Appendix B

Exposure Indicator
–Supplement to “Derivation of the IMA Formula” –

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1. Introduction

This paper titled “Exposure Indicator” is a supplement to our paper on the IMA approach “Derivation of the IMA formula -RPI calculation” in which we proposed an actual formula and a calibration methodology for the IMA. We believe that the latter provided a big step towards establishment of an explicit formula for the IMA.

In order to complete this approach, it is crucial to determine what kind of indicator in the IMA formula would best reflect the size of risk. On this point, regulators as well as private sector banks are having active discussions. Given this background, we would like to explain Exposure Indicator in detail in this paper. Our aim is to make clear what is the best Exposure Indicator.

Before starting discussion on the main subject, EI, we would like to review the content of the “Derivation of the IMA formula”.

First of all, the fundamental structure of the IMA formula shown in CP2 is as follows□

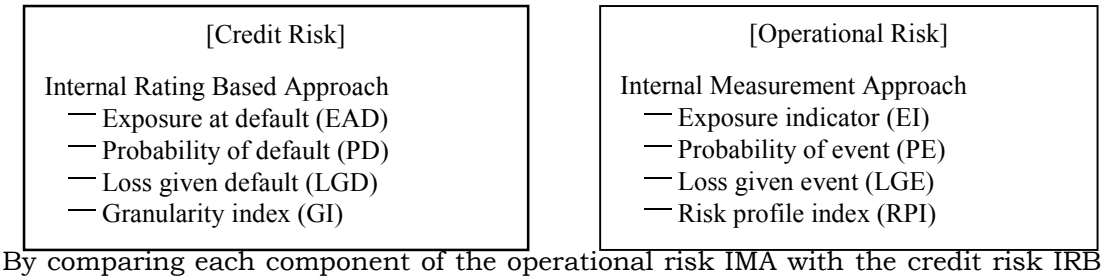
Expected loss = EI (Exposure indicator) * PE (Probability of loss event)* LGE (Loss given event),

and

Required capital for each Business line/Event type = g * EI * PE * LGE * RPI (Risk profile index).

In other words, required capital has the expected loss as its core and is obtained by multiplying EL by γ and RPI.

The point here is that the IMA formula for operational risk can be compared with the formula under the Internal Ratings Based Approach for credit risk.
In the following figure, the IRB formula for credit risk as shown in CP2 is summarized on the left hand side. The component of the IMA for operational risk are summarized on the right-hand side and they are compared with each other like this.



By comparing each component of the operational risk IMA with the credit risk IRB, we can discuss operational risk by analogy with credit risk.

The factor in the IRB formula which corresponds to the EI in the IMA is EAD. As EAD, normally we use loan balance. We may consider gross income as an alternative for EAD. It is true indeed that gross income is somehow linked to loan balance, but the degree of such a linkage must be different from bank to bank. What is directly exposed to credit risk is loan balance. Accordingly, it is not appropriate to choose gross income as EAD. Nobody would use gross income as EAD. This argument has a significant implication for the determination of EI in the context of operational risk we discuss in this paper.

In “Derivation of the IMA formula”, we proposed an explicit formula for operational risk IMA by analogy with credit risk IRB approach as shown in this figure. The points are summarized as follows.

First of all, we proposed the notion of RPI corresponding to the Granularity Index in the IRB approach. This is a term that reflects the “low frequency, high severity” situation, which is characteristic of operational risk, and it is determined by the distribution of EI and the frequency of events.

As for PE, we proposed a non-linear operational risk ratio function by analogy with the risk weight function in the credit risk IRB approach.

Calibration is carried out by performing a regression analysis on the actual loss distribution and the result of the formula. We obtained a formula by event type, which is common to all the business lines with a very high coefficient of determination. Actually, the formula has the same structure for processing risk and systems risk, and only the coefficient λ is different , i.e. 0.014 and 0.029, respectively.

This is the summary of the explicit IMA formula, which we proposed in the previous paper.

2. Issue to be considered on Exposure Indicator

$$\text{Required capital} = EI * f(PE) * LGE * RPI$$

The next crucial step for the completion of the IMA formulation is to determine what should be employed as the components of the IMA formula which we derived. Among others, various candidates have been proposed for EI. What matters here is how to define the EI to reflect the size of risk appropriately for which data collection is practically possible.
Now we have to think about the role of EI in the IMA formula, in other words, what are the requirements for EI.

The first point is that the EI in the IMA formula must be an item that is exposed to operational risk, not a simple scaling factor. This holds true for the Standardized Approach.
In the context of credit risk, this corresponds to the argument that EAD must be loan balance, not gross income.
In other words, the EI should represent the size of operational risk exposure in the IMA formula.

As a candidate for the term that can represent the size of operational risk exposure, we proposed total transaction amount in our previous paper. CP2 mentioned also gross income, annual average assets and so forth.

Another requirement for the EI is that it should implicitly contain the information to determine the RPI. RPI can be decomposed into the adjustment factor for severity and the adjustment factor for frequency. It reflects the “low-frequency” and the “high-severity” characteristic of operational risk, both of which depend on the distribution of the amount exposed to operational risk, i.e. EI. The analysis in our last paper showed that by incorporating the RPI reflecting the EI distribution into the IMA formula, the fitness of the formula for the actual loss distribution is improved to a great extent. The dispersion of the EI is an important and essential factor to determine the ratio between UL and EL. Therefore, EI must be an item that contains the information for measurement of dispersion.

3. Candidates for Exposure Indicator

Now we would like to discuss the candidate for the indicators, which can fill the roles of EI mentioned earlier, that is, to represent the size of operational risk exposure and also contain the information to determine the RPI.

For the business lines we consider, i.e. retail and wholesale commercial banking, trading & sales and processing services subsidiaries, as well as the event types we consider i.e. processing risk and systems risk, loss due to operational risk is incurred in execution of transactions. Therefore, operational risk is proportional to transaction amount, which should be the candidate for EI. By the way, we exclude natural disaster case in our analysis. This matter should be discussed separately. Actually, as we demonstrated in the previous paper, the formula best fit in with the actual loss distribution when we selected transaction amount as EI.

In the following sections, we will illustrate that, when we define EI as transaction amount, it is possible to specify it for each business line as well as to collect the relevant data.

3.1. Examples of Exposure Indicator –Commercial Banking (Retail) Case–

3.1.1. Examples of transaction data by business line / sub-category

Table 3.1 Examples of Exposure Indicator –Commercial banking (retail) –

Broad business line	Sub-category	Examples of Exposure Indicator
Commercial banking (retail)	**Deposit / money transfer**	Amount paid out Amount paid in Amount transferred
	Credit	Amount of credit disbursed Amount collected (principal/interest) Notional principal amount for derivatives
	Loan	Amount of loan drawn down Amount of loan collected Limit amount for card loan
	Foreign Exchange	Amount transferred Transaction amount
	Payment services	Amount paid out

In this section, we discuss what kind of Exposure Indicators are available for each business line / sub-category. In the previous section, we showed transaction amount as a candidate. Examples for retail commercial banking are listed in the above table. This table covers all the transactions that are listed either on asset or liability side. Accordingly this classification is exhaustive. Here, retail commercial banking business line is further divided into 5 sub-categories according to the activity, i.e. deposit / money transfer, credit, personal loan, foreign exchange and payment services.

For each activity, the relevant transaction data is specified as shown in the far-right column.

For example, as to deposit / money transfer, it would be amount paid-out, amout paid-in, and amount transferred. As to credit, it would be amount of credit disbursed, etc. As to personal loan, it would be amount of loan drawn down, limit amount for card loan and so on. Among the operational risks associated with card loans, the risks arising from the action to establish the limit itself is captured as the loan limit amount. On the other hand, the risks arising from the drawdown and collection of card loans are captured by using as EI the data on pay-in / out of the account of the borrower. The EI defined like this can be determined uniquely for each activity. In other words, we can maintain a level playing field. There is no room for cheating.

In the following section, we will look into each activity in a little bit more detail.

3.1.2. The case of deposit transaction
Deposit transaction is analyzed in the following figure.

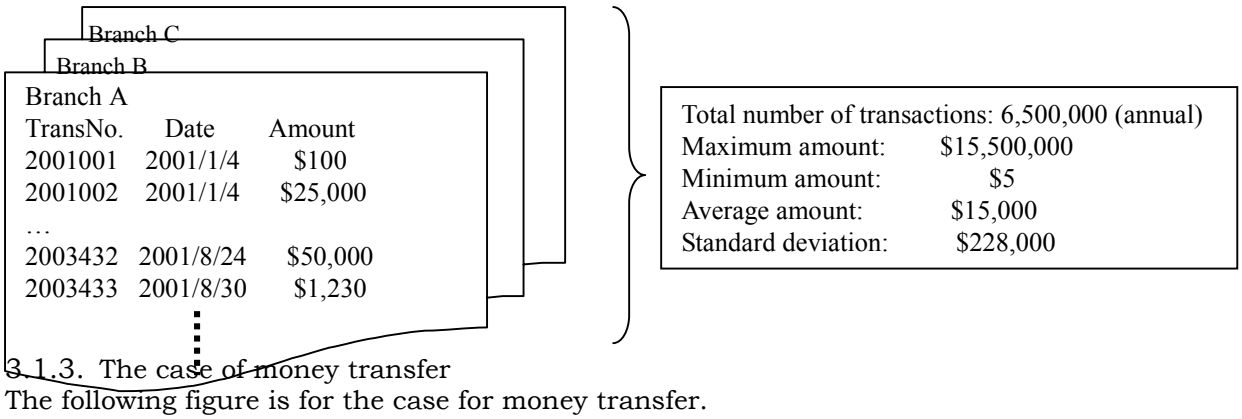
Examples of accidents in deposit transaction include the cases where customer deposit is accidentally paid out due to operational errors or fraud.

In terms of event classification, this case corresponds to fraud or execution. The effect is write-down.

One of the candidates for Exposure Indicator in this case is amount of cash paid-out. If we define the EI this way and collect the relevant data, this kind of event must be included in the data without any exception. For example, the case where customer deposit is accidentally paid out by the fraud of an employee is recorded on the transaction data as an illegal operation conducted somewhere.

Accordingly, we define the amount of cash paid-out as Exposure Indicator and collect the relevant data. The figure on this page shows a record of cash payout transactions at a certain branch office. How much money was paid out when is recorded here. In this way, we collect the detailed data on each transaction for the past one year for example at all the branches. This enables us to measure the total and the distribution of EI, i.e. mean and standard deviation.

Chart 3.1 Examples of transaction data



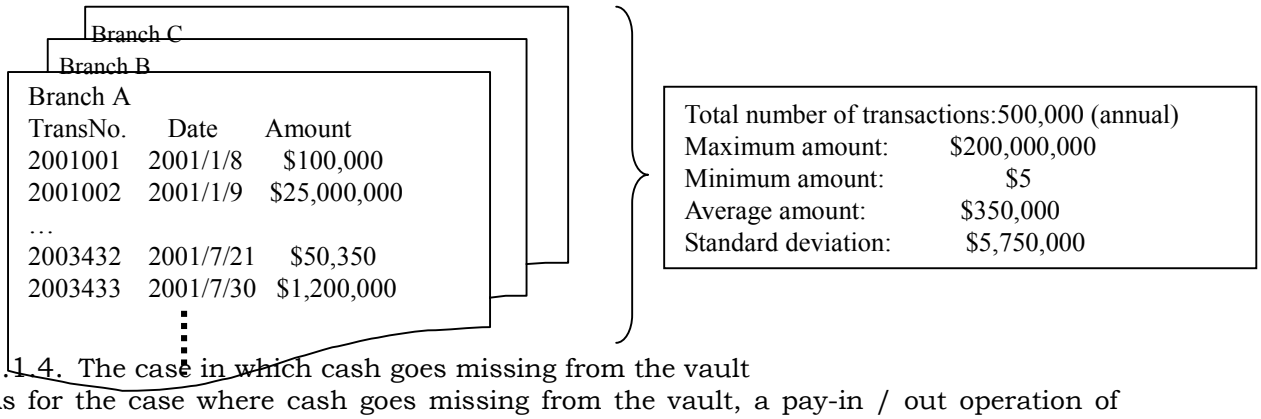
3.1.3. The case of money transfer
The following figure is for the case for money transfer.

Examples of accidents in money transfer include the case where the money erroneously transferred due to an incorrect payment order becomes irrecoverable. In terms of event classification, this case corresponds to fraud and execution. The effect is write-down.

One of the candidates for Exposure Indicator in this case is the amount of money transferred. If we define the EI this way, this kind of event must be included in the data without any exception. For example, the case of incorrect payment order due to an operational error is recorded on the transaction data as an inappropriate operation conducted somewhere.

Accordingly, we define the amount of money transferred as Exposure Indicator and collect the relevant data. The figure on this page shows a record of the amount of money transferred at a certain branch office. How much money was transferred when is recorded here. In this way, we collect the detailed data on each transaction for the past one year for example at all the branches. This enables us to measure the total and the distribution of EI, i.e. mean and standard deviation.

Chart 3.2 Examples of transaction data



3.1.4. The case in which cash goes missing from the vault

As for the case where cash goes missing from the vault, a pay-in / out operation of vault cash must have bean conducted somewhere, which means that the incident must be included in one of the transaction data. Accordingly, if we collect the transaction data for all the cases, we can capture this kind of event without any exception.

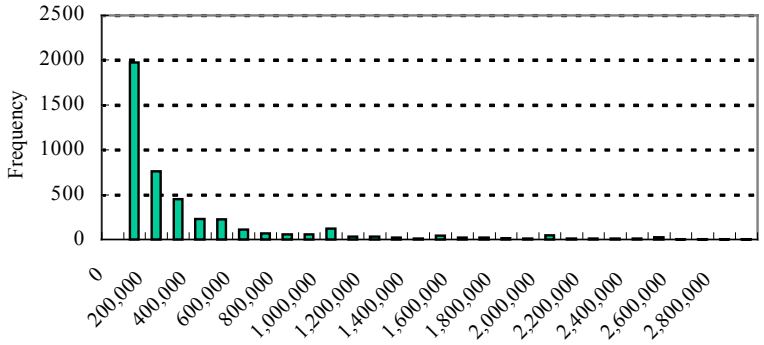
3.2. Reflection of Exposure Indicator on IMA formula

The total and the distribution of EI measured in this way are reflected on the IMA formula. The total of EI is reflected on the EI as transaction amount in the IMA formula. The graph shown below is the histogram of the transaction amount collected.

This is the distribution of EI, and the mean and the standard deviation of EI can be measured based on it.

The distribution of EI is reflected on the RPI, which is the adjustment factor for severity and frequency that are characteristic of operational risk and therefore important components of the IMA formula.

Chart 3.3 Distribution of amount handled in operational transactions



3.3. Sample measurement of Exposure Indicator

As I explained earlier, the total, mean and standard deviation of EI are important factors in the IMA. The following table shows the actual calculation of them for retail commercial banking. We defined EI as shown on page 8 and collected all the relevant transaction data. As you can see here, the total number of transactions is about 200 million, all of which have been considered for analysis. The total amount handled, the mean and the standard deviation regarding these transactions are shown in this table. The number of transactions is used as the denominator for PE calculation. The total transaction amount is used as EI. The mean and the standard deviation of the EI are required for RPI calculation. All these factors are essential to IMA calculation. In summary, the measurement of these was made possible by defining EI as transaction

amount.

Table 3.2 Measurement of Exposure Indicator

Number of transactions	EI = Total amount (annual) [USD mil]	f of EI [USD]	σ of EI [USD]
232,220,352	8,534,966	36,754	1,080,616

3.4. Loss Given Event

In relation to the definition of EI, it is necessary to touch on LGE. The reason is as follows. The is defined as the proportion of the loss finally incurred to the exposure of a loss event which has actually occurred for each business line / event type. The denominator of LGE, i.e. transaction amount has to be consistent with the EI. In other words, the loss amount when an event occurs is expressed as EI x LGE in the IMA formula, and if the definition of the denominator to calculate LGE is not the same as for EI, the resulting loss amount will be meaningless. Accordingly, if EI is defined as transaction amount, the denominator to calculate LGE should also be action amount. For each business line, LGE is set conservatively based on the LGE data for all the events. We assume that there is no correlation between the occurrence of an event and the relevant transaction amount. Therefore, the IMA formula which multiply EI by LGE both of which are calculated independently, is appropriate.

LGE is determined for each business line in this way. In the case of Sumitomo Mitsui Banking Corporation, for example, 100% and 5% have been assigned to the two business lines as shown here. For wholesale commercial banking and trading & sales, denominator to calculate LGE is the EI defined as notional principal amount of derivatives. As a result the LGE is comparatively small.

3.5. Application of IMA

Now, based on the preparation we have described so far, we can calculate the required capital using the IMA formula.

Table 3.3 Application of IMA

EI Total amount (annual) [USD mil]	Number of transactions	Number of event (annual)	PE	f(PE)	LGE	f of EI [USD]	σ of EI [USD]	RPI1/C1 =f	RPI2 =1/	RPI =1+10*RPI1*RPI2
8,534,966	232,220,352	157	0.000068%	0.000107%	100%	36,754	1,080,616	29	0.1	24

The EI in the IMA formula is the total transaction amount. f(PE) is a non-linear operational risk ratio function which incorporates the PE, i.e. the number of events divided by the total number of transactions. LGE is set for each business line. It is 100% for retail commercial banking. RPI has been calculated based on the mean and the standard deviation of EI in addition to the number of events. The value of PRI is 24.

By applying these numbers to the IMA formula, we can calculate the required capital amount. For the business line of retail commercial banking and the event type of processing risk. The result is: EI [= 8,534,966] * f(PE) [= 0.000107%] * LGE [= 100%] * RPI [= 24] = 224USDmil. In summary, what we have demonstrated here is that defining EI as transaction amount enables us to calculate required capital using the IMA formula.

3.6. Commercial Banking (Wholesale) Case

3.6.1. Sample measurement of Exposure Indicator

So far, we mainly discussed retail commercial banking. Now, this is the case for wholesale commercial banking. Exposure Indicator can be defined like this for each sub-category.

Table 3.4 Examples of Exposure Indicator –Commercial banking (wholesale) –

Broad business line	Sub-category	Examples of Exposure Indicator
Commercial banking (wholesale)	**Credit**	Amount of credit disbursed Amount of credit collected (principal/interest) Notional principal amount for derivatives
	Treasury	Settlement amount Amount of funds taken/placed
	Foreign Exchange	Amount transferred Transaction amount

Examples for credit are: Amount of credit disbursed, amount of credit collected and notional principal amount for derivatives. We will explain notional principal amount for derivatives later. The following table shows the result of the calculation for the total amount, the mean and the standard deviation of the EI using the relevant data collected. Compared to retail commercial banking, the number of transactions is small. But, of course, the mean and the standard deviation of EI are higher because the lending amount is larger and the proportion of derivative and money market transactions in the business of the bank is higher.

Table 3.5 Measurement of Exposure Indicator

Number of transactions	EI = Total amount (annual) [USD mil]	of EI [USD]	σ of EI [USD]
1,287,913	3,154,143	2,449,034	17,423,371

3.6.2. Application of IMA

The following formula shows a sample application of the IMA formula in the case of wholesale commercial banking. EI is the total transaction amount. f(PE) is a non-linear operational risk ratio function which incorporates the PE, i.e. the number of events divided by the total number of transactions. LGE is set for each business line. It is 5% for wholesale commercial banking. RPI has been calculated based on the mean and the standard deviation of EI in addition to the number of evens. The value of RPI is 9. By applying these numbers to the IMA formula, we can calculate the required capital amount. For the business line of wholesale commercial banking and the event type of processing risk the result is: EI [= 3,154,143]* f(PE) [= 0.004479%] * LGE [= 5%] * RPI [= 9] =61 USD mil.

Table 3.6 Application of IMA

EI Total amount (annual) [USD mil]	Number of transactions	Number of event (annual)	PE	f(PE)	LGE	of EI [USD]	σ of EI [USD]	RPI1/C1	RPI2 =1/	RPI =1+10*RPI1*RPI2
3,154,143	1,287,913	86	0.006677%	0.004479%	5%	2,449,034	17,423,371	7	0.1	9

3.7. Trading & Sales case

3.7.1. Sample measurement of Exposure Indicator

The next figure shows a sample for trading & sales. One of the examples of Exposure Indicator is notional principal amount for derivatives.
Now, we would like to explain why the definition of EI is not the asset size. If EI is defined as an asset amount, there may be a case where EI=0. It is true indeed that there is no credit risk involved in such a case, but operational risk should be considered to remain. Accordingly, asset-based definition of EI is not appropriate. EI defined as notional principal amount reflects operational risk as it is directly linked to the actual operation of the relevant transactions.

Therefore, we think that notional principal amount is an appropriate definition, rather than the one based on asset amount.

The total amount, the mean, and the standard deviation calculated using the relevant data collected are shown in the bottom table.

The number of transactions is extremely small compared to retail commercial banking. But the mean and the standard deviation of the EI are much larger.
In other words, a wrong definition of EI would not give incentive for risk management. As we have shown earlier, for credit card loan as well as derivatives, asset size is not appropriate for EI.

If asset size should be chosen as EI, the regulatory capital framework for operational risk would be drawn back to just a part of credit risk capital framework, which is the present regulatory capital framework.

Accordingly, it is necessary to define an appropriate EI for operational risk and determine the appropriate calculation method for operational risk capital. This is why we have proposed them in this paper.

Table 3.7 Example of Exposure Indicator

Broad business line	Example of Exposure Indicator
Trading & Sales	Notional principal amount for derivatives

Table 3.8 Measurement of Exposure Indicator

Number of transactions	EI = Total amount (annual) [USD mil]	$\hat{f}$ of EI [USD]	σ of EI [USD]
333,051	2,262,206	6,792,372	24,438,858

3.7.2. Application IMA

Table 3.1 is a sample application of the IMA formula in the case of Trading & Sales.
EI is the total amount of transaction data. f(PE) is a non-linear operational risk ratio function which incorporates the PE, i.e. number of events divided by the total number of transactions. LGE is set for each business line. It is 5% also for Trading & Sales. RPI has been calculated based on the mean and the standard deviation of EI in addition to the number of events. The value of RPI is 8.

By applying these numbers to the IMA formula, we can calculate the required capital amount. For the business line of trading & sales and the event type of

processing risk, the result is: EI [= 2,262,206] * f(PE) [= 0.005118%] * LGE [= 5%] * RPI [= 8] = 47USDmil.

Table 3.9 Application of IMA

EI Total amount (annual) [USD mil]	Number of transactions	Number of event (annual)	PE	,†PE)	LGE	ƒ f EI [USD]	σ of EI [USD]	RPI1/C1 =ƒ Ê	RPI2 =1/□ a	RPI =1+10*RPI1*RPI2
2,262,206	333,051	26	0.007807%	0.005118%	5%	6,792,372	24,438,858	4	0.2	8

3.8. Summary

So far, we have discussed the processing risk. But also for other event types, for example, systems risk, we can use the IMA formula in the same way. The result is summarized below.

Table 3.10 Required capital

[USD mil]

Event type / Business line	Processing	Systems	total
Commercial banking (retail)	224	464	688
Commercial banking (wholesale)	61	0	61
Trading & sales	47	54	101
Payment & settlement			
Agency services			
Asset management			
Retail brokerage			
total			

4. Summary

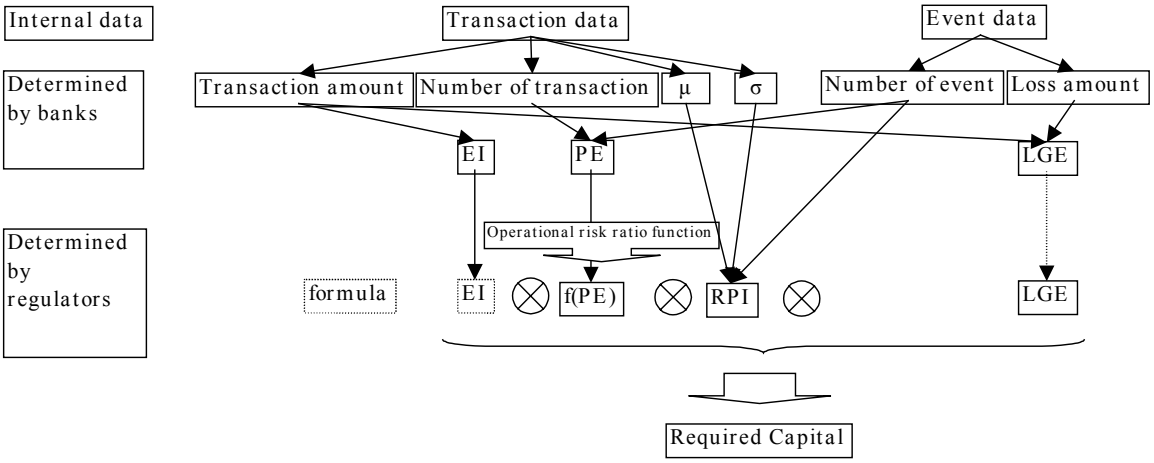
4.1. Summary (1)

The following flow chart summarizes the process of IMA calculation which we have described so far.

Banks internally collect transaction data and event data. Banks then obtain the EI and the total amount from the transaction data, and the PE and the LGE from both of transaction data and event data. Banks also calculate the mean and the standard deviation of EI, which are the factors of PRI for which regulators will determine coefficients etc.

The structure of the IMA formula is determined by regulators. Required capital is measured by applying the above number obtained by banks to this IMA formula.

Chart 4.1 Process of IMA calculation



4.2. Summary (2)

The next figure summarizes the results of the calculations which we have explained for each business line. Table 4.1 shows the factors in the IMA formula calculated based on the bank's internal data according to the flow chart in the previous figure. Table 4.2 shows the regulatory capital calculated using the formula determined by regulators. IMA will be made possible by collection of data and calculation of each factor by each bank according to this format.

Table 4.1 Internal data

	Total amount (annual) [USD mil]	Number of transactions	Number of event (annual)	PE	$\hat{\mu}$ of EI [USD]	σ of EI [USD]	LGE
Commercial banking (retail)	8,534,966	232,220,352	157	0.000068%	36,754	1,080,616	100%
Commercial banking (wholesale)	3,154,143	1,287,913	86	0.006677%	2,449,034	17,423,371	5%
Trading & Sales	2,262,206	333,051	26	0.007807%	6,792,372	24,438,858	5%

Table 4.2 Required capital

	EI [USD mil]		$\hat{\mu}$(PE)		RPI		LGE		Required Capital [USD mil]
Commercial banking (retail)	8,534,966	X	0.000107%	X	24	X	100%	⇨	224
Commercial banking (wholesale)	3,154,143		0.004479%		9		5%		61
Trading & Sales	2,262,206		0.005118%		8		5%		47

Finally, we would like to repeat that we demonstrated today that it is possible to calculate operational risk regulatory capital based on banks' internal data such as transaction data and event data, both of which are crucial for their operational risk management. Therefore, we are convinced that the framework we proposed today will

give contribution to enhancement of operational risk management capability.

The numbers used in this paper are for illustration purposes only and do not necessarily reflect the reality.