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Banking Risk

A bank's core business, credit activity, is centered on borrowing and lending, thus mainly dealing with two components: money and risks.

The first component, money, seems to be the simplest to measure, as all balance sheets and income statements report only money values. In fact, the different contracts, timing, and liquidity require much more attention than expected.

Every economic activity implicitly includes risk, as the economic framework always includes uncertainty. But a bank's activity is centered on risk, as its core business is in borrowing money, and lending it, bearing all risks of counterpart: default, maturity transformation, market values variation, liquidity, and so on.

Diverse layers of bank activity are cross-linked, and take part in maintaining the equilibriums in terms of revenue, economic stability, and operational activity. As a consequence, the bank's activity analysis is always complex.

The ways for analyzing credit activity are multiple.

On one hand, the banking activity is a specification of firms management, so it can be analyzed with the same attitude in terms of internal processes, costs and income, business models, personnel management, and so on.

Another possibility is to evaluate the activity results of banks from the outside, by means of regression analyses, so as to find a posteriori a description of their actual activity, results, and business models distribution and evolution.

Banking Systems Simulation: Theory, Practice, and Application of Modeling Shocks, Losses, and Contagion, First Edition. Stefano Zedda.

Banks play a key role in financing the real economy, thereby sustaining and promoting the economic growth; their activity is often considered to be of national interest, and in some countries it is directly held by public companies.

In fact, the credit support of a firm or sector can substantially change its evolution and growth; choosing which firm to finance or which sector to support can be in some cases more effective than some public policy interventions.

Other fundamental aspects of banks activity are related to the volume of money managed in stock exchange and bonds markets, where the buying and selling activity can significantly affect values. Even when considering issuers of large dimensions, as in the case of sovereign bonds, the bank's attitude to buying or holding bonds to maturity can be of fundamental importance, and often the interest of governments in keeping the availability of banks in this can sometimes affect the government policy toward the banking sector.

This key role in sustaining the economic growth and the fact that banks are typically large firms induces specific attention toward the bank's activity, as the banks' default not only stops the support of economic growth but also can induce huge effects of market instability, lack of confidence in banks and in savings, bank runs, and disruptive effects on the real economy.

Thus, the analysis of a bank's activity, and of its different layers and interconnections, and the supervision and regulation of banks, are of fundamental importance for preserving savers' confidence in banks, the bank's action in channeling savings to firms, thus sustaining economic growth and preserving economic and financial stability.

The credit activity also carries a specific characteristic, as it involves buying and selling money—different maturity, contracts, risks, but always money. There is no actual goods production or transformation. This simplifies some aspects, but also induces a greater interrelationship between the different activity layers; so, as an example, there can be no strict separation, as it happens in industrial or commercial activities, between real goods or services production, and financial activities.

At a first glance, a bank's balance sheet seems to be quite similar to any other firm's balance sheet: The assets side mainly includes customer loans, bonds, interbank credits, and some other assets such as cash, buildings, and so on. As banks do not buy, transform, or sell goods, there is no motivation for quantifying the values of goods at the beginning and end of each year. The liabilities side includes deposits, interbank debts, issued bonds, and capital.

A more significant difference with respect to nonfinancial activities, such as the industrial activity, appears when comparing the assets side with the income statement: For banks, the total revenue is only a fraction of total assets, while industries typically register sales revenues in value closer to the total assets.

As an example, the FCA 2015 group's consolidated balance sheet[1] reports total assets of €105,040 million, equity of 16,255 (15.5% of TA), and net revenues of €110,595 million (105% of TA), while the Deutsche Bank 2015 balance sheet[2] reports total assets of €1,436,029 million, capital of 45,828 (3.2% of TA), and main income values (interest income, current income, commission income, and other operating income) summing up to a total of €31,086 million, around 2% of total assets.

It is evident that when analyzing a bank's activity, our attention is more on the assets volume than on income. It is worth noting that Germany's GDP for 2015 was estimated to be €3,025,900 million,[3] while Deutsche Bank's total assets in 2015 were about 47% of its home country's GDP.

This assets dimension also explains why risks are so significant in banking activity. Referring to the values above, a reduction of 3.5% in value for FCA assets will reduce the equity value from 15.5 to 12.4% of total assets, while in the case of Deutsche Bank the capital will be completely wiped out.

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1 Source: Fiat Chrysler Automobiles 2015 Annual Report.

2 Source: Annual Financial Statements and Management Report of Deutsche Bank AG 2015.

3 Source: Eurostat.

Another signal of banks' central role is shown by the number of governments' interventions in rescuing banks during financial crises: Interventions on capital are absolutely fundamental when a large bank is likely to fail, and the cost of non-intervention is typically much higher than the cost of capital injection needed for rescuing the bank.

In fact, not only can the effects of uncertainty in assets and liabilities deeply affect income, and thus banking stability, but also dealing with risks is the basis of the banking activity.

So, even if the primary focus with respect to a bank's activity is toward their assets value, the uncertainty of values intrinsically inherent in the lending activity is the key reference for understanding why banking is almost a synonym for risk management.

1.1 Single Bank Risk

The first reference for analyzing a bank's activity is in considering its balance sheet main values.

(JPMorgan Chase & Co./2015 Consolidated Annual Report)

Starting from the assets side (Table 1.1), the most important exposure of banks is for customer financing, by means of loans.

Loans are the traditional banks' core business, which brings a fundamental part of revenues and carries the most significant risks.

In fact, the main activity of banks consists in evaluating whom to lend money, how, and how much to lend. Analyzing a firm's balance sheets, cash flows, and tendencies (hard information), or verifying the firm's reputation, management capabilities, and reference market stability (soft information) are some of the important ways of evaluating the firm's credibility: that is, if there is a strong probability that the firm will meet its obligations and pay back the debts as scheduled.

It is evident that this evaluation cannot be exact. On one hand, it depends on future events that are not possible to forecast exactly, and moreover speculating the reactions of the firm management on these unforeseeable events will be even more difficult. On the other hand, it is not possible to analyze in depth all the firm's aspects and details, and this intrinsically results in

Table 1.1 Bank balance sheet: assets.

Assets	
Cash and due from banks	20,490
Deposits with banks	340,015
Federal funds sold and securities purchased under resale agreements	212,575
Securities borrowed	98,721
Trading assets	343,839
Securities	290,827
Loans	837,299
Allowance for loan losses	13,555
Loans, net of allowance for loan losses	823,744
Accrued interest and accounts receivable	46,605
Premises and equipment	14,362
Goodwill	47,325
Mortgage servicing rights	6,608
Other intangible assets	1,015
Other assets	105,572
Total assets	2,351,698

widening the confidence intervals of the creditworthiness estimation.

As a consequence, it is fundamental for banks to use all possible strategies to reduce the total risk of the lending activity.

The traditional, and still fundamental, strategy is based on diversification. In fact, if the exposures are affected by different risk sources, the total risk is lower than the sum of individual risks. In practice, this means that it is unlikely that all exposures will default at the same time; instead, a good diversification ensures that the fraction of defaults tends to remain near the expected value. In this way, it is possible to maintain the bank's financial stability covering the expected value of defaults by means of interest spreads, and store a

capital buffer for possibly absorb losses when its value is higher than expected.

It is worth noting that the bank risk is due to the uncertainty of loss value, and not due to its intrinsic value. For clearer evidence, we can consider the example of two banks of the same size, $100 million—the first exposed to firms with higher default probability, say 10%, and strong diversification (or other risk covering), so the total loss variance is of 2%; the second exposed to less risky firms, with a default probability of 5%, but no diversification (or other risk covering), so a higher variance in total losses, say of 5%. In the first case, there are expected losses of 10 and an uncertainty of 2, while in the second we have expected losses of 5, but an uncertainty of 5. The second is much more exposed to risk, even if the first bank's exposures are for riskier firms, and the expected value of losses is higher, as the second case is more subject to uncertainty.

The second important value in our simplified representation of a bank's balance sheet is for bonds, either held to maturity or for trading.

In traditional bank activity, bonds were one way of lowering the average risk, as typically bonds are issued by large firms or by governments (sovereign bonds), so the risk of counterpart default is typically lower, and as bonds are traded on financial markets, they also have a liquidity reserve role, fundamental for covering unexpected cash needs. Evidently, the lower the risk, the lower the expected income on these investments.

More recently, and in particular for large banks, the trading activity has had an important evolution, visible in the balance sheet as a movement from bonds "held to maturity," to bonds "held for trading." Evidently, this activity is really different from the traditional banking activity, as it is aimed not at financing an investment, but at having an income in buying and selling bonds (or shares, or derivatives) so as to profit from a price differential, thus much more similar to the commercial activity. This kind of operation is mainly exposed to market risk (in addition to the counterpart risk, always present).

Another fundamental value in our representation refers to interbank loans. In fact, banks often lend money to other banks,

here also for liquidity management, for investing some momentary money excess, or for covering some momentary cash need. But it can also be due to a specific business model, for which some banks attract deposits, only using part of this savings volume for direct lending, while some prefer instead to invest in the interbank wholesale market, thus concentrating their activity on lending. This role distinction in some countries is between different bank categories, while in other cases it is just a role distinction within a banking group. Banking groups also tend to have a centralized treasury/liquidity management, so that the interbank lending within the group is typically much higher than the lending outside the group.

With reference to liabilities (Table 1.2), the main funding source is in deposits, typically available at sight or on short-term contracts, which provide the bank the funds, but also introduce a mismatching between funding and lending, typically lent with higher maturities.

The stockholders' equity includes common and preferred stock, and retained earnings and other capital reserves, which represent two main sources of bank capital: the issuing of new shares and the retaining of (part of) the earnings produced by the banking activity. The equity is the main shock absorber for banks, and its value is the first reference for limiting the risk of bank default.

The other side of a bank's activity includes reporting the income statement (Table 1.3). It is typically presented starting from the interest income, interest costs, and deriving the interest differential, the net interest income. This value is then corrected for considering the provisions for credit losses. The second layer includes commissions and trading activity for having the noninterest income.

The third layer is mainly devoted to operational costs, but also includes the other values that sum up to the total noninterest expenses. The taxes are then computed for obtaining the net income.

The final result of all the activity is kept by the net income (or loss).

As is well known from the accounting standards, the net income can be distributed among the shareholders, or stored

Table 1.2 Bank balance sheet: liabilities and equity side.

Liabilities	
Deposits	1,279,715
Federal funds purchased and securities loaned or sold under repurchase agreements	152,678
Commercial paper	15,562
Other borrowed funds	21,105
Trading liabilities	126,897
Accounts payable and other liabilities	177,638
Beneficial interests issued by consolidated variable interest entities	41,879
Long-term debt	288,651
Total liabilities	2,104,125
Stockholders' equity	
Preferred stock	26,068
Common stock	4,105
Additional paid-in capital	92,500
Retained earnings	146,420
Accumulated other comprehensive income	192
Shares held in restricted stock units (RSU) trust, at cost	(21)
Treasury stock, at cost	(21,691)
Total stockholders' equity	247,573
Total liabilities and stockholders' equity	2,351,698

for raising the capital value; however, if the bank registers a loss, it must be accounted as a reduction of the capital value.

An important detail with reference to the bank's activity reporting is that some categories of financial investments (in particular, the change in value of "available for sale" investments) are directly imputed on equity, so they do not affect the total and net income, but impact the final equity value. Thus, when evaluating the bank's activity result, it is necessary to reconcile the two, as is done by some commercial databases like

Table 1.3 Bank income statement.

+	Interest and similar income	
−	Interest expense	
=		Net interest income
−	Provision for credit losses	
=		Net interest income after provision for credit losses
+	Commissions and fee income	
+/−	Net gains (losses) on financial assets/liabilities	
+/−	Other income (loss)	
=		Total noninterest income
−	Compensation and benefits	
−	General and administrative expenses	
−	Other noninterest expenses	
=		Total noninterest expenses
=		Income (loss) before income taxes
−		Income tax expense
=		Net income (loss)

Bankscope that specifically takes it into account in its "Fitch Comprehensive Income" value (see Andrew Fight, *Understanding International Bank Risk*, Wiley Finance, 2004).

The banking activity includes several fundamental mechanisms, which are briefly presented here.

The first one is the money channeling from the actors and sectors with more money than needed, mainly depositors but also bondholders or other banks, to the sectors investing in economic activities and producing an income sufficient to pay both the debt and interest.

The evaluation of the firm's ability to pay back debts, so as to have sufficient income and to afford the evolution of the

economic framework, is the most important and specific activity of the bank.

This funding transfer needs some specific attention, as the depositors typically have the right to withdraw all of their own deposits without notice, even if they normally need only a fraction of their current account values. So, the bank has to properly quantify which fraction of deposits must be kept available as cash, and which part can be invested in loans or other interest-bearing activities. This quantification is fundamental, since if the cash requests from depositors are higher than the available cash, the bank has to sell some of its activities to obtain the money. But as the ability to evaluate the counterpart creditworthiness is complex, estimating the value of a loan is not simple, and so selling loans contracts in a short time often results in fire selling, thus losing part of the expected interest income. Thus, on one hand, banks continuously monitor the total amount or deposits and cash needs, and, on the other hand, part of their investments is in "liquid" assets, typically in highly traded bonds that can be easily sold at reasonably stable prices.

This is due to another specific aspect of a bank's activity: the maturity transformation. In fact, the liabilities, and mainly deposits, have a short maturity (days), while investments, and loans in particular, are often characterized by a longer maturity (years). This side of the bank's activity is fundamental for the real economy financing, as firms not only need money for financing their investments, but also need it for all the planned investment time. Thus, the bank has to deal with possible deposit volume changes over time, so it is fundamental to attentively monitor the turnover of investments and the related cash needs, so as to maintain the equilibrium in their assets–liability management.

So, on the basis of the actual ongoing deposits volume and stability, banks have to continuously adapt both the volume of high income and high maturity investments (loans) and the low income but highly liquid investments (as sovereign bonds).

Liquidity management can be crucial for banks, as the lack of liquidity is one of the causes of loss of confidence in banks by depositors, which can cause bank runs.

A bank run, even when not justified by actual difficulties in the bank, forces the bank to sell first the liquid assets, and then, if it is insufficient to cover the cash request, to fire sell the high income investments, resulting in important losses, and possibly causing the bank to default. If caution is not exercised, even the false suspicion that a bank is likely to fail can cause a bank run, which can cause the bank eventually to fail!

For this reason, in almost all countries a deposit guarantee scheme is implemented so that depositors may know that their deposits are covered by a guarantee, and any rumors of a possible bank failing would cause less worry and nervous reactions.

Other possible sources of risk are related to the difference between the contracts held on two sides of the balance sheet. For example, as the liabilities side is typically oriented to shorter maturities, it is more exposed to the variability of the interest rate, while the assets side quite often is oriented to fixed interest rates. This mismatching between assets and liabilities brings an interest rate risk, which can be a source of income, when the average interest rates differentials are higher for the bank, but also a possibility of suffering from significant losses in case the floating rate goes above the fixed one.

Similar problems are related to currencies and also to other risk sources.

So, a bank's soundness must be evaluated on different sides, as in the FDIC approach that includes the consideration of *c*apitalization, *a*ssets quality, *m*anagement capabilities, *e*arnings, *l*iquidity, and *s*ensitivity, commonly known as CAMELS.

Finally, banks have to hold equilibriums on different layers, but banks' problems quite often originate from income difficulties or from losses caused by risk exposures, which only become evident later as liquidity problems. In fact, a low income induces banks to take higher risks, such as raising the share of high

income operations, with higher rigidity, thus with more exposure to liquidity shortage, while on the liabilities side the low income can induce a reduction in confidence by possible lenders and difficulties in funding.

The risk management activity is evidently of fundamental importance for banks, and needs a detailed and continuous attention for maintaining subtle equilibriums on each of the different risk factors, each one affecting the others. One complete and detailed description of the techniques adopted with this aim is in Resti and Sironi (*Risk Management and Shareholders' Value in Banking*, Wiley Finance, 2007).

If, instead, we analyze a bank's results as the outcome of the whole activity without detailed information on each contract, we can analyze its distribution and evaluate the actual capability of the bank to manage and control the risk equilibriums and, subsequently, to assess the bank's default risk.

If we look at a time series of bank results, we will have something like that shown in Figure 1.1.

In Figure 1.1a, we present the time series of bank results in terms of profits or losses. In Figure 1.1b, we report the frequencies for each percentage, so 0% occurs in year 4, 6, and 8, with a frequency of 3, while −1% only happens once in year 5.

The graph in Figure 1.1a, rotated, gives the standard frequency representation of the profit/loss distribution reported in Figure 1.2.

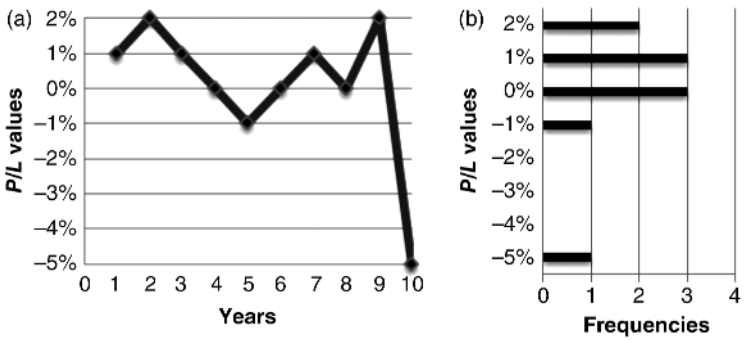

Figure 1.1 Profit/loss (P/L) values and frequencies.

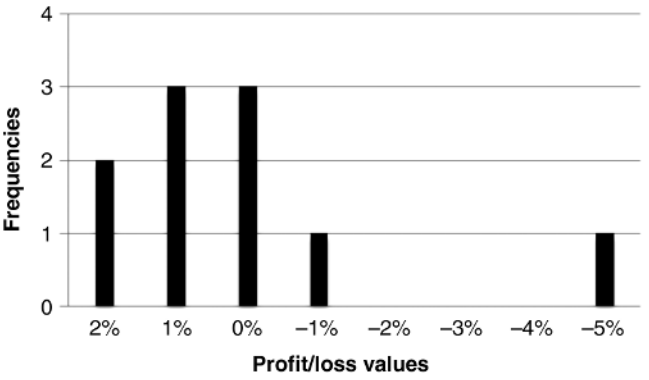

Figure 1.2 Profit/loss frequencies.

This distribution is due to the risks affecting the bank's activity, which on the right side is bell-shaped with a maximum possible loss given by the total value of exposures, while on the left side, as the minimum value of losses is zero, the shape is different. Depending on the exposures riskiness, the left side can decrease from the origin, in case of low riskiness, or it can first increase and then decrease, in case of higher riskiness, similar to what happens in a Poisson distribution depending on the expected frequency of the event.

The leftmost part of the probability distribution, up to the expected value, is covered on provisions, and included in the income equilibrium as a cost, similar to what happens for interest expenses. So, when evaluating the actual losses of the banking activity, the reference is to the expected value, positive numbers represent the value of losses exceeding the expected value, and negative numbers are for the cases where the value of losses is lower than expected.

Following the nomenclature of Demirguc-Kunt (1989), a bank is defined to be economically insolvent when the present value of its assets, net of implicit and explicit external guarantees, falls below the present value of claims from the banks' creditors.

Banks are considered to be in default when losses exceeded capital:

$$L_i > K_i \tag{1.1}$$

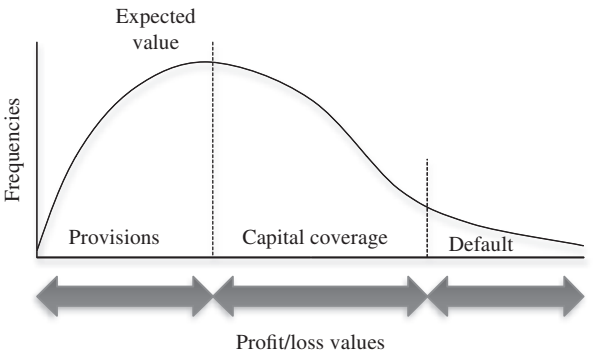

Figure 1.3 Profit/loss probability distribution.

The rightmost part of Figure 1.3 refers to the case when losses are higher than the capital coverage; so, if there is no recapitalization, the bank fails.

This representation explains why the capital coverage has acquired a central role in banking regulation. The Basel Committee on Banking Supervision, since the "Basle Capital Accord" of July 1988, formally "International Convergence of Capital Measurement and Capital Standards," has centered attention on the evaluation of banks' default risk on two fundamental aspects: the assets riskiness evaluation, fundamental for approximating the losses distribution, and the capital coverage, as a main barrier for containing excess losses and limiting the default risk.

1.2 The Basel Committee on Banking Supervision Approach to Regulation

The Basel Committee on Banking Supervision has its origins in the financial crisis that followed the breakdown of the Bretton Woods Accords. After the collapse of the Bretton Woods system of managed exchange rates in 1973, and the following financial market turmoil, many banks suffered from large foreign currency losses. In response, the central bank governors of the G10 countries decided to set up a forum for regular

cooperation between its member countries on banking supervisory matters. Consequently, at the end of 1974, they established a Committee on Banking Regulations and Supervisory Practices, located at the Bank for International Settlements in Basel, and later renamed the Basel Committee on Banking Supervision (BCBS).

Since then, the Basel Committee has been the primary global standard-setter for the prudential regulation of banks. Its mandate is to strengthen the regulation, supervision, and practices of banks worldwide with the purpose of enhancing financial stability.

The Committee develops and proposes new supervisory standards and guidelines, and recommends sound practices, seeking endorsement from the Group of Governors and Heads of Supervision (GHOS). Its proposals have no legal power but are provided in the expectation that individual national authorities will implement them.

One fundamental aim of the Committee since its start was to reduce the differences in international supervisory coverage and standards. A first step in this direction was the paper known as the "Concordat" issued in 1975 that set out principles for supervisory standards on banks' foreign branches, subsidiaries, and joint ventures.

In the early 1980s, capital adequacy became one of the main focuses of the Committee's activities. After the convergence on a weighted approach to the measurement of risk, the "Basle Capital Accord" of 1988, also called Basel I framework, established minimum levels of capital for internationally active banks, in order to strengthen the soundness and stability of the international banking system.

In order to assess the capital adequacy of banks, the Committee introduced a weighted risk ratio, in which capital is related to different categories of on- and off-balance sheet exposures, each one weighted according to broad categories of relative riskiness. Considering that for most banks the major risk source is credit risk, even if many other kinds of risk are present—such as interest rate risk, exchange rate risk, concentration risk—the framework was mainly focused on credit risk.

1.2.1 The Basel I Framework

Within Basel I, all banks' assets are classified into five categories, each one with a defined weighting, from 0 to 100%.

In brief:

0% weighting includes cash, and claims on central governments and central banks in national currency or equivalent;

0, 10, 20, or 50% weighting (at national discretion) is for claims on domestic public sector entities, excluding central government, and loans guaranteed by or collateralized by securities issued by such entities;

20% weighting mainly includes claims on multilateral development banks, on banks incorporated in the OECD, or on securities firms subject to comparable supervisory and regulatory arrangements, or on non-OECD banks with a residual maturity of up to 1 year;

50% weighting is for loans fully secured by mortgage on residential property;

100% weighting is for claims on the private sector, fixed assets participations, and all other assets.

In the same approach, all off-balance sheet activities are classified into broad categories as follows:

100% credit risk conversion factor for the activities that substitute for loans (e.g., general guarantees of indebtedness, bank acceptance guarantees, and standby letters of credit serving as financial guarantees for loans and securities).

50% credit risk conversion factor for certain transaction-related contingencies (e.g., performance bonds, bid bonds, warranties, and standby letters of credit related to particular transactions), and for commitments with an original maturity exceeding one year.

20% credit risk conversion factor for short-term, self-liquidating trade-related contingent liabilities arising from the movement of goods (e.g., documentary credits collateralized by the underlying shipments).

0% weight for shorter-term commitments or commitments that can be unconditionally cancelled at any time.

Capital consists of different accounting components. Within the Basel framework, these are grouped into two categories:

Tier 1, the first and more reliable component in terms of loss-absorbing capacity, includes paid-up share capital and disclosed reserves.

Tier 2 includes undisclosed reserves, asset revaluation reserves, general provisions and loan loss reserves, hybrid (debt/equity) capital instruments, and subordinated debt.

The weighted sum of the assets categories values gives the risk-weighted assets (RWA) value, and the minimum capital requirement for banks is set to 8% of the RWA (of which the core capital element will be at least 4%).

Table 1.4 reports an example of RWA computation based on balance sheet values.

Table 1.4 Computation of risk-weighted assets and minimum capital requirement under Basel I.

	Value	Weighting (%)	RWA
On-balance sheet			
Category 1	12,000	0	0
Category 2	54,500	20	10,900
Category 3	31,000	50	15,500
Category 4	101,500	100	101,500
Total on-balance sheet			127,900
Off-balance sheet			
Category 1	0	0	0
Category 2	0	20	0
Category 3	0	50	0
Category 4	5,000	100	5,000
Total off-balance sheet			5,000
Total risk-weighted assets			132,900
Minimum capital requirement		8	10,632

The Basel I approach had a substantial success, so the Committee continued its job and evolved the analysis that led to an important evolution in particular in the assets riskiness evaluation.

In January 1996, the Committee issued the so-called *Market Risk Amendment to the Capital Accord,* designed to incorporate within the Accord a capital requirement for the market risks arising from banks' exposures to foreign exchange, traded debt securities, equities, commodities, and options.

1.2.2 The Basel II Framework

The *Revised Capital Framework* released in June 2004, generally known as "Basel II," revised the whole framework, so as to have a more complete and more accurate mapping of risks and capital coverage. The new framework comprised the following three pillars:

I) minimum capital requirements, which sought to develop and expand the standardized rules set out in the 1988 Accord;
II) supervisory review of an institution's capital adequacy and internal assessment process; and
III) effective use of disclosure as a lever to strengthen market discipline and encourage sound banking practices.

Basel II also widened the risk categories considered for minimum capital requirements (MCR) and, beside credit risk and market risk, has added the operational risk component.

Counterparty risk refers to the possibility that the counterparty will not pay back its debts. This refers not only to loans but also to bonds (including sovereign bonds), interbank lending, and traded assets.

Market risk refers to the risk of selling an asset at a lower price than it was bought for. It only refers to traded assets, is limited to the price variations, and does not include the risk that the issuer of the traded assets defaults, the latter being incorporated in the counterparty risk.

Table 1.5 Computation of capital requirement and solvency ratio under Basel II.

Credit risk	257.1
Market risk	13.1
Operational risk	22.9
Total risk-weighted assets	293.1
Minimum capital requirement	23.5
Actual capital	38.6
Solvency ratio	13.2%

Operational risk refers to all technical problems that might arise, such as robberies, frauds, technical failures, errors, and so on.

In a typical medium-sized commercial bank, counterparty risk accounts for about 80–90% of the overall risk, 5–10% is for market risk, and 5–10% is for operational risk.

Another fundamental innovation of the Basel II framework is that the credit risk weighting is based no more on the assets or off-balance sheet categories, but on the single exposure risk quantification, in terms of probability of default (PD) and loss given default (LGD).

Thus, the minimum capital requirement and solvency ratio are provided in Table 1.5.

Evolving the Basel I 8% fixed rate of capital coverage, within Basel II, the minimum capital requirement for credit risk can be computed on the basis of several different approaches.

Under the standardized approach to credit, risk will be to measure credit risk in a standardized manner, supported by external credit assessments.

Under the internal ratings-based (IRB) approach, banks are allowed to use their internal rating systems for credit risk, with two different options.

Under the foundation approach, banks provide only their own estimates of PD, the other parameters being based on supervisory estimates, while the advanced approach allows banks to internally estimate PD, LGD, and maturity, on the basis of

several regulatory constraints and subject to the supervisor explicit approval. For both the foundation and advanced approaches, banks must always use the risk-weight functions provided by the Basel II framework for deriving capital requirements.

The function for computing the unitary capital requirement for each exposure is given by

$$C = \left[\mathrm{LGD} \times N \left[\sqrt{\frac{1}{1-R}} N^{-1}(\mathrm{PD}) + \sqrt{\frac{R}{1-R}} N^{-1}(0.999) \right] - \mathrm{PD} \times \mathrm{LGD} \right] \times \frac{1 + (M - 2.5) \times B}{1 - 1.5 \times B} \times 1.06 \tag{1.2}$$

where the maturity adjustment B is given by

$$B = [0.11852 - 0.05478 \ln(\mathrm{PD})]^2 \tag{1.3}$$

and correlation R is proxied by

$$R = 0.12 \frac{1 - e^{-50 \times \mathrm{PD}}}{1 - e^{-50}} + 0.24 \left[1 - \frac{1 - e^{-50 \times \mathrm{PD}}}{1 - e^{-50}} \right] - 0.04 \left[\frac{S - 5}{45} \right] \tag{1.4}$$

depending even on the loan LGD, maturity (M), and firm size (S).

Under the foundation approach, the reference value for LGD is 45% for claims on corporates, sovereigns, and banks.

1.2.3 Credit Counterparty Risk

As acknowledged by the BCBS since its first version of the Capital Accord of 1988, for most banks the major risk source is the counterparty risk, hence the risk that the counterparty will not make the required payments.

As already mentioned, the evaluation of the counterparty capability (and willingness) to pay debts is the core activity of a bank. In fact, a large share of banks' assets is on customer

credit, which requires an attentive evaluation of to whom, how, and how much money to lend.

The first question, whom to lend money to, refers to the ability of the customer business activity to produce sufficient income to remunerate the investment, and refund the loan and interests in the agreed time. It is thus evident that the answer cannot be separated from the other two, how and how much to lend, as the amount and conditions are part of the evaluation of the whole investment or business planning.

For the creditworthiness evaluation, a first fundamental step is in knowing and understanding the firm: on the one hand the management, and its capability to plan the business, to have adequate feedbacks for identifying the business problems and opportunities, and adapt the activity to the changes in the market and technical conditions; on the other hand it is fundamental to have adequate information on the firm ability to produce income, cash flows, financial equilibrium, and business plans and projects.

The amount of funding to be agreed by the bank is another fundamental evaluation, to be attentively tailored on the specific firm and investment plan conditions, as it must be sufficient for the firm to actually realize and manage the investment and business activity, but commensurate with the firm's income capabilities.

Finally, the contract conditions enable the firm to be better able to realize the investment or business, and for the bank to have adequate information on the planned investment or business.

When financing a plant building, it is normal to finance it on the basis of the work progress. So, to monitor the actual building process, and agree for a loan payback with an adequately long time for starting the new production and benefit from the resulting income, or when financing a higher trading volume for a commercial activity, more attention will focus on the exposure flexibility and on the use of the current account for the bank to monitor the ongoing business, and so on.

Another point, with reference to the contract conditions, refers to collaterals and guarantees: in case the direct obligor is not able to pay their debt, some goods are sold for it

(collaterals, quite often bonds or goods with high saleability) or the guarantee that some person or firm (with higher creditworthiness) pays for it. Collaterals and guarantees cannot be the basis of the creditworthiness evaluation, but can help provide a better estimation.

These focuses on the contract conditions are important for a good approximation of the actual risk, but the most relevant attention for the subsequent modeling of the bank risk is on the costs, that is, interest rates and spreads.

The basic criterion is a risk-based pricing, so the higher the risk, the higher the price.

In fact, the bank net interest income equilibrium is based on the difference between interest total income and interest costs plus loan losses. This can also be seen as the difference between interest income minus loan losses and interest costs.

In the latest representation it is more evident that the loan losses and interest income are to be considered as the outcome of the lending activity, and for each risk category of customers there must be a reasonable net positive result so as to cover the interest and operating costs of the bank.

Thus, if the expected losses of one risk category are higher than another, the interest rate or spread must be higher than the other so as to compensate the higher losses costs.

In addition, as the higher default risk includes not only higher losses but also, ceteris paribus, a higher variability in the actual losses, a higher flexibility (with lower income) is needed on the other assets of the bank. So, high-risk exposures for balancing the bank income equilibrium have to equilibrate not only the expected losses value but also the higher variability, and the key variable here is the loan pricing.

The source of information for assessing the firm creditworthiness is often classified into two main categories: hard information and soft information. Hard information refers to easily verifiable data such as income statements, balance sheets, and credit ratings. Hard information, for its high objectiveness, is often the basis of the information exchange between the different responsibility levels, so it is more useful and important for large banks.

Soft information is instead often the basis of relationship lending, and includes all the subjective evaluations, such as management capabilities, their honesty, how they react under pressure, the organizational flexibility, and so on. Relationship lending is based on multiple interactions between bank and borrower, on proprietary information coming also from other firms (suppliers, customers, and competitors), and from the current account or other financial information passing through the bank. Soft information and relationship lending is typically more important for local banks and when dealing with small and medium-sized enterprises (SME).

After the evaluation of the creditworthiness of single firms, the bank's attention must be related to the loans portfolio. As already mentioned, diversification is a highly powerful tool for reducing the portfolio riskiness, given the single customer riskiness.

Table 1.6 shows the effect of the correlation on the sum of two sectors results. Even if the results of the two sectors are the same

Table 1.6 Correlation effects.

Correlation	– 0.25			0.79		
	Sector 1	Sector 2	Total	Sector 1	Sector 2	Total
	−35.1	−49.6	−84.7	−35.1	−210.9	−246.0
	−40.0	311.1	271.1	−40.0	−271.4	−311.4
	−63.4	493.9	430.5	−63.4	−538.6	−601.9
	−19.4	241.7	222.3	−19.4	−77.2	−96.6
	−35.0	−149.7	−184.7	−35.0	−149.7	−184.7
	−10.7	362.4	351.7	−10.7	241.7	231.0
	86.5	−210.9	−124.4	86.5	362.4	448.9
	−101.9	−271.4	−373.3	−101.9	−49.6	−151.5
	6.9	−538.6	−531.7	6.9	311.1	318.0
	110.6	−77.2	33.4	110.6	493.9	604.5
Mean	−10.1	11.2	1.0	−10.1	11.2	1.0
Variance	4,187	107,580	101,316	4,187	107,580	145,289

in the two cases, just differing for the order, as in the left side the values are less correlated, the sum variance is lower (101 instead of 145), so the uncertainty in the bank results is lower.

The correlation effects are even more evident when considering more sectors, or, in general, more diversified sensitivities to the risk sources. The higher the distinction, the lower the correlation and the higher the stability of bank results.

What is surely important is to limit the concentration of exposures highly influenced by some specific risk source. This problem, often termed concentration risk, can be due to a large number of exposures to one foreign country, or to a sector highly sensitive to some raw material prices (such as oil prices), or to specific currencies. Evidently, the worst case in this sense is to have a large exposure to a single firm or counterpart, as this can possibly threaten the bank stability in case of a single counterpart default.

Anyway, it is not possible to remove all correlations, as firms are exposed to a number of common risk sources. As an example, with reference to a domestic panel of firms, a change in the tax rate will affect all firms. More generally, firms are exposed to the same economic framework, even if each firm acts in a different way, and so is differently exposed to each economic variable. Hence, the firms' results are almost partially correlated with the macroeconomic framework, and part of the bank risk cannot be excluded by means of diversification.

It is worth considering that, as losses are the possible effect of risk, and thus have an intrinsic uncertainty, banks cannot base the pricing on the actual losses, but on its expected value. This value is determined on the basis of the assets riskiness, and the amount is the reference for the "loan losses allowance" imputed in the balance sheet for correcting the loans value, and of the "loan loss provisions" in the income statement for correcting the interest income.

Within the Basel II framework, no specific methodology is suggested for assessing credit risk. Banks should adopt a sound methodology able to correctly address risk assessment policies, and include procedures and controls for identifying problem loans and determining loan loss provisions.

For an in-depth analysis of the credit risk theory and techniques, see Darrell Duffie and Kenneth J. Singleton, *Credit Risk: Pricing, Measurement, and Management*, Princeton University Press.

1.2.4 Market Risk

In addition to the possible default of the borrower, which is classified as a credit risk, banks are exposed to another risk source related to the assets prices variability—the risk of selling items at a value lower than expected. This can happen when selling positions before their maturity.

In fact, banks hold securities and other financial instruments with two possible horizons. The banking book includes securities that the bank intends to hold up to their maturity, classified as "held to maturity" (or even "available for sale"), for maintaining the liquidity and diversification equilibrium in the banking activity. Instead, the trading book consists of positions in financial instruments and commodities held either with trading intent or in order to hedge other elements of the trading book. It refers to a different activity, trading in financial instruments, that in the last decades has increased its importance in bank balance sheets such that in some cases it becomes the main activity.

Different from the banking activity, where contract conditions, in particular costs and maturities, are fixed before the actual contract starts, so there is a reference value at maturity, the trading activity involves buying and selling at market conditions of financial instruments, so that there is a higher uncertainty on the actual profitability of each transaction, which depends on the actual market conditions.

It is worth noting that also the trading book is exposed to the counterparty risk, as the risk that the counterparty will default in intermediate payments (coupons), or that the firm will go bankrupt (shares and securities), is always present. With reference to this, in particular for foreign exchange risk and commodities risk, market risk is connected to counterparty risk, as the market prices typically internalize the default risk.

Market risk is defined as the risk of a negative impact of adverse fluctuations of financial instruments (on- and off-balance sheet positions) arising from movements in market prices. The risks refer to three main sources:

- *Interest rate risk:* The risk of a change in the fair value of a financial instrument or the future cash flows from a financial instrument due to a change in interest rates, or from movement in the credit spreads for indices or issuers; variations in the interest rate directly affect the variable-income securities by means of its coupons, which will be higher if the interest rate rises, while for fixed-income securities the effect is on prices, the interest rate rise causing a reduction in the security price, proportional to its residual duration. Interest rate risk is measured by means of either the duration or maturity of contracts.
- *Foreign exchange risk:* The risk of a change in the fair value of a financial instrument due to a change in exchange rate or gold price. This evidently applies to financial instruments denominated in foreign currencies, but also to financial instruments sensitive to it, similar to equity derivatives on firms highly exposed to specific markets. Gold is treated as a foreign exchange position rather than a commodity because its volatility is more in line with foreign currencies, and banks manage it in a similar way to foreign currencies.
- *Commodities risk:* The risk of a change or volatility in the price of commodities, for example, agricultural products, minerals (including oil), and precious metals, but excluding gold, or commodity market indices. This also applies to financial instruments sensitive to it, such as equity derivatives on firms highly exposed to these commodities, for example, energy industries to oil prices. The price risk in commodities is often more complex and volatile than that associated with currencies and interest rates, and this can make price transparency and the effective hedging of commodities risk more difficult. In fact, commodity markets are typically less liquid than those for interest rates and currencies, so the changes in supply and demand can have a higher impact on prices and volatility.

The most important and often-used valuation methodology for market risk is based on "marking-to-market."

Marking-to-market is the regular (daily) valuation of positions at market prices (or quotes from several independent reputable brokers). As these values are easily observable and objective, regulation often states that banks must mark-to-market as much as possible. Where marking-to-market is not possible, banks may mark-to-model, i.e. calculate the position value indirectly from a market input, by means of an appropriate model.

The central element of the market risk measurement system is the value at risk (VaR). VaR can be defined as the maximum theoretical loss on a portfolio in the event of adverse movements in market parameters, over a given time frame, and for a given confidence level. Standard references (Basel II) for market risk VaR are a confidence level of 99%, and a time frame of 1 day using 1 year of historical data.

No particular type of model is prescribed by the Basel II standards; banks are free to use models based, for example, on variance–covariance matrices, historical simulations, or Monte Carlo simulations.

In this way, the market risks in trading activities can be monitored on a daily basis by quantifying the estimated maximum level of loss in 99 out of 100 cases, after inclusion of a number of risk factors (interest rate, foreign exchange, asset prices, etc.). The intercorrelation of such factors affects the maximum loss amount.

Each bank must meet, on a daily basis, a capital requirement expressed as the higher of (a) its previous day's value-at-risk and (b) the average of the preceding 60 business days' value-at-risk, multiplied by a multiplication factor set by individual supervisory authorities on the basis of their assessment of the quality of the bank's risk management system, with a minimum of 3.

In 2009, the BCBS, considering that the VaR capital charge computed at 99% threshold was not considering significant large daily losses occurring less frequently than two to three times per year, introduced new standards based on a 99.9% confidence

interval over a capital horizon of 1 year, coherently with the whole framework, that reflects a 99.9% soundness standard.

1.2.5 Operational Risk

Operational risk is defined, in the Basel II framework, as the risk of loss resulting from inadequate or failed internal processes, people and systems, or from external events. This includes legal risk, but excludes strategic and reputational risk.

Operational risks are usually not part of the standard "risk management" activity, as these risks are not diversifiable and cannot be managed within the bank credit activity. Instead, as it refers to processes and structures, operational risks can be estimated and, in some cases, reduced, but not fully eliminated, and as long as people, systems, and processes remain imperfect, operational risk must be considered.

Three main methods are accepted for calculating operational risk capital charges, in a continuum of increasing sophistication and risk sensitivity:

1) The Basic Indicator Approach simply requires that banks hold capital for operational risk equal to 15% of the average over the previous 3 years of positive annual gross income.
2) In the Standardized Approach, the capital charge for each business line is calculated by multiplying gross income (of that specific business line) by a factor (denoted beta) assigned to that business line.

   The total capital charge may be expressed as follows:

$$K_{\mathrm{TSA}} = \frac{\sum_{t=1}^{3} \max\left[\sum (\mathrm{GI}_{1-8} \times \beta_{1-8}), 0\right]}{3} \tag{1.5}$$

where

K_{TSA} is the capital charge under the Standardized Approach;
GI_{1-8} is the annual gross income in a given year, as defined above in the Basic Indicator Approach, for each of the eight business lines;
β_{1-8} is a fixed percentage, set by the Committee, relating the level of required capital to the level of the gross income for

Table 1.7 Business lines and beta factors for operational risk under Basel II.

Business lines	Beta factors (%)
Corporate finance (β1)	18
Trading and sales (β2)	18
Retail banking (β3)	12
Commercial banking (β4)	15
Payment and settlement (β5)	18
Agency services (β6)	15
Asset management (β7)	12
Retail brokerage (β8)	12

each of the eight business lines. The beta factors are detailed in Table 1.7.

3) Under the Advanced Measurement Approach (AMA), the regulatory capital requirement is given by the risk measure generated by the bank's internal operational risk measurement system, using quantitative and qualitative criteria subject to supervisory approval.

The approach or distributional assumptions used to generate the operational risk measure for regulatory capital purposes are not a priori specified, so banks can choose the best fit for their specific conditions. However, each bank must be able to demonstrate that its approach captures potentially severe "tail" loss events: Whatever approach is used, its operational risk measure must meet a soundness standard comparable to that of the internal ratings-based approach for credit risk (i.e., comparable to a 1 year holding period and a 99.9 percentile confidence interval).

Qualifying points of the methodology include the following:

- To calculate its regulatory capital requirement as the sum of expected loss (EL) and unexpected loss (UL);
- A bank's risk measurement system must be sufficiently "granular" to capture the major drivers of operational risk affecting the shape of the tail of the loss estimates;

- Include the use of internal data, relevant external data, scenario analysis, and factors reflecting the business environment and internal control systems;
- Have a credible, transparent, well-documented, and verifiable approach for weighting these fundamental elements in its overall operational risk measurement system.

Under the AMA, banks are allowed to consider the risk mitigating impact of insurance in the measures of operational risk used for regulatory minimum capital requirements, with a maximum of 20% of the total operational risk capital charge.

1.2.6 Basel III

Starting from June 2011, the BCBS introduced a comprehensive set of reform measures to strengthen the regulation, supervision, and risk management of the banking sector, and add a macroprudential overlay, aiming to improve the banking sector's ability to absorb financial and economic shocks.

The target of this reform is twofold: at bank level (microprudential, regulation), to raise the resilience of individual banking institutions to financial and economic stress; at system level (macroprudential regulation), to reduce systemwide risks across the banking sector and avoid the procyclical amplification of these risks.

The new framework includes a stricter definition of capital and a substantial strengthening of the counterparty credit risk framework.

The effects of the reconsidered loss-absorbing capacity of banks capital (see Table 1.8) nearly halved the previously considered effectiveness of the capital endowment as a shock absorber, as evaluated by the EBA quantitative impact study of 2011.

Apart from the definitions of capital and risk, the framework also includes an increase in minimum capital requirements, that is, from the 8% of RWA for total capital, 4.5% for Tier 1 and 3% for Common Equity are set to a new minimum of 6% for Tier 1 and 4.5% for Common Equity. On top of this, a capital

Table 1.8 Average estimated change in total capital ratio and RWA due to Basel III.

	Group 1 (%)	Group 2 (%)
Average Tier 1 capital ratio as of June 30, 2011	11.9	10.9
Average Tier 1 capital ratio under Basel III	6.7	7.4
Change in RWA due to Basel III	21.2	6.9

Source: EBA (2011).

conservation buffer of 2.5% is introduced for all banks, and an additional Common Equity Tier 1 (CET1) capital requirement ranging from 1 to 2.5% (depending on a bank's systemic importance) is set for the global systemically important financial institutions (SIFIs), to reflect the greater risks that they pose to the financial system.

So, the minimum capital requirement reaches 10.5%, for all banks but the SIFIs, for which an additional loss-absorbing capacity is required, ranging from 1 to 2.5% depending on the systemic role of the bank (Table 1.9), so that the total capital requirement ranges from 11.5 to 13%.

Another requirement is introduced with reference to liquidity, so that banks are required to have sufficient high-quality liquid assets to withstand a 30-day stressed funding scenario, a net stable funding ratio, and risk management; new references for capturing the risk of off-balance sheet exposures and securitization activities, managing risk concentrations, and other specific related problems.

The Basel III framework is planned to be fully in place in 2019.

The specific reference to global systemically important banks (G-SIBs) is based on the possible cross-border negative externalities posed by G-SIBS, which bring wider spillover risks the system must be protected from.

The moral hazard related to the implicit guarantee by the governments on too-big-to-fail financial institutions can lead to

Table 1.9 Basel III phase-in arrangements.

	2013 (%)	2014 (%)	2015 (%)	2016 (%)	2017 (%)	2018 (%)	2019 (%)
Minimum common equity capital ratio	3.5	4.0	4.5				4.5
Capital conservation buffer				0.625	1.25	1.875	2.5
Minimum common equity plus capital conservation buffer	3.5	4.0	4.5	5.125	5.75	6.375	7.0
Minimum Tier 1 capital	4.5	5.5	6				6
Minimum total capital		8					8
Minimum total capital plus conservation buffer		8		8.625	9.25	9.875	10.5
G-SIB additional CET1 loss-absorbing capacity				Gradual introduction			1–2.5
Liquidity coverage ratio—minimum requirement			60	70	80	90	100

Source: BIS.

suboptimal outcomes for the system, which, in consequence, has to include these issues in the policy design.

The main aim of the policies is to increase the loss-absorbing capacity of G-SIBs, so as to reduce its probability of failure.

The Basel Committee has developed a specific methodology based on indicators, for determining the systemic importance of G-SIBs, on the idea that it must be measured in terms of the impact that the bank failure can have on the global financial system and economy. While the crisis prevention is based on a reduction of the probability to default, the acknowledgment of

Table 1.10 Buckets and additional loss-absorbing capacity for G-SIBs.

Bucket	Score range	Minimum additional loss absorbency (common equity % of RWA)
5	D-	3.5
4	C–D	2.5
3	B–C	2
2	A–B	1.5
1	Cutoff point–A	1

the systemic importance is based on its impact on the system, and also on its loss given default.

The indicators used for assessing the systemic relevance reflect the size of banks, their interconnectedness, the lack of readily available substitutes or financial institution infrastructure for the services they provide, their global (cross-jurisdictional) activity, and their complexity.

The composite index is based on an equal weight to each of the five categories of indicators, each of which is normalized to a score of 1.

On the basis of their scores, G-SIBs are assigned to one of the four categories of systemic importance (Table 1.10), with varying levels of additional loss absorbency requirements.

1.3 Banking Risk Modeling and Stress Testing

The risk splitting introduced by the Basel II framework is operatively effective, even if it categorizes the risk in a strong division, while, in fact, these risks are cross-linked.

With reference to the regulation, some of these linkages are acknowledged. On the one side, the maturity transformation realized by banks implicitly includes interest rate risks, as the shorter and longer maturities can have different variations, which can induce significant risks of reduction, or even negative values, for the net interest income.

On the other side, counterparty credit risk is always present and has to be considered with reference to the trading activity, so it is strictly connected to market risk, as even traded assets are exposed to the risk that the counterparty could default before the final settlement of the transactions cash flows.

In addition, market and credit risk tend to be driven by the same economic factors. For example, both stock and bond values are sensitive to the macroeconomic environment changes. Hasan *et al*. (2009) proved that correlations between macroeconomic variables and asset prices, and prices of default-sensitive instruments are significant from both a statistical and an economic point of view. So, the same values are exposed to both counterparty and market risk variations, as a consequence of the same variables variations. One example can be in the effect of a worsening of the expected income of a bond issuer, which increases its default risk, thus inducing a reduction in market prices.

So, this separate estimation and aggregation, often used in industry and regulation, excludes nonlinear interactions and linkages, such as diversification benefits, and may lead to biases in the overall risk estimation.

A consistent approach must include the integrated evaluation of at least the credit and market risk, and include all sources of income and losses.

Some studies analyzed the two main risk sources from an integrated point of view, with reference to diversification, liquidity, and measurement.

Tang and Yan (2010) examine the impact of the interaction between market and default risk on corporate credit spreads. Using credit default swap (CDS) spreads, we find that average credit spreads decrease in GDP growth rate, but increase in GDP growth volatility. They also find that a major portion of individual credit spreads is accounted for by firm-level determinants of default risk, while macroeconomic variables are directly responsible for a lesser portion.

Drehmann *et al*. (2010) derived a consistent and comprehensive framework to measure the integrated impact of both risks and assess the integrated impact of credit and interest rate risk

on banks' economic value and capital adequacy. They showed the importance of measuring and stress-testing the impact of credit and interest rate risk jointly, and that a deterioration in a bank's fundamentals can increase its funding costs, thereby further lowering its profitability in a potential vicious circle.

Breuer *et al.* (2010) showed that when financial positions depend simultaneously on both market risk and credit risk factors, an approximation of the portfolio value function separating the two risk components can lead to an incorrect assessment of true portfolio risk.

With reference to regulation, the integrated effects are one of the problems to be considered when setting the stress tests required for banks using the internal models approach. In this case, a rigorous and comprehensive stress-testing program must include the effects of the external shocks on the different sides of the banking activity.

Another possibility is in starting from the a posteriori statistical distribution of the actual results, which implicitly includes all the effects affecting banks' results. With appropriate time series and cross-sections analyses, it is possible to describe the actual banking expected losses distribution, and to evaluate the role of the different variables affecting it.

But even this approach suffers from several limits. One is in the difference between risk measurement and the actual expression of results variability: If we toss a coin three times, and register three "heads" results, this does not means that the coin is loaded, or that the fourth try will result in one more heads result. It is also one possible result of a standard coin tossing with actual probability of ½ for each possible result. The risk and results measuring are two different measurements that need different methods, even if each one is linked to the other.

Another important difficulty is due to the actual loss acknowledgment timing.

A liquidity problem for a loan debtor can result in its default, and the bank will register a loss hitting the income.

But if the bank allows for credit flexibility, raising the credit limit for the debtor, the firm can avoid the default, and the

impact of this different strategy will just result in a higher risk weighting of the loan, and a higher correction in the expected losses. This results in a higher RWA value, but with a much smaller impact on income.

Thus, the actual results (losses) not only depend on the different risk profiles and diversification strategies chosen by each bank but also are influenced by the balance sheet policy.

In addition, the actual losses are almost always the result of a loan granted 1 or more years before the actual default, and it is not directly evident from the balance sheet which is the risk level of the exposures. Only a indirect evaluation can be done from the loan losses provisions, which refer to all the loans and exposures, and can be set with some subjectivity by the bank.

Finally, the a posteriori analysis of results distribution, even if it is not sufficient to assess each bank's actual risk level, is actually useful to picture the framework, evaluate the main influencing variables, and produce an adequate representation of the possible results of the banking activity.

1.4 Contagion

As already mentioned, banks have a key role in financing the real economy, sustaining the economic growth, and allowing a higher growth rate. In addition, not only do banks channel financial resources to the creditworthy firms, as do a substantial selection between the possible investments, but also the intermediation role of banks realizes a maturity transformation that increases the possibility of firms financing, which cannot be possible by the direct contact between investors and money suppliers. Thus, every bank default is a seriously important accident that induces significant effects on the whole economic system: losses for depositors, quite often consumer families, with social and economic disruptive effects; lack of confidence in banks, and thus a lower attitude to deposit money in banks and a lower capability of firms financing; fire selling of traded assets, with subsequent effects of markets instability, and so on. So, even when the bank default is not causing direct effects on

the rest of the banking system, it still affects the system owing to its indirect effects.

Evidently, the larger the bank, the larger the effects on the rest of the system, but the worst case after a bank default is due to contagion.

Similar to what happens for some diseases, where the illness of one person can spread to more people, the default of a bank can be the cause of other banks' defaults, and this propagation can continue in a domino effect, transforming a bank crisis into a systemic crisis. If the default of one bank is already a significant problem for its impacts in the real economy, systemic crises have disruptive effects on the economic system and public finances, often affecting the real economy to a large extent, not only in its values for the years of crises, but also changing the trend for subsequent years.

The recent financial crisis demonstrated what the consequences of a banking crisis can be. But this is just the last example: Laeven and Valencia (2013) reported 147 banking crises episodes over 1970–2011, and a median value of 23.2% of output loss across all episodes reported. Figure 1.4 reports some examples of the effects on GDP of banking and financial crises.

The knowledge of the disruptive effects a systemic crisis can have on the economic system induced the regulators and supervisors to analyze in depth the mechanisms possibly causing a systemic crisis, and in particular bank defaults and contagion.

In fact, contagion channels and mechanisms are multiple, and we already mentioned the loss of confidence and the destabilizing effects of fire selling; others are related to the derivative markets, to the interrelationship with public finances, but the most significant and direct effect is due to interbank lending.

As considered with reference to the counterparty risk, even when the counterparty is a bank, the risk that a loan will not be repaid is always present. Thus, the default of a bank normally implies that the interbank loans are not, or not fully, paid back, so the creditor bank suffers from direct losses. In addition, as the interbank lending is part of the liquidity management, even the indirect effects, such as interbank lending freezing, restoring liquidity equilibriums, and the subsequent effects on the other

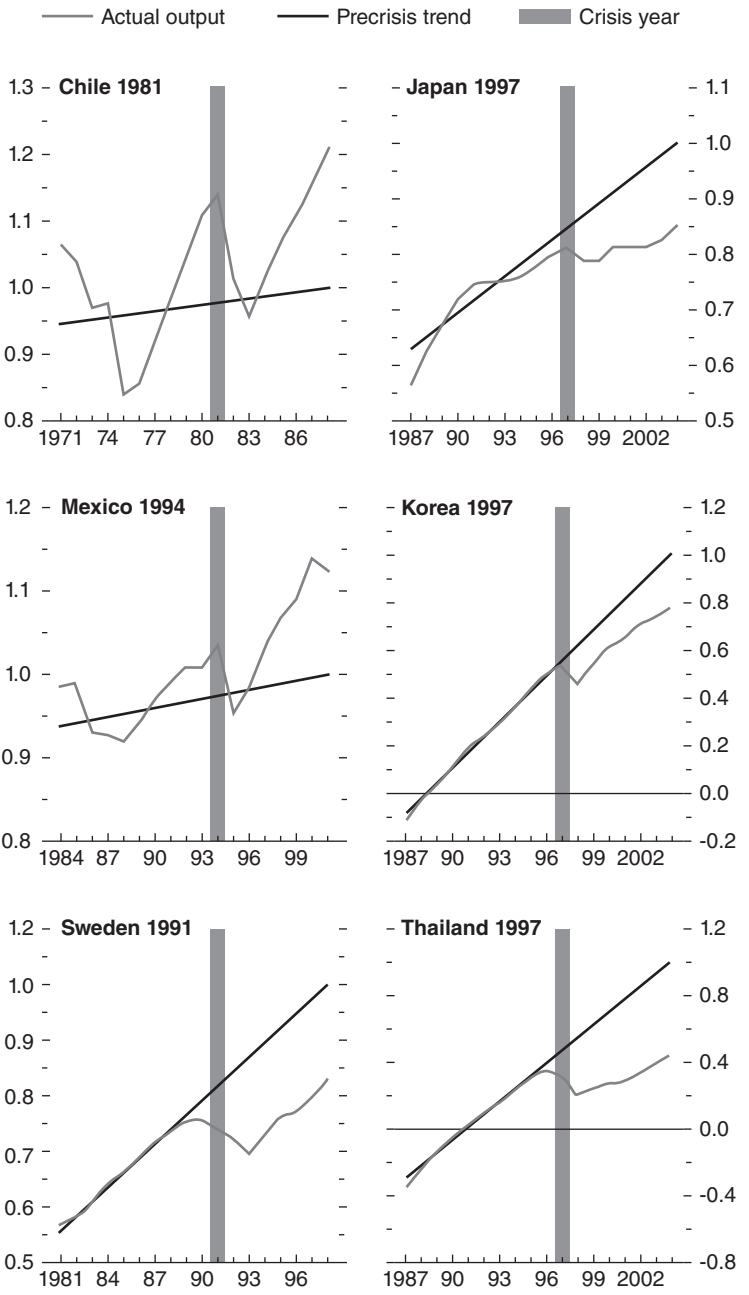

Figure 1.4 Medium-term output per capita after financial crises: case studies. *Source:* IMF (2009). Reproduced with permission of IMF.

layers of the banking activity, result in higher costs or in lower income for the affected bank.

And when these losses are important, or when the bank is already weakened by other problems, the creditor bank can default itself, causing more interbank losses to other banks, possibly summing up to the previous default losses, and so on. This chain reaction is one of the worst fears of the supervision institutions, the costs for stopping the mechanism being huge, and in some cases above the national government capabilities.

One important piece of evidence, similar to what happens for diseases, is that the earlier the intervention, the lower the impact of the crisis and the costs of stopping the domino effects. So, quite often possible bank defaults are stopped with early interventions, as the default can be the lighter of a burning disaster. But if the crises have important costs, even the interventions for preventing it are costly, so it is important to have a correct perception of which crises can introduce serious risks to the system, in order to have more effectiveness and efficiency in using the tools designed to maintain financial stability.

The first evidence is in the role of the size of the defaulting bank. Large banks are so important that they can induce a systemic crisis just for the size of the losses induced to the counterparts. Quite often, the larger banks are qualified as "too big to fail," as no government would be able to withstand the effects of their default, so early interventions are always put in place to avoid it.

This also induced a number of distortions related to possible moral hazards. In fact, some rating agencies when evaluating the soundness and safeness of banks also include in their evaluations the attitude of governments to intervene to avoid a possible default. So, the "too big to fail" or "systemically important" banks benefit from a higher rating, because of better market conditions due to this implicit guarantee. But in some cases it can also be exploited in moral hazard terms by management, and taking more risks than appropriate, knowing that if the risk outcome is a higher profit, this will benefit for the management (and shareholders), while if the risk outcome is a

loss, the government (taxpayers) will pay to cover the losses. Evidently, some mechanisms have been adopted in many countries for correcting this strain.

Another important evaluation is detecting the kind of shock causing the bank default. The main distinction is between the so-called idiosyncratic shocks—risks specific to the affected bank—and systemic shocks, variations in the economic framework affecting all banks, or a large part of banks in the system.

Examples of the first case can be the crisis of a large firm that is a big borrower from a bank, a local housing or specific crisis for a highly specialized bank, or the effects of fraud. In these cases, when the shock is seriously affecting only the defaulted bank, and when the defaulted bank is small, the counterpart banks can absorb the interbank losses. Instead, when the shock is due to a widespread economic crisis, financial market instability, or any other problem affecting the whole system, as many banks are already weakened, they can be seriously hit by more losses coming from interbank defaults, and so are more likely to default and be involved in domino effects.

Castiglionesi (2007) investigated the role of central banks in preventing and avoiding financial contagion, and found that the liquidity reserve role is fundamental in facing adverse shocks that could cause contagious crises.

It is also important to consider the central bank role as a lender of last resort that can also play the role of money centre for interbank lending during the banking crises, as banks have a lower confidence in the interbank lending and the use of the central bank as counterpart can restore confidence, make the interbank market work, and avoid the liquidity shortage that characterizes systemic crises.

Co-Pierre (2013) proved that the liquidity provision by the central bank results in a significant stabilizing effect. However, its effects are only significant above a certain threshold; this stabilizing effect is nonlinear, so that even slight changes in the collateral requirements can have significant stabilizing effects if performed around the critical value; and the precise value of the threshold depends on the specific parameterization and network structure.

1.5 System Modeling

After considering the different problems that banks have to face and the risks they have to manage, the analysis can be aimed at studying the banking system as a whole.

The main components characterizing each banking system are the distribution of the banks' values, the direct linkages of interbank lending, and the specific framework they share, in terms of loans market, national economic policy, and in particular banking and financial policy and supervision, and the direct linkages. In terms of modeling, this is translated in contagion transmission channels and correlation among bank results.

The distribution of banks, values is the way of mapping dimensions and roles, and evaluating the system structure.

Domestic banking systems can be characterized by a large number of small banks, or concentrated into a small number of larger banks. Quite often, the different dimension classes correspond to different roles in the system. Smaller banks are typically characterized by relationship lending, direct deposits funding, and high assets shares invested in loans, while large banks tend to have a more structured activity, including trading, corporate finance, and merchant banking.

The definition of a banking system is typically based on the homogeneity and on the linkages among the considered banks.

In this sense, quite often the analyses are referred to national banking sectors, as the homogeneity of laws and reporting standards and the common counterparts, both on the loans and on the policy and supervision.

The national policies the banks are exposed to refer not only to specific banking regulation and interventions but also to all the economic framework. The government countercyclical actions for smoothing the business cycles, support for specific economic sectors or regions, and the public finances equilibrium are only some of the examples of the policies directly affecting the banking activities and results.

The public finances are particularly relevant with reference to the banking system, as the channels linking public finances and banks are multiple, both sectors being exposed to the interest

rate and money quantity control by the central bank, the country risk affecting both ratings of sovereigns and banks, the role of banks, and so on.

But the direct linkages between banks and public finances are due to the exposure of banks as sovereign bonds holders, and of the government as an implicit guarantee of rescuing the bank in case of default.

On the exposure of banks in sovereign bonds, it is worth noting that the large size of a banking group makes it an important market maker. This is particularly significant for countries with a large public debt, thus requiring continuous support for the bonds issues, giving these banks a strong position in its relationship with the government. On the other hand, banks are exposed to possible losses as a consequence of the public finances weakening.

The government's implicit guarantee is a consequence of the evidences of the banking crisis effects: When contagion spreads, the cost of nonintervention or of a delayed intervention can be thousands of times higher than the early intervention—preserving the agents' confidence and avoiding the nervous and often irrational sudden changes in the financial sector behavior limit the disruptive effects of the crisis spreading over the economic system. But this contingent liability and the actual costs of rescuing the banks can substantially hit the public finances equilibriums. In a weak phase of the business cycle, this mutual support, of banks sustaining sovereign bond prices by buying and holding important shares of public debt, and of governments guaranteeing for banks rescue, can be a tough exercise.

The IMF Committee on the global financial system (2011) described the risk of lower profitability for banks as a consequence of public finances weakening mainly passing through four channels, as explained by and shown in Figure 1.5:

- A fall in the value of the government bonds held by banks, weakening banks' sovereign portfolios.
- *An increase in banks' funding costs:* A deterioration in a sovereign's creditworthiness reduces the value of the collateral

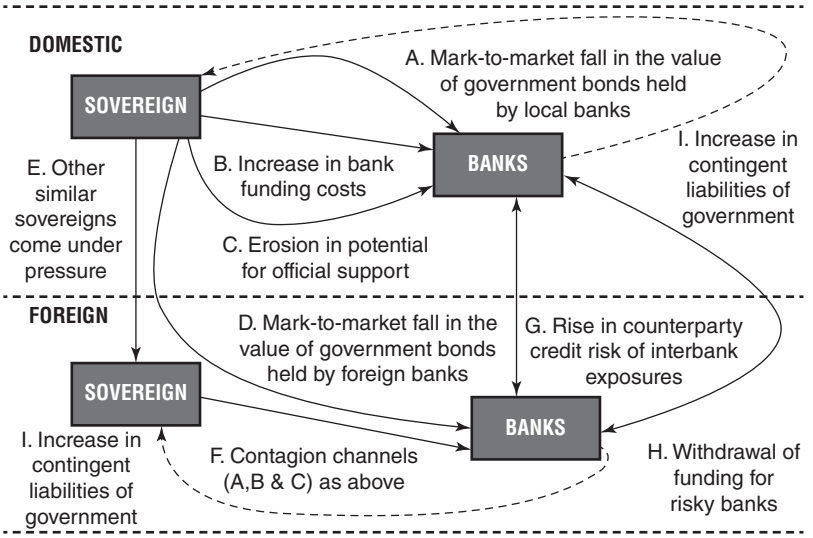

Figure 1.5 Spillover effects from sovereign to banks and from banks to sovereigns. *Source:* Laeven, 2010. Reproduced with permission of IMF.

that banks can use for wholesale funding and to obtain liquidity from the central bank.

- *Erosion of the potential for official support:* The affected sovereign's ability to backstop the financial system comes into further doubt, as rising funding costs increase the magnitude and likelihood of interventions in banks.
- Sovereign downgrades generally cause lower ratings for domestic banks, increasing their wholesale funding costs, and potentially impairing their market access.

In addition, the role of banks in funding firms and supporting the economic growth makes the domestic banks an important interlocutor for any government, and the banking sector one fundamental actor in implementing and realizing the economic policy.

With reference to the modeling, it is fundamental to highlight that many risk factors affect all banks in the system, even if with differentiated impacts.

The first common exposure is to the national business cycle, which affects firms' economic framework, and ultimately their capability to pay back bank loans.

Because all firms (and customers) are affected by the same business cycle, the results of counterpart risks for different banks are correlated. This effect is enhanced by the possibility, often realized, that the same firm is actually financed by more banks, as, in this case, the risk is shared by all the concerned banks. Other risk sources shared by the banks in the same system are related to interest rates, domestic stock exchange values and trends, policy interventions affecting propensity to save or consume, and so on.

With reference to linkages, a system can be characterized by its interbank direct exposures, so that a group of banks can be reasonably defined as a system if their linkages are mainly held to other banks in the system. In this way it is possible to reasonably approximate the possible states of the system, and include the main determinants of its possible instability. The same problem can be referred to a system represented by only a sample of banks that can correctly approximate the actual system as soon as the banks in the sample banks are actually representative of the system distribution.

For large banking groups, the framework is significantly different. On the one hand, large banks are typically operating in more countries, and hence are exposed to more risk sources, while on the other hand, diversifying risks are coming from different countries. This means that when modeling their risks and behavior either the correlation is referred to international business cycles or its results are represented as the weighted average of the economic framework for each considered country.

The second difference is that quite often, due to the intermediated volumes, large banking groups are exposed among them, in an upper layer of the banking network. In this case, there is an actual homogeneity between the large and internationally active banks and banking groups (so-called "group 1" banks), so that it can be modeled as a system even if there is no national communality.

What is in fact fundamental is to represent, as correctly as possible, the actual system behavior and dynamics.