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Improving the Quantification Model of Internal Control Impact on Banking Risks

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Abstract—Risk management in banking sector is a key issue linked to financial system stability and its importance has been elevated by technological developments and emergence of new financial instruments. In this paper, we improve the model previously defined for quantifying internal control impact on banking risks by automatizing the residual criticality estimation step of FMECA. For this, we defined three equations and a maturity coefficient to obtain a mathematical model which is tested on all banking processes and type of risks. The new model allows an optimal assessment of residual criticality and improves the correlation rate that has become 98%.

Keywords—Risk, Control, Banking, FMECA.

I. Introduction

BANKING risk management has to set strategic targets and manage different type of risk related to its activities using strict controls [1]. Accordingly, the FATF (Financial Action Task Force) recommendations have flexibility, enabling jurisdictions to craft effective and appropriate controls taking into account the relevance of expanding access to financial services [2]. Risk management of Money creation has to assess risk before and after such mitigating controls are in place; service providers and regulators can evaluate the effectiveness of such mechanisms [3]. Therefore, the risk IS/IT management activities can start either with control systems analysis or risk analysis [4]. Measurement and management of liquidity risk are addressed on BASEL 1 in the following 2 principles [5]:

- Principle 5: A bank should have a sound process for identifying, measuring, monitoring and controlling liquidity risk. This process should include a robust framework for comprehensively projecting cash flows arising from assets, liabilities and off-balance sheet items over an appropriate set of time horizons.
- Principle 6: A bank should actively monitor and control liquidity risk exposures and funding needs within and across legal entities, business lines and currencies, taking into account legal, regulatory and operational limitations to the transferability of liquidity.

Moreover, bank liquidity management policies should comprise a risk management structure, a liquidity management and funding strategy, a set of limits to liquidity risk exposures and a set of procedures for liquidity planning under alternative scenarios, including crisis situations [6]. Also, interest rate risk formalization of principles will strengthen qualitative approach to supervising interest rate risk in the banking book [7].

The monitoring process assesses presence and functioning of the operational risk management policies and procedures over time through a combination of ongoing monitoring activities and specific evaluations. The scope and frequency of specific evaluations depends on an assessment of risk and the effectiveness of ongoing monitoring procedures [8]. In that context, some researchers see unexplored potential for the control theory, which could be used to more precisely and systematically detect important nodes and there after mitigate the systemic risk in the whole system by dynamically imposing supervisory action [9].

The main risk management measures are prevention and mitigation,its strategies can accept, control, avoid or transfer the risk [10]. To establish and maintain the IT security of enterprise is a whole process, it is necessary to achieve a relevant diagnostic of information system, implement protective controls, check the response accuracy of IT security and maintain information system security [11].

Risk assessment of the emergency plan application must include data on post accident system condition with emphasis on system components essential for the execution of recovery measures, available means for performing recovery measures [12].

The purpose of the current evaluations domains of residual risk on health was also done, however, is similar to that of the previous model evaluations [13]. Residual risk reduction is a process which provide a framework to qualify, quantify and reduce risk in systems[14] and risk appetite needs to be measurable. Otherwise there is a risk that any statements become empty and vacuous. Shareholder value may be an appropriate starting point for some private organizations; stakeholder value or ”Economic Value Added” may be appropriate for others [15].

The previous model is based on both maturity and type of control, then we have noted that only mature control can reduce risk criticality and we decided to reduce number of model parameter by focusing just on maturity of control.

II. Related Works

Several methods exist for Risk Assessment [16]. The used method(FMECA) [17] is based on an inductive reasoning (causes-consequences) to study causes, effects of failures and their criticality. Residual criticality of risk represents the level of actual exposure [18] and gives an appreciation of the impact of controls on risk criticality. It is obtained by estimation of

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residuals likelihood and severity during work sessions using FMECA method. This step of FMECA method has some limits:

- requires many work sessions with compromises in case of disagreement
- requires significant level of expertise
- requires time and personal investment
- the impact of internal control are appreciated differently by interlocutors
- they are some estimation error rate of residual risk criticality

Besides, the existing control maturity scale has five levels as defined in the following table:

TABLE I
SCALE OF CONTROL MATURITY

Scale	Wording	Meaning
1	Not present	Any impact on risk
2	Informal	Insignificant impact on risk
3	Systematic	Medium impact on risk
4	Integrated	Significant impact on risk
5	Optimized	Optimal impact on risk

Considering that, we had defined a previous model which has some characteristics:

- correlation rate is 95%
- 6 parameters and 5 variables

III. Our Contribution

A. New Model Advantages

The new a model has several advantages including:

- Automatize calculation of risks residual criticality
- Decrease estimation error rate of residual criticality
- Reduce time for obtaining residual criticality
- Optimize assessment of internal control maturity
- Facilitate risk analysis of in baking sector

Aside from the benefits of the previously model, the new model has additional advantages including:

- improve correlation rate
- reduce number of model parameters
- reduce number of model variables
- reduce time for obtaining residual criticality
- easy to implement

B. New Model Specificity

In our work, we propose a new model based on control maturity and taking into account the following main characteristics of control maturity:

- Control existence
- Control documentation
- Control execution
- Control traceability
- Control effectiveness
- Control efficiency
- Control management
- Control archiving
- Control assessment
- Control reporting

For each characteristic, we have defined a impact percentage based on 10 main characteristics of control maturity:

C. New Model Principles

To propose the new model which take into account 10 main characteristics of control maturity, we used the following 5 principles:

- Principle 1: Risk may have one or more controls
- Principle 2: Control treats the identified and assessed risks
- Principle 3: Control has only one maturity
- Principle 4: Only mature control can reduce risk criticality
- Principle 5: Control impact depends on maturity level

D. New Model Equation

The equation of the proposed model which calculates residual criticality is declined as:

$$C_{resu} = C_{ini} - [MatCoef * [\sum_{1}^{n_{ctl}} (mat_i)/n_{ctl}]] \quad (1)$$

Initial Criticality $(C_{ini} = [1, 2, 3, 4, 5, 6].[1, 2, 3, 4, 5, 6])$
Maturity Coefficient $(MatCoef = 0.1)$
Control maturity $([mat_i] = [1, 2, 3, 4, 5])$
Number of Control $([n_{ctl}] = [1, 2, 3])$

IV. Tests

A. Application of the Model to Different Risk

We test the new model on 333 risks and 491 controls by calculating for each risk the average of control maturity and identified the number of controls before applying the model. The following graphs are related to residual values between model and estimation for each risk.

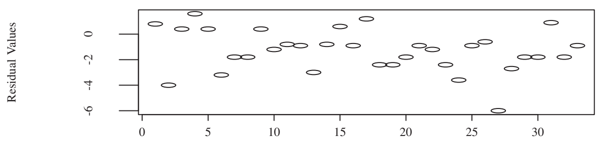

Fig. 1 Risks of Operations and Transactions Process
Our Model vs Estimation

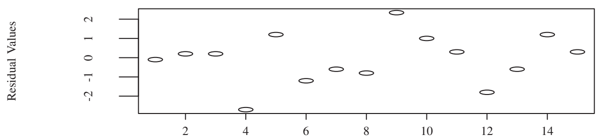

Fig. 2 Risks of Compliance and Risk Process
Our Model vs Estimation

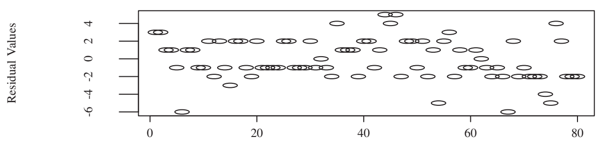

Fig. 3 Risk of Information System Process
Our Model vs Estimation

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TABLE II
MAIN CHARACTERISTICS OF CONTROL

Level	Characteristics	Percentage
1	Exits	10%
2	Exits and Documented	15%
3	Exits,Documented and Executed	35%
4	Exits,Documented,Executed and Traceable	45%
5	Exits,Documented,Executed,Traceable and Effective	55%
6	Exits,Documented,Executed,Traceable,Effective and Efficient	65%
7	Exits,Documented,Executed,Traceable,Effective,Efficient and Self-assessed	75%
8	Exits,Documented,Executed,Traceable,Effective,Efficient,Self-assessed and Managed	85%
9	Exits,Documented,Executed,Traceable,Effective,Efficient,Self-assessed,Managed and Reported	95%
10	Exits,Documented,Executed,Traceable,Effective,Efficient,Self-assessed,Managed,Reported and Archived	100%

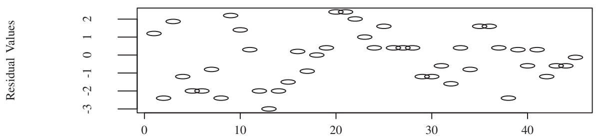

Fig. 4 Risks of Products and Customers Process
Our Model vs Estimation

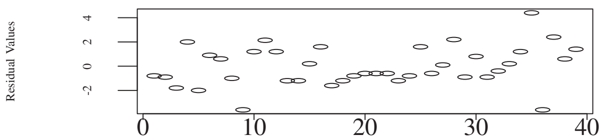

Fig. 5 Risks of Finance and Budget Process
Our Model vs Estimation

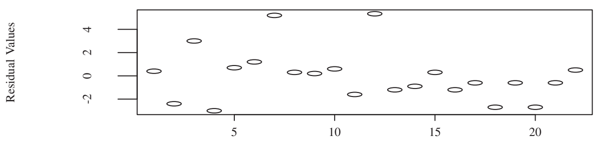

Fig. 6 Risks of Strategy and Governance Process
Our Model vs Estimation

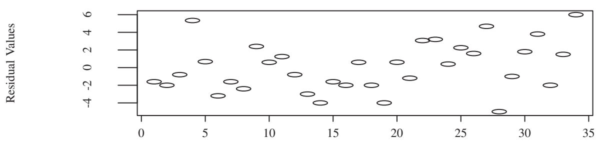

Fig. 7 Risks of Administration and Resources Process
Our Model vs Estimation

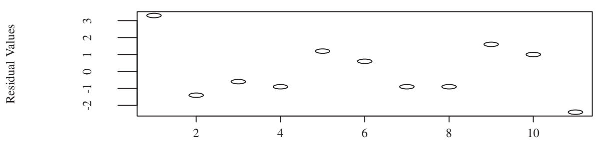

Fig. 8 Risks of Regulations and Standards Process
Our Model vs Estimation

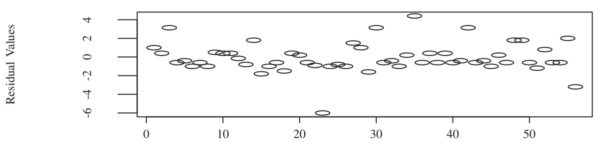

Fig. 9 Risks of Security and Fraud Process
Our Model vs Estimation

V. RESULTS 1

- Model values are slightly upper or lower than estimation values
- Residual values between model and estimation are random

A. Application of the Model on Different Processes

We also test the model on 9 banking processes by calculating the average of residual criticality by process. The correlation rate between model and estimation as shown in the following table:

TABLE III
COMPARISON BETWEEN ESTIMATION AND MODEL CORRELATION RATE BY PROCESS

Processes	EstimationValues	ModelValues	CorrelationRate
Operations/Transactions	8,7	8,45	97%
Compliance/Risk	5,33	5,26	99%
Information/System	9,48	9,14	96%
Products/Customers	7,82	7,65	98%
Finances/Budget	6,23	6,19	99%
Strategy/Governance	8,38	8,36	99%
Administration/Resources	11,32	11,37	99%
Regulations/Standards	7,5	7,33	99%
Security/Fraud	8,42	8,33	99%
AVERAGE	8,13	8,01	98%

The following graphs compare the model and estimation by process:

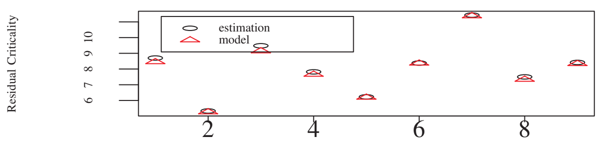

Fig. 10 Residual Criticality by Process
Model vs Estimation

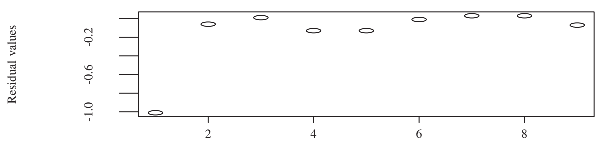

Fig. 11 Residual Values by Process
Our Model vs Estimation

VI. Results 2

- Correlation rate by process is equal 98%
- Residual values between model and estimation by process are random

A. Application of the Model on Different Types of Risk

After that, we test the model on 7 types of banking risk [19] by calculating the average of residual criticality by type of risk. The correlation rate between model and estimation as shown in the following table:

TABLE IV
Comparison between Estimation and Model Correlation Rate by Types of Risk

Type of Risk	EstimationValues	ModelValues	CorrelationRate
Credit	7,00	6,83	97,57%
Strategic	12	11,47	95,58%
Funding	9,00	8,87	98,56%
Market	7,57	7,20	95,18%
Political	5,00	5,03	99,40%
Operational	9,20	9,35	98,40%
Legal	7,18	7,31	98,28%
AVERAGE	8,13	8,01	98%

The following graphs compare the model and estimation by type of risk:

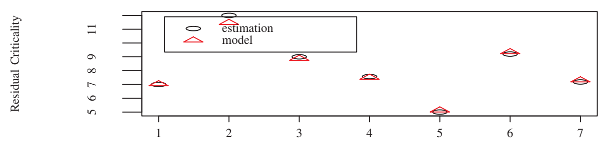

Fig. 12 Residual Criticality by Type of Risk
Model vs Estimation

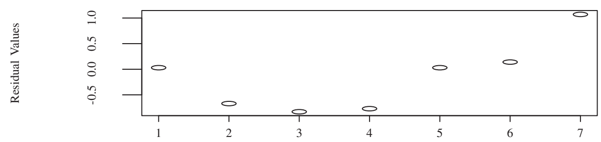

Fig. 13 Residual Values by Type of Risk
Our Model vs Estimation

VII. Results 3

- Correlation rate by type of risk is equal 98%
- Residual values between model and estimation by type of risk are random

VIII. Comparison between Model I and Model II

A. Comparing Correlation Rate

Correlation rate for model II is upper than model I as indicated in the following tables.

B. Comparing Residual Values

Residual values are random and for both models as indicated in the following tables:

TABLE V
Comparison between Model I and Model II Correlation Rate by Process

Processes	CorrelRateModelI	CorrelRateModelII
Operations/Transactions	91,75%	97%
Compliance/Risk	93,75%	99%
Information/System	97,89%	96%
Products/Customers	96,02%	98%
Finances/Budget	99,18%	99%
Strategy/Governance	90,34%	99%
Administration/Resources	95,66%	99%
Regulations/Standards	95,76%	99%
Security/Fraud	95,05%	99%
Average	95%	98%

TABLE VI
Comparison between Model I and Model II Correlation Rate by Type of Risk

Type of Risk	CorrelRateModelI	CorrelRateModelII
Credit	97%	97,57%
Strategic	98%	95,58%
Funding	95%	95,18%
Market	96%	99,40%
Political	95%	97,47%
Operational	90%	98,40%
Legal	95%	98,28%
Average	95%	98%

TABLE VII
Comparison between Model I and Model II Residual Values by Process

Processes	ResidValuesModelI	ResidValuesModelII
Operations/Transactions	-0,27	-1,01
Compliance/Risk	-0,33	-0,06
Information/System	0,22	0,01
Products/Customers	-0,31	-0,13
Finances/Budget	-0,05	-0,03
Strategy/Governance	-0,52	-0,01
Administration/Resources	-0,32	0,03
Regulations/Standards	-0,32	0,03
Security/Fraud	0,43	-0,07

TABLE VIII
Comparison between Model I and Model II Residual Values by Type of Risk

Type of Risk	ResidValuesModelI	ResidValuesModelII
Credit	-0,21	0,03
Strategic	0,10	-0,67
Funding	-0,37	-0,83
Market	0,03	-0,77
Political	0,05	0,03
Operational	-0,43	0,14
Legal	0,12	1,07

TABLE IX
Comparison between Model I and Model II Residual Variance by Process

Processes	ResidVarianceModelI	ResidVarianceModelII
Operations/Transactions	2,12	3,33
Compliance/Risk	1,63	1,21
Information/System	2,87	3,09
Products/Customers	2,00	1,49
Finances/Budget	2,03	1,71
Strategy/Governance	2,59	3,14
Administration/Resources	1,14	4,27
Regulations/Standards	1,96	1,22
Security/Fraud	2,06	1,88

TABLE X
COMPARISON BETWEEN MODEL I AND MODEL II RESIDUAL VARIANCE BY TYPE OF RISK

Type of Risk	ResidVarianceModelI	ResidVarianceModelII
Credit	1,87	1,61
Strategic	1,98	1,58
Funding	1,96	1,91
Market	2,24	4,24
Political	2,37	1,47
Operational	2,65	2,59
Legal	2,14	3,24

C. Comparing Residual Variance

Residual variance is more constant for model I than model II as indicated in the table:

D. Comparing Parameters,Variables,Constants and Win of time

Model I has more variables and parameters than model II but model II is more easy to use as indicated in the following table:

TABLE XI
COMPARISON BETWEEN MODEL I AND MODEL II PARAMETERS, VARIABLES AND WIN OF TIME

Characteristics	ModelI	ModelII
Parameters	6	1
Variables	5	2
Constants	0	1
Win of time	1 min per risk	2 min per risk

IX. CONCLUSION

In this article, we defined a new mathematical model for quantifying internal control impact on banking risks. This model does not require evaluators or evaluation sessions and makes automatic the step of risk residual criticality estimation of FMECA Method. The Residual values between model and estimation are random and residual variance is not constant; this model increase correlation rate by process and type of risk and reduces equation parameters and variables. Our future works could be summarized as follows:

- Improve the model by making constant residual variance
- Implemented a tool for integrated risk management
- Extend tests to another field different to banking
- Use another method different to FMECA

APPENDIX A
PROOF OF THE FIRST EQUATION

Equation (1) is based on the principles 1, 2, 3, 4 and 5 and provides coefficient of control maturity.

Maturity Coefficient = Impact Value/Max level

$MatCoef_i = ImptVal_i/Maxlevel_i$

i=1,2,3,4,5,6,7,8,9,10

The result is in the following table:

$$MatCoef = [\sum_{1}^{10}(MatCoef)_i]/10 \quad (2)$$

MatCoef = 0.1

TABLE XII
PERCENTAGE, IMPACT VALUE AND MATURITY COEFFICIENT OF CONTROLS

Level	Percentage	Impact Value	Maturity Coefficient
1	0%	0	0,00
2	25%	0,25	0,13
3	35%	0,35	0,12
4	45%	0,45	0,11
5	55%	0,55	0,11
6	65%	0,65	0,11
7	75%	0,75	0,11
8	85%	0,85	0,11
9	95%	0,95	0,10
10	100%	1	0,10

APPENDIX B
PROOF OF THE SECOND EQUATION

Equation (2) is the product of Maturity Coefficient and Average of control maturity:

Maturity Impact = Maturity Coefficient * Average of control maturity

$$MatImpact = [\sum_{1}^{10}(CoefMat)_i/10]*[\sum_{1}^{n_{ctl}}(mat_i)/n_{ctl}] \quad (3)$$

$$MatCoef = 0.1/[mat_i] = 1,2,3,4,5/[n_{ctl}] = 1,2,3$$

APPENDIX C
PROOF OF THE THIRD EQUATION

Residual criticality = Initial criticality - Maturity Impact

$$C_{resu} = C_{ini} - [[\sum_{1}^{10}(CoefMat)_i/10]*[\sum_{1}^{n_{ctl}}(mat_i)/n_{ctl}]] \quad (4)$$

$$MatCoef = 0.1/[mat_i] = 1,2,3,4,5/[n_{ctl}] = 1,2,3$$

APPENDIX D
GLOSSARY

- Risk: A potential events that occur internally or externally and which are likely to affect the implementation of the strategy and the achievement of organizational goals
- Risk Management: A set of activities which identify and assess all enterprise risks and implement appropriate measures to eliminate or decrease their consequences
- Integrated Risk Management: Managing based on a global approach of risk at all levels of the organization
- Risk identification: Identify risks and determine main elements(wording, cause, consequence)
- Risk assessment: Qualitative and quantitative risk assessment and determination of the appropriate analysis
- Risk exposure: Variable to measure risks which organization is actually exposed
- Likelihood of risk: Possibility for a risk to occur
- Severity of risk: Negative consequences of risk
- Control: A set of measures to control risks
- Preventive control: Based on preventing the risk occurring
- Detective control: Based on risk communication out
- Corrective control: Based on treatment of risk detected

- Criticality of risk: Aggregated measure of risk
- Initial criticality: Criticality without consideration of controls
- Residual criticality: Criticality after taking into account the controls
- Risk appetite: Value which provide assurance that the residual risk levels do not exceed the level of risk appetite defined by the management
- Risk tolerance: Ability of a company to lose all or part of an investment
- FMECA: Failure Modes and Effect Criticality Analysis

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