Open Risk White Paper

Federated Credit Systems

Part I: Unbundling The Credit Provision Business Model

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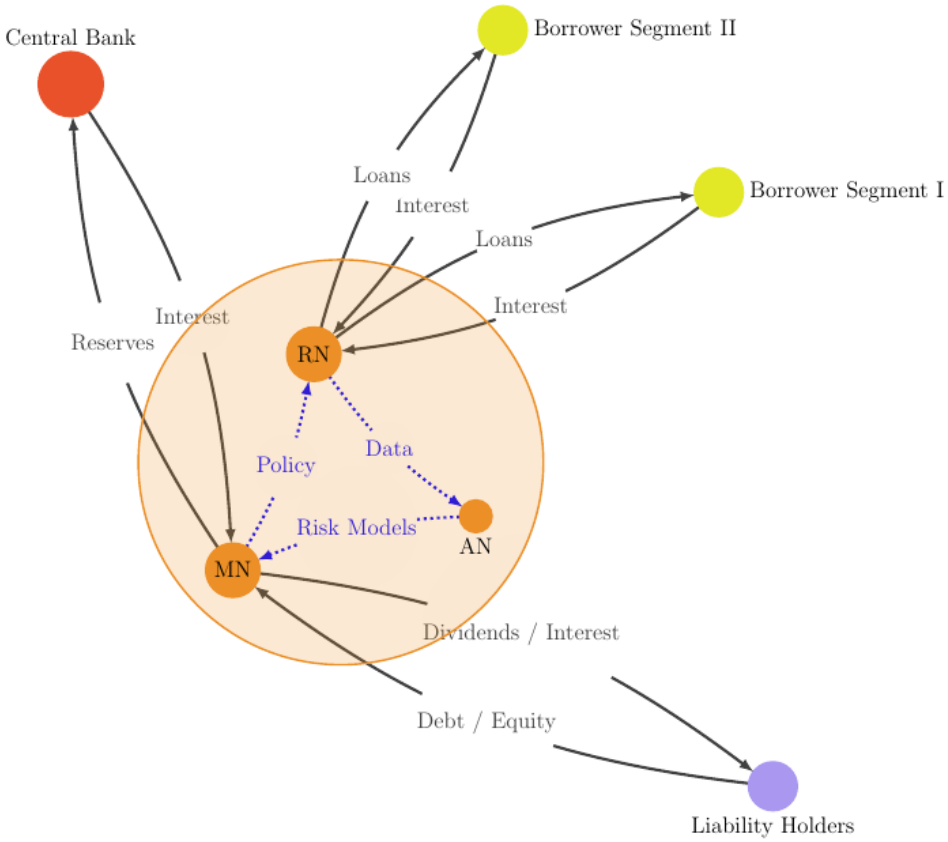

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SUMMARY

In this Open Risk White Paper, the first of series of three, we introduce and explore the concept of *federated credit systems*. We review the rapidly developing fields of *Federated Analysis* and *Federated Learning* as already actively studied in the domains of medicine and consumer computing devices. This form the backdrop for understanding the potential and challenges of applying similar concepts in finance and more particular *credit provision*. The context of modern banking is substantially different from the above mentioned use cases. Understanding and shaping federated information systems to cater to its unique features and constraints (key added value, competitive landscape, regulatory frameworks) will help accelerate the adoption of new designs. Towards that purpose we construct a framework that conceptually *unbundles* the complex operation that is modern credit provision. We introduce a number of fundamental business entities (sub-units) and their associated functions and discuss the underlying business models. We discuss, in particular, how and why they exchange data and metrics and the key risk management challenges of each. Finally we sketch current architectures for credit information sharing with an overture to the new possibilities opening up with federation architectures.

Further Resources

- The Open Risk Manual is an open online repository of information for risk management developed and maintained by Open Risk and contributing Authors. Concepts mentioned in this White Paper may be further explained / documented using Open Risk Manual entries (suitably hyperlinked).
- The Open Risk Academy offers a range of online courses around risk and portfolio management, which utilize the latest in interactive eLearning tools. Please inquire at **info@openriskmanagement.com** about eLearning possibilities.

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Introduction

The dictionary definition of *federation* is an encompassing political, economic or societal entity formed by uniting smaller or more localized entities. It is a form of cooperative organization where federation members maintain control over their own operations but (voluntarily) elect to share a combination of resources, processes or policies. In a more narrow, *technical*, context of information exchange, federation refers to different entities adhering to a standard of operations in a collective manner to facilitate communication.

As an architectural design and information technology approach, federation has received increased attention in domains such as the medical sector (under the name **federated analysis**), in official statistics (under the name **trusted data**) and in mass computing devices (smartphones), under the name **federated learning**.

A primary domain where federated data and analyses are being considered is medical health records and their statistical analysis and modeling. Healthcare data are typically distributed across diverse institutions and medical units, reflecting the nature of the healthcare system and its processes. E.g., different hospitals may only have access to the clinical data of their own patient populations. Such data are highly sensitive and are considered protected health information. For example, training a tumor detection algorithm requires a large database encompassing a spectrum of possible anatomies, pathologies, and input data types. *Data anonymisation* might bypass some limitations but it is frequently not sufficiently adequate protection. Federated analysis of medical records aims to move the computation to the data (i.e. the data does not leave the organization). As such, the business, legal, technical and other risks inherent with data transfer and data centralization are reduced. For a review of recent developments in this space see [1],[2]. A live example of an operational federated data system used for genomics and health research is CanDIG, deployed to analyze health data across Canada.

Another branch of recent activity clusters around federated learning[3]. This is motivated by a combination of data scarcity and data privacy issues around mass market consumer computing devices (more simply: smartphones / mobile phones). The essence of the proposed architectural solution is to train algorithms across decentralized devices, each holding their own local data samples, hence without the need to transmit to a central party potentially sensitive information. The construction of a global model is achieved through the exchange of derived data (gradients, parameters, weights etc). This design stands in contrast to traditional model estimation where all data must already reside (or brought into one computational environment). Reviews of ideas, opportunities and challenges of federated learning are given in[4],[5], [6].

The office of European Statistics is also evaluating the use of federated data systems for its work on Trusted Smart Statistics for National Statistical Institutes. The intent of this work is to establish a set of policy indicators that would be informed by an array of private-sector inputs from multiple industry sectors. As the European Commission notes, "Statisticians have a new opportunity to produce official statistics that use an extended data ecosystem. These Trusted Smart Statistics are a service provided by smart systems, embedding auditable and transparent data life cycles, ensuring the validity and accuracy of the outputs, respecting data subjects' privacy and protecting confidentiality."

Federated Credit Systems

Placing the federation architecture in the context of finance and in particular credit provision leads to the concept of **Federated Credit Systems:** The set of principles, tools, organizational arrangements and practices adopted by entities originating credit contracts that aims to reduce information barriers in a cooperative / coo-petitive context. There are three broad categories of benefits in pursuing federated credit systems:

- Addressing scarce data issues for analysis and model building purposes (without violating privacy constraints)
- Creating more powerful risk management tools (including early warning indicators)
- Economizing technical resources through standardization and rationalization
- Raising overall service quality through benchmarks and cross-validation functionality

A Rainbow of Federation Options

There are many dimensions along which one might consider ”federation” of credit provision infrastructure. Some facets are already covered implicitly of explicitly. For example the use of academic journals to publish credit risk models is a widespread means to disseminate information about relevant algorithms and create a collective ”knowledge base”. Similarly the collaborative development of standards such as ISO 20022 facilitate exchange of payment and other data across independent infrastructures. An enumeration of different federating dimensions would include:

- **Standardization and Federating of Credit Data**. This is a basic (first level of federation) which facilitates more powerful options for Federated Analysis.
- **Standardization and Federation of Mathematical Abstractions** (e.g Credit Models) and associated Model Parameters. Together with federated credit data this opens the possibility of *federated model development* using techniques such as federated learning.
- **Federating Model Source Code**. Broadly speaking this is the adoption of *open source* practices (both using and contributing). While not necessary, pieces of model code may also be exchanged during federated model development.
- **Federating Infrastructure** (Compute and Storage). For example shared procurement and deployment of models by independent economic entities.

These different facets of federation are related in various ways but they are not a hierarchy of ”ever closer union”: For example, federating credit data information is a prerequisite for federated model development but does not require it. Similarly, entities may adopt an open source credit model platform without federating any credit data. As a final example, IT infrastructure could be procured and run on a joint basis while completely ring-fencing any other information exchange.

We will not attempt here an exhaustive discussion of federation possibilities across all those dimensions. We will focus on providing a framework for productive analysis. We aim to illustrate that in the context of commercial credit provision, federation enables various forms of coopetition, where overall

better outcomes can be achieved without restricting the ability of individual entities to act autonomously. As a reminder, "coopetition occurs when companies interact with partial congruence of interests. They cooperate with each other to reach a higher value creation if compared to the value created without interaction and struggle to achieve competitive advantage. Often coopetition takes place when companies that are in the same market work together in the exploration of knowledge and research of new products, at the same time that they compete for market-share of their products and in the exploitation of the knowledge created."

Box 1. Indicative Application Domains employing or considering Federation Principles and the Accuracy/Privacy tradeoff

Federation of data and/or quantitative models is a very general principle and can considered in quite diverse statistical contexts. A non-exhaustive list that spans relevant dimensions would include the following three domains:

- Federating Medical Data and Models across the medical sector. The objective is to enhance analysis without violating medical data privacy.
- Federating Image / Language Data and Models in mass consumer devices. The objective is improve services without violating personal data privacy.
- Federating Official Statistics in the context of IoT infrastructures. The objective is to improve official statistics without violating personal and commercial privacy.

These three domains highlight an important issue affecting the architecture of digital systems: the tradeoff between increased accuracy and reduced privacy. Federation plays an important role in opening up some additional possibilities.

The Economic and Business Context of Credit Systems

The accuracy / privacy trade-off we mentioned is usually examined and explored in a context where the federating entities are not *commercial competitors*. E.g., in contrast with the medical domain (significant role of non-profit institutions) and mass computing domains (a duopolistic arrangement), federated credit systems must be developed in line with the business and regulatory context of modern credit provision. In this section we go over various aspects of how modern credit provision is structured, with the objective to abstract a framework that helps query the plausibility of concrete alternative federation scenarios. It answers the question of forms of federation are possible *in principle* while keeping in mind that practical schemes will almost certainly have to accommodate the "pre-existing" conditions of how the vast majority of current systems are organized and operated.

Credit relations between individuals go back to the dawn of history[7] and have undergone dramatic changes as societies and economies became ever more complex and technologically sophisticated. In modern times formal credit arrangements typically involve *monetary credit* (promises, IOU's (I-Owe-You) that are expressed and operationalized in terms on an underlying *monetary payment system*. Simply put, a loan is a formal promise (legally enforceable contract) to repay a nominal amount of "money" sometime

in the future.[1]

Today credit provision is typically (but far from exclusively) a for-profit business offered by private enterprise *intermediaries* (e.g. commercial banks). It is a vast business sector with different arrangements and operating conventions both within a given jurisdiction and even more so across different legal systems, countries and cultures. Importantly, there are many potential alternative pathways to credit provision. While *Banking* is the first association we make, *Shadow Banking* or *Non-Banking Financial Institutions* are such alternative channels and are by now of substantial size [8]. One of the non-banking channels involves *securitisation*, an approach that has various similarities and differences with traditional banking [9]. While we will not explicitly cover these alternatives in this paper, much of our discussion here applies as there as well with some modifications.

When discussing the credit provision function we will ignore various complications of the integrated (bundled) nature of modern banking. Most importantly the interactions with payment systems, central bank money and interest rates. We will use only one (imagined) client segment with uniform characteristics. We will focus on stylized credit risk analyses (which we will document in Parts II and III in more mathematical / technical detail) but we will ignore associated risk types and many practical complications. While all these simplifications reduce some of the generality of the discussion they enable an "end-to-end" view of the process and illustrate the potential practically of federation (and the challenges / focus points).

The picture we start with is one of *interconnected economic agents* engaging in activities such as trading (transacting) and entering into economically relevant contracts of various forms (more details for this view point available in [10]). In Figure 1 we illustrate how these nodes form loosely connected networks of related entities. This type of granular and visual depiction of economic networks is not the norm in traditional economic / financial expositions, yet as the possibilities of *digital networks* in enabling new types of financial architectures are growing, it promises to be a useful, if not required, paradigm. In this paper we will significantly narrow the scope and detail of the networks that we examine, but it will be useful to have this broader context in mind. In Table (1) we list in more detail the types of economically active nodes that are (in principle) present in such networks and what they are generally up to. Each one of these nodes "owns" digital infrastructure (a private digital domain) that contains economically / financial relevant information controlled by each respective node. A node *only* exchanges information with other entities via formal channels (e.g. application programming interfaces (API's).

[1] While the debate about the meaning and form of digital money has never been more active, we push it here into the background. This may not be completely justified: the credit theory of money suggests that money itself is a form of credit that can be used to settle future obligations. Nevertheless these two forms of credit operate at different level. While a more profound evolution of future monetary/credit systems cannot be discounted, many of the elements of federated credit assessment we examine here are likely to be relevant.

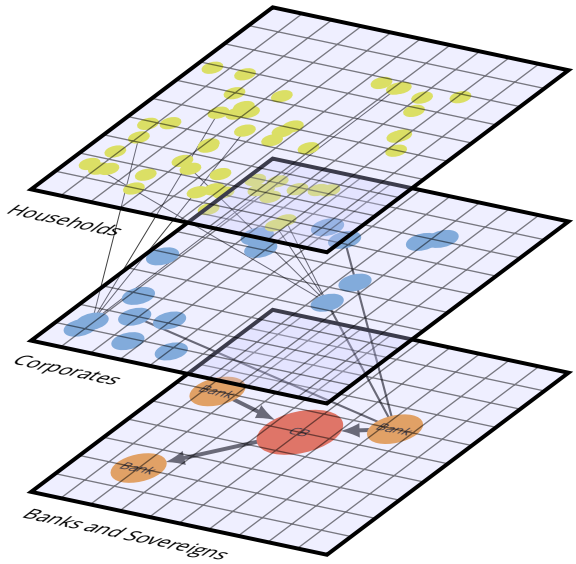

Figure 1: A bird's-eye view of an economic network that includes interacting (transacting, contracting) legal entities such as households, corporates, banks and sovereigns. The arrows symbolize contractual relationships between entities or possible transactions (not necessarily just credit contracts). While this representation of an economy is quite abstract, it helps to motivate it if we imagine that each one of these nodes is a proxy for a *distinct data environment*. Thus an economic network gets mapped into a digital network.

A list of main economic and legal entities involved in traditional (two-tier) banking

	Real Person	Produces	Lends / Borrows	Issues Money	Issues Shares
Households	Y	Y	L/B	N	N
Corporations	N	Y	L/B	N	Y
Private Banks	N	N	L/B	Y	Y
Central Bank	N	N	L/B	Y	N
Sovereign	N	Y	B	N	N

Table 1: The first column indicates the legal entity type: All nodes except households are actually *virtual* legal constructs. Most nodes will engage in transactions and possibly some type of lending (e.g savings) or borrowing contracts. There vast differences in the further scope and economic role of each class of nodes. E.g. issuing money assets is the prerogative of banks (whether private or public / central banks). Issuing equity shares is on the other hand confined to the corporate sector and private banks. In a digital economy all nodes poses private data within their own domain that they may choose to exchange to facilitated transactions and contracting. In this paper we will focus on borrowers and lenders, where the borrower is assumed to be (as a working hypothesis) a corporate entity.

Borrowers

Corporate entities of various types are the cornerstone of modern economies and form the primary means of organizing economic production. They are entirely *legal* constructs and as legal entities they become counterparties to countless contracts and transactions. Out of this complex nexus of contracts that a corporate entity engages in, bank credit systems are focused on bilateral loan contracts.[2]. The larger the size of the corporate, the more complex its nexus of contractual relations. In Box 2 we have a cartoonish representation of the corporate node (its activities and relationships).

[2]It is entirely possible to have a corporate entity that does not have formal credit contracts (unlevered). But in general there is always some credit exposure when engaging in transactions, e.g. the credit risk associated with trade receivables

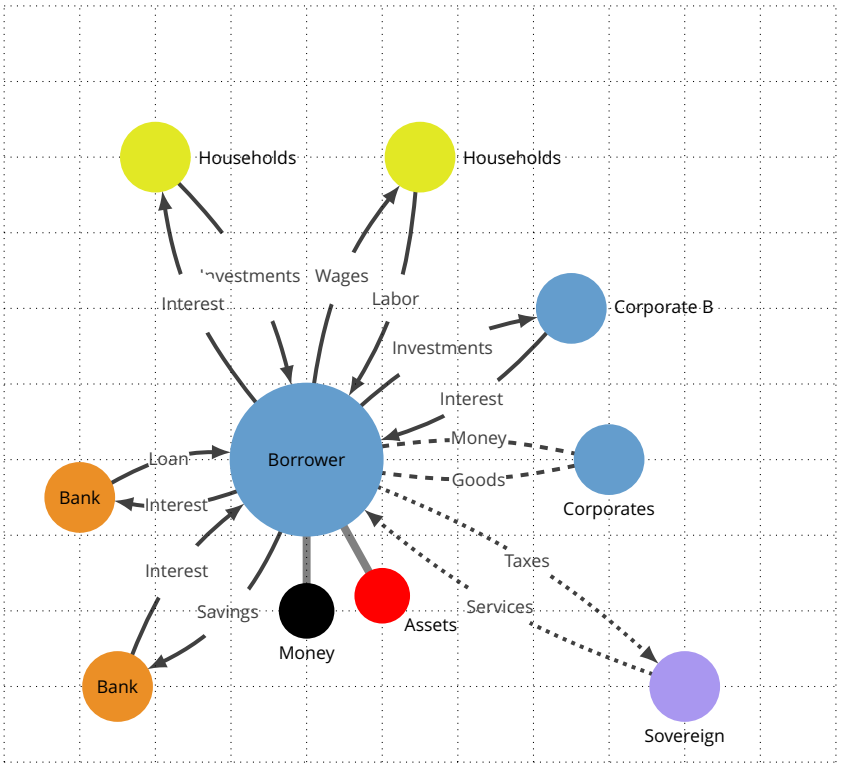

Figure 2: Visual illustration a (corporate) borrower node and its interactions with other economic nodes. The bank-corporate relationship will be our focus but obviously the economic reality is more complex: Borrowed funds will be *circulating* in the economy via wages, production costs, sales etc and only finally return back as payments to the lender (as interest and principal).

Box 2. The activities and nexus of contracts of a commercial borrower

Understanding the likelihood of a corporate entity honoring a particular contract is linked to understanding what other economic activity it is involved in. A sample of the transactions and contracts that affect the economic state of a borrower:

- Sells goods and services to most other economic nodes (via transactions)
- Employs households (receiving services and paying wages)
- Holds real assets (inventory)
- Holds cash (monetary assets)
- Issues a variety of short / long term debt bonds and shares (only large corporates)
- **Borrows bilaterally from Banks** (← the contract class we will focus on)
- Invests in equities or bonds for income purposes
- Invests in equities for strategic reasons
- Pays sales tax
- Engages in yet more types of contracts (various forms of insurance, pensions, etc)

From the perspective of the counterparty providing the loan (e.g. the bank or other credit underwriter), a key question is whether the terms of the contract will be honored (and if not, what will be the im-

plications). It is clear that assessing the likelihood of such an outcome cannot be conducted without awareness and integration of all material economic circumstances of the borrower. Thus, on the face of it, assessing the credit risk of a corporate entity is a formidable problem as there is a large number of dependencies and correlated risk factors. Historically some progress has been made by using simplification strategies. These tools were not specifically developed for credit risk analysis - they address broader usability challenges associated with the management of corporate entities. In particular entities that seek investments from large pools of investors - which requires creating some transparency about the economic state of the enterprise engage in the collection and *report* of various pieces of information. The most important such information tool is arguably the balance sheet and its associated *financial statements*.

The balance sheet is a stylized *representation* of a corporate node's economic state at any given point in time. Its aim is to include all material persistent properties characterizing that state, converted (where possible) to "objective", quantitative metrics. The basic mechanism to achieve this powerful aggregation is to convert all properties, assets, contracts etc., into a *monetary value*[3]. This process is usually called *valuation*. Valuation is thus a map M from the property / contract space of an economic node to a numerical (monetized) value. For example, "real" corporate assets are typically valued with reference to a variety of markets (where such assets are traded) while corporate cash balances are assigned *face* value).

The balance sheet is thus a *static* (snapshot) view of the internal state of an economic entity. Economic transactions (exchanges of goods and services against payment, purchases) do not feature explicitly in the balance sheet. Other financial statements like the cashflow statement and the income statement provide more "dynamic" views that aim to capture changes occurring between timepoints. These flows represent instead *changes of state*. Such dynamic "flows" are reported in the income statement and/or the schedule of cashflows. More technical details about the mapping processes are given in [10]. Here we are mostly interested in the fact that these abstractions create useful credit data points. For example, the net worth of the corporate is simply the summation of all the valuation items in scope (assets minus liabilities). This is an important variable in relation to credit risk (solvency) assessment.

Lenders

We turn now to the lending counterparty, namely the entity providing a loan or credit to the borrowing (corporate) node. As mentioned, a large component of modern credit provision is through the two-tier banking model. An overview of various elements of banking from an economic perspective is given in [11]. Understanding the *business model* of a commercial bank (what it does and why it does it) is important help to understand the incentives, constraints and possibilities in federating credit systems. A full exposition would take us too far afield but we need to cover the essential elements around credit provision.

A business model is not an easily defined concept, certainly not in rigorous quantitative terms. In most realistic instances it involves quite complex relationships between various actors, diverse tangible and intangible assets and processes. Practically a business model is the orchestration of such intangible and tangible processes, resources and attributes that characterize a business entity[12], primarily in its pursuit of a *Value Proposition*.

[3]Obviously a far cry from what the amount of activity that is actually happening inside the entity and its relations with a surrounding economy but our purpose is not to identify broader limitations and blind spots of how the economic system is being accounted for, but rather to place existing tools in a useful context

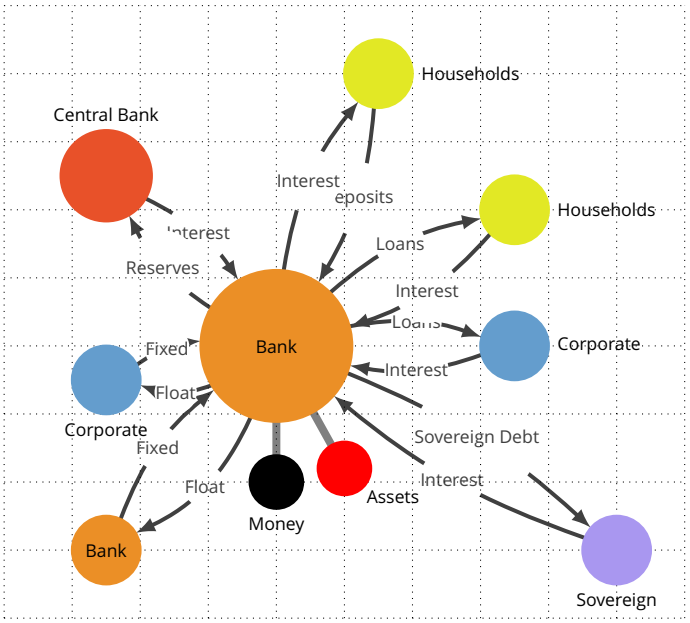

Figure 3: A bank node in a two-tier banking system represented as a nexus of contracts and transactions with other nodes. The arrows represent either contracts or cash exchanges between various parties. A large modern bank is an exceedingly complex operation, comprising of multiple business lines, many customer segments, thousands of financial products and complex relations with various external stakeholders (including the government, monetary authorities and prudential regulators). While a bank is frequently imagined as a "balance sheet", it is productive to keep in mind that the balance sheet is only a *projection* of what is a much more complex reality.

Most modern financial intermediation is performed by banks that are large corporate entities. They operate multiple business models with considerable internal flexibility. A typical (large) bank might engage in a number of distinct activities such as being a Payments Provider, a Fractional Reserve Bank (Offering deposits, Maturity transformation (ALM and Liquidity management)) ([13]), a Credit Insurer (Credit Underwriting (lending) including risk assessment, credit portfolio management), a Capital Markets Intermediary (Issuance of Equity / Debt) and also Performing Advisory Activities, Asset Management, Custody and a host of other financial system related functions. Hence the overall value proposition of a bank is a complex conglomeration of individual value propositions. In the context of modern *digital transformation* of the banking system it has become fairly popular ([14]) to talk about "unbundling the bank". There are various conceptual handles in how to tackle this "unbundling" task in a structured way. One fairly incisive tool is to focus on the role of a banking intermediary as the manager of diverse financial and other risks.[15]. In this strategy the bank in "unbundled" with reference to the underlying risk that is being underwritten or managed and the value proposition that flows from that competency.

Of the diverse business lines, value propositions and associated risks, it is *Credit Underwriting* (Lending) that involves large scale bilateral contracting with other actors in the economy. In Figure 3 we sketched the different actors with which a bank engages and the type of contractual relationship. The business model of lending is considerably narrower than the multitude of operations of a large modern bank is still quite complex[16]. Even the most "vanilla" banking model involves, besides the business risks facing any business, a range of complications: Interest rate uncertainty that emanates from the linkage with formal monetary systems, other associated risks (prepayment of funds, unforeseen drawdowns), various complicated liabilities (which again emanate from the link to the rest of the financial system), deposit insurance and many additional complexities coming through regulatory constraints and requirements. The execution of the business objectives utilizes a large number of internal and external functions and

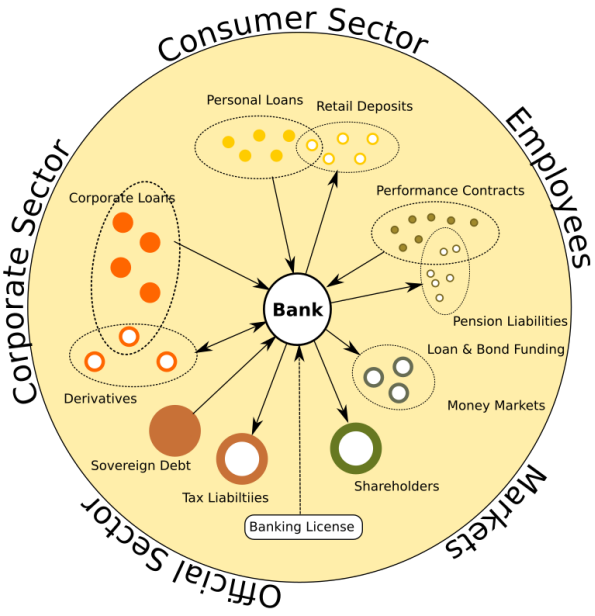

Figure 4: Sketch of internal bank structure with a heavy focus on the key *contractual relationships*. Arrows represent contracts of various types. E.g loan contracts, deposits, derivatives, employment contracts, pension liabilities etc. In order to discuss federation in a productive context we will abstract away many of those "complications" and we will perform a stylized "un-boundling" of the loan generation process that involves only three internal nodes

businesses. In Diagram 4 we see the classes of distinct stakeholders arranged around the core "Banking Node". In order to make progress we will have to "hide away" a lot of that complexity.

We now perform "laser surgery" on the complex cell structure of the commercial bank we outlined before. We will attempt to isolate three distinct entities (nodes) that we will focus on in the sequel. The operations and the internal and external relations of those distinct nodes will outline the overall business model (at least for our purposes). First we describe the proposed decoupling and then we go over the detailed description of each node.

Box 3. Unbundling the Bank: Three key sub-units that enable the credit provision process

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The functions and responsibilities of the credit business can be split into three units. The value proposition, tools, liabilities and risks of these entities are quite distinct. These units can also *potentially* exist as standalone businesses (in which case the provision of credit requires *partnerships* between such units)

- The Credit *Relationship* Node (**RN**). This is the core *client facing* entity. It can be thought of as the bank's physical or digital "front-end".
- The Credit *Management* Node (**MN**). This is the core *back-end* of the bank but it is also an externally unity, acting as the key *liability management* entity (and the linkage to the rest of the financial system).
- The Credit *Assessment* Node (**AN**). This is a "narrow purpose" node that performs primarily an analytic function in relation to credit risk. Yet that fairly narrow function is a cornerstone of credit provision and indeed its perfromance in a federated context the subject of this paper.

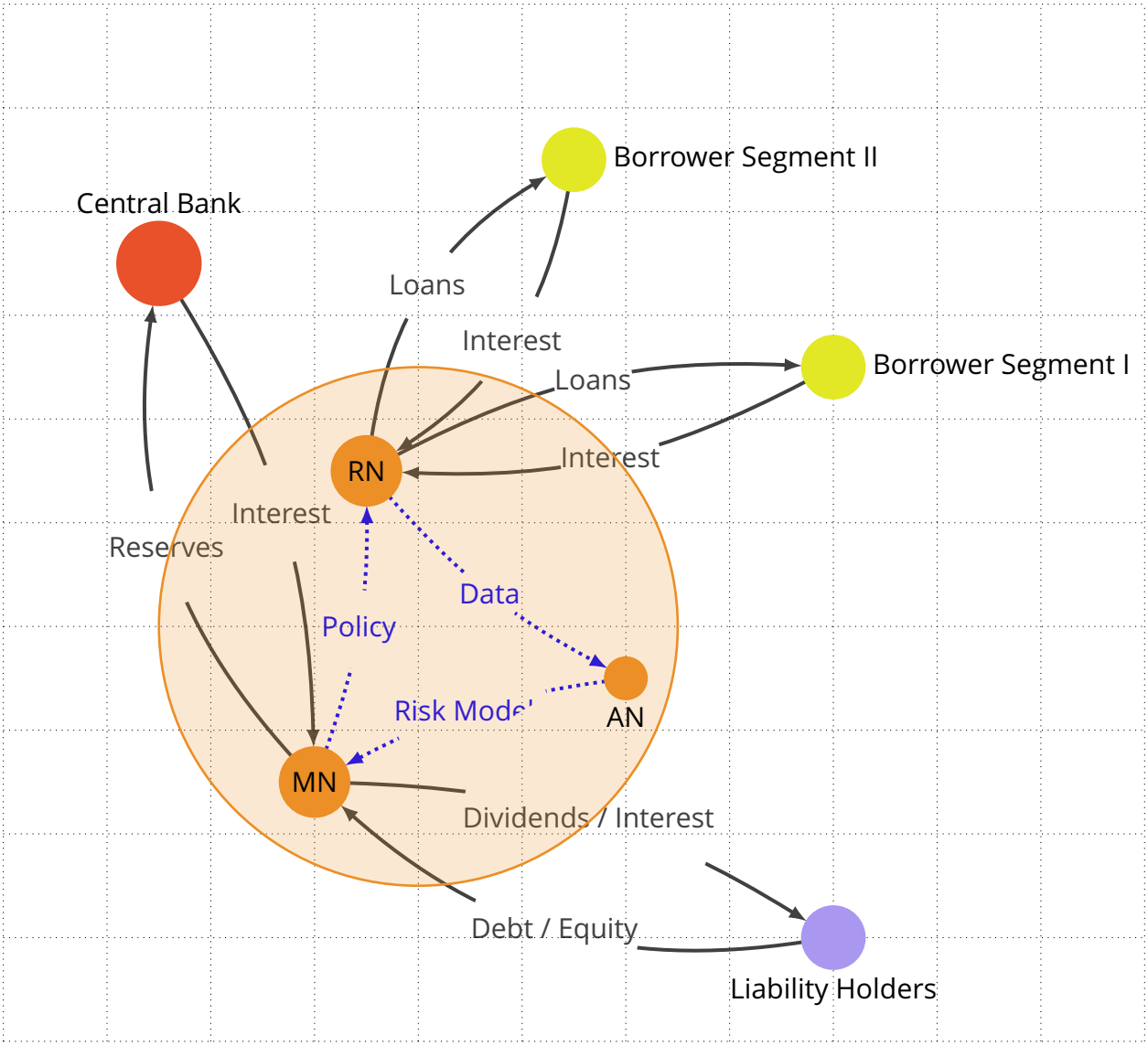


Figure 5: Illustration of the grouping of internal bank functions that are involved in credit provision. The principal entity engaging with clients is the *Credit Relationship Node* (RN). This is a business unit that interfaces physically or virtually with clients, provides the actual lending service and manages the client relationship from a communications and legal perspective.

The *Credit Management Node* (MN) bundles many other key decision making functions concerning the entire asset and liability portfolio that enables the lending activity. It also manages relationships with key stakeholders such as regulators and capital / liquidity providers. It can be considered the back-end of the bank, its record keeping infrastructure but also its linkage with the rest of the monetary / financial system.

The *Credit Assessment Node* (AN) performs primarily an analytic function. It collects data from RN (or directly from clients). It receives business requirements and operational constraints both from the RN/MN units. Its main function is to construct forward looking views of credit risk that is delivered e.g. via credit risk models. This function is the most clear-cut (and relatively thin compared to the other two - indicated with its slightly smaller size) but its importance in the credit provision process is significant.

The Credit Relationship Node

The first of the sub-units we will examine is the *credit relationship node* (RN or C_R). This is an independent business (or business line as part of a larger entity) that engages in the provision (marketing, sales, origination and ongoing servicing) of credit contracts. It can be considered as the "front-end" or the client-facing element of credit provision. This is a simplification, as this part of the bank includes also many back-end type functions that are deeply integrated into the process. As the primary client-facing unit that provides an actual service to the outside economy, the RN can be considered as the main "inheritor" of the bundled banking model[4].

Box 4. Real World Examples of Credit Relationship Nodes

Proxies of credit relationship nodes operating autonomously in the market are mortgage brokers or fintech type entities (Non-Bank Financial Companies) that intermediate credit origination on a commission / fee basis without relying on a banking license. An interesting such case is the Indian government program for Co-Origination of Loans by non-bank financial institutions.
Interestingly, once the credit relationship *sours* (a credit or loan becomes non-performing), it is not unusual that the relationship is handed over to a separate entity, the NPL servicer.

We discuss below the key attributes of the credit relationship business model by examining in turn its various dimensions. Very importantly for our discussion of federated credit systems, the RN unit is the conceptual *Data Owner* of key customer data. These are obtained in the context of engaging in a credit contract with a Borrower. Such data start with the all-important *identity* information and extend to the variety of qualitative and quantitative data we mentioned in Section

1. **The Value Proposition:** The core value being delivered to clients (the borrowing parties) is the ability to obtain credit, which can be of enormous value as it enables economic activity. The ability is realized primarily through: i) *legal technology* and documentation (which links and legitimizes (literally) the business model within a legal framework and jurisdiction) ii) the *information technology* that facilitates identity management, initial and ongoing data processing (this technology may or may not be digital!) iii) sundry artefacts (bank branches, apps, phones that facilitate establishing and maintaining relationships. This value proposition is thus bundling several distinct components that conceptually could be further refined. But even in this integrated form, it is seldom seen provided standalone. As mentioned already, in traditional banking models it might be mixed with a host of other ancillary services (from payments infrastructure to financial advice etc).

2. **Core Risk Management Competencies:** The RN unit bears and manages several important business risks (predominantly the risk of losing market share or failing to gain market share at a sustainable profit level but also a host of operational risks). We will see a more comprehensive discussion of risks later.

[4]Incidentally, this dominant relevance is occasionally also a factor in internal remuneration arrangements within banks. The client-facing unit is primarily responsible for achieving the business objectives. In for-profit firms this is typically expressed in terms of various profitability metrics)

3. **Customer Segments:** There is a large variety of borrowing entities (in principle all the different economic agents active in an economy. A minimal segmentation would be along a "B2C" and "B2B" split (private individuals versus corporate entities) with many possible subdivisions (e.g. regular (mass) retail clients, wealthy clients, SME vs large corporates etc). Credit relationship business models are typically molded around such broad customer characteristics.

4. **Distribution Channels:** There are multiple and complex delivery channels and they are generally adapted to the respective customer segments. They differ very markedly in the B2B versus B2C realizations. Effective use of channels to identify, approach and engage with clients seeking credit is a key enabling function of the RN unit.

5. **Customer Relationships:** Credit provision in this business model typically involves an ongoing relationship (physical and/or virtual interaction) that is established with customers. The nature of the relationship reflects the nature of product and business model. *Relationship banking*, as the name already suggests focuses on the engagement between the bank and the borrower, which among others provides potentially deep insights into the client's prospects and economic future. Other business models for credit provision (capital markets / securitisation) may involve less close relationships.

6. **Revenue Streams:** The revenue stream reflecting the overall credit provision is embedded in the contractual *interest rates* and/or fees charged to borrowing customers. Frequently there is no clear-cut split or natural allocation / matching of such revenues to the underlying costs: Bundled business models share various resources and the profitability of financial product typically compensates besides credit risk also other interest rate and more esoteric risks.

7. **Key Resources:** As we hinted already, the RN will use diverse resources such as physical assets (bank branches, offices), personnel, legal know-how, digital infrastructure etc to materialize the value proposition of credit provision to clients.

8. **Key Activities:** The activities required to materialize the value proposition of credit provision includes the "manufacturing" and the "maintenance" of the credit product (sometimes indicated as the Credit Life Cycle: the marketing, sales, origination and ongoing support and servicing throughout a contracts legal life. Some activities may be deemed as non-core / specialized and might be outsourced to entities that focus on particular aspects (e.g., IT infrastructure, Non-performing loan (NPL) servicing etc) (see Partners).

9. **Key Partners:** Businesses (or business lines) engaging in credit provision might partner with specialized entities, suppliers, or other collaborating entities e.g. credit bureaus, credit rating agencies, information technology providers, legal and accounting experts, specialized servicers etc. They might also partner with a *regulated* balance sheet / risk capital providers who enable the integration of credit provision into a formal credit / monetary system. These partnerships indicate - in principle - the broad outlines where the business model can be segmented.

10. **Key Stakeholders:** The RN has the range of "usual" stakeholders (clients, employees) but as a regulated entity features additional strong dependencies. Credit provision provides economic actors within an economy with (potentially unlimited) amounts of leverage. If abused it can have various distorting effects in the markets and even destabilizing effects for the entire economy. Over time,

quite strict regulation has evolved that controls i) who gets access to the credit system (e.g AML regulation) ii) under which terms (e.g. monetary policy) and iii) subject to which constraints (risk capital requirements). The first type of regulation (AML) is the one most relevant to the RN unit.

11. **Cost Structure:** The cost structure of this node includes all expenses incurred via the Activities, Resources and Partners mentioned already in the realization of the Value Proposition. Importantly, from the RN perspective, credit risk (the loss associated with contract not repaid) is treated as a cost (on an expected basis), e.g., alongside the cost of sourcing funds from the formal monetary system.

12. **Competition:** Credit provision in modern market based economies operates in a competitive, for-profit context. RN is the primary unit facing external competition for clients. Depending on circumstances, multiple businesses may be targeting the same customer segments with similar or overlapping value propositions. This may lead to over-banking. In the opposite extreme, there may be a limited offering (under-banking) when the overall costs / profitability calculus is not favorable for lenders.

It is worthwhile mentioning that credit assessment is definitely not the only data driven function that might be relevant for the RN unit. E.g., data analytics supporting marketing campaigns would also be handled within the Credit Relationship Node.

The Credit Management Node

The *credit management node* (MN, C_M) of our abstraction is a vital component of the banking structure. In a typical bank the MN comprises a cross-section of Portfolio Management, Credit Risk Management, Asset and Liability Management / Capital Management, Business Strategy / Business Management and Finance / Accounting. From a functionality perspective it can almost be seen as the bank (including its management) minus the RM and AN units! MN will engage with Partners or other Stakeholders such as regulators to ensure ongoing access to the financial system: MN engages in the *aggregate* management not only of credit portfolio assets but also of its liabilities.

Box 5. Real World Examples of Credit Management Nodes

All commercial banks have an embedded MN type unit in some form or other. The embedding / distribution within a bigger business may obscure its essential (and distinct) business model. An (imperfect) proxy for the functions bundled in MN is a credit asset manager that is setting up and managing special purpose vehicles for the securitisation of credit assets. The proxy is imperfect because such units typically will also undertake credit assesment and source credit in the market.

Next we proceed to analyze key attributes of the credit management business model using the same schema as for the RN unit. As we alluded to already, this is a critical and large bundle of functions which links a firm's credit provision into a global financial system. Our exposition here will not do it justice in this respect, but we will try to isolate the facets that link to the issues around federating credit assessment.

1. **Value Proposition:** The core value being delivered by MN to the *ultimate clients* (the contracting parties) is the *formal linkage* with the regulated financial / banking system. This has both monetary

(sourcing funds) and prudential aspects (securing risk capital). This linkage enables operating e.g., a fractional reserve banking model or otherwise completing the *intermediation* architecture that is required for the financial system to operate. Activities include locking-in competitive *interest rates*[5], participating in deposit insurance protection schemes, creating lending capacity (both risk capital and liquidity) and the (macro) steering of the credit portfolio.

2. **Core Risk Management Competencies:** The MN unit bears and manages many important "macro" type risks (interest rate, liquidity risks) and similarly macro aspects of credit risk (portfolio wide or sectoral developments). It has its own operational risk profile, e.g. in business execution.

3. **Customer Segments:** Simply put, an RN unit cannot operate without partnering with one (or more) MN units. In the bundled bank model the internal customers of MN are thus the different business lines (RN units) that engage in credit provision. Depending on internal arrangements, these might be competing (bidding) for lending capacity.

4. **Distribution Channels:** The delivery channel of MN is straightforward as it only caters to internal clients. It materializes via proprietary tools and technology platforms.

5. **Customer Relationships:** The customer of MN being an internal unit, there is typically ongoing interaction and flow of information between RN / MN, which may be more or less "active" / "proactive", e.g. hedging in anticipation of future RN business.

6. **Revenue Streams:** Conceptually MN enjoys / splits with the RN unit the same revenue stream obtained from the contractual *interest rates* and/or fees charged to customers. As mentioned, frequently there is no clear-cut split and allocation of such revenues to the underlying costs but various mechanisms exist (Funds Transfer Pricing)

7. **Key Resources:** The MN will use diverse resources such as specialized personnel with legal, accounting, financial markets and regulatory know-how and digital infrastructure.

8. **Key Activities:** The MN activities are quite diverse and include external engagement with stakeholders and markets (e.g., issuing equity and/or debt) and internal processes such as ALM and capital management.

9. **Key Partners:** Beside the internal partnerships, MN can also form external partnerships of various forms (e.g. to enable strategic risk sharing)

10. **Key Stakeholders:** MN manages critical stakeholder relations with funding and risk capital markets. In terms of its regulatory stakeholders it is liquidity and regulatory capital requiremetns that are the most prominent.

11. **Cost Structure:** The expenses incurred via Activities, Resources and Partners in the realization of the MN units Value Proposition would include funding / capital costs and operational costs.

12. **Competition:** The MN unit is frequently internally a "monopoly". On the other hand it faces external competition e.g. when originating liabilities in the wholesale markets.

[5] One extra complication of the bundled business model is that the RN we already discussed might also engage in qualitatively very different contracts, namely deposit accounts. These are *liabilities* of the bank and thus conceptually belong to the same class as shareholders or other lenders offering the bank (wholesale) lending and would (normally) belong to the remit of MN.

Naturally this (largish) management unit can be further decoupled into more focused business models. For our purposes (analysing the incentives and information flows around federated credit architectures) it would complicate the discussion without offering an *immediate* advantage at this stage of development.

The Credit Assessment Node

Finally we reach the function that is the main focus our federation credit systems discussion. The *credit assessment node* (AN, C_A) is an independent business or captive business function that analyses the credit profile, in the broad sense, of entities that seek (or have already obtained credit). The concrete outcomes of such analyses would be credit sensitive measures, metrics and indicators such credit scores, credit ratings, valuations, risk parameters (probability of default, loss-given-default, exposure-at-default) and more.

Important for our discussion, the AN unit is the conceptual *Model Owner* of any quantitative / statistical model developed to assess the credit risk of Borrowers. It owns the intellectual property, related know-how and development tools. The economic ownership of the actual infrastructure for constructing and delivering modeled estimates internally / externally may vary. This unit is, in principle, *liable* for the associated model risk. In the process of developing credit assessment, the AN unit will acquire a variety of important client data. The acquisition can be either directly from borrowers or indirectly via their RN (or other) relations.

Box 6. Real World Examples of Credit Assessment Nodes

In existing practice, there are various ways in which the credit assessment process is organized:

- An internal (captive) process: Data collection and models are delivered by a specialized unit within a banking type institution. The costs are borne collectively.
- As an external process: Data collection and models are done externally by a third party. The credit assessment might be paid for by the lender OR by the borrower (borrower-pays versus lender-pays models).
- Hybrid combinations: E.g. external credit data and models might be sourced, integrated and used alongside internal data and models

Examples of credit assessment nodes operating completely autonomously in the market abound (See e.g., a list of Credit Bureaus) or Credit Rating Agencies. They differ quite significantly in terms of the type of information collection and processing that is being offered, taking also into account the legal, regulatory and market conditions in different countries.

Next we proceed to analyze the key attributes of the credit assessment business model. While modern credit risk assessment may well use fairly advanced analytical tools, historically banks have operated without such processes for many centuries. Heuristic rules around credit risk assessment (e.g.the five C's of credit) can be considered the precursor technology to the standard practices and models used today. Current approaches have largely been established in the last two decades but the ongoing digitalization of underlying economies suggests already there are material improvements possible (at least in principle).

1. **Value Proposition:** The core value being delivered to the lender by the credit assessment unit is reducing the *information asymmetry* between borrower and lender. The use of credit risk management technology, in particular initial and ongoing (*credit risk assessment*) aims to support credit decision making (whether to grant on not credit, the terms and conditions etc). In principle, this process lowers the cost of providing credit by reducing the likelihood of underwriting contracts that will not be honored.The objective of reducing information asymmetry is served through i) the systematic collection of data ii) the processing of such data to distill *views* around credit risk and iii) the formulation of *policies* that make use of those views in the various stages of the credit provision process.

2. **Core Risk Management Competencies:** We mentioned already that the AN unit bears and manages predominantly model risk, the risk that the credit assessment process (the entire lifecycle from data sourcing to credit decision outcomes) is flawed and not inline with expectations. Model risk is essentially generated by the individuals (experts) involved in the model development process. Underlying factors may be both unintentional (limited knowledge, limited resources) and intentional (fraud, or conflicts of interest). As a standalone business it will of course face a host of other business and operational risks linked to the provision of this service.

3. **Customer Segments:** The ”customer” of the AN node can in principle be either end of the credit contract (the lender or the borrower). In the former case, customers are the different classes of lenders, in the latter case, the different classes of borrowers. When operating inside a bank, the customer is the lender, primarily the credit relationship function. An assessment unit may have sub-units specializing in the various customer segments. The credit assessment methodologies, the required data etc. can be quite varied across borrower segments, reflecting the complexities and operating models of different borrower classes and sectors.

4. **Distribution Channels:** The channel for the AN unit to deliver its value heavily depends on whether it works along the borrower-pays or lender-pays model and, ofcourse, the customer segment. For example, credit rating agencies operating under the borrower-pays model make their assessment of the credit worthiness of companies *public* (via rating reports).

5. **Customer Relationships:** The relationship with the borrower has typically two components: Engagement during *Initial Assessment* and subsequently as part of *Ongoing Monitoring*. The precise relationship depends on whether it is an autonomous model or piggy-bagging on the RN unit.

6. **Revenue Streams:** The revenue stream of the AN unit (when operating autonomously) is a fee for performing the credit risk assessment. In a captive business model this will simply be any internally allocated cost.

7. **Key Resources:** AN’s use specialized personnel with legal, economic and statistical know-how, and they deploy digital infrastructure as the primary resources for delivering their value proposition.

8. **Key Activities:** The activities are of a (data) analytic nature. Data and information gathering that can be manual or automated, quantitative or qualitative, historical and current, across a vast spectrum of possible information sources. For commercial entities it will be leveraging the financial

statements and other disclosures or reports already compiled internally. On top of such data collections, a variety of credit risk models effectively summarize the data and create measures and metrics that can be used for credit risk management.

9. **Key Partners:** Besides internal partners, a AN unit may partner externally to source additional data, computational resources or other related services or know-how.

10. **Key Stakeholders:** The provision of credit assessment is subject to model risk (with potentially dire consequences if it goes wrong on a systemic scale. Regulators are key external stakeholders and there is increasingly strong emphasis on Model ValidationModel Validation requirements.

11. **Cost Structure:** Expenses are incurred via the Activities, Resources and Partners in the realization of the credit risk assessment, which will include data sourcing costs, personnel, IT systems etc.

12. **Competition:** In principle credit risk assessment can be obtained by any entity suitably equipped to provide the service (and having access to the requisite data). The issue of competition (or not) and its possible impact (rating shopping) are well known and studied phenomena, especially since the Great Financial Crisis.

Putting it all back together

Now that we have concluded the identification of the three distinct business models involved in credit provision we are ready (in principle) to consider how and why we could put them together with an eye towards federated systems. Diagram [6] illustrates basic information flows and relationships in the *standard* credit provision process.

A borrower B_i (lightgreen color), for example a new potential client engages with the credit relationship node C_R (steelblue color), through one of the distribution channels. In the context of that interaction they provide data points D_i^T at time T. This data set will likely be augmented as the engagement deepens (starting with identity information and growing to more economic data). This set will be evaluated and transmitted (potentially augmented with other data) to the credit analysis node C_A (orange node).

The C_A node will uses this information (potentially along with other external data and model resources) to apply a credit model M_g. Such models are generally developed off-line (using cumulative, historical, datasets representing similar borrower segments and extending to past periods). The model produces risk assessments $\{S_i\}$ (e.g. credit scores, credit rating or associated metrics) and *explanations* E_i about the assessment. Such metrics are also communicated to the credit management node C_M that maintains the overall portfolio view. Potentially a sub-set of explanations E_i is also transmitted back to the client.

At a future time $T+1$ additional information is generated under the relationship (updated data set D_i^{T+1}) which in turn leads to updated metrics etc. At some future point the model version might be revised (M_{g+1}) using additional data or other approaches. This basic set of information flows should be seen embedded in a dynamic environment that applies specific risk appetite criteria in a continuous feedback between nodes.

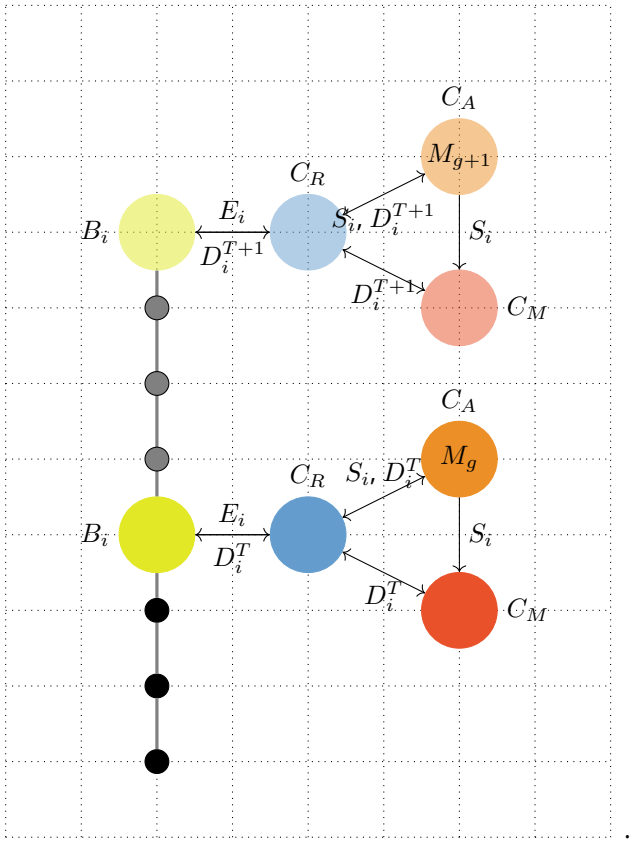


Figure 6: A diagram illustrating information flows and relationships in the standard credit provision process. A borrower B_i engages with the credit relationship node C_R, providing data points D_i^T at time T. Those are being transmitted to the credit analysis node C_A, which uses them (potentially along with other data / model resources) to apply a model M_g, modeled risk assessments $\{S_i\}$ (e.g. a credit score, credit rating or associated metrics and *explanations* about the assessment. Such metrics are also continuously communicated to the credit management node C_M that maintains the overall portfolio view and also (potentially a sub-set E_i) to the client. At a future time $T+1$ additional information is generated under the relationship (updated data set D_i^{T+1}) which in turn leads to updated metrics etc. At some future point the model version might be revised (M_{g+1}) using additional data or other approaches.

Challenges, Risks, Incentives and Counter-Incentives of Federation

We already mentioned in the previous segments (epigrammatically) the top risk management challenge faced by each one of the "unbundled" credit provision functions. Now we will do a more comprehensive review. We will do that by "mapping" each node to the Open Risk Taxonomy[17]. The Open Risk Taxonomy aims to be a holistic picture of risks facing an organization (in particular financial organizations) in support of holistic risk management. The highest level decomposition (and a distinctive future of the taxonomy) is the use of *contracting* as key differentiating aspect of risk types. Contractual Risks typically allow better defined notions of risk exposure, which in turn renders them more amenable to Risk Quantification. Business Risks, which are not explicitly linked to contractual relationships, and thus are generally less tangible / harder to quantify, although decidedly not less real or with lower potential negative impact.

Business Models mapped to the Open Risk Taxonomy

For ease of exposition and brevity we will flatten the taxonomy to its lowest level (leaves) and we will only mention the areas that have (historically) notable risk associations. The colored boxes in the table indicate which risk type is most representative of the risk that a unit is facing / managing. The aim is not to give an exhaustive analysis of risks for each unit but to highlight how *different* their intrinsic risk profiles. In turn this will be an important consideration when considering the incentives for federation of credit systems.

It is instructive first to discuss how the main contractual risk of credit provision (namely credit risk of

loans and other financial products) is seen from the different nodes. For both the Credit Relationship (RN) and Credit Management (MN) nodes, it is the risk of unexpected (large) loan defaults that forms a major threat. For the RN unit the scenario erodes the profitability built-in in credit margins. For the MN unit it may endanger its ability to source funds and risk capital at viable rates. In contrast, the AN unit does not directly experience a financial loss in this scenario (but may incur reputation loss, depending on the reasons of the excess credit loss) and to the degree that its financing depends on repeat business its long term viability is also affected.

Federation Incentives

Now that we have a first decomposition of business models and associated risks it is an opportune time to ponder how the possibility of *federating data and tools* reflects on the objectives of the different nodes. The overall argument revolves around improved credit provision (more inclusive, more accurate and robust, less costly etc.) but that argument must be resolved for each one of the constituent entities:

Incentives for the Analytic Function

For the analytic node (AN), federation seeks a balance between delivering a better credit assessment service and at a lower cost, versus competition and market share in the credit assessment "market". Objectively the sourcing of adequate credit data and modeling credit risk can be problematic in various contexts. E.g., constructing sufficiently complete risk profiles is one of the long standing issues. The regulatory document "Principles for effective risk data aggregation and risk reporting" [18] identifies some important and relevant dimensions. For any customer segment / portfolio the number of credit events available to assess credit risk might be insufficient during a narrow enough temporal observation period [19].

Entities that believe they already perform the best possible credit assessment job *and* have large market share would thus be reluctant to participate. On the other hand firms might cooperate if they can substantially improve their service and gain market share versus non-cooperating firms. If market share is not a concern (e.g., for captive internal units that are "monopoly" providers to their respective businesses) the incentives are more favorable: federation will in general only reduce their key model risk. Alas, in that arrangement the analysis is complicated by the close relationship with their internal partners. If, e.g. the RN unit absorbs the costs of credit assessment, its incentives for federation will depend on how this impacts their own market share (of borrowers).

Incentives for the Relationship Function

For the credit relationship node (which in many arrangements owns the enabling credit data) the sourcing of better / lower cost credit assessment is seen through a complex prism of internal risk and cost allocation and its precise split with the management (MN) unit that provides risk capital and funding. In one extreme design, the RN unit acts as a risk-insensitive broker. In this case any restriction on market share would be seen as a negative. In contrast, any setup that enables market share is positive. For example if federation unlocks a previously inaccessible market this would be seen as a net plus. This works both ways. If increased accuracy reveals the need of *restricting* underwriting to a risky segment this might be seen as "unwelcome" news. In the other extreme (where credit losses are directly affecting remuneration

	Credit Relationship	Credit Management	Credit Assessment
Business Risk Category			
Revenue Risk	Uncertain market share / profit margins from lending	Risk of ALM mis-matches	Market share / margin from credit assessment
Business Model Risk	Alternative business models for delivering credit	More efficient methods to intermediate credit provision	Lower cost / more accurate methods to assess credit
Reputation Risk	Borrower perceptions	Funding Markets / Regulatory perceptions	Lender perceptions
Business Execution Risks	Marketing / Sales Strategies	Raising Funds	Model Risk
External Fraud	Fraudulent borrower behavior		Inaccurate data
Legal Risk	Mis-selling of products to clients	Mispresentations to liability holders	Misrepresentation to lenders
Political Risk and Regulatory Risk	Changing conditions around lending	Changing capital / liquidity requirements	Changing model risk governance
Funding Risk		Access to funding markets	
Contractual Risk Category			
Credit Risk	Unexpected Loan Defaults	Unexpected Loan Defaults	
Optionality Risk		Prepayment Risk / Drawdown Risks	
Market Risk (in general sense)		Interest Rate (possibly FX) Risks	
Performance Risk	”Rainmaker” Risk (key performers)	Key Person (expert) Risk	Key Person (expert) Risk
Outsourcing Risk	Infrastructure providers	Infrastructure providers	Infrastructure providers

Table 2: In this table we apply it the Open Risk Taxonomy to the three sub-business models comprising credit provision (Credit Relationship, Credit Management, Credit Assessment). The highest level decomposition is between contractual risks and business risks (the former being directly link to contracts that are undertaken by the different nodes. The colored cells indicate the ”signature” risk faced by each business model. Empty cells suggests the corresponding node does not have particularly noteworthy exposure to some risk type. We can simplify the situation as follows: revenue risk is primarily outsourced to the relationship node, funding and various macro risks are outsourced to the management node, the direct impact of excess credit losses is split between relationship and management, whereas the risk of poor credit risk assessment is the main preoccupation of the assessment node.)

/ other incentives) the picture is quite a bit more complex: Improving accuracy reduces credit costs but it may also reduce market share.

Incentives for the Management Function

For MN, the management node, improving the performance of credit forecasting tools, is ceteris-paribus, a net positive. It reduces portfolio volatility and leads to more favorable funding terms, in principle allowing to lock-in a better spead. Federation can create a win-win situation where participating firms collectively improve their access to capital and funding (ultimately also increase lending market share) at the expense of non-participating firms.

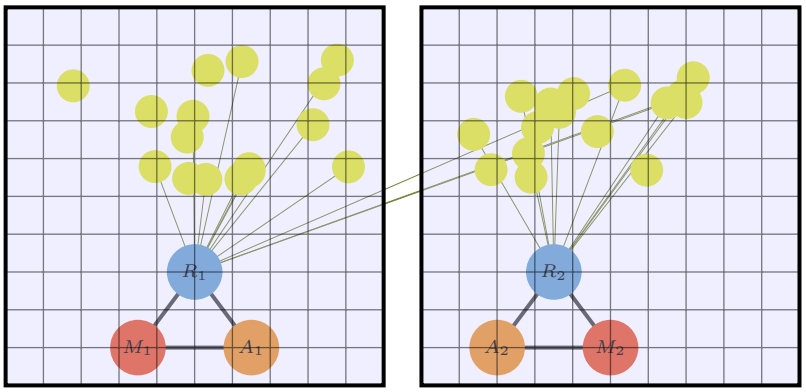
The non-profit angle

For non-profit initiatives in general the conflicting commercial interests sketched above would be attenuated. This does not imply overwhelming incentives for using federation. In such business models other phenomena may start becoming important (e.g. brand positioning, partnerships etc).

Federation Counter-Incentives

There are a host of potential issues and counter-incentives for federation to be initiated / succeed.

- IP protection / competitive advantage / business secrets. Ensuring absence of raw data exchange which is a key strategy of modern federation architectures means that sensitive and/or granular information is not exchanged. Yet even the exchange of aggregate information (or even participating in the harmonization of metadata) may be considered by some entities as revealing too much valuable information.
- Free riding by federation participants. Without safeguards that ensure ”fair” contributions it is possible that most members will aim to extract benefit from the federation, the phenomenon known as the ”tragedy of the commons”.
- Costs of new systems, cost of maintaining additional systems and cost of training of personnel. These costs are absorbed by the corresponding business model but to the degree they are not clearly separated / matched against benefits there might be reluctance to commit.
- Risks from adversarial behavior. While participating entities will in general be reputable and regulated entities, the possibility of one or more entities undermining the federation would have to be isolated and safeguarded against.
- Extra complexity to decision-making processes. In general, decision making using federated infrastructure will involve more governance.
- The credit granting process is a regulated industry. The requirements are particularly elevated for business models that involve deposit contracts and the general population. Hence federation would have to be seen within the regulatory environment. The long established operation of credit bureaus / rating agencies etc. suggests that it is possible to orchestrate credit data information exchange.



Bank Network I Bank Network II

Figure 7: **Classic Banking:** Visual illustration of traditional, "federate-nothing", credit provision. Each bank network structure has its own contractual relations with borrowers, lives on its own "data universe" and employs its own Relationship, Assessment and Management nodes.

- Creating new types of outsourcing intermediaries (where risks and liabilities are unknown and mitigation measures not yet developed).

Old and New Architectures of Credit Data Sharing

In this section we sketch various possible arrangements of federating the credit risk assessment in economic networks with different data sharing topologies and different business models. The structure of such arrangements and the degree to which they are adopted in practice influences 1) the added value of different arrangements, 2) the successful exploitation of incentives and 3) the negation of counter-incentives.

Classic Banking

As a baseline we start with traditional banking. Two different banks operating in the same segment would effectively have their own two "networks". It is a "share nothing" arrangement (but only to a first approximation).[6]. An important (if obvious) feature of an arrangement with multiple banking providers is that borrowers can establish contracts with multiple banks. In the sketch, data collection happens through the Relationship node (R_1, R_2 respectively for the two networks.) From a credit risk assessment perspective this is a highly non-trivial feature: the capacity of a borrower to repay is strongly related their total liability profile and behavior. The accuracy of such assessment depends on the *fidelity* that an assessment unit can achieve.

Adding Credit Bureaus Nodes

Over time various external business entities have emerged to help mitigate the data scarcity around credit provision. Two very representative categories are the "credit bureau" and the "credit rating agency". There are various significant differences in their setup, the nature of data collection / processing, business models etc. Let us start with the Credit Bureau.

[6]There are many exceptions. We mentioned already the diffusion of intellectual property through academia, banks may also cooperate in e.g. setting up standards, investing in certain types of common infrastructure etc.

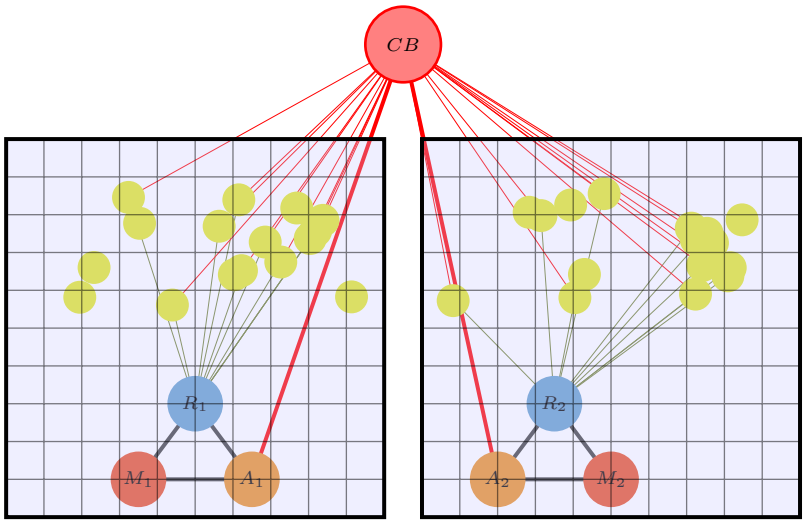


Figure 8: **Credit Bureaus:** A typical modern credit information arrangement using an external entity (the Credit Bureau CB) that sources credit data for the borrowing population (retail and SME). Such data are then used by internal credit assessment units along with possible internal data sourced through the relationship structure.

A Credit Bureau(CB) is an entity that engages in Credit Referencing namely collecting information about individuals or organizations about their track record with Credit Risk. The credit bureau collects data from the aggregate borrower population (including historical data) and compiles reports and/or models that can then be integrated into enhanced decision making and models. The practice occurs in many countries around the world (in different forms) with the primary purpose of collecting and providing information to help lenders make better credit decisions. The Credit Bureau industry is very diverse[20]:

- The business model may be a for-profit enterprise (e.g. a joint lender venture or an independent entity) or a public sector / non-profit entity.
- Credit Bureaus offer a diverse set of services: Credit reports / credit histories, Credit Scoring, Consultancy Scorecard development, Software provision, Fraud prevention, Identity check, Marketing Services, Check of current account, Debt Collection etc.
- The borrower segments are primarily individuals and SME's. The CB does not in general have a strong relationship with the borrower.
- Credit scoring methodologies are not (in general) public.
- The source of the credit data can be lenders or other clients that extend credit (e.g. utilities), public registers or the borrowers themselves.

The types of data collected by CB's are quite diverse. Some indicative categorizations: Identity data, Credit application data (inquiries), Legal information (bankruptcies etc), Payment data (defaults on contracts), Loan data (e.g., original amount of credit, duration) and outstanding amounts. The information sources can be further split into Credit Positive vs Credit Negative data. Credit bureaus comply with various laws and regulations ranging from the protection of personal data and consumer protection and banking laws to specific credit reporting acts. The CB might be operating under various business models (e.g., as a joint venture of lenders, a non-profit or an independent entity). A distinguishing feature of the arrangement is that the borrower does not (in general) pay for this service.

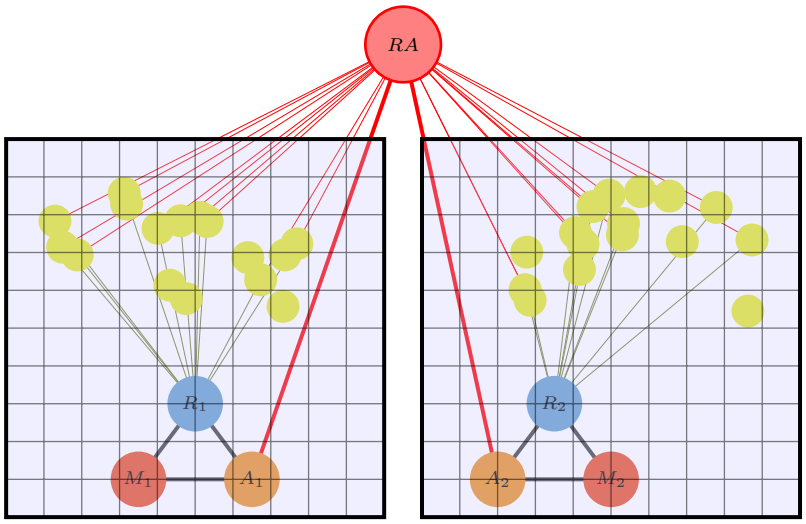


Figure 9: **Credit Rating Agencies:** An alternative credit information arrangement using an external entity (the Credit Rating Agency RA) that sources credit data for a different segment of the borrowing population (Corporations, Sovereigns etc). The Credit Rating Agency operates a business model where the borrower pays for the service.

The efficacy and role of traditional Credit Bureaus is changing. An interesting recent study[21] explored the impact of additional data and different models in improving credit assessment: They compared true positive rates versus false positive rates for borrowers at different thresholds for three different models: (I) a logistic regression with only the credit bureau score on firm i at time t as dependent variable; (II) a logistic regression with the credit bureau score and additional borrower characteristics; and (III) a machine learning model based only on the Mercado Libre internal rating. They find significant lift, in particular for the machine learning model (see also [22] on the use of digital footprints and, so-called, Alternative Credit Data).

Credit Rating Agencies

A Credit Rating Agency plays a similar information collecting role but with some significant differences:

- The borrower population concerns large(r) legal entities such as corporations, sovereigns or sovereign-type entities (local governments) and specialized entities such as project finance.
- The borrower pays for the service and maintains an important relationship with the credit rating agency.
- The credit rating methodologies are public (at least in broad outline).

While the architecture looks superficially similar to the previous case, the business model is substantially different (the borrower pays for the credit assessment), which means that in certain scenarios the credit information produced may be biased towards under-representing credit risk.

The role of credit rating agencies has come under enormous scrutiny after the great financial crisis (GFC) of 2008, in particular in relation to structured finance ratings. This major historical episode underscores how the design of credit information flow in the financial system is both directly relevant and acts (potentially) as a systemic and destabilizing risk factor. In terms of our Risk Taxonomy, as discussed in the previous section, this is an example of model risk. In simplified terms, a core feature of the Rating Agency business model (the borrower-pays model) means that there are potential conflicts of interest that may

lead to biased credit assessment (under-estimating credit risk). It is not our purpose here to review all the issues and remedies that have been proposed in the aftermath of the GFC. A list of the oversight areas that have been instituted by regulators in recent years gives good insight[23] about the relevant friction points: Adherence to Policies, Procedures, and Methodologies; Management of Conflicts of Interest; Implementation of Ethics Policies; Internal Supervisory Controls and Governance; Compliance and Internal Complaints (raised by employees); and Post-Employment Policies (the role of personnel transitions between rating agencies and clients). In the language

Open Banking

We now explore a setup that attracts much current interest, the concept of Open Banking. *Open Banking* denotes a number of recent initiatives[24] that aim to enable more widespread exchange of customer data between banks and other intermediaries (targeting primarily retail / SME customers). Open Banking requires banks (subject to client consent) to give third parties access to current account information through direct application programming interfaces (API's). First some (unavoidable) terminology around the actors (and corresponding business models).

- Payment Service Users (PSUs) are the economic actors (the first party) wanting to engage in payments (hence not strictly corresponding to entities seeking credit).
- Account providers include banks, building societies and payment companies also known as Account Servicing Payment Service Providers (ASPSPs). They the "second party".
- Third Party Providers (TPPs) are Account Information Service Providers (AISPs) and Payment Initiation Service Providers (PISPs). Third-party-providers can initiate payments on the behalf of PSUs.
- AISPs, account information services, give consumers and businesses an overview of their financial situation by consolidating information across the different payment accounts they may have with one or more payment service providers
- PISP, payment initiation services, help consumers make online payments and inform the merchant immediately of the payment initiation, allowing for the immediate dispatch of goods or immediate access to services purchased online. PISP need access to the PSU's current account (held by an ASPSP).
- Technical service providers (TSPs) are companies that work with regulated providers to deliver open banking products or services.

The primary objective of Open Banking is to enable more customer choice when making (digital) payments. Open Banking implements the exchange of customer *payments* data between ASPSP's.

- Open Banking is primarily about payments, not credit. Yet credit granting firms are typically also PSP's and potential third parties may aim to add value around credit assessment.
- Payment data (transactions) are being exchanged at the request / with consent a client. From a credit risk analysis perspective customer transaction data may provide additional insights into the client risk profile[25] but in general will be insufficient to enable a full credit assessment of the customer.

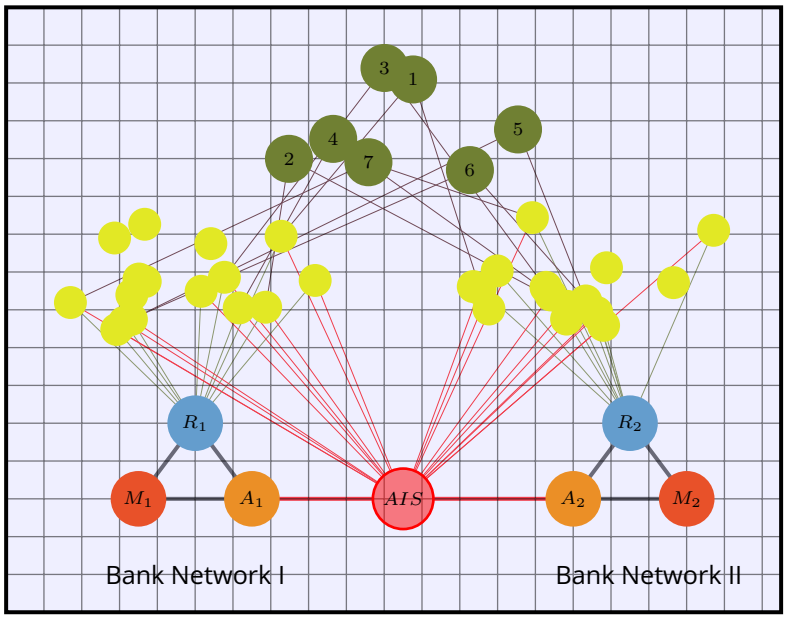


Figure 10: **Open Banking:** Credit provision in an architecture that is implemented around the Open Banking concept. Open Banking enables the exchange of customer payment data. Clients (light green dots) are making payments to various entities (numbered dark green nodes) using payment accounts held with credit granting nodes (R_1, R_2). These information flows are shown as the red links between nodes.

- The overall data exchange supported by Open Banking does not support (by itself) credit model building (it may not be historically complete, it is not representative of the population etc.)
- Open Banking regulations and infrastructures are establishing IT platforms (API's) that can be extended to support Federated Credit Systems.

The data owner (RN) are emitter and/or receivers of payments data under and Open Bank API through the intermediation of third party (Account Information Service Provider).

Trusted Third Parties as Risk Data Aggregators

Another mechanism available for the structured sharing of information between entities follows the pattern of a *trusted third party*. A distinct legal entity, which is nevertheless setup and controlled by a collection of market participants becomes a central node that setups up the infrastructure, standards etc. around the collection, processing and dissemination of relevant information. Members are incentivised to fund the effort and contribute information in order to reap the benefits of a higher quality data set.

Two current examples of such arrangements are:

- **Global Credit Data** (GCD), a banking industry initiative to pool credit data for certain segments of corporate borrowers. It is a non-profit association owned by its member banks. The mission is to help banks better understand and model their credit risks through data pooling and benchmarking activities.
- **Operational Riskdata eXchange Association**, (ORX) is similarly a non-profit association owned and driven by member institutions focusing on the operational risk domain.

This type of data exchange is more akin to an offline process that is not directly to the credit provision activities (but may feedback into those, subject to the policies of each lender.)

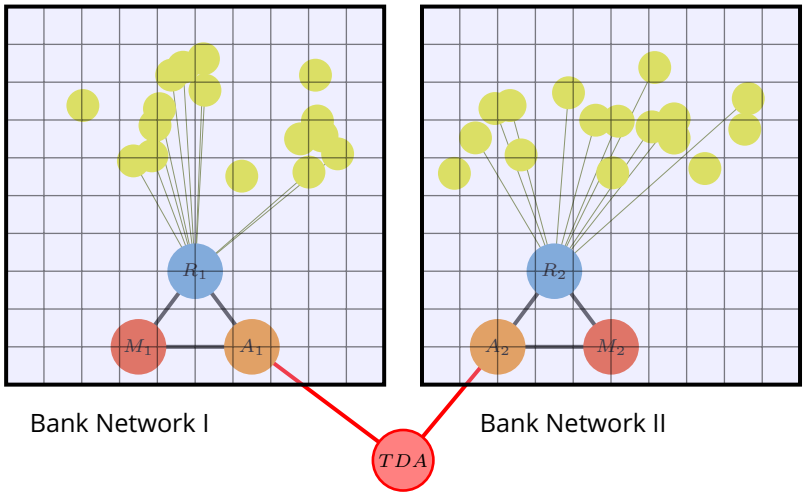


Figure 11: **Trusted Data Aggregator:** This architecture is in most respects identical to traditional banking. The additional connectivity / information flow is provided through an entity that is setup jointly by tje lending institutions (TDA). It is a trusted data aggregator, namely a third party that each of the participating entities considers as a safe place for the information they provide.

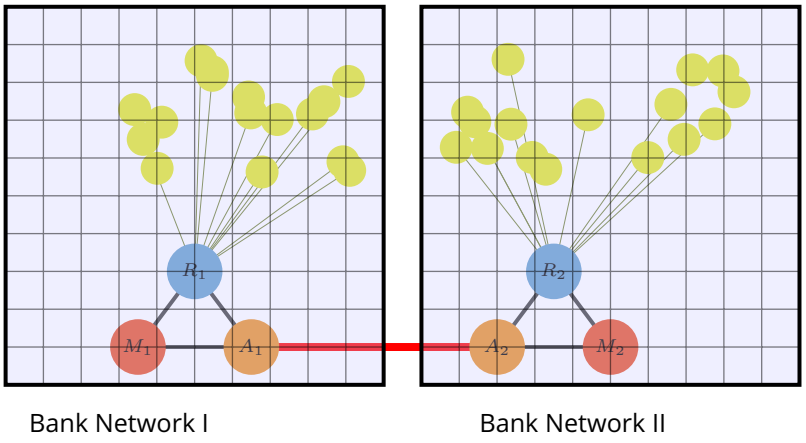


Figure 12: **Federated Credit System:** Credit provision in a federated architecture where two distinct banking networks (as represented by relationship and management nodes) use credit assessment nodes that structurally and systematically exchange credit information derived from their respective borrower portfolios (represented by their direct link).

Federated Credit Systems

We are now ready to define the class of architectures that we want to explore further in this series of white papers, namely *federated credit systems.* The concept is defined in analogy with the use cases we saw in the medical / mobile computing domains but is quite distinct as it must be minimally adapted to the context of commercial competing entities (and features many other challenges specific to this domain).

Definition: Federated Credit Systems

A Federated Credit System is an arrangement of credit provision where multiple lenders in a coopetitive arrangement obtain informational gains *without* aggregating their individual data but instead perform credit analyses and develop globally shared credit models on locally stored data.

A Federated Credit System is thus an architecture that does not introduce third parties as economically independent entities or even as trusted third parties collecting data. Instead the principal design element

is to connect participating entities and create / share valuable knowledge *without* the physical exchange of data. The extraction of the information dividend is achieved by performing local computations according to globally shared procedures and algorithms.

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