

Operational Risk Measurement in Banking Institutions and Investment Firms: New European Evidences

BY ENRIQUE BONSON, TOMÁS ESCOBAR, AND FRANCISCO FLORES

The banking/investment sector must deal with a new variable, Operational Risk, for explaining various recent crises and bankruptcies. Operational Risk, which can be defined briefly as the risk generated by possible failures of a entity's Information Systems (IS), must be measured, covered, mitigated and managed by applying a series of methodologies, each of which assumes that the IS of the bank operates at a certain Stage of Sophistication. The present study proposes a scheme of evolution that details the stages of enhancement in the sophistication of their IS that banking entities may implement, so as to be capable of capturing, mitigating and managing Operational Risk. Using econometric methods, we create a proxy variable to capture the IS Sophistication of each entity. Then, the factor of entity size has been analyzed, and the country effect is explored. Additionally, the importance of intangible assets is weighted, among others entity aspects. The entity size has been revealed as the variable with most influence on the plans formulated in this respect by European entities, against other variables also considered in the present study, such as the country effect or the importance of intangible assets. The work shows how IS decisions referring to Operational Risk management are very influenced by size. It could introduce competition differences in the European banking system.

I. INTRODUCTION

Financial entities in particular, and national economies in general, have in recent decades suffered some traumatic events (de Fontnouvelle et al. (2003)) that have involved enormous financial losses and have highlighted the need for major organizational and technological changes. The nature of these events has not always been associated with the specific characteristics and business environment of the financial activities of the entities affected, but often with unexpected events or events not adequately taken into account by the existing IS (Information System) of the entity. Frauds, faults and disasters have caused serious difficulties for important entities, and consequently new and more efficient IS are evolving to take into account these new circumstances. The way in which banks will face these challenges is an *a priori* question for analysts and researchers to be clarified.

Another important effect is that the monitoring of banking/investment activity, both internally by the management of entities and externally by supervisors and regulators, is now becoming increasingly complex. This is such a major issue that banks are finding it advantageous to outsource their IS: among the incentives for this are access to the latest technologies, the by-passing or minimization

of internal conflicts, access to expertise or better control of IT costs (Baldwin et al. (2001)). New challenges and threats are emerging in the business context of banking/investment entities. Competition and internationalization are growing, and the media are always reporting a new banking crisis somewhere in the world. Recent examples of such crises have been seen in Germany, Japan, Norway, Spain, Sweden, Switzerland, the United Kingdom and United States, and have been analyzed by the Basel Committee (2005). According to this analysis, a considerable number of the banking crises mentioned are due to the malfunctioning of the bank's IS, therefore the review and development of these systems has become necessary, especially when the capacity for innovating in IS is emerging as a key element that contributes to the success of the entity (Mustonen-Ollila and Lyytinen (2004)).

Basel II is an agreement for "good practices" in respect of the structures and operating procedures of banking/investment entities. The Bank for International Settlements of Basel is the oldest international financial institution that still exists, and its function is to enhance collaboration and provide services to central banks, with the goal of promoting the stability of the global financial system. The IS of banks, and in particular their systems for monitoring risks, take the regulations recommended by the BIS as a major point of reference. As a result of serious economic crises in the 1970s and 1980s, the Basel Committee was established by the central bank Governors of the G-10 countries to supervise banks that are internationally active (Bakker (2004)). The reality today is that all the banking/investment entities of these countries find themselves affected profoundly by the regulation imposed indirectly by the Bank for International Settlements, whatever their size or the extent of internationalization of their operations (Danielsson and Jonsson (2004)). The activity of the Basel Committee has culminated in the publication of the document "International Convergence of Capital Measurement and Capital Standards: a Revised Framework" (Basel Committee (2004)), known as Basel II. It is within the framework of this agreement that Operational Risk appears for the first time as a key accounting variable for banking/investment entities, and thus needs to be taken into account as a significant variable in the configuration and evolution of the IS of banks.

Despite the importance of ensuring efficient functioning and adequate evolution in the IS of banks, not all banking/investment organizations adopt the same strategies or achieve the same degree of success in the implementation of an advanced IS. Often when an organization attempts to implement a new system of business information, it is not sufficient just to recognize its advantages; even if these are clear, some entities have great problems with the actual implementation (Chenhall (2004)). Therefore, there is a real need to determine those characteristics of banking/investment entities that predispose them to innovate successfully in IS, and in particular the stages in the evolution of an enhanced system (that we call Stages of Sophistication) through which the entity may pass, and then to characterize these Stages.

The present study firstly proposes a scheme of evolution by which banking/investment entities can enhance the sophistication of their IS, so as to be

capable of capturing and mitigating Operational Risk, and thus confront the challenges presented by today's business environment. This scheme is based on the contributions from both Mustonen-Ollila and Lyytinen (2004) and the Basel Committee itself (2005). Secondly, the study explores the plans of European entities in this respect, to seek those variables characterizing the entities that seem to influence how the entity progresses from one Stage to another in this scheme; that is, the variables that seem to determine the degree of sophistication of the IS implemented.

II. OPERATIONAL RISK

In recent decades, operational failures have caused dramatic results, in some cases even leading to collapse (Aparicio and Keskiner (2004)). de Fontnouvelle et al. (2003), Bakker (2004), and Rachev et al. (2005) have compiled a list of some significant events (Table 1), not limited to the area of financial entities, to which we add some approximate figures. Financial institutions have suffered more than 100 Operational Loss events exceeding 100 million dollars each, over the past decades.

From an analysis of the more recent banking crises, the Basel Committee has detected faults in the IS of banks as a substantial cause of the losses, that are materialized and categorized as what has been formally designated as Operational Risk. In effect, this new variable highlighted in the studies conducted by the Basel Committee and in its recommendations (especially in Basel II), has had a truly revolutionary impact on the implementation of banks' IS, in the sense of it puts the spotlight on specific faults and deficiencies in these systems that on occasions have caused the actual failure of the banking/investment organization affected.

According to Basel II, Operational Risk is defined as the risk of loss resulting from inadequate or failed internal processes, people and systems or from external events. This definition includes legal risk, but excludes strategic and reputational risk. This is the definition of Operational Risk with which we are working, but it differs from other previous definitions, and from approaches such as those

Table 1: Examples of Operational Losses

Entity or Event	Operational Losses
Allfirst Financial	681 Million Dollars
Household Finance	484 Million Dollars
September, 11 Attack	140 Million Dollars
Barings Bank.	826 Million Pounds
Orange County	1600 Million Dollars
Daiwa Bank	1100 Million Dollars
NatWest	130 Million Dollars
Allied Irish Banks	750 Million Dollars

maintained in the past by some large Japanese banks, which had argued that such risks were not susceptible of measurement (Hiwatashi and Ashida (2002)). However, the scope that this conception of risk is acquiring, and its imminent and full incorporation in various normative frameworks, makes it rather pointless for us to enter into discussion on the suitability of the definition. The fact is that the attention given to this new variable is having a great impact in the banking/investment sector (Chapelle et al. (2004)). With the appearance on the scene of the Operational Risk, a new variable becomes visible for the accounting systems of financial entities (Bonsón et al. (2007)). On a more detailed analysis, the losses caused by Operational Risk can be divided into seven types, according to their origin or nature. Similarly, each loss can be placed under one of the eight lines of business that are typically established by these entities. It is not at all simple to foresee the amount of losses that an entity could incur under these headings, and the degree of accuracy of these measurements depends to a large extent on the stage of sophistication of the bank's IS.

The objective of Basel II in pressing banking/investment organizations to forecast the amount of operating risk that they could incur is to ensure that, having determined this amount, the entities should make use of accounting mechanisms and policies systematically to cover the losses that may be expected. The accounting mechanism selected is the designated capital requirement; this consist of establishing a series of amounts of capital and reserves that quantitatively would cover the forecast Operational Risk, as occurs with others risks of a more clearly financial character. Therefore, the bank's IS must be capable of measuring potential Operational Risk, quantifying it, and providing this information to the responsible executives of the banking/investment entity, so that they may take appropriate precautionary measures in terms of strategic, organizational, accounting and insurance actions.

III. STAGES OF SOPHISTICATION IN OP RISK MEASUREMENT

When the entity decides to what level or stage its IS must to evolve to meet these requirement, it will need to consider aspects such as its point of departure, and the possible costs and incentives of bringing its IS up to one or other of the stages of sophistication possible. There are, of course, considerable difficulties to overcome in enhancing the sophistication of a bank's IS to face the challenge of effectively and actively managing Operational Risk, and Wilson (2004) indicates the following difficulties:

- The responsibility for the implementation of the IS innovations is not clear.
- The increased complexity makes the new framework difficult for the members of the organization (i.e., the bank's staff) to understand.
- The date for the legal implementation of Basel II (2007–2008 in the context of the EU) is seen as too distant, and short term issues tend to command most of the attention of the entities' managements.

For this reason, it is considered useful to make explicit in this study, and in detail, the theoretical and practical characteristics that may be implied for each stage of sophistication of a bank's IS, combining the theoretical advances of Mustonen-Ollila and Lyytinen (2004) and the practical recommendations of Basel II. Mustonen-Ollila and Lyytinen distinguish four types of IS process innovations (ISPI): base line technologies (T), tools (TO), description methods (D), and managerial innovations (M). As their definition of an ISPI, they take that given by Swanson (1994) who defines it as any new way of developing, implementing, and maintaining information systems in an organizational context.

For the purposes of our study, we have delimited four stages of sophistication in banking/investment IS, in terms of capturing information relevant for management of Operational Risk. At the same time, we have related each Stage of Sophistication to the different types of ISPI indicated.

THE BASIC INDICATOR APPROACH

This first Stage of Sophistication (Figure 1) involves the implementation of a specific Pertinent Indicator that allows the entity to determine, by means of a process of Calculation, the level of Potential Operational Losses to which its would be exposed. To be capable of providing and maintaining this information, the banking/investment entity must simply ensure that its internal databases function

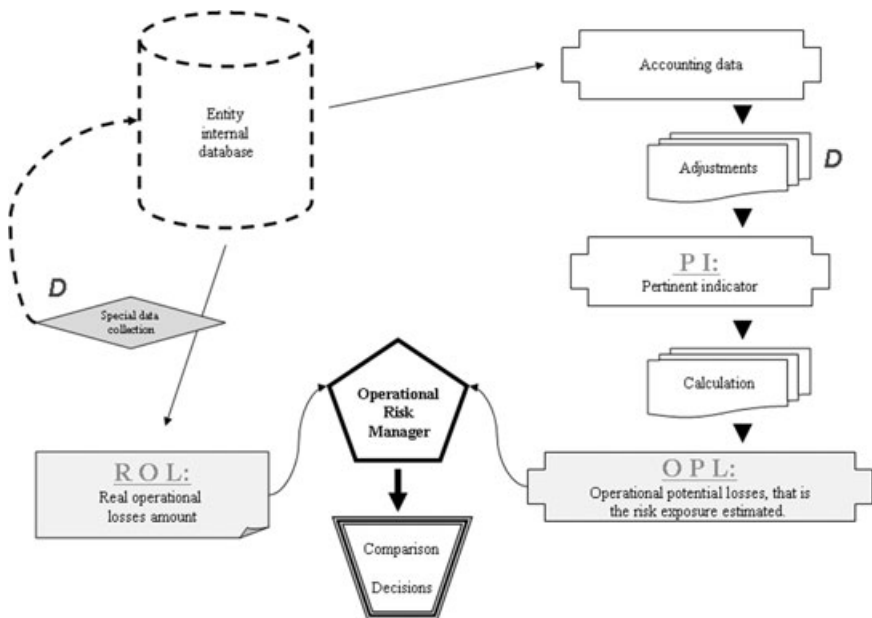


Figure 1: IS Stage 1, Basic Indicator Approach.

correctly, and implement an adequate data collection procedure based on the data that the entity has collected directly, to which simple adjustments are applied, such as taking the mean value of several years, or eliminating particular accounting items. In this stage then, it is only necessary to reform the bank's existing IS so that it can incorporate the new terminology of Operational Risk. From an ISPI point of view, this would imply a type of innovation consistent with Description Methods (D), since the rest of requirements of the method can be met with the existing management and technical structure.

The Calculation mechanism consists of quantifying the possible losses due to Operational Risk by applying a fixed factor of 15% to the mean of the Pertinent Indicator (PI), which is the gross income obtained by the entity in the last three previous financial years that were not negative or nil. When there is an accounting year with zero or negative gross income, that year is excluded from the calculation in both numerator and denominator. The resulting figure serves to inform the entity of how much capital and reserves it must have available to cover its Operational Risk. Therefore, the Basic Indicator Approach consists of applying the following formula (1):

$$POL = \left(\sum PI_{1 \dots n} * \alpha \right) / n \tag{1}$$

where:

- POL = the estimated amount of Potential Operational Losses
- PI = the Pertinent Indicator, that is, annual gross income, where positive, over the previous three years
- n = number of the previous three years for which gross income is positive
- α = 15%, which is set by the Committee

Each year the accounting system of the entity produces new figures for the PI, so the entity re-estimates its POL, and modifies the level of protection of the entity against Operational Risk in consequence, comparing the estimated figures in each case with the values that the same internal database provides with respect to the Real Operational Losses, ROL.

There is no need to create an organizational unit with persons and tools specifically dedicated to monitoring Operational Risk. Of course, the executives responsible, or the organizational structure in which this approach is adopted, must utilize the information provided by this type of IS to take appropriate decisions in respect of the level of protection possessed by the banking organization, and take the necessary measures to obtain or maintain this capital.

THE STANDARD APPROACH

To reach this next level of evolution (Figure 2), the bank's IS must reconfigure its information structures to adapt them to the division by lines of activity that the

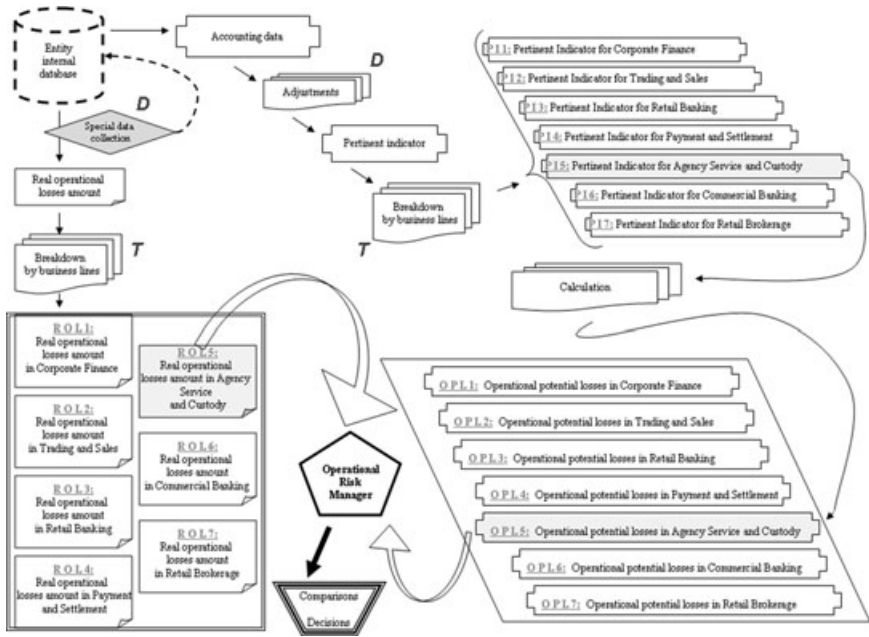


Figure 2: IS Stage 2, Standard Approach.

method requires. To achieve this, it may be necessary to make new investments in Base Line Technologies (T), to connect hardware or software applications, and to ensure that the IS acquires the terminology and controls the new variables that are seen, by means of some appropriate Description Methods (D), such as internal manuals of good practices, special training courses for the personnel charged with dealing with these matters, and others. However, as occurs in the Stage described previously, the managerial structure (M) should be able to support these changes without undergoing modifications, and without major technological changes (TO).

The Calculation process applicable at this Stage similarly involves extracting from the internal database of the entity a Pertinent Indicator, which again is the gross income, but in this case broken down under each major line of business. Subsequently, a fixed percentage factor is applied to the gross income, although in this case a different percentage factor (from α_1 to α_8) is applied for each line (Table 2):

This procedure explicitly acknowledges the reality that not all the lines of business are necessarily subject to the same degree of risk (Aparicio and Keskiner, 2004). Each year, as described for the previous Stage of Sophistication, the entity's exposure to Operational Risk is again determined, the measures that may be required to manage this risk in each business line are taken, and the ROL's that are attributable to each line of business are used as reference.

Table 2: Breakdown of business lines and the Operational Risk ratio decided for each line

Corporate Finance	$\alpha_1 = 18\%$
Trading and Sales	$\alpha_2 = 18\%$
Retail Banking	$\alpha_3 = 12\%$
Payment and Settlement	$\alpha_4 = 15\%$
Agency Services and Custody	$\alpha_5 = 12\%$
Commercial Banking	$\alpha_6 = 18\%$
Asset Management	$\alpha_7 = 15\%$
Retail Brokerage	$\alpha_8 = 12\%$

THE ADVANCED MEASUREMENT APPROACH

We refer to the third and highest Stage of Sophistication of the banking/investment IS as the Advanced Measurement Approach. Although its implementation costs will be higher, in so far as more fundamental organizational changes are required, the greater degree of sophistication in the monitoring of each pair of values (Event Type, Business Line) gives management the opportunity to supervise OR in more detail and more comprehensively. This stage is defined by more abstract requirements, in both quantitative and qualitative terms, than the stage previously described. It is, for this reason, more flexible and adaptable to the characteristics of each entity and each normative area. It is a system that is not “blind”, in the sense that it is the only approach that involves a direct measurement of the circumstances that may aggravate or mitigate Operational Risk. In addition, it carries the need for changes in organization and procedures in the operating structures of banking/investment entities involving the entity’s internal controls and communication structure; hence it necessarily means that the entity must review and change its technical and human systems.

The responsibility for designing the Advanced Measurement Approach belongs to the entity itself, which must develop the system to suit its own specific business model. At this level the mission of the supervisory authority in respect of each entity’s approach should be one of supervision, of submitting the systems to control tests and, where applicable, of validating the approach and systems in use. For the design and implementation of an Advanced Measurement Approach that serves the purpose and achieves external validation by the supervisor, the senior directors of the entity must be involved in the implementation of the method. An independent unit must exist, shown in the organization chart, with responsibility for the implementation and functioning of the approach to OR. Systems of internal reporting and auditing of the processes established should be implemented. The bank must implement correct policies and procedures that are periodically documented. The thresholds of materiality adopted for capturing data for the measurement of Operational Risk must be suitably justified and explained.

The principal difficulties arise from the high cost in time and resources that may be involved in its implementation, given the changes necessary for putting it into operation. In addition to this cost, the entity must make the choice between the different incentives that arise when choosing between one or other method of measurement. The cost of implementation of the more advanced method may be so significant that the entity will not assume this cost if it is not sure about its effect, positive or negative, on its competitive position (Milligan (2004)). Lastly, each entity must choose the method that it considers, in its best judgment, is best in terms of quality and capacity for covering the Operational Risk faced; hence it must be convinced that the hypotheses underlying each method are valid, both objectively and considering its own specific circumstances. Efficiency in this choice must be based on a full understanding of the implications of all the new problems that are affecting the IS of banking/investment entities; this understanding in respect of the new framework for OR cannot be assumed in all banking/investment organizations (Wilson (2004)).

The implementation of an Advanced Measurement Approach represents the highest degree of utilization of ISPI mechanisms. Putting it into operation requires new IT tools (TO), changes in existing technologies (T) in order to support the implementation of the new investments, the complete acquisition of the corresponding terminology, together with making visible the new variables (D) and profound changes in managerial responsibilities and structures (M).(see Fig. 3).

ANOTHER ADVANCED APPROACH

From actually exploring the plans that banking/investment organizations are outlining in respect of the sophistication of their IS, it has become apparent that there is an intermediate Stage not contemplated in Basel II; we are calling this option “Another Advanced Approach”. The features of this phase would be special to each entity, but we can characterize all the banking/investment IS to which this phase corresponds by these aspects:

- Several of the features of the Advanced Measurement Approach have been implemented, such as the designation of a specific unit for the monitoring of Operational Risk.
- The entity has made IT investments with the object of reinforcing the IS implemented.
- The entity uses its own methodologies and nomenclatures, which sometimes emanate from its pre-existing elements, and which usually differ from those of Basel II.

In these respects, the stage corresponding to Another Advanced Approach is characterized by major technical innovations (TO), accompanied by implementation of the managerial changes (M) that the entity considers necessary, but without taking onboard all the terminological “baggage” of Basel II. However,

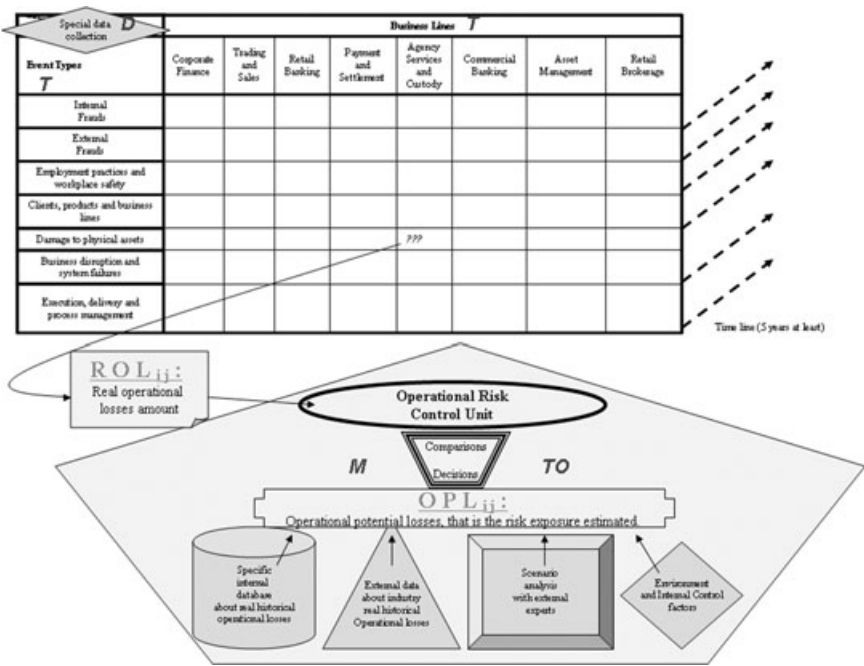


Figure 3: Stage 4, Advanced Measurement Approach.

apart from these details and due to the heterogeneity inherent in the systems that are being installed, we cannot give a more exact picture of a model that would satisfactorily explain all these implementations.

By means of the model of Stages of Sophistication proposed here (Table 3), the implications of each degree of evolution of a bank’s IS can be better understood,

Table 3: Relationship between IS stages of sophistication and ISPI types

Stage of IS sophistication	Type of ISPI implied in each stage			
	Base Line Technologies (T)	Tools (TO)	Description Methods (D)	Managerial Innovations (M)
1-Basic Indicator Approach			✓	
2-Standard Approach	✓		✓	
3-Another Advanced Approach		✓		✓
4-Advanced Measurement Approach	✓	✓	✓	✓

in the context of an imminent reform of the IS of banks in the face of the need to monitor and manage Operational Risk. We have considered it would be of interest to explore the current situation of the principal banking/investment entities in respect of this scheme of stages, and the factors conditioning the decision to move from one stage to another.

IV. EMPIRICAL EVIDENCE

The objects of the research described in this article also include an exploratory study to detect some of the variables that may influence a banking/investment entity in deciding the Stage of Sophistication at which to position its IS for managing OR. In order to identify the plans that banking/investment entities have formulated in this respect, we have referred to the corresponding statements made in the Annual Reports of the entities for the year 2005, the year when the Basel Committee issued the latest version of Basel II. We have formulated three hypotheses.

HYPOTHESES

H1: *The home country of the entity constitutes a differentiating factor in the choice of the Stage of Sophistication of the banking/investment IS.*

Basel II represents a peculiar normative framework. As we have commented, the Bank of International Settlements of Basel does not have the juridical authority to issue standards, but its recommendations are eventually incorporated in the binding regulations of the various member countries. In the context of the European Union, the incorporation of the Basel II standards will be effected by the reform of Directives 2000/12 and 93/6 (Boixo and Flores (2005)), and this EU legislation will then be translated into the corresponding regulation of each EU member country. As Hofstede (2001 and 1991) comments, although companies compete in a global environment, cultural differences between European countries are important and influential. Therefore, we shall test to see if the country in which the Head Office of the entity is registered influences the particular Stage of Sophistication chosen by banking/investment entities for their IS.

H2: *The size of the entity has a positive influence in the choice of Stage of Sophistication for the banking/investment IS.*

The relationship between size and innovation has been widely studied (Bonsón and Escobar (2002)). Thus, Pirchegger et al. (1999) detect a relationship between the quality of the Web page of Austrian companies and their size, suggesting that larger entities tend to invest more in IT-IS. It is logical to think that larger entities would aim for an enhanced degree of sophistication in their IS (although large size is often associated with rigidity and reluctance to change!). The Basel Committee itself expects that all banks, beginning with the larger ones, would enhance their

IS in terms of sophistication to meet stricter supervisory requirements. Therefore, we shall test if the entity size necessarily implies the intention to implement a more advanced IS.

H3: The relative amount of intangibles on the Balance Sheet of the entity implies the choice of a more advanced Stage of Sophistication for the banking/investment IS.

The capacity of an entity to create knowledge has become a vital question for organizations (Nonaka and Takeuchi (1995)). This creation of knowledge is partially reflected in the items of the balance sheet that come under the heading of intangible assets. The importance and exactitude of this accounting magnitude has been extensively discussed, but there is agreement on the fact that, for example, IT investments have an influence on firm value (Dehning et al. (2005)). Our hypothesis constitutes a test of whether firms with greater weight of intangibles in their assets aim to implement more advanced Stages of Sophistication in their IS.

SAMPLE

The sample analyzed comprises the banks and similar institutions whose shares are listed in the Dow Jones EUROSTOXX index, for the codes 8355, 8771 and 8777 of the ICB (Industry Classification Benchmark), and is formed by a total of 54 banks and other financial entities. The choice of the sample can be attributed to the importance of the Eurozone in the international context, to the forthcoming application in the Eurozone of the principles of Basel II (Boixo and Flores (2005)), and to the utilization of English as the language in which the information referring to the level of the development of the IS is expressed, as previously argued by Adams et al. (1998). The population represented by this sample is formed by the corresponding number of entities of the Eurozone that undertake activities analogous to those referred to under the ICB codes utilized in the selection. Despite having selected a sample that includes the largest entities, this possible bias does not alter the representative nature of the results, in so far as the entities selected are more active internationally, and for this reason are exposed to greater risks and are subject to more pressure to enhance the capabilities of their IS. In addition to this, the Annual Reports of these entities are more reliable, since they are addressed to a large number of stakeholders and include information that has been audited externally.

VARIABLES

Stage of sophistication:

The entities of the sample have been rated according to the Stage of Sophistication which they are aiming for in their own IS, in the light of the statements made to this effect in the Annual Reports dated to the 2005 year-end. Thus, the entity has been given a score of 0 if it has not made any reference to Operational Risk. When it

has indicated its intentions in this respect, it is given a score from 1 to 4 depending on the corresponding IS stage applicable to the entity (**SOPHISTICATION**). In addition, a dummy or dichotomous variable has been generated for each Stage of Sophistication contemplated (from **STAGE1** to **STAGE4**).

Country Factor:

We record the country in which the Head Office of each entity is located, in accordance with the information provided by STOXX Limited (2006); whether or not a country figures as the entity's home country is reflected as a dichotomous variable. Thus 10 dummy type variables are generated, one for each country among those that appear as home countries of the sample entities; these are Austria (**AT**), Belgium (**BE**), France (**FR**), Germany (**DE**), Greece (**GR**), Italy (**IT**), Ireland (**IE**), the Netherlands (**NL**), Portugal (**PT**), and Spain (**ES**).

Size:

We include two size factors:

- **ASSETSIZE:** Value of the entity according to the total assets reported at the end of 2005.
- **MARKETSIZE:** Market value of the entity, as supplied by STOXX Limited (2006) at this date.

Intangibles:

To reflect the importance of intangible factors in the banking/investment organization, we have taken the ratio (**INTANGIBLESRATIO**) of Intangible Assets over Total Assets, for each entity. All the financial statements studied comply with the International Financial Reporting Standards at the date of the study; this means that, like the rest of the accounting variables considered, we are working with variables that are homogeneous from the point of view of accounting regulations.

MODELS

The models estimated with the variables described above are presented in Table 4. When the dependent variable is dichotomous, the estimation of Least Squares has been substituted by that of the Logic Model type, of binary output (27).

ANALYSIS

Once each entity has been scored (from 0 to 4) in respect of the Stage of Sophistication it intends for its IS, the results obtained are analyzed by simple statistics. Rather less than half (40.74%) of the entities do not provide information to allow their intentions on the Stage of Sophistication of their IS to be determined. However, half of the entities (24.07% plus 25.93%) intend or plan to position their IS at an advanced stage (the third and the fourth stages, respectively) (Table 5).

Table 4: Models estimated

Model	Dependent Variable	Independent Variables	Coefficient Name	Stimulation Method
1	STAGE1	AT, BE, FR, DE, GR, IT, IE, NL, PT, ES	β 1, β 2, β 3, β 4, β 5, β 6, β 7, β 8, β 9, β 10	Binary regression (logit model)
2	STAGE2	AT, BE, FR, DE, GR, IT, IE, NL, PT, ES	γ 1, γ 2, γ 3, γ 4, γ 5, γ 6, γ 7, γ 8, γ 9, γ 10	Binary regression (logit model)
3	STAGE3	AT, BE, FR, DE, GR, IT, IE, NL, PT, ES	θ 1, θ 2, θ 3, θ 4, θ 5, θ 6, θ 7, θ 8, θ 9, θ 10	Binary regression (logit model)
4	STAGE4	AT, BE, FR, DE, GR, IT, IE, NL, PT, ES	δ 1, δ 2, δ 3, δ 4, δ 5, δ 6, δ 7, δ 8, δ 9, δ 10	Binary regression (logit model)
5	SOPHISTICATION	AT, BE, FR, DE, GR, IT, IE, NL, PT, ES	φ 1, φ 2, φ 3, φ 4, φ 5, φ 6, φ 7, φ 8, φ 9, φ 10	Least Squares
6	STAGE1	INTANGIBLESRATIO	α 01 (free coefficient), α 11	Binary regression (logit model)
7	STAGE2	INTANGIBLESRATIO	α 02 (free coefficient), α 12	Binary regression (logit model)
8	STAGE3	INTANGIBLESRATIO	α 03 (free coefficient), α 13	Binary regression (logit model)
9	STAGE4	INTANGIBLESRATIO	α 04 (free coefficient), α 14	Binary regression (logit model)
10	SOPHISTICATION	INTANGIBLESRATIO	α 05 (free coefficient), α 15	Least Squares
11	STAGE1	LOG(MARKETSIZE)	π 01 (free coefficient), π 02	Binary regression (logit model)
12	STAGE2	LOG(MARKETSIZE)	π 02 (free coefficient), π 12	Binary regression (logit model)
13	STAGE3	LOG(MARKETSIZE)	π 03 (free coefficient), π 13	Binary regression (logit model)
14	STAGE4	LOG(MARKETSIZE)	π 04 (free coefficient), π 14	Binary regression (logit model)
15	SOPHISTICATION	LOG(MARKETSIZE)	π 05 (free coefficient), π 15	Least Squares
16	STAGE1	LOG(ASSETSIZE)	ψ 01 (free coefficient), ψ 02	Binary regression (logit model)
17	STAGE2	LOG(ASSETSIZE)	ψ 02 (free coefficient), ψ 12	Binary regression (logit model)
18	STAGE3	LOG(ASSETSIZE)	ψ 03 (free coefficient), ψ 13	Binary regression (logit model)
19	STAGE4	LOG(ASSETSIZE)	ψ 04 (free coefficient), ψ 14	Binary regression (logit model)
20	SOPHISTICATION	LOG(ASSETSIZE)	ψ 05 (free coefficient), ψ 15	Least Squares

Table 5: Stages and the sample

Stage of Sophistication	% of entities
Without information about IS sophistication in Operational Risk management	40.74%
Basic Indicator Approach	0.00%
Standard Approach	9.26%
Another Advanced Approach	24.07%
Advanced Measurement Approach	25.93%

The sample has also been divided into quartiles (Table 6), the segment Q1 of the sample corresponding to the entities of smallest size and Q4 to those of largest size. The first quartile presents a mean score (arithmetic mean) of Sophistication of only 1.4667; successive quartiles show higher mean scores, with the entities of the fourth quartile reaching a mean score of 3.0833. This relationship between size and sophistication also appears evident in Figure 4.

With respect to the statistical inference made, the models estimated that have produced significant results are Model 19 (Table 7) and Model 20 (Table 8). According to these two models, a significant relationship exists between the degree of evolution intended for the banking/investment IS and the size of the entity, measured by asset value. Model 19 gives this result by setting the explanatory variable against the level of the SOPHISTICATION score obtained by each entity, while Model 20 gives this conclusion by relating the same explanatory variable to whether or not the entity's intention is to position its IS at the fourth and most advanced stage, STAGE4, corresponding an Advanced Measurement Approach to OR.

The country effect was not found to be conclusive. The differences in regulation and culture can explain the existence of differences, but not the direction in which their effect is produced. For the moment, we have to limit ourselves to stating the existence of significant differences from country to country, taking into account also that, in the sample taken, there are countries that are the home base of very few entities, which in this case takes significance away from the results in respect of the country differences (Table 9).

Regarding the impact of the weight of Intangibles in the sophistication of the IS, Models 6, 7, 8, 9 and 10 have not thrown up statistically satisfactory results,

Table 6: Descriptive statistics on sophistication score

	Average Sophistication
Q1	1.4667
Q2	1.5385
Q3	1.8571
Q4	3.0833

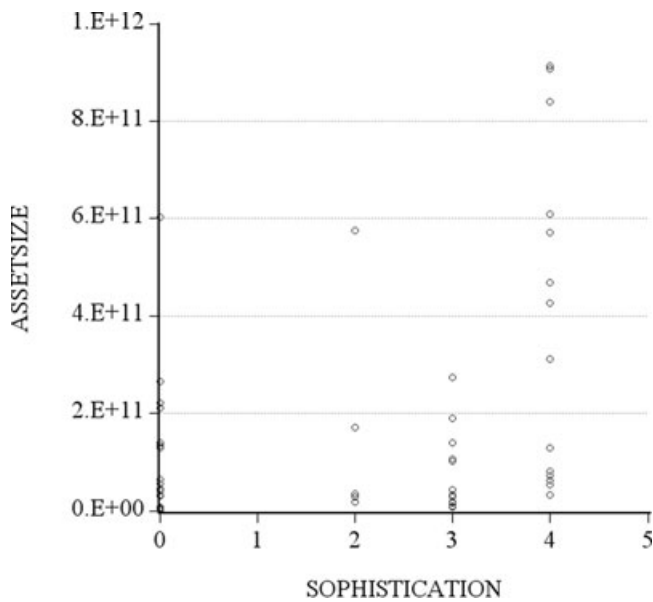


Figure 4: Sophistication and size.

so this leads us to conclude that no detectable impact exists, at least in the way that this variable has been treated in the present study.

All these results considered, it can be concluded from the analysis that hypotheses 1 and 3 (influence of the entity’s home country and of the weight of intangibles, respectively, in the sophistication of the banking/investment IS) have to be rejected, but hypothesis 2 (influence of entity size in the IS sophistication) can be accepted.

Table 7: Sophistication and size

Dependent Variable: SOPHISTICATION				
Method: Least Squares				
Sample: 1 54				
Included observations: 54				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOG(ASSETSIZE)	ø05 = -8.199377	3.453239	-2.374402	0.0213
	ø15 = 0.407751	0.138531	2.943394	0.0048
R-squared	0.142813			
F-statistic	8.663570		Prob(F-statistic)	0.004842

Table 8: Position within the more sophisticated stage and size

Dependent Variable: STAGE4				
Method: ML – Binary Logic Model				
Sample: 1 54				
Included observations: 54				
Independent Variable	Coefficient	Std. Error	z-Statistic	Prob.
	$\phi_{04} = -26.13488$	8.056996	-3.243750	0.0012
LOG(ASSETSIZE)	$\phi_{14} = 0.988813$	0.313042	3.158719	0.0016
McFadden R-squared	0.243756			

V. DISCUSSION AND LIMITATIONS

In the light of the results obtained in the empirical analysis, from among those variables studied, entity size appears as the variable that most influences the Stage of Sophistication at which the entity intends to position itself. The country effect has not proved conclusive, since for the moment, we lack sufficient means to analyze in more depth the differences detected. In respect of the weight of intangibles in the set of elements put into operation by the entities, it has been shown that, in the form specified, a clear relationship does not exist. Thus the analysis suggests that only variables that differentiate the entities in a definitive way, like size, seem to have influence in the posture taken by the entity in respect of the degree of sophistication intended for its IS.

Another aspect to consider is the fact that the explanatory variables utilized in this study are ones that characterize the financial entities in respect of their most external and visible qualities. It would be useful, in future studies, to test also the value found for the sophistication score against another set of variables of internal organizational character, such as, for example, the capacity of banking/investment

Table 9: Country effect on the IS sophistication stage

	Average Sophistication of the entities analyzed
Austria	2.00
Belgium	0.00
France	1.57
Germany	3.67
Greek	1.38
Ireland	3.00
Italy	3
The Netherlands	4.00
Portugal	2.33
Spain	2.71

organizations to implement technological and organizational advances in parallel. Experience shows that the investments made in IT must be accompanied by careful redesign and/or restructuring of the organization to obtain many of the anticipated benefits of the investment (Dos Santos and Sussman (2000)). It would be necessary also to study carefully the budgetary possibilities of each entity, especially of those that do not wish or intend *a priori* to operate a very sophisticated IS, and to check whether the entities are really backing away from technical advances that may not offer a very quick or “guaranteed” return on the investment; the return on investment in IT is known to be particularly difficult to forecast, in value and timing (Irani and Love (2002)). An in-deep study must be done about IS implementation concrete issues, as the role of non-hierarchical flows of information within organizations (Mackenzie (2005)).

The challenge of enhancing the sophistication of banks’ IS, and the strategic decisions on this matter that are currently being taken in many entities could result in a certain polarization of the sector according to the position of a particular bank’s IS on the scale proposed. It may be that the advantages thus generated are attainable only by the larger entities or those capable of making the necessary investments and changes. Such entities would thereby gain further competitive advantages derived from the degree of evolution attained by their IS, widening the gap between them and their smaller or more conservative competitors. If this came about, the homogenizing effects of the Basel II framework could end up being negated in reality by the incapacity of many entities to build and operate a sufficiently sophisticated IS. This outcome seems a real possibility given the finding that, in their Annual Reports, almost the half of the entities studied have not declared a clear position taken on this strategic issue.

VI. SUMMARY AND CONCLUSION

In the present study a model has been presented that enables the different ISPI types to be related to the various methods for the measurement of Operational Risk that will shortly be implemented in banking/investment entities. This theoretical analysis has allowed us to identify the challenges that each entity will have to face depending on the Stage of Sophistication it requires in the design and operation of its own IS. In addition to this, through an empirical exploration, we have demonstrated how the size of an entity is the most significant factor when deciding on where to position itself in the scheme of system sophistication proposed. Further research is strongly needed, especially for cases in which banks decide to increase IS sophistication (for example, correlation (Berkelaar et al. (2006)) between loss captured in different event types and/or business lines). This research and its design could benefit from the fact that, as it has been demonstrated, banks actively measuring Operational Risk will be the best performing entities.

Banking/investment entities are a key part of the economic framework and clear examples of complex organizations; as such they face the challenge of

deciding how sophisticated to make their IS, at a strategic level, and whether to seize this opportunity to obtain new and long-lasting competitive advantages by strengthening their ability actively to manage Operational Risk.

VII. REFERENCES

- Adams, C. A., W. Y. Hill, and C. B. Roberts. 1998. "Corporate Social Reporting Practices in Western Europe: Legitimizing Corporate Behaviour?" *British Accounting Review* 30:1–21.
- Aparicio, J. and E. Keskiner. 2004. "A Review of Operational Risk Quantitative Methodologies Within the Basel-II Framework." Accenture Technology Labs. May.
- Bakker, M. R. A. 2004. *Quantifying Operational Risk within Banks according to Basel II. Risk and Environmental Modelling*. Delft Institute of Applied Mathematics in cooperation with PricewaterhouseCoopers.
- Baldwin, L. P., Z. Irani, and P. E. D. Love. 2001. "Outsourcing information systems: drawing lessons from a banking case study." *European Journal of Information Systems* 10:15–24.
- Basel Committee on Banking Supervision. 2004. "Bank Failures in Mature Economies." Unpublished paper, Bank for International Settlements.
- Basel Committee on Banking Supervision. 2005. *International Convergence of Capital Measurement and Capital Standards: a Revised Framework (Basel II Accord)*. November.
- Berkelaar, A. B., A. Kobor, and M. Tsumagari. 2006. "The Sense and Nonsense of Risk Budgeting." *Financial Analysts Journal* 62:5:63–75.
- Boixo, I. and F. Flores. 2005. "New Technical and Normative Challenges for XBRL: Multidimensionality in the COREP Taxonomy." *The International Journal of Digital Accounting Research* 5:971–104.
- Bonsón, E., T. Escobar, and F. Flores. 2007. "Sub-Optimality of Income Statements – Based Methods for Measuring Operational Risk under Basel II: Empirical Evidence from Spanish Banks". *Financial Markets, Institutions & Instruments* 16:4:201–220.
- Bonsón, E. and T. Escobar. 2002. "A Survey on Voluntary Disclosure on the Internet. Empirical Evidence from 300 European Union Companies." *The International Journal of Digital Accounting Research* 2:3:27–52.
- Chapelle, A., Y. Crama, G. Hübner, and J. P. Peters. 2004. "Basel II and Operational Risk: Implications for risk measurement and management in the financial sector." Unpublished paper, Université Libre de Bruxelles, Université de Liège, Maastricht University, and Deloitte Luxembourg.
- Chenhall, R. H. 2004. "The role of cognitive and affective conflict in early implementation of activity-based cost management." *Behavioral Research in Accounting* 16:19–44.
- Danielsson, J. and A. Jonsson. 2004. "Does one size fit all? On the Impact of Capital Regulations. Preliminary Draft." <http://www.RiskResearch.org>

- de Fontnouvelle, P., V. De Jesus-Rueff, J. S. Jordan, and E. S. Rosengren. 2003. "Using Loss Data to Quantify Operational Risk." Unpublished paper, Federal Reserve Bank of Boston and FitchRisk.
- Dehning, B., V. J. Richardson, and T. Stratopoulos. 2005. "Information technology investments and firm value." *Information & Management* 42:7:989–1008.
- Dos Santos, B. and L. Sussman. 2000. "Improving the return on IT investment: the productivity paradox." *International Journal of Information Management* 20:6:429–440.
- Hiwatashi, J. Y. and H. Ashida. 2002. "Advancing Operational Risk Management Using Japanese Banking Experiences." Unpublished paper, Federal Reserve Bank of Chicago.
- Hofstede, G. 1991. *Cultures and Organizations*. New York: McGraw-Hill.
- Hofstede, G. 2001. *Culture's Consequences*. second edition. Sage Publications.
- Irani, Z. and P. E. D. Love. 2002. "Developing a frame of reference for ex-ante IT/IS investment evaluation." *European Journal of Information Systems* 11:1:74–82.
- Mackenzie, M. L. 2005. "Managers look to the social network to seek information." *Information Research: an international electronic journal* 10:2:216.
- Milligan, J. 2004. "Who will choose Basel II." *ABA Banking Journal* 96:11:61–66.
- Mustonen-Ollila, E. and K. Lyytinen. 2004. "How organizations adopt information system process innovations: a longitudinal analysis." *European Journal of Information Systems* 13:1:35–51.
- Nonaka, I. and H. Takeuchi. 1995. *The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation*. New York: Oxford University Press
- Pirchegger, B., H. Schader, and A. Wagenhofer. 1999. "Financial information on the Internet. A survey of the homepages of Austrian companies." *European Accounting Review* 8:2:383–395.
- Rachev, S. T., A. Chernobai, and C. Menn. 2005 "Empirical Examination of Operational Loss Distributions." Unpublished paper, Universitat Karlsruhe, University of California-Santa Barbara and Cornell University
- STOXX Limited. <http://www.stoxx.com/index.html>
- Swanson, E. B. 1994. "Information systems innovation among organizations." *Management Science* 40:9:1069–1088.
- Wilson, I. 2004. "Implementing Basel II: A case study based on the Barclays Basel II preparations." *Journal of Financial Regulation and Compliance* 12:4:297–305.
- Wooldridge, J. M. 2000. *Introductory Econometrics. A modern approach* South-Western College Publishing.

VIII. NOTES ON CONTRIBUTORS/ACKNOWLEDGMENTS

Enrique Bonsón-Ponte is a professor of Financial Accounting and Information Systems. He is currently working at the Department of Accounting and Information Systems in the University of Huelva (Spain). His main research interests are IT,

artificial intelligence, international regulation, internal control, digital reporting and continuous auditing. He has published international articles in various journals, books and other publications. He has worked with academic and professional institutions all over the world. He is Vice-president of XBRL Spain, and director of the Research Group of New Technologies in Accounting and Business Administration.

Tomás Escobar-Rodríguez is an associate professor of Management Accounting and Information Systems. He is currently working at the Department of Accounting and Information Systems in the University of Huelva (Spain). His main research interests are Scorecards, Expert Systems, digital reporting, digital transparency on the web and Strategic Management using IT. He has published international articles in various journals, books and other publications. He is President of the Taxonomies Groups of XBRL Spain.

Francisco Flores-Muñoz is a full-time researcher in New Technologies in Accounting and Business Administration at the Business Faculty of the University of Huelva (Spain). His main research interests are IT, digital reporting, digital transparency on the web, Basel II, internal controls and the impact of the international regulations. He has published international articles in various journals, books and other publications. He is a member of the COREP-XBRL Group, reporting to the Committee of European Banking Supervisors for the implementation of Basel II in the European Union.

This study has been made possible thanks to the comments of anonymous personnel who work every day in Spanish banks and savings banks; these are people who are specialized in incorporating the IFRS into the accounting systems of credit-issuing entities, and are aware of the new challenge represented by the entry into force of the Basel II Capital Accord.

Copyright of *Financial Markets, Institutions & Instruments* is the property of Blackwell Publishing Limited and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use.