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Research Article

Assessing the Volume of Changes to Banking Assets and Liabilities Using Genetic Algorithms in Additional Funds Needed Model

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Abstract.
This paper investigates Small-Medium Banks' (SMBs) business plans in accordance with the structure of Additional Funds Needed (AFN) model. The Key Profitability Variables (KPVs) are the size and structure of deposits, loans, and their interest rates. This study employs a Genetic Algorithm (GA) problem with hard constraints, to point out the limits to changes in the structure of deposits and loans and the effects of those changes on the P&L of a banking institution. After examining 10,000 iterations with Evolver, an innovative optimization software that uses GA, OptQuest, and linear programming, the alternations, have been narrowed down to 3700 which satisfy both, a) constraints and b) maximization of profits. Having also the distributions, this paper concludes that it is a useful methodology that must be further exploited by applying risk weights, mainly for credit risk, to the structural components of the Balance Sheet, and to other competitive institutions.

Keywords: banking institutions, genetic algorithms, additional funds needed, operational research

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1. Introduction

Academicians and practitioners use a wide range of methodologies to examine profit, accounting models, efficiency management, strategic financial planning, and risk connected with banking institutions. The purpose of this article is to explore the volatility of banks performance utilizing Key Profit Variables (KPVs) based on core financial numbers given in the Financial Statements and Income and Expenditure for the development of Key Performance Indicators (KPIs). It is aimed towards Small and Medium-Sized Banks' (SMBs) business strategies, using a prototype economic modelling technique based

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on the framework of a particularly adapted for financial institutions Additional Funds Needed (AFN) model. The KPVs are the size and structure of deposits, loans, and their interest rates. Then a Genetic Algorithm (GA) problem is constructed with necessary conditions or as expressed in GA terms, hard constrains, mainly regarding the sum of every Balance Sheet structural component, to add up at 100% and the maximization of profits.

Following this methodology, the study tried to point out the limits of changes to structural accounts of sources and uses or deposits and loans as seen from a banking point of view and the effect of those changes to the P&L of a banking institution. After examining 10,000 iterations with Evolver, an innovative optimization software that uses Genetic Algorithm (GA), OptQuest, and linear programming, the alternations were narrow down to 3,700 which satisfy at the same time both, a) constraints and b) maximization of profits. Having also the distributions, it is concluded that it is a useful methodology that must be farther exploited by applying weights associated with Probability of Default (PDs) mainly for credit risk, to the structural components of loans on the Balance Sheet.

At this point the article didn't examine the pricing of interest rates, taking as a fact the decisive role of monetary policy as laid out by central banks, in this case European Central Bank. In future research, the component of the interest rates which are related to market risk must be examined. The projected financial statements are used as a fundamental step in the AFN technique, which takes a parametric approach. Furthermore, it was investigated if the AFN method could be applied in dynamic or variable settings to improve governance, and a Monte Carlo simulation was utilized in this study [1]. As a consequence of this, the study that was discussed discovered that the AFN approach was suitable for the long-term viability between operating and financial planning, which ultimately led to successful planning process in the business environment. As a consequence of this, the objective and goal both reinforced by other research as well as in a more general context; hence, the purpose of this paper is to explore AFN especially in relation to the profitability of SMBs utilizing GAs.

2. Literature Review

The following classification of the independent variables may be seen within the scope of the study that was produced for banking institutions with regard to effectiveness and profitability and the factors that influence these two factors. The majority of research divide the components that they investigate into three primary categories, which are as

follows: a) macroeconomic variables b) Sector variables c) Internal variables. Exogenous elements may refer to either the players in a sector or the variables in the macroeconomic environment. Both types of components are considered to be external factors.

Studies that investigate the endogenous factors that have an effect on productivity and profit make use of a wide variety of variables to describe such aspects. The scale of the company's operations, resources, risk mitigation, expenditure management, and so on are some of the variables that are taken into consideration. There is a wide range of variability in the variables that are used to indicate the elements that influence the internal environment. There is a statistically significant relationship between the scale of the company activity and the levels of both profitability and efficacy.

The research presented in [2,3,4,5,6,7] provides support for the beneficial impact. It has been shown in each of the aforementioned research that there is a correlation that is both positive and statistically significant connecting the size of the functional area and the levels of profit and efficiency. The results shown above are applicable to small and medium-sized banks the most in some of these studies. According to the findings of [4], there is a positive correlation between the amount of industry concentration and both efficiency and profitability. Additionally, there is a positive correlation between a higher quality of administration and both efficiency and profitability. [5] concur with these results, and they discover that there is a statistically significant and negative association among liquidity position and profitability and efficacy. [5] also show that this relationship is causal. This conclusion is regarded to be appropriate due to the fact that high levels of liquidity indicate low-risk placements and, as a consequence of this, low levels of efficiency and profitability.

On the other hand, [8] found in their research that there is a significant and positive association between liquidity, efficiency, and profitability. In their research, the authors create a number of positive relationships, including one among labor costs and effectiveness and profitability, one between leverage and profitability and efficiency and one between labor costs and profitability. [5] Determine the negative impact that financial risk has on both profitability and operational effectiveness. Greater levels of projection are a direct result of high-risk financing, also known as high-risk loans, which, in turn, results in lower levels of profit and efficiency. In this particular instance, the following method was carried out by [9], and it was assumed that the pattern of increasing productivity and profits is likely to continue over the course of time. This may be a reflection of elements such as the accumulation of the industry, its susceptibility to financial instability, etc. Their research [10,11,12] all seem to have come to the same conclusions.

In a number of different research, contradictory findings have been reported. Studies [13,14,15] show that there is a significant and negative association between capital and efficiency and profitability. These findings are corroborated by the findings. It seems that different studies come to different conclusions about the relationship between financial danger (credit risk) and efficiency and profitability. The majority of these research use the subprime estimation percent to all loans as their method for calculating the level of financial risk. The way this element plays out in the future will have an impact on both efficiency and profitability.

This research discovers, via an analysis of previous scholarly work, that there are a variety of strategies for determining how effective banks are at meeting their customers' needs. For the sake of test procedure and credit risk modelling, for instance, [16] outlines a scenario where the bad loans (NPL) percentage is modeled against with the nominal rate, the rate of inflation, the changes in gross Domestic product, and the variation in the the trade terms. [17] Suggest an alternate approach that takes into consideration simultaneous shifts in the macroeconomic variables as well as the interactions between those variables, much as is customarily the case in the macroeconomic scenarios that are created from systemic macro models. [18] Apply a shock of three standard deviations to the variables of GDP and interest rate; similarly, [19] employ a shock of five standard deviations for one of the macroeconomic variables of the GVAR model. [66] Describe a methodology for determining the level of liquidity risk that was created by the monetary authority of Hong Kong. The RAMSI model is based on the balance sheet and was established by the Bank for England. It is often used in the framework of the biggest banks while estimating the components from the comprehensive income and taking into consideration macro-credit exposure as well. [20] provides a description of this model. Furthermore [21] approach profitability through a holistic three step approach of a universal baking model.

Studying the relationship between Banking Balance Sheet and Profit and Loss figures with the methodology of Genetic Algorithm one can find an extensive survey of [22]. According to their survey the main fields of study for Genetic Algorithms applications are:

1. Abnormal noise and fraud detection (ABN)
2. Arbitrage (ARB)
3. Bankruptcy detection (BKR)
4. Cash management (CM)

5. Credit portfolios (CP)
6. Credit scoring (CS)
7. Fundamental analysis (FA)
8. Forecasting (FC)
9. Index tracking (ITR)
10. Market simulation (MKS)
11. Procurement (PRC)
12. Portfolio optimization (PSP)
13. Trading (T) and
14. Trading execution (TX)

From the above research topics of GAs, this study distinguishes and lays out the most relevant researchers accordingly. [23,24], studied Bankruptcy detection (BKR). [25] focused on Cash Management (CM). [26,27] researched Credit Portfolios (CP). [28,29,30,31,32] studied Credit Scoring (CS). Fundamental Analysis (FA) was approached by [33,34]. Forecasting (FC) was intensively studied by [35, 5, 36, 37, 38, 39, 40, 27, 41, 42, 43, 44, 45, 46, 47, 48, 49, 2, 50, 51, 52, 53, 54]. Portfolio optimization (PSP) is another extensive researched topic by, [55,56,57,58,59,60,61,30,62].

3. Data and Methodology

A simplistic model is developed by collecting the information from the financial statement of a small bank in Greece. This offers a controllable testing method that relies solely on the main factors and critical success drivers that are significant for assessing the profitability of the bank. The use of econometric analysis relies on the use of a simplified structure of financial statements that is compliant with the Additional Funds Needed (AFN) model. This structure was developed using IAS and IFRS. For identifying and analyzing the models used in this study, the use of quantitative approaches and advanced analytics is required.

Already in IFRS7 - Financial Instruments: Disclosures, there is a mention made to the need of using sensitivity analysis and Monte Carlo Simulation or any other kind of econometric study for the objectives of this standard. In addition, the International

Financial Reporting Standards (IFRS) 9: Financial Instruments makes mention of the potential use of regression analysis to the process of adopting this standard.

his research makes use of the AFN outputs from three different projections durations to establish a GAs problem with obligatory conditions, also known as hard constraints, in Genetic Algorithms terms. These hard constraints are primarily concerned with the sum of each Financial Statement constituent adding up to 100% and the optimality of profits.

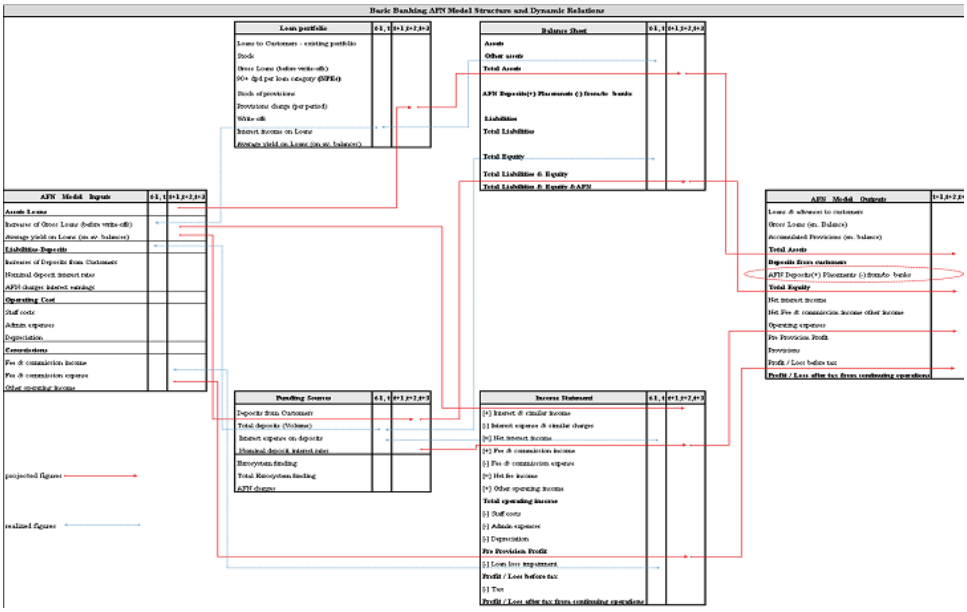
In terms of the technique, this study makes use of an AFN banking model that has a total of four primary worksheets in its construction. Presentation, Financial Statements, Loan Applications, and Other Sources of Funding Every one of them has a five-year timeframe with two of the most recently publicly disclosed annual financial reports (t-1 and t) and three of future annual predictions (t+1, t+2, and t+3).

It is clear from looking at Figure 1 that all the sheets have been dynamically connected with Presentation. In the Presentation worksheet, the inputs are taken as calculation data from the Loans and Funding worksheets. These inputs represent the historic (t-1 and t) amount and product structure of loans and deposits, as well as their yields and nominal interests' rates accordingly. In addition, these inputs represent their anticipated proportion of the total changes in volume and structure, as well as their yields and nominal interests' rates in time (t+1, t+2, and t+3). On the other hand, the Inputs that concern Other Costs and Other Income (not produced from deposits and loans), as well as their past volume (t-1 and t), and change in (t+1, t+2, and t+3), are being accepted as calculation data for the Financial Statements worksheet. In exchange, Financial Statements, Loans, and Funding provide summary data to the Outputs in Presentation worksheet. On this worksheet, chosen data from the previous worksheet are displayed, such as Profit / Loss after Taxes from Continuing Operations and Additional Funds Needed.

Given the preceding framework of Figure 1, the model is capable of being broken down into segments of loans and deposits in accordance with prototype formats established by the European Banking Authority (EBA). These categories and their indicative amounts are listed in Tables 1 through 5, respectively.

Table 1 demonstrates the initial input parameters of the AFN model. The parameters are broken down in four main groups. Assets, Liabilities, Operating Cost, and Commissions. Each of the above-mentioned groups are further analyzed by time criteria (realized t-1 and t, projected t+1 through t+3) and by product segments.

Table 2 is describing the data regarding the Loans Portfolio. The main categories are Gross Loans, Non-Performing Exposures, Stock of Provisions, Provision Charge per



Source: Author's own work

Figure 1: Simplified AFN model structure.

period, Write offs, Interest Income on Loans and Average Yield on Loans. Each of the above-mentioned groups are further analyzed by time criteria (realized t-1 and t, projected t+1 through t+3) and by product segments.

Table 3 demonstrates the data regarding the Funding Sources. The main categories are: the volume of Total Deposits, the interest expense on deposits, the Nominal deposit interest rates and the Total Eurosystem funding. Each of the above-mentioned groups are further analyzed by time criteria (realized t-1 and t, projected t+1 through t+3) and by product segments.

Following the realized data and projected ones that constitute the Tables 1 to 3, Table 4 brakes down the Balance Sheet and Profit and Loss Accounts data that are formatted according to the above-mentioned data and also follow the rule of time criteria (realized t-1 and t, projected t+1 through t+3) and by main financial accounting subcategories.

Following the formatted Balance Sheet and Profit and Loss financial accounting data of Table 4, Table 5 is presenting the main results of the AFN banking model process, where main financial figures are been projected after taking into account all the previous information and data. Furthermore, Accumulated figures from the Loans Portfolio are presented to formulate the Total Assets. Then Deposits and other sources of funding the Assets are presented. Any difference – shortfall has been automatically matched by the parameter of AFN Deposits (+) Placements (-) from/to banks, so as to reach the Total Equity. The last 5 elements represent main figures of Profit and Loss accounts so as to formulate the final amount of Profit / Loss after tax from continuing operations.

Table 1: Break down by segment and time of AFN banking model inputs.

AFN Model Inputs		Units	t-1	t	t+1	t+2	t+3
Assets-Loans							
Increases of Gross Loans (before write-offs)		%			**2%**	**2%**	**2%**
	Mortgage		13%	12%	13%	13%	13%
	Consumer		3%	3%	3%	3%	3%
	Credit cards		2%	2%	2%	2%	2%
	Other		3%	3%	3%	3%	3%
	Public sector		1%	1%	1%	1%	1%
	Large Corporate		28%	27%	28%	28%	28%
	SMEs		33%	33%	32%	32%	32%
	SBL		19%	19%	19%	19%	19%
	All of Gross Loans		100%	100%	100%	100%	100%
Average yield on Loans (on av. balances)		%					
	Mortgage		2.1%	2.1%	2.2%	2.5%	2.5%
	Consumer		3.8%	3.6%	4.0%	4.0%	4.0%
	Credit cards		3.4%	3.0%	4.0%	4.5%	5.0%
	Other		2.2%	2.0%	2.3%	2.3%	2.3%
	Public sector		4.8%	3.4%	4.5%	4.5%	4.5%
	Large Corporate		4.5%	3.6%	4.1%	4.1%	4.1%
	SMEs		4.5%	3.6%	4.5%	5.0%	5.0%
	SBL		5.0%	4.2%	5.0%	5.2%	5.5%
Liabilities-Deposits							
Increases of Deposits from Customers		%			**3%**	**3%**	**3%**
	Savings		22%	23%	22%	22%	22%
	Sight		26%	28%	28%	28%	28%
	Term		51%	49%	49%	49%	49%
	Other		1%	1%	1%	1%	1%
	All Deposits from Customers		100%	100%	100%	100%	100%
Nominal deposit interest rates		%					
	Savings		0.7%	0.7%	0.7%	0.5%	0.5%
	Sight		1.3%	0.8%	1.2%	1.0%	0.8%
	Term		3.0%	2.4%	2.8%	2.5%	2.5%
	Other		0.0%	0.0%	0.0%	0.0%	0.0%
AFN charges interest earnings			0.5%	0.5%	0.5%	0.5%	0.5%
Operating Cost		EUR mn					
Staff costs			30	30	34	35	36
Admin expenses			30	30	36	30	30
Depreciation			6	6	6	6	6
Commissions		EUR mn					
Fee & commission income			20	20	22	24	26
Fee & commission expense			4	4	4	5	6
Other operating income			5	5	6	6	6

Source: *Author's own work*

Table 2: AFN Banking Model Loans portfolio breakdown.

Units in EUR mn (unless otherwise stated)	Unit	t-1	t	t+1	t+2	t+3
Loans to Customers - existing portfolio						
Stock						
Gross Loans (before write-offs)	EUR mn	**4000**	**4400**	**4497**	**4596**	**4697**
Mortgage		500	510	562	574	587
Consumer		120	130	135	138	141
Credit cards		60	70	67	69	70
Other		120	140	135	138	141
Public sector		40	50	45	46	47
Large Corporate		1100	1200	1259	1287	1315
SMEs		1300	1450	1439	1471	1503
SBL		760	850	854	873	892
90+ dpd per loan category (NPEs)	EUR mn	**1000**	**1000**	**1022**	**1044**	**1067**
Mortgage		50	50	51	52	53
Consumer		40	40	41	42	43
Credit cards		20	20	20	21	21
Other		40	40	41	42	43
Public sector		-	-	-	-	-
Large Corporate		150	150	153	157	160
SMEs		400	400	409	418	427
SBL		300	300	307	313	320
Stock of provisions		**1000**	**1000**	**1022**	**1044**	**1067**
Provisions charge (per period)		**20**	**20**	**26**	**28**	**31**
Write-offs		-	-	4	6	8
Interest income on Loans	EUR mn	**163**	**146**	**183**	**198**	**205**
Mortgage		11	10	12	14	15
Consumer		5	5	5	5	6
Credit cards		2	2	3	3	3
Other		3	3	3	3	3
Public sector		2	2	2	2	2
Large Corporate		46	42	50	52	53
SMEs		58	50	65	73	74
SBL		36	34	43	45	49
Average yield on Loans (on av. balances)	%	**4.2%**	**3.5%**	**4.1%**	**4.4%**	**4.4%**
Mortgage		2.1%	2.1%	2.2%	2.5%	2.5%
Consumer		3.8%	3.6%	4.0%	4.0%	4.0%
Credit cards		3.4%	3.0%	4.0%	4.5%	5.0%
Other		2.2%	2.0%	2.3%	2.3%	2.3%
Public sector		4.8%	3.4%	4.5%	4.5%	4.5%
Large Corporate		4.5%	3.6%	4.1%	4.1%	4.1%
SMEs		4.5%	3.6%	4.5%	5.0%	5.0%
SBL		5.0%	4.2%	5.0%	5.2%	5.5%

Source: *Author's own work*

Table 3: AFN Banking Model Funding resources.

Units in EUR m (unless otherwise stated)	Unit	t-1	t	t+1	t+2	t+3
Deposits from Customers						
Total deposits (Volume)	EUR mn	**2720**	**2870**	**2956**	**3045**	**3136**
of which:						
Savings	EUR mn	600	650	650	670	690
Sight	EUR mn	700	800	828	853	878
Term	EUR mn	1400	1400	1448	1492	1537
Other	EUR mn	20	20	30	30	31
Interest expense on deposits	EUR mn	**63**	**43**	**54**	**48**	**48**
of which:						
Savings	EUR mn	3	4	5	3	3
Sight	EUR mn	6	6	10	8	7
Term	EUR mn	54	33	40	37	38
Other	EUR mn	0	0	0	0	0
Nominal deposit interest rates *	%	**2.3%**	**1.5%**	**1.9%**	**1.6%**	**1.6%**
Savings	%	0.7%	0.7%	0.7%	0.5%	0.5%
Sight	%	1.3%	0.8%	1.2%	1.0%	0.8%
Term	%	3.0%	2.4%	2.8%	2.5%	2.5%
Other	%	0.0%	0.0%	0.0%	0.0%	0.0%
*Effective nominal rates for each deposit category						
Eurosystem funding						
Total Eurosystem funding	EUR mn	**210**	**407**	**352**	**294**	**212**
AFN charges		1	2	2	1	1

Source: *Author's own work*

All the above analysis is also following the time criteria (realized t-1 and t, projected t+1 through t+3).

Because these are presumed to be the decisions made by management, the amount of variation in capacity for Aggregate Deposits and Loans must be reported for each of the five periods that make up the Inputs category. Additionally, the average return on loans (based on average balances), in addition to the basic interest rate on deposits both requirements must be met accordingly. According to the EBA, the primary categories for the specifications of loans are Mortgage, Consumer, Credit Cards, Other, Public Sector,

Table 4: The AFN banking model projected balance sheet and profit and loss statements.

Units in EUR mn (unless otherwise stated)			t-1	t	t+1	t+2	t+3
Balance Sheet							
Assets							
		Cash & balances with Central Bank	50	55	50	50	50
		Due from banks	10	6	5	5	5
		Loans & advances to customers	3000	3400	3483	3563	3645
		Gross Loans (en. Balance)	4000	4400	4501	4602	4705
		Accumulated Provisions (en. balance)	1000	1000	1018	1038	1059
		Derivative financial instruments	10	10	10	10	10
		Securities portfolio	80	60	50	50	50
		Investment in subsidiaries & associates	0	0	0	0	0
		Property & equipment	100	100	100	100	100
		Goodwill, software & other intangibles	40	40	40	40	40
		Deferred tax asset	100	90	80	65	44
		Other assets	100	100	100	100	100
Total Assets			**3490**	**3861**	**3917**	**3984**	**4045**
AFN Deposits (+) Placemnets (-) from/to banks			**210**	**407**	**352**	**294**	**212**
Liabilities							
		Deposits from customers	2720	2870	2956	3045	3136
		Other borrowed funds	10	10	10	10	10
		Provision for empl. Benef. & conting. Liab.	30	30	30	30	30
		Other liabilities	20	20	20	20	20
Total Liabilities			**2780**	**2930**	**3016**	**3105**	**3196**
Total Equity			500	524	550	585	637
Total Liabilities & Equity			**3280**	**3454**	**3566**	**3689**	**3833**
Total Liabilities & Equity &AFN			3490	3861	3917	3984	4045
Income Statement							
	[+]	Interest & similar income	163	146	183	198	205
	[-]	Interest expense & similar charges	64	45	56	50	49
	[=]	Net interest income	99	101	127	148	156
	[+]	Fee & commission income	20	20	22	24	26
	[-]	Fee & commission expense	4	4	4	5	6
	[=]	Net fee income	115	117	145	167	176
	[+]	Other operating income	5	5	6	6	6
		Total operating income	120	122	151	173	182
	[-]	Staff costs	30	30	34	35	36
	[-]	Admin expenses	30	30	36	30	30
	[-]	Depreciation	6	6	6	6	6
		Pre Provision Profit	54	56	75	102	110
	[-]	Loan loss impairment	20	20	26	28	31
		Profit / Loss before tax	34	36	49	73	79
	[-]	Tax	10	10	14	21	23
Profit / Loss after tax from continuing operations			**24**	**26**	**35**	**52**	**56**

Source: *Author's own work*

Table 5: AFN Banking model Outcomes and Impacts.

AFN Model Outputs (EUR mn)	**t-1**	**t**	**t+1**	**t+2**	**t+3**
Loans & advances to customers	3000	3400	3483	3563	3645
Gross Loans (en. Balance)	4000	4400	4501	4602	4705
Accumulated Provisions (en. balance)	1000	1000	1018	1038	1059
Total Assets	**3490**	**3861**	**3917**	**3984**	**4045**
Deposits from customers	**2720**	**2870**	**2956**	**3045**	**3136**
AFN Deposits (+) Placements (-) from/to banks	210	407	352	294	212
Total Equity	**500**	**524**	**550**	**585**	**637**
Net interest income	99	101	127	148	156
Net Fee & commission income other income	29	29	32	35	38
Operating expenses	66	66	76	71	72
Pre Provision Profit	54	56	75	102	110
Provisions	20	20	26	28	31
Profit / Loss before tax	34	36	49	73	79
Profit / Loss after tax from continuing operations	**24**	**26**	**35**	**52**	**56**

Source: *Author's own work*

Large Corporate, SMEs, and SBL, while the primary categories for the specifications of deposits are Savings, Sight, Term, and Other.

Operating Cost, which includes Staff costs, Admin expenditures, Depreciation, and Commissions, must also be reported, considering that they are not results of volume and rates of deposits and loans. Fees and Commissions revenue, Fees and Commissions expense, and other operating profit must also be stated. For Outputs, the AFN model calculates the values for the categories as indicated below and for five periods. This calculation is based on the Inputs as well as the created data from the other sheets (Loans, Funding Sources, B/S and PnL).

The provision of loans and advances to consumers, Total Assets, Deposits from Customers, AFN Deposits (+) Placements (-) from/to Banks, AFN Deposits (+) Placements (-) from/to Banks, Gross Loans (end Balance), Accumulated Provisions (end Balance). Total Equity, Net Interest Income, Net Fee & Commission Income and Other Income, Operating Expenses, Profit Before Provisions, Provisions, Profit or Loss from Continuing Operations Before Tax and Profit or Loss from Continuing Operations After Tax.

Using the Palisade econometric software package and in specific the specialized GAs software Evolver, this research provides use of the AFN outcomes from three predictive intervals in to develop a GA problem with mandatory settings or as represented in GA terms, hard constraints. These hard constraints are primarily concerning the total amount

of each Financial Statement structural element to add up at 100% and the optimization of earnings in to observe the factors that contribute to these outcomes. The AFN The following is an explanation of the issue that requires the use of GAs as a solution to be resolved.

The objective is to optimize profit or loss after taxes from ongoing operations. This will be accomplished by working through 10,000 iterations while simultaneously considering specific restrictions on loans and deposits, as well as specific constraints on loans, deposits, and funding. The overall growth in Gross Loans (before to write-offs) may range anywhere from 0% to 5% and can be further broken down into the following categories depending to the product line:

Mortgage from 10% to 22%. Personal Loans with Interest Rates from 2% to 5% Credit card interest rates range from 2% to 5%. Other loans: between 1% and 5%; public sector: between 1% and 5%; large corporations: between 10% and 25%; small and medium-sized enterprises: between 20% and 35%; small business loans: among 15% and 30%. In contrast d, the Constraints on Deposits apply to increments ranging from 0 to 5%, and they may be further broken down into the following categories based on the product line:

Between 10 and 30 percent of savings, between 10 and 30 percent of sight, between 40 and 70 percent of term, and between 1 and 1.5 percent of other. Finally, the constraints should be placed on deposits, loans, and the funding of loans. It is required that the total amount of all loan product lines make up no more than 100 percent of the total gross amount of loans. The total of all product categories of deposits must be between one percent and one hundred percent of all deposits at the maximum, and the amount of money available for loans must be less than or equal to the total of deposits plus equity.

The issue is broken down into its component parts in Table 6, which may be seen below.

Setting out the GAs optimization problem the article is now moving to the initial Findings.

4. Findings

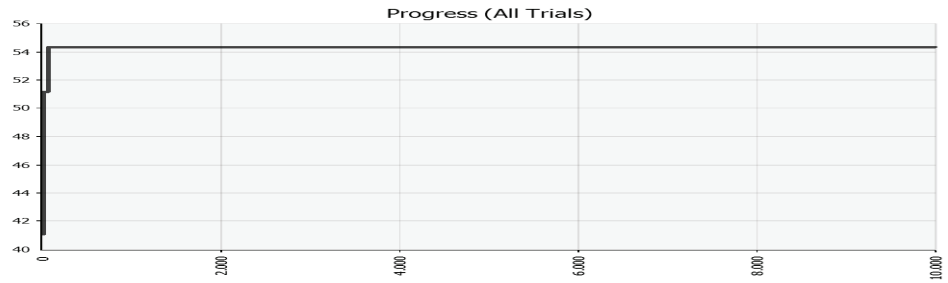
From the initial interpretation of the findings, one can observe the following as shown also in Figure 2, Tables 7, 8 and 9.

TABLE 6: Summary of Objective function, Restrictions and Constraints of the GAs problem.

		GAs problem to be solved	
Objective function	**Maximize**	**Profit / Loss after tax from continuing operation Product or Balance Sheet line**	
Restrictions on Loans			
0%	<=	5%	Increases of Gross Loans (before write-offs)
10%	<=	20%	Mortgage
2%	<=	5%	Consumer
2%	<=	5%	Credit cards
3%	<=	7%	Other
1%	<=	5%	Public sector
10%	<=	25%	Large Corporate
20%	<=	35 %	SMEs
15%	<=	30%	SBL
Restrictions on Deposits			
0%	<=	5%	Increases of Deposits from Customers
10%	<=	30 %	Savings
10%	<=	30 %	Sight
40%	<=	70%	Term
1%	<=	1.5%	Other
Constraints			
on Loans	=	1 or 100%	All of Gross Loans
on Deposits	=	1 or 100%	All Deposits from Customers
on Funding Loans	<=		Deposits+Equity

Source: Author's own work

Figure 2 demonstrates that the best value of 54.34 mil euro was reached as soon as the 60th trial and remained so throughout the rest of the 10,000 trials.



Source: *Author's own work*

Figure 2: Progress of GAs optimization prob.

Table 7 demonstrates the summary of results on Objective function. There was a total of 10,000 iterations, but only 7887 of them were legitimate. This indicates that 2113 of the iterations that were not valid did not satisfy the requirements. The profit or loss from continuing activities had an initial value of 41.1 million euros after taxes when it was

first calculated. The 60th trial produced the best value, which was determined to be 54.34 million euros. The most noteworthy discovery was that while the initial values for growth of Gross Loan and Total Deposits were 2% respectively, the optimal value was at 0% to obtain the best value of 54.34 mil euro. This was even though both values were originally set at 2%. The maximizing of earnings may be achieved after 3392 iterations. Therefore, it can be deduced that only 33,92% of the iterations ultimately succeed in overcoming all the limitations.

Table 8 demonstrates the restrictions and constraints on the objective function. As pointed out, the constraint is that Loans & advances to customers must be a total amount that is less or at most equal to Total Equity & Deposits from customers. The Constraint type is hard, meaning that this is an absolute constraint that must be satisfied at all times, in a absolute 100 percent manner.

Table 9 demonstrates the descriptive statistics of results on objective function, restrictions, and constraints. The data are presented according to two major groups, that is Loans and Deposits. Furthermore, every group is then analyzed by presenting the main products segments. Regarding Loans the discrimination follows criteria like the collateral type (Mortgage, Consumer, Credit Cards, Other) sector type, (Public Sector), and size of the client (Large Corporate, Small and Medium Enterprises, and Small Business Loans). On the other hand, for the group of deposits the main criteria is time and liquidity, analyzing to Savings, Sight deposits, Term deposits and other type of deposits.

From a total of 10,000 iterations 7887 where valid, which means that 2113 not valid didn't satisfied the constraints. The original value of the Profit /Loss after tax from continuing operations was 41.1 mil euro. The best value was found at the 60trial and was 54.34 mil euro. The most interesting finding is that although the original values for increase of Gross Loan and Total Deposits was 2% respectively, the best value was at 0% to achieve the best value of 54.34 mil euro. 3392 Iterations satisfy the maximization of profits. So, it is concluded that only a 33.92% of the iterations finally pass all the constraints.

5. Conclusions

From the initial examination of AFN banking model as base for GAs optimization problem, it is obvious that it is a useful methodology that must be farther exploited by applying weights associated with Probability of Default (PDs) mainly for credit risk, to the structural components of loans on the Balance Sheet. At this point the pricing of interest rates was not examined, taking as a fact the decisive role of monetary policy

Table 7: Summary of Results on Objective function.

Results	
Valid Trials	7887.00
Total Trials	10,000.00
Original Value	41.1
Best Value Found	54.34
Best Trial Number	60
Adjustable Cell Values	Mortgage
Original	10%
Best	10%
Adjustable Cell Values	Consumer
Original	2%
Best	2%
Adjustable Cell Values	Credit cards
Original	2%
Best	2%
Adjustable Cell Values	Other
Original	3%
Best	3%
Adjustable Cell Values	Public sector
Original	5%
Best	5%
Adjustable Cell Values	Large Corporate
Original	13%
Best	13%
Adjustable Cell Values	SMEs
Original	35%
Best	35%
Adjustable Cell Values	SBL
Original	30%
Best	30%
Adjustable Cell Values	Savings
Original	30%
Best	30%
Adjustable Cell Values	Sight
Original	29%
Best	29%
Adjustable Cell Values	Term
Original	40%
Best	40%
Adjustable Cell Values	Other
Original	2%
Best	2%
Adjustable Cell Values	Increases of Gross Loans (before write-offs)
Original	2%
Best	0%
Adjustable Cell Values	Increases of Deposits from Customers
Original	2%

Source: *Author's own work*

as laid out by central banks, in particular European Central Bank for Greece. In future

TABLE 8: Summary of Restrictions and Constraints on Objective function.

Constraints	
Description	All of Gross Loans = 100.00%
Definition	Gross Loans = 1
Constraint Type	Hard
Precision	1.00E-03
Satisfied for % of Trials	100.00%
Description	All Deposits from Customers =100.00%
Definition	Deposits = 1
Constraint Type	Hard
Precision	1.00E-03
Satisfied for % of Trials	100.00%
Description	Loans & advances to customers <= Total Equity & Deposits from customers
Definition	Loans <= Total Equity & Deposits from customers
Constraint Type	Hard
Precision	0
Satisfied for % of Trials	78.87%

Source: *Author's own work*

TABLE 9: Descriptive Statistics of Results on Objective function, Restrictions and Constraints.

StatTools Report															
Analysis:	One Variable Summary														
Performed By:	Trigkas Sotirios														
		LOANS									DEPOSITS				
		Mortgage	Consumer	Credit cards	Other	Public Sector	Large Corporate	SMEs	SBLs	Increase of Gross Loans (before write offs)	Savings	Sight	Term	Other	increase in Deposits
Mean	54.18	0.10	0.02	0.03	0.03	0.05	0.13	0.35	0.30	0.00	0.30	0.29	0.40	0.01	0.00
Variance	5.53%	0.00%	0.00%	0.01%	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.02%
Std. Dev.	23.51%	0.12%	0.62%	0.99%	0.20%	0.62%	0.95%	0.44%	0.22%	0.00%	0.48%	0.47%	0.28%	0.12%	1.32%
Skewness	-1.17	7.56	2.39	1.58	5.36	-3.10	-1.10	-4.58	-4.76	11.44	-1.81	0.95	3.91	-2.63	2.69
Minimum	53.50	10.00%	2.00%	2.00%	3.00%	1.00%	10.00%	27.81%	26.92%	0.00%	26.61%	25.17%	40.00%	1.00%	0.00%
Maximum	54.34	12.06%	5.00%	5.00%	6.00%	5.00%	17.88%	35.00%	30.00%	0.09%	30.00%	30.00%	43.35%	1.50%	5.00%
Range	0.84	2.06%	3.00%	3.00%	3.00%	4.00%	7.88%	7.19%	3.08%	0.09%	3.39%	4.83%	3.35%	0.50%	5.00%
Count	3392	3392	3392	3392	3392	3392	3392	3392	3392	3392	3392	3392	3392	3392	3392
1%	53.56	10.00%	2.00%	2.00%	3.00%	2.00%	10.00%	32.87%	29.07%	0.00%	28.32%	27.85%	40.00%	1.00%	0.00%
3%	53.63	10.00%	2.00%	2.00%	3.00%	2.62%	10.00%	33.60%	29.29%	0.00%	28.53%	28.16%	40.00%	1.00%	0.00%
5%	53.69	10.00%	2.00%	2.00%	3.00%	3.37%	10.29%	33.93%	29.45%	0.00%	28.64%	28.38%	40.00%	1.17%	0.00%
10%	53.77	10.00%	2.00%	2.00%	3.00%	4.00%	10.94%	34.37%	29.68%	0.00%	28.85%	28.50%	40.00%	1.32%	0.00%
20%	53.97	10.00%	2.00%	2.00%	3.00%	4.65%	11.95%	34.78%	29.90%	0.00%	29.40%	28.50%	40.00%	1.40%	0.00%
80%	54.34	10.05%	2.46%	3.14%	3.09%	5.00%	13.00%	35.00%	30.00%	0.00%	30.00%	29.00%	40.17%	1.50%	0.06%
90%	54.34	10.12%	3.20%	4.60%	3.19%	5.00%	13.01%	35.00%	30.00%	0.00%	30.00%	29.56%	40.42%	1.50%	2.04%
95%	54.34	10.19%	3.85%	4.95%	3.31%	5.00%	13.27%	35.00%	30.00%	0.01%	30.00%	29.80%	40.69%	1.50%	4.64%
98%	54.34	10.25%	4.27%	4.98%	3.67%	5.00%	13.67%	35.00%	30.00%	0.01%	30.00%	29.92%	40.91%	1.50%	4.78%
99%	54.34	10.50%	4.67%	5.00%	4.10%	5.00%	14.30%	35.00%	30.00%	0.02%	30.00%	30.00%	41.36%	1.50%	4.99%

Source: *Author's own work*

research it is intended to examine the component of the interest rates which are related to market risk.

The first stage in determining the effectiveness of a bank's operations is to develop a static model with the help of managerial accounting data by integrating the AFN approach and doing so. Because the AFN model is a static model, it is affected by exogenous factors. These exogenous factors are primarily macroeconomic variables such as an economic crisis. As a result, a particular group of intrinsic bank performance parameters is evaluated in this article, and their future values can be predicted using a maximization GAs problem.

It is necessary to conduct additional research in order to demonstrate that the AFN for banks methodology, when combined with GAs maximization problem solving, can produce a compact and robust framework that can be utilized to evaluate the effectiveness and management of a banking institution. The incorporation of additional methodologies is incrementally balancing the deficiencies of each other, boosting the chance of the estimation methods contributing to the strategic and financial planning process in the business sector, and so improving the likelihood of robustness. It is recommended that the model be validated using data from a variety of local and international bank settings. Doing so will help ensure the conclusions are accurate and reliable.

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