assets are too expensive. In this case the liability cash-flow is only **approximately** reproduced on the asset side. All other assets are invested in a way to keep their duration shorter than that of the liabilities. This also secures a high probability of liquidity in the worst case scenario.

DYNAMIC METHODS

Dynamic methods are similar in the assumption that the decision maker does not take his decision for a single act to be made only at the beginning of the period, but a dynamic problem that needs to be solved **continuously**. Because of this the following methods try to preserve the value of the company in case of multiple and larger changes also.

[12] For example one cannot buy all possible Arrow-Debreu securities.
[13] More detailed see: *Ostaszewski* (2002).

Dynamic methods are divided into three subgroups. The **passive** methods, which are all value-driven[14], are some kind of immunization, and try to synchronize some features of the assets and the liabilities. The **active** methods are much more flexible. They enable active trading based on the decision-maker's expectations. The **value driven** methods use value indicators, while the **return driven** methods return indicators in making the trading decisions.

Passive value-driven methods

These methods are dynamically minimizing the risks caused by the differences of the asset- and the liability structure.

The main passive value-driven methods are[15]:

- Duration;
- Partial duration;
- Key rate duration;
- Model dependent duration;
- Option-adjusted spread;

Duration is one of the most common techniques used in asset-liability management[16]. Frederic Macaulay at Berkeley[17] and John Hicks at Oxford[18] made their research separately, on how changes of the yield affect the bond prices. With a simple derivation the duration formula emerged. The basic idea of this method is the matching of the interest rate **sensibility** of assets and liabilities, so the matching of the partial derivate according to the yields[19]. The formula of duration is, as follows:

$$-(\Delta P / P) / \Delta r \qquad (1)$$

In the formula P is the price in T = 0, ΔP is the price-, while Δr is the yield-change[20]. This method is really dynamic. This is proven by the fact that as time passes, both asset and liability durations changes, and usually not by the same amount.

One shortcoming of this method is that it supposes perfect information on future cash-flows, while in reality both the volume – like the dividend of shares – and the

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[14] Although among the passive methods value- and return-drivenness makes no difference, in practice this label made the standard, since the basic aim of these models is to guarantee the equality of the asset and the liability values at the end of the planning horizon.

[15] Beyond what is given some use dollar – or some other currency – duration, which shows the dollar change of the value of the product for the one percentage point yield shift, some other the redemption-, spread-, swap-, and the stock duration, as in: Society of Actuaries (2003).

[16] According to the Canadian Institute of Actuaries (2002) this is the second mostly used ALM technique right behind the deterministic scenario-analysis for Canadian insurers; *Weinsier* (2002) points to the research by *Tillinghast* (2001) according to which 64% of the companies are using this method.

[17] See: *Macaulay* (1938).

[18] See: *Hicks* (1939).

[19] In ALM duration was firstly applied by *Redington* (1952). His results were not really used in practice for about 30 years, because of the stability of the yields. A similar topic was considered by *Samuelson* (1945).

[20] This is one way of calculating duration, the so called Macaulay-duration; the other, so called modified duration is equal with the Macaulay-duration divided by (1 + r).

timing – let's think of the prepayment option – can vary[21]. It also neglects the non-payment risks. Further problem is that it only deals with small changes of the yield-curve[22], and only for parallel shifts[23].

The **partial duration** is able to manage the risks of non-parallel shifts in the yield-curve. Here the yield is only changing for a **part** of the curve, and the percentage changes of product prices are analyzed. The formula of partial duration is as follows:

$$-(\Delta P / P) / \Delta r_i \tag{2}$$

In the formula P is the base price, ΔP is the price-, while Δr_i is the yield change in the examined parts of the yield-curve. With this method we can examine the effects of the changes in the **shape** of the yield-curve on the value of the equity. If we divide the whole yield curve into sections then the sum of the partial durations is equal with the traditional duration. Although this method gives much more information than the traditional duration, it still unable to consider the non-payment risks, is only applicable for small yield changes, and can hardly be used for the analysis of path-dependent, structured products.

The **key-rate duration** is closely related to partial duration. This method is introduced by *Reitano* (1991) and *Ho* (1990). The yield-curve is again divided in maturity sections, and for each of them we specify a key-rate[24]. Then the yield-curve is **interpolated** by linear functions of the key-rates. We get the key-rate durations as partial derivates of the price of the product by the key-rates.

Although by having a growing number or key-rates we can manage more and more types of yield-curve changes, this method also can not handle the non-payment risks[25].

Using the previous two methods there is a chance of over insurance of the liabilities. This means that we also match such partial derivates, which – apart from the other derivates – could not change according to our opinion or to the observation of the market. With the **model-dependent duration** we can lower the costs of these over insurances, in a way that we only manage those risks that we consider as real[26]. The cost of this advantage is that – opposite to the previous methods – here we have to determine the **stochastic process** of the yield-curve first. The model-dependent duration is given by the sensitivity of the price of the product for minor changes of the parameters of the yield-curve. The immunization is done in a way to match the model-dependent durations of the assets and the liabilities. Out of all above models this has the greatest efficiency if the supposed stochastic yield-curve process is correct[27].

A notable advantage of the method is that the valuation of the products and the optimization is done by the same yield-curve model. Further advantage is that it can be

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[21] Independently from the interest rate changes.

[22] *Ostaszewski* (2002) proposes the consideration of more Taylor-series elements as a solution, which we can't completely agree with, since this method is also only able to reproduce the function in a small surrounding.

[23] See more detailed *Vanderhoof* (1972), *Babbel* (1995) and *Babbel* (1999). The topic of duration, convexity and immunization is to be found in: *Mikolasek* (1996), and *Száz* (1999).

[24] For example 3 months, 1, 5 and 10 years expiration.

[25] A practical realisation of key-rate duration can be found: *Mikolasek* (1998), and *Mikolasek* (1999).

[26] The method is developed by *Cox, Ingersoll and Ross* (1985).

[27] According to Smink (1995) on finite model-tree a perfect hedge can be done with this method; in reality there is no guarantee for this, since the equation system to solve could be contradicting.

applied for more complex, option dependent products also. Using this model for immunization can particularly be disadvantageous if the parameters for the model are chosen incorrectly. Even choosing the right parameters does not always a guarantee the efficiency of the model, especially when the parameters aren't stable in time[28].

Another yield curve based model, which is also applicable for products containing financial options, is the **option-adjusted spread** method, which is developed by *Herskowitz* (1989). It was first applied for mortgage-papers to analyze the effects of an early redemption. The basic feature of the method is the calculation of the **surplus yield** which is paid by the paper containing an option compared to a risk free paper. This extra yield can be calculated from the yield-tree based on the actual futures yields and the implicated volatility. The option-adjusted spread is that extra yield, with which the yearly yield of every scenario has to be raised to make the expected discounted cash-flow equal with the present market value. This yield premium is the fee of the option contained by the security. The goal of the decision-maker is to equalize the sensitivity of the assets and the liabilities for this spread, and so dissolve the risks of volatility- and credit rating changes.

A general **problem** of all duration oriented methods is that the values in different currencies can not be added up, or even compared – since duration would only apply for a given currency. Besides most duration based models aren't able to handle products containing options, also they only measure local sensitivity, so the effect of major changes in factors can not be immunized.

Active value-driven methods

The passive methods are fairly inflexible. There is only one existing strategy for the decision-maker and this is the complete immunization. This way there is no room to utilize her expectations towards the market into a profitable trading[29]. The methods discussed next provide an **active** asset-liability management, which is combined with an insurance-like boundary to lower the effects of unfavorable price-, rate-, or yield changes.

The major value-driven methods are:

- Contingent immunization;
- Portfolio insurance;
- Constant proportion portfolio insurance;
- Pay-off distribution optimization.

The practice of **contingent immunization** is based on the works of *Leibowitz and Weinberger* (1982, 1983). The main point of the method is that the portfolio-manager can only follow an active trading until the value of the equity drops to a previously determined **minimum**. If this occurs, full immunization is needed to hedge against further drops in equity. The only requirement of the method is liquidity[30] when we are forced to stop active trading[31].

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[28] *Hull and White* (1991) suggests the combination of the model with the key rate duration in practice.

[29] As *Albrecht* (2001) states, for the usual ALM-techniques, like the dedication and the immunization the main point is stability, and the aim is to eliminate all risks possible, so the institutions applying these methods will have less expected profit, than their competitors.

[30] Both financing- and trade-liquidity are important.

[31] Since this mostly happens on bear markets, so in practice liquidity is most needed when one has the greatest liquidity problems – see f.e. the case of LTCM.

The theory of the **portfolio-insurance** is based on *Leland and Rubinstein* (1981). *Black* (1988) improved it further. While at the contingent immunization the active and passive trading was strictly separated in time, at this method they exist parallel. The decision-maker can follow an active trading all the time, while a **put option** gives the same downside insurance, what the passive trade has given at the previous method – namely not to have the value of the equity fall under a given minimum. The option can be either bought or synthetic. For a complex asset-liability portfolio, it requires a sophisticated model to know that for which product and at what strike price we need to buy options[32]. If we choose to use a synthetic option[33], liquidity will become a central issue for us again.

The basics of the **constant proportion portfolio insurance** were laid by *Black and Jones* (1987)[34]. According to this method, predetermined **proportion** of the asset-portfolio is kept in risk-free investments. This is the reserve. All assets besides this reserve are actively traded. While using the previous methods the lack of market liquidity at some points can cause the value of the equity to fall bellow the declared minimum, this technique rules out this possibility[35].

Pay-off distribution optimization, introduced by *Cox and Huang* (1989), while *Dybvig* (1988a, 1988b) and *Smink* (1993) developed it further, is a **dynamic stochastic programming** formulation of the decision-makers problem: how can one build an optimal investment portfolio which matches the decision-makers preferences? The method can be used for any risk preferences. Besides this it can handle different scenario distributions than the implied ones. The first step of the method is to determine the most favorable pay-off distributions according the liabilities and the decision-makers preferences. As a second step an asset-portfolio is to be built up, that fits this kind of pay-off distribution the most. Precise determination of the yield-curve model and liquidity are also crucial using this method.

Active return-driven methods

In the previous subchapter the driver of the active trading strategy was a value-based indicator. Within this subchapter we will review those active trading strategies, which have a **yield-based** indicator.

The most important yield-driven methods are:

- Spread management;
- Realized return optimization.

Spread management is the sophisticated version of the bankers' well-used golden-rule: get a loan on five percent and grant it as credit on ten percent. This method divides the liabilities into groups. Then it specifies an asset-portfolio for each liability group, which portfolio provides a **greater return** than the return of the liability group. Two important tools of this method are the previously mentioned option-adjusted spread and the spread-duration[36].

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[32] On this topic more detailed see: *Zhao and Ziemba* (2001).

[33] This decision could depend on if there is no traded option for the given product or duration or if there is an option but the market doesn't have the right liquidity or the strike price is not adequate or the market misprices the option.

[34] Here we have to mention the works of *Perold and Sharpe* (1988), also *Black and Perold* (1992).

[35] However, the value of the equity can drop bellow the minimum for other reasons, like a raise in the yield of the „risk-free" asset or a bankruptcy of the emitter.

[36] See in detail: *Ostaszewski* (2002).

The **realized return optimization** worked out by *Miller, Rajan and Shimpi* (1989) divides the decision-maker's role into **4 steps**. As the first one, she determines the number of scenarios in the model. Secondly she calculates the return for all liabilities for each scenario. Then she calculates the return for some previously determined asset-portfolios for the same scenarios. Finally as the fourth step using linear programming she determines that asset-portfolio, which – if there is any – provides a greater return for all scenarios, than the return of the liabilities. This method stands in its techniques very close to the pay-off distribution optimization. Therefore here it is also critical to choose an adequate yield-curve model as well as the needed liquidity[37].

FURTHER APPROACHES

Finally we should say that although the classification used by us is widely accepted in the related literature there are further approaches to the topic. *Ong* (1998) as an example uses the following classifications:

- Traditional techniques of asset-liability management
  - Interest rate risk management
    - Net interest income sensitivity analysis
      - Maturity-gap analysis
    - Net portfolio value sensitivity analysis
      - Duration-gap and convexity analyses
    - Scenario analyses of the above
      - Prepayment modeling
    - Liquidity and funding report
    - Hedge report
    - Risk limits and compliance reports
    - Capital requirement reports
      - Solvency status
      - Leverage ratios
      - Regulatory capital ratios
- Non-traditional techniques of asset-liability management
  - Re-defined role of the treasurer and ALCO
  - Option-adjusted spread analysis
  - Integrated enterprise-wide risk management
    - Integrated view of credit risk and market risk
      - Value-at-risk methods
      - Introduce new risk measures
    - Risk-adjusted return performance measurement
      - Economic capital
      - Risk models of loss
    - Portfolio optimization
  - Credit risk management
    - Asset securitization program
    - Expanded role of credit derivatives
    - Collateral management systems

[37] See in detail: *Smink* (1995).

The classification of *Jimeno and Lohse* (2002) are as follows:

- Static methods
  - Descriptive models
    - Cash flow calendar
    - Gap analysis
  - Normative models
    - Cash flow matching
    - Duration matching
    - Conditional immunization
- One periodical stochastic methods
  - Descriptive models
    - Sensitivity analysis
    - Scenario analysis
    - Value at Risk
  - Normative models
    - Asset management (as modeled by Markowitz)
    - CAPM and it's variants
    - Surplus management
- Multiperiodical stochastic methods
  - Descriptive models
    - Monte-Carlo simulation
  - Normative models
    - Wise/Wilkie model
    - Russell-Yasuda-Kasai model

Our choice among groupings was not only based on popularity but also on that this seems to be the most comprehensive and adequate. The choice also ment, that we can not fit some methods in our structure in this article. Few examples are the liquidity- and funding reports, the hedge reports, the risk limits and compliance reports, the capital requirement reports and the Monte-Carlo simulation.

All this does not mean that these methods won't be important according to our way of grouping. Most of them are an important step or component of the methods chosen by us[38].

We probably miss the practically and theoretically very popular value at risk method at most[39]. Especially since the application of VaR is a widely used among the stochastic asset-liability management techniques. *Ong* (1998) emphasizes the role of VaR in measuring market and credit risks. *Rosen and Zenios* (2001) puts VaR, CVaR and EaR as an important component of corporate risk-management and asset-liability management. *Anderson et al.* (2001) have built a VaR-limit based credit risk optimization model. And let us mention, that Riskmetrics mentions VaR as an alternative

[38] The liquidity- and funding reports, the hedge reports, the risk limits and compliance reports, the capital requirement reports and the Monte-Carlo simulation all can be an important element of the payment-distribution- or the realized return optimization method.

[39] According to the survey of *Kinzler and Berg* (2000) VaR is the third most important ALM-method besides cash flow fitting and duration for the major European insurers. According to the survey of the Canadian Institute of Actuaries (2002) 57% of the main Canadian insurers uses VaR, 22% uses it daily, 22% weekly, while 33% monthly.

to asset-liability management[40]. For deeper look we would need to actually consider it more detailed but this would go beyond the possibilities of this article[41].

CONCLUSION

In this article we have tried to introduce and classify the basic methods of asset-liability management. We have used a basic classification according to methods are being static or dynamic. As dynamic methods are considered we will make the subdivisions passive and active processes, and as active processes are considered we will further divide it according to if they are value or return driven.

As a conclusion to this article let's take a look at the grouping of asset-liability management methods (*Table 1*).

Table 1

The classification of the methods of asset-liability management

Group (1)	Methods (2)
Static methods (3)	Cash flow payment calendar Gap analysis Segmentation CF-matching
Passive value-driven methods (4)	Duration Partial duration Key rate duration Model dependent duration Option adjusted spread
Active value-driven methods (5)	Contingent immunization Portfolio insurance Constant proportion portfolio insurance Pay-off distribution optimization
Active return-driven methods (6)	Spread management Realized return optimization

1. táblázat: Az ALM módszerek

Csoport(1), Módszerek(2), Statikus eszközök(3), Passzív value-driven módszerek(4), Aktív value-driven módszerek(5), Aktív return-driven módszerek(6)

[40] With this approach we cannot fully agree, since the ALM models have a large toolbar, most of which can hadly fit to the VaR, also ALM can integrate more kind of risk measures, while VaR is one alternative. ALM can deal with any kind of risks, while VaR is mostly considered for market risks. ALM is able to manage statute and corporate boundaries, while for VaR these do not count as relevant factors. Finally the main goal of ALM is the definition of allocation, while VaR has the primarily goal to measure risks.

[41] For those that are interested in the subject, we recommend the works of *Király* (1998) and *Jorion* (1999).

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